



POLYMETALLIC NODULES RESOURCE CLASSIFICATION

Proceedings of the
International Seabed
Authority and the
Ministry of Earth Sciences,
Government of India
Workshop held in Goa, India,
13-17 October, 2014

**POLYMETALLIC NODULES
RESOURCE CLASSIFICATION:
Proceedings of the
International Seabed
Authority and Ministry of
Earth Sciences, Government
of India Workshop held in
Goa, India,
13-17 October, 2014**

POLYMETALLIC NODULES RESOURCE CLASSIFICATION

Proceedings of the International Seabed Authority and
Ministry of Earth Sciences, Government of India
Workshop held in Goa, India, 13-17 October, 2014



International Seabed Authority
Kingston, Jamaica

The designation employed and the presentation of materials in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the International Seabed Authority concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers or maritime boundaries.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior permission of the copyright owner. Application for such permission, with a statement of purpose and the extent of the reproduction, should be addressed to the International Seabed Authority, 14-20 Port Royal Street, Kingston, Jamaica.

National Library of Jamaica Cataloguing-in-Publication Data

International Seabed Authority.

Polymetallic nodules resource classification : proceedings of the International Seabed Authority and ministry of earth science, government of India workshop held in Goa, India 13-17 October 2014.

pages : colour illustrations, colour maps ; cm.

ISBN 978-976-8241-39-9 (pbk)

ISBN 978-976-8241-40-5 (e-book)

1. Ocean mining 2. Marine mineral resources – Research

I. Title

622.17 – dc 23

ISBN: 978-976-8241-40-5

Copyright © 2017 International Seabed Authority

TABLE OF CONTENTS

	Opening Statements	1
	List of Participants	7
	Executive Summary	10
PART I	MINING TECHNOLOGY FOR THE CLASSIFICATION OF POLYMETALLIC NODULE RESOURCES IN THE AREA	22
Chapter 1	International Standards for Resource and Economic Evaluation: Applications for Deep Seabed Mining <i>Caitlyn L Antrim, Director, Centre for Leadership and Global Diplomacy, Virginia, USA</i>	23
Chapter 2	Nodule collector subsystems-organization of the OMI pilot mining test programme and its use in collaborative tests by contractors <i>Ted Brockett, President, Sound Ocean Systems Inc. Redmond, Washington, USA</i>	33
PART II	EMERGING INTERNATIONAL STANDARDS FOR MINERAL RESOURCE EVALUATION	44
Chapter 3	Information needs of financiers, investors and resource managers <i>Michael Stanley, Mining specialist, World Bank, Washington</i>	45
Chapter 4	Purpose, design and content of scoping, pre-feasibility and feasibility studies <i>Caitlyn L. Antrim, director, Centre for Leadership and Global diplomacy, Virginia, USA</i>	55
Chapter 5	United Nations Framework Classification (UNFC) - how it works in practice and its application to seabed mineral resources <i>Charlotte Griffiths, Senior Economic Affairs Officer, UNFC and Resource Classification</i>	62
Chapter 6	Resource classification – comprehensive extraction and the importance of environmental and social issues <i>David MacDonald, Chair, Expert group on resource classification of the United Nations Economic Commission for Europe (UNECE)</i>	69
Chapter 7	The committee for Mineral Reserves International Reporting Standards (CRIRSCO) - Classification Code <i>Pat Stephenson, past Co-chair, CRIRSCO (2005/06), director, AMC Mining Consultant, Vancouver, Canada</i>	85
Chapter 8	The ‘Competent Person’ in mine-site evaluation and responsibilities for study design, management and findings <i>Matthew Nimmo, Principal Geologist, Golder Associates, Australia</i>	99

Chapter 9	Best practices - general and specific guidelines from CRIRSCO and its member organizations <i>Pat Stephenson, past Co-chair, CRIRSCO (2005/06), director, AMC Mining Consultant, Vancouver, Canada</i>	115
Chapter 10	Identification of special aspects of polymetallic nodule deposits of the Area that should be addressed in reporting standards <i>Mathew Nimmo, Principal Geologist, Golder Associates, Australia</i>	122
Chapter 11	Identification of any issues arising from differences in national reporting standards to which the Authority should respond <i>Paul Kay, Manager, Offshore Minerals, Geosciences, Australia</i>	130
PART III	STATUS OF CONTRACTOR ACTIVITIES IN RESOURCE ASSESSMENT	142
Chapter 12	Activities of the IOM within the scope of geological exploration for polymetallic nodule resources <i>Tomasz Abramowski, Director General, Interoceanmetal Joint Organization</i>	143
Chapter 13	The Concept of the Russian Exploration Area Polymetallic Nodules resource and reserve categorization <i>Ponomareva Irina], deputy Chief Geologist, State Enterprise YUZHMOREGEOLOGIYA, Russian Federation</i>	154
Chapter 14	Status of Korea Activities in Resource Assessment and Mining Technologies <i>Chan Min Yoo & Sup Hong, Ministry of Oceans and Fisheries, Republic of Korea, Korea Institute of Ocean Science & Technology (KIOST)</i>	160
Chapter 15	COMRA's Activities in Resource Assessment <i>JIN Jiancai, Secretary General, China Ocean Mineral Resources R & D Association (COMRA)</i>	173
Chapter 16	Polymetallic Nodule Resource Evaluation: How we are doing? <i>Masatsugu Okazaki, Deep Ocean Resources Development Co., Ltd. (DORD)</i>	181
Chapter 17	Polymetallic Nodules Resources Classification. French effort: 1970-2014 <i>Y. Fouquet, G.Depauw, GEMONOD consortium, Institut français de recherché pour l'exploitation de la mer (Ifremer)</i>	188
Chapter 18	Polymetallic Nodules Programme - Resource Evaluation <i>M. Shyamprasad, Ministry of Earth Sciences, Government of India, CSIR-National Institute of Oceanography</i>	198
Chapter 19	CCZ Nodule Projects: 2013 Mineral Resource Estimate per N143-101 <i>John Parianos, Tonga Offshore Mining Limited (TOML)</i>	213
Chapter 20	Lead up of the Polymetallic Nodules Project and Context <i>Jacques Paynjon, Global Sea Mineral Resources NV (GSR)</i>	219

PART IV	WORKING GROUP RECOMMENDATIONS	224
	Working Group 1 Report	225
	Working Group 2 Report	229
	Working Group 3 Report	230
PART V	CLOSING REMARKS	231
ANNEX 1	International Seabed Authority Reporting Standard for Polymetallic Nodules	235
ANNEX 2	Workshop Background Paper	256

OPENING STATEMENTS

Dr. S. Rajan, Director, National Centre for Antarctic and Ocean Research (NCAOR), Goa

His Excellency Mr. Odunton, Dr. S.K Das, distinguished delegates of the workshop, colleagues from the Ministry of Earth Sciences, NCAOR, friends from the media, ladies and gentlemen.

On behalf of Dr. Shailesh Nayak, Secretary to the government of India- Ministry of Earth Sciences, the National Centre for Antarctic and Ocean Research, let me at the outset welcome you all to this very important workshop. We are honoured that the International Seabed Authority chose the state of Goa as the venue for this workshop. Nothing could be more befitting than this gesture. Not because Goa is one of the more touristy places in India, but more so because the history of deep sea mineral exploration by India was kick-started from the shores of Goa. That was way back in 1981 when the vessel *R. V. Gageshani* set sail from the shores of Goa and recovered the first nodules from the equatorial Indian Ocean under the leadership of NIO. The rest as they say is history. I am glad to see that representatives of NIO also are here; Dr. Prasad, Dr. Sudhakar and Dr. Jauhari. I am glad to see all of you are here.

India went on to attain pioneer investor status and entered into an exploration contract with the ISA, and has developed considerable expertise in the exploration of polymetallic nodules, environmental impact assessment, metallurgical processes, and demonstration of a flexible rising mining system concept. The story doesn't end there. A few years back, the Government of India decided to expand and build up on our expertise in deep water mineral exploration. Goa as the launching pad except the National Centre for Antarctic and Ocean Research, the Ministry's own R&D arm was chosen as the lead agency.

Based on the results of the geoscientific surveys carried out by India, an area of 10,000 sq.km in the Central and SW Indian Ridges was identified for hydrothermal exploration and an application was submitted to the Authority for grant of license in March 2013. On the 21st July 2014, the LTC recommended the approval of our plan of work for exploration for hydrothermal deposit, submitted by the government of India through the Ministry of Earth Sciences to Council.

As I mentioned before, it is only natural that Goa again finds a place in today's meeting. The workshop could not have been organized at a more appropriate time. Nearly half the contracts entered into by the Authority by the various stakeholders would be expiring two to three years from now. While I understand, the contracts stipulate the kind of information and data that have to be submitted to the Seabed Authority on expiry of the contract, there is a need to develop internationally accepted standards and practices applicable to the assessment and reporting of mineral resources of the seabed and more importantly to sensitize all the stakeholders on these standards. This is vital not only for understanding whether the explored areas are indeed financial assets from a mining point of view but also for a seamless transition of a mining operation from exploration to exploitation stage.

Not only the policy aspects, but the technologies and our scientific knowledge itself has also had a quantum jump over the past four-odd decades, since the first trial of a prototype nodule- mining system was carried out on the Blake Plateau. Previous studies had predicted that the incidence of hydrothermal venting would be extremely low on ultraslow-spreading ridges. But we know better now. Abundant hydrothermal venting has been documented from the Gakkel Ridge of the Arctic, which is among the slowest spreading ridges (0.6-1.3 cm yr.⁻¹). So technology also has improved and we have to look back to what have we achieved, when the technology was at a rudimentary stage and where we stand now, so that we can develop a standard operating procedure for the years to come. I would say that is a critical component of this workshop. But I don't think I should be expounding on the objectives of this workshop or what is expected of it to you the experts who are assembled here today. Almost sacrilegious I should say, like carrying coal to New Castle. But from India's point of view, as one of the pioneer investors registered with the Authority, the deliberations hold out enormous significance for the country in its endeavours at exploring for non-living resources of the deep ocean floor . There is a lot we can learn from each other and a lot we can share with each other as befits the ocean space.

Two days back when I was discussing the workshop with secretary, Dr. Shailesh Nayak, who very much regrets that he won't be in a position to participate in the deliberations of the workshop because he had to accompany the president of India to Norway, he said to give all support to this workshop and see what is expected of us, the Ministry of Earth Sciences, Government of India, as a research and development organization. All of us would be at the forefront to see that we have an important role to play and what is expected from India would not be found short of responsibilities.

To quote *Paul Snelgrove*, we know more about the surface of the moon or about Mars than we do about the deep seafloor. Despite the fact that we have yet to extract a gram of food or ore, a breath of oxygen or a drop of water from those bodies. So there is lot we have to learn, a lot we have to talk to each other about to understand its significance.

I hope you find the deliberations of the workshop and the ambience of the place equally exciting without one precluding or over-shadowing the other. Enjoy and relish your stay here. We realize that you have a rather heavy agenda before you over the next four days. Notwithstanding that, we have also chalked out an itinerary for you beyond the four walls of this hall including visits to the two Institutes - NIO and NCAOR. I would take this opportunity to extend you a warm welcome to my own institute NCAOR, which is very close to the airport. This is a unique institute in the sense that we look after all programs related to Antarctica, and Arctic, Southern Oceans. We are the only institute in the country which has people working in the North Pole, in the South Pole, oceans and the Himalayas. You name an area, we have couple of people working there. So again, I extend a warm welcome to you; I request you all to also take some time off to visit our own sister organization, the National Institute of Oceanography (NIO) which is where the action started. Talk about India's polymetallic nodule program, everybody understands NIO is the place where it all started.



NA Odunton, SK Das, S Rajan

As I sign off this welcoming address, let me also take this opportunity to thank the people who have been with me over the last several days on the forefront in organizing the workshop. I have with me a bunch of

youngsters led by Dr. John Kurian

who have been shouldering all the responsibilities related to organizing this workshop. Incidentally these are the same people who would be carrying forward India's legacy of deep sea exploration in days to come. Thanks to everybody, my friends from the Ministry, Pratima Jauhari who has been constantly bombarding us with mails. Each morning I would expect a mail from her saying that this is what has not been done, this is what you should be doing and thank-you very much because that has kept us on our toes. And my friends, Dr. SK Das, Dr. Wakdikar and friends of the press who have been kind enough to come from all this way for this important event. Thank- you so much! Keep the message across – which is what this workshop means for a country like India. Thanks very much, thank-you all.

Dr. S. K. Das, Advisor/Scientific Secretary, ESSO, Government of India, Ministry of Earth Science

Good morning participants. It is a privilege to be a part of the distinguished experts and representatives from contractors. I also, on behalf of MOES thank the Secretary-General, Nii Allotey Odunton for choosing India for this collaborative workshop on classification of polymetallic nodule resources during 13-17 October 2014. The response to this workshop is a testimony of the work of the Authority.

The United Nations Framework Classification (UNFC) classification for reserve and resources is aimed at the digital code based system of classification of resources, taking into consideration the parameters of economics, feasibility and geological exploration.

Classification of mineral resources is an important aspect for investment decision in the present context of market economy. Proper resources classification will provide better understanding and firmer knowledge of exploitability of mineral resources available and serve to reduce risk of investment.

Unlike other seabed mineral resources in the Area, the regulation of polymetallic nodules prospecting and exploration adopted by the Council after exhaustive work carried by pioneer investors and also as a part of the relinquishment exercise, the review of the process and approach towards assessing resources at this stage would be an additional burden on the pioneer investors and needs to be viewed cautiously. The high, high gain characteristics of further exploration demands a more careful approach in its planning and execution.

I have great confidence that this workshop, designed by the Authority, for interaction among contractors, pioneer investors and experts will provide an excellent opportunity to discuss the matter in a constructive way to fulfil the objectives of the workshop.

H.E. Mr. Nii A. Odunton, Secretary-General International Seabed Authority

Good morning everybody. I am glad to see you all here. I believe it bodes extremely well for what I hope to be an interesting and progressive week to which the international community will begin to get a very good idea of the resources associated with polymetallic nodules that we have in marine areas beyond national jurisdiction.

Dr. Rajan, Director, National Centre for Antarctic and Ocean Research of India, distinguished delegates from the Government of India, experts on classification and other aspects of deep seabed polymetallic nodule mining, eminent representatives of the Contractors for polymetallic nodules exploration, members of the Legal and Technical Commission of the Authority.

I wish to thank all of you for the effort that you have made to be present for the ISA workshop on polymetallic nodule resource classification. This is a very important workshop for the Authority. It is our very first cut at trying to establish standards for the classification of polymetallic nodule resources.

It has been polymetallic nodules that resulted in the establishment of the ISA. It was indeed polymetallic nodules that was an extremely important part of the Law of the Sea Convention. An entire section of Part 11 of the Convention is dedicated to polymetallic nodules which gave scientists and engineers an opportunity at that time to also become part of the deliberations leading to the adoption of the Convention on the Law of the Sea.

It has been a long road since. I recall when discussions were going on at United Nations. The idea that we could be mining 5000 m underwater sounded strange at that time. We already had mountains of ore on land. We had technology for mining these resources. People were being taught how to apply the technology to mining these resources in schools all over the world. We could mine underground. We collected the minerals, processed them and got the metals. At this Law of the Sea Conference, we were talking 5000m, and several thousand km from land.

This July, the Authority celebrated its 20th Anniversary. I am indeed very grateful to be able to report that the Authority now has a considerable number of contractors for polymetallic nodule resources. We also have contractors for polymetallic sulphides as well as contractors for cobalt-rich ferromanganese crusts. We however started with polymetallic nodules.

The International Seabed Authority has been established for 20 years and we have contractors who are almost at the end of their exploration contracts for polymetallic nodules.

We've had problems. Problems going back to polymetallic nodules and while these have been discussed over long periods of time, the international communities' knowledge of resources *in situ*, as far as these nodules are concerned, has been limited.

One of the directives the Authority has, is to establish standards for resources in the Area. Our job is to administer these resources. As the exploration phase continues, more effort is being made to get a better idea of the resources that are on the deep seabed. We understand that this is a novel venture and that mining is yet to take place.

It is our hope that the technology development of our contractors will result in a better idea of what is available today to this community to mine at a profit, that are ISA reserves. We also are interested in the other resources –and to what extent any mining can take place for polymetallic nodules down the line.

I hope that at the end of this week we will have a basic framework for standards for resource classification of polymetallic nodules in the Area. We have contractors who have engaged in this exercise for over a year. Presently we have some that are close to their licenses coming to an end. It is not obvious in the reports we have that anybody is about to relinquish their areas. It is also not very clear what we actually have in place. For that reason we are holding this workshop with the following objectives:

- to ascertain the work being undertaken by contractors for polymetallic nodule exploration in the Area with a view to the standardization of the exploration and resource data required in Section 11 of the standard clauses of Exploration contracts;
- to review of current practice in land-based mineral development on national reporting standards for exploration results and resource classification;
- to identify of special aspects of polymetallic nodule deposits that should be addressed in resource reporting standards;
- to identify of any issues arising from differences in national reporting standards to which the Authority should respond;
- to assist contractors to identify and implement best practices in polymetallic nodule resource evaluation;
- to identify the work to be completed by contractors to fulfil item;
- to determine the time required to fulfil item (v), and for this workshop; and
- to provide guidance to the ISA regarding relations with mineral information standards organizations, including potential cooperation with CRIRSCO's work

I am very happy to have you all here. I have no expertise in this area and I am like many who have gathered here to listen to what the experts have to tell us about work in this area. I also am very interested to learn from what the contractors tell us of the results of their work to date and the practices they have been following. We will also hear from the experts about best practices in this regard.

To this end, we wish to take the results of our work this week and make them available to the entire body of the Legal and Technical Commission in February 2015 and have them make recommendations to the Council - a decision making body - on standards for the development of these standard classification of these resources, we hope to have this material as input for a decision that has to be taken by the Council in July 2015 regarding the extension of exploration contracts.

I have been following the work of the USGS resources and their distribution worldwide on land or ocean and keep reading about inferred resources. I believe the contractors spend a lot of money and have a lot of work and with their role in economic development we can move this process further than merely inferred resources.

I would also like you all to consider how the Authority can continue to work on these standards. I do not expect it completed in four days for nodule resources when it has taken us a considerable period of time and knowledge to get us to where we are able to do what has been done for land-based resources.

I look forward to an exciting week. I see this as a great opportunity to learn something. For the experts, I hope the knowledge they may gain for marine mineral resources will be a little bit more than they had before they attended this meeting For the contractors, hopefully we will have standards. The reports you give the Authority for consideration by the Legal and Technical Commission will be a basis for the Authority to inform the international community as to what is actually out there.

Thank you.

PARTICIPANTS LIST

NAMES	ORGANIZATION	CONTACT
INVITED SPEAKERS		
Caitlyn Antrim	Director, Center for Leadership & Global Diplomacy	Caitlyn@oceanlaw.org
Ted Brockett	President, Sound Ocean Systems	ted@soundocean.com
Charlotte Griffiths	Senior Economic Affairs Officer, UNFC	Charlotte.Griffiths@unece.org
David MacDonald	Vice President, Segment Reserves, BP Exploration	David.G.Macdonald@uk.bp.com
Michael Stanley	Mining Specialist, World Bank	mstanley@worldbank.org
Pat Stephenson	Past Co-Chair, CRIRSCO Director, AMC Mining Consultants	pstephenson@amcconsultants.com
Matthew Nimmo	Principal Geologist, Golder Associates Pt Ltd	MNimmo@golder.com.au
Paul John Kay	Manager, Offshore Minerals Resources Advice & Promotion	Paul.Kay@ga.gov.au
LTC MEMBERS		
Russell Howorth	Matadrevula Advisory Services	matadrevula@gmail.com
M. Sudhakar	Advisor, Ministry of Earth Sciences	m.sudhakar@nic.in
Pedro Madureira	Adjunto do Responsável da EMEPC, Estrutura de Missão para a Extensão da Plataforma Continental	Pedro.madureira@emepc.mam.gov.pt
Georgy Cherkashov	Deputy Director, Institute for Geology & Mineral Resources	gcherkashov@gmail.com
CONTRACTORS		
Masatsugu Okazaki	DORD	okazaki@dord.co.jp
Tadayuki Ishiyama	DORD	ishiyama@dord.co.jp
Tomasz Abramowski	IOM	t.abramowski@iom.gov.pl
John Parianos	TOML	jmp@nautilusminerals.com
Jacques Paynjon	GSR	Paynjon.jacques@milan-int.be
Jincai Jin	COMRA	jin@comra.org
Ning Yang	COMRA	yangning@sidsse.ac.cn
Kechao Zhu	COMRA	kczhu2006@163.com
Ming Kong	COMRA	Sandy.kong@163.net
Ning Yang	COMRA	yangning@sidsse.ac.cn

NAMES	ORGANIZATION	CONTACT
Cheng Bing Song	COMRA	Song_cb@163.com
Yves Fouquet	IFREMER	Yves.Fouquet@ifremer.fr
Tae Kyeong Yeu	KORDI	yeutk@kriso.re.kr
Sang Bum Chi	KORDI	sbchi@kiost.ac
Chan Min Yoo	KORDI	cmyoo@kiost.ac
Kong Ming	KORDI	kongming@brgimm.com
Sup Hong	KORDI	suphong@kriso.re.kr
Ki Seong Hyeong	KORDI	kshyeong@kiost.ac

INDIAN DELEGATES

S. K. Das	Ministry of Earth Sciences	skod@yahoo.com
S. W. A. Naqvi	National Institute of Oceanography	naqvi@nio.org
Shyam Prasad	National Institute of Oceanography	shyam@nio.org
S. Rajan	National Centre of Antarctic & Ocean Resources	rajan@ncaor.gov.in
S Jaisankar	National Institute of Oceanography	siva@nio.org
T. R. P. Singh	Ex-EIL	Trp_singh@yahoo.com
John Kurian	National Centre for Antarctic & Ocean Resources	john@ncaor.gov.in
M. P. Wakdikar	Ministry of Earth Sciences	mpw-dod@nic.in

ISA SECRETARIAT

H.E. Nii Allotey Odunton	Secretary-General	nodunton@isa.org.jm
Sandor Mulsow	Head, Office of Resources & Environmental Monitoring	smulsow@isa.org.jm
Pratima Jauhari	Marine Geologist, OREM	pjauhari@isa.org.jm
Gwenaëlle Le Gurun	Legal Officer, OLA	glegurun@isa.org.jm
Anna Elaise	Webmaster, OSG	annae@isa.org.jm
Christine Griffiths	Executive Assistant, OSG	cgriffiths@isa.org.jm



EXECUTIVE SUMMARY

Following the adoption of the Regulations on Prospecting and Exploration for polymetallic nodules in the Area, in July 2000, the Authority has entered into thirteen exploration contracts for polymetallic nodules with entities from Belgium, China, France, Germany, India, Japan, Kiribati, Korea, Nauru, Poland, the Russian Federation, Tonga and the United Kingdom. As required by the regulations, these entities are engaged in assessing the resources in their respective exploration areas, developing technologies for mining their deposits and for processing nodules into the metals of commercial interest, and acquiring baseline environmental data for environmental impact assessments prior to obtaining contracts for mining.

Six of these exploration contracts expires in 2016 and another in 2017. A review of the resource assessment work reported in the annual reports of contractors show considerable variation, with no uniform standards applied. The development of a polymetallic nodules deposit on the deep ocean floor is expected to be a multi-billion dollar investment, making it important that investors, partners and lenders have clear guidelines with which to compare claims of resource endowment used to justify investment and loans. A classification system for deep sea minerals has yet to be developed.

The objectives of the workshop were to ascertain the work being undertaken by contractors for polymetallic nodule exploration in the Area with a view to standardizing the exploration and resource data required in Section 11 of the standard clauses of Exploration contracts; to review current practice in land-based mineral development on national reporting standards for exploration results and resource classification; to identify special aspects of polymetallic nodule deposits that should be addressed in resource reporting standards; to identify issues arising from differences in national reporting standards to which the Authority should respond; to assist contractors to identify and implement best practices in polymetallic nodule resource evaluation; to identify the work to be completed by contractors and determine the time needed to fulfil item; and to provide guidance to the ISA regarding relations with mineral information standards organizations, including potential cooperation with CRIRSCO¹ and UNFC's² work.

The five-day workshop was attended by 40 participants from 15 different countries and involved eleven presentations by experts and nine by the contractors addressing specific topics. The participants then formed three working groups to craft the workshop recommendations.

The first working group was tasked with addressing state of the art collector devices, possible collaboration among contractors to test their collectors with a view to identifying where standardization is required.

¹ For 20 years the *Committee on Mineral Reserves International Reporting Standards* (CRIRSCO) has surveyed professional practice, drafted guidelines and best practices, and prepared professional codes and procedures for the assessment and reporting of exploration results, mineral resources and mineral reserves that have been further refined over the years. CRIRSCO produced a robust international standard that provides a widely accepted international standard addressing public reporting of exploration results, mineral resources and mineral reserves. CRIRSCO was granted Observer Status to the ISA at the 21st session of the Authority.

² The UN Economic Commission for Europe began work on a comprehensive Framework Classification for mineral and energy resources in the 1990s, preparing its "Framework Classification for Reserves and Resources of Solid Fuels and Mineral Commodities" in 1997. Continuation of this work led in 2009 to the release of "United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009." Consultations between CRIRSCO and the UNECE led to the incorporation of the CRIRSCO definitions of reserves and resources into the UNFC.

The second working group was charged to address the guidelines for estimation of mineral resources and reserves as per international reporting standards and the steps required to implement them for the deep seabed mineral resources, and to help the contractors to standardize the classification of polymetallic nodule resources into proven, probable and possible reserves of metals. This group was also asked to discuss any issues arising from differences in national reporting standards and how they can be resolved.

The third working group was to determine the amount of work required by each contractor to complete the resource classification exercise for their respective areas and how long it would take.

A brief summary of each one of the presentations (experts and contractors) is given as background information together with the three working group recommendations.

International Standards for Resource and Economic Evaluation: Applications for Deep Seabed Mining

Caitlyn Antrim, Center for Leadership and Global Diplomacy, Virginia, USA

Dr. Antrim's presentation provided an initial framework of standards as required by different stakeholders. She informed that at the beginning of the century mineral results were reported succinctly as proved, probable and probable reserves. By the early 21st century, governments applied two and three dimensional taxonomies to categories resources by economic value, technological feasibility and geological assuredness. The United States Geological survey published during 1976-80, known as the "McKelvey Box", which served as the basis for the modern public and private systems in use today.

Evaluations are required to be conducted by "competent" or "qualified" experts subject to professional discipline by their peers. Industry standards and best practices provide guides for evaluations and the national societies working together as the Committee for International Mineral Reserve International Reporting Standards (CRIRSCO) established a common template that could be adapted for use by other countries. Where the CRIRSCO standards addressed the resource assessment needs of developers, investors and regulators, a parallel development addressed needs of public resource managers. The United National Economic Commission for Europe undertook to develop a common "Framework Classification", known as the UNFC, for energy and mineral resources. UNFC added a third dimension that separated technical feasibility from economic factors to provide a more rich understanding of a national, regional or global resource endowment.

Collaboration between CRIRSCO and the UNECE provided links between CRIRSCO's categories of Proven and Probable Reserves and Measured and Indicated Resources and the related UNFC boxes in their three-dimensional matrix. Dr. Antrim said that the CRIRSCO "Template" could provide the basis for conforming mineral reserve and resources reports required of Contractors to the Authority with the international reporting standards. If reports made by Contractors to the International Seabed Authority are consistent with the CRIRSCO standards, they will meet the needs of all stakeholders on one hand and mineral management and planning functions that may be undertaken by the Authority on the other.

Nodule Collector Sub-Systems – Organization of the OMI Pilot Mining Test Programme and its Use in Collaborative Tests by Contractors

Ted Brockett, Sound Ocean Systems Inc. Redmond, Washington, USA

Dr. Brockett presented the Ocean Management Inc. [OMI]’s collective development programme, which was a consortium in the 70s with 4 primary partners. In 1977, OMI conducted a test of high speed exploration with a 30 kHz side scan sonar based on a back scatter system. In 1978, it completed a pilot nodule mining test (PMT) project in the CCZ in 5,400m depth, aboard SEDCO 445. The primary collectors for the OMI PMT was an incredibly simple passively towed runner sled, called the 2M hydraulic collector, which had an active width of 2m and four independent dredge heads. Two submersible pumps, installed in line with rigid type riser system were used while testing the collector and 40 metric tonnes nodules an hour was expected. The moving water was used to separate the nodules and sediment from the seafloor and to transport the nodules within the collector both vertically and transversally and to introduce the nodules into the riser system.

Two key parameters had a big impact on the development of collectors - (i) nodules were considered to be a surface deposit only, (ii) a Monte Carlo approach to mining the mine site, had significant impact on the collector designs. Dr. Brockett said that another issue (to consider) would have been the active width of the collector for increasing the collection efficiency. The bow waves have a very significant adverse impact on collector’s efficiency. More needed to be done to eliminate or minimize bow waves, to reduce the bearing load even further, and a steerable collector with options of side by side tracks.

Dr. Brockett said that the OMI favored hydraulic designs, and the key was the Collector’s reliability.

Information Needs of Financiers, Investors and Resource Managers

Michael Stanley, World Bank

Mr. Stanley said that there continues to be a global structural shift on what defines sustainable mining and the locations in which sustainable mining is taking place. The key challenges for going forward are – the financiers and investors assess investment opportunities viz. sector governance, with emphasis on environmental / social performance. Regulatory compliance no longer earns a social license to operate. As a result, governance and investment risks are inseparably intertwined with continued limitations in mining finance. For the purpose of resource planning, a resource classification system having accounting of socio-economic performance is needed.

Mr. Stanley was of the opinion that the UNFC 2009 is a superior process for resource classification and resource planning, and that it would be an appropriate framework for understanding the environmental /social blockages (conflicts) that impede various mineral resources from moving to production. He concluded that consultants working on the pilot projects have found it preferable to begin with UNFC 2009, and then migrate information to be reported to security exchange commissions into the CRIRSCO template.

Public Reports and Studies in the Mineral Industry

Caitlyn Antrim, Center for Leadership and Global Diplomacy, Virginia, USA

Dr. Antrim addressed the issues of mining in a commercial environment. She identified two broad categories: i) technical reports and ii) integrated economic assessments. An integrated economic assessment involves factors such as geology and resources of the property, infrastructure, management and labor, environmental and permitting requirements and overall budget economics. An integrated study involves the technical and economic scoping study on the potential viability of mineral resources at the introductory level, the prefeasibility study to assess the likelihood of a viable operation, a key decision-making full feasibility study and an engineering study, using the best design approach.

Dr. Antrim stated that the scoping and feasibility studies are economic measures and serve design and decision functions. These studies may become public documents to inform investors and regulators and be governed by national reporting laws and international codes. The same rules would apply to a seabed miner wanting to be a part of the mining industry.

United Nations Framework Classification (UNFC) – How it Works in Practice and its Application to Seabed Mineral Resources

Charlotte Griffiths, UNFC & Resource classification

Dr. Griffiths said that the UNFC is the UN framework classification for fossil energy and mineral resources. It's a global generic, principle based system, based on three fundamental criteria, represented by three axes. Dr. Griffiths said that the UNFC has a powerful numerical quantification system. The fundamental principle of the UNFC is that resources are classified in a series of projects with differentiation on each of the three axes, the social and economic axis, the project feasibility axis and the geological knowledge axis. She said that three criteria or axes are the most real and that they're found in most other classification systems either as implicit attributes or as direct criteria. Dr. Griffiths said that because the UNFC is direct on all three, it provides the framework through which other classification systems can be compared and harmonized, thus making the UNFC an extremely powerful tool. UNFC implicitly meant the CRIRSCO template as well, because the two were part of one package.

The UNFC is managed by the Economic Commission for Europe (UNECE), because of UN Economic and Social Council (ECOSOC) decision adopted in 2004. She said that the work on energy and on resource classification was the flagship of UNFC's activities, i.e. the development of laws and standards, best practice guidance, and conventions to provide a neutral platform for stakeholders through an open and transparent process.

She also said the UN had developed the system because of a demonstrated need for a common system for solid minerals and mineral commodities. She noted that the work on this resource management tool started in 1992 and that it had gone through inclusive and transparent processes over twenty years, resulting in a solid and robust volunteer system that was approved in 2009, and that became operational in 2013.

Resource Classification – Comprehensive Extraction and the Importance of Environmental and Social Issues

David MacDonald, Expert Group on Resource classification of the UNEC of Europe

Mr. MacDonald described the UNFC as a framework classification that captured, measured and quantified reserves and resources. He said that it is based on a set of definitions for different categories; a list of specifications gave detailed application guidelines around these definitions with a series of bridging documents, that acted as guidelines and existing specifications for different commodities.

Mr. MacDonald said that the UNFC system is based on three criteria represented by **E** (economic and social viability), **F** (feasibility) and **G** (geology) axes. Each of the axes is sub divided. The E axis has three and the F and G axes each have four major categories. In the UNFC system therefore, 111 would mean level 1 on the E, F and G axis and it would be the highest level of achievement. In the case of composites being discussed at the workshop, Mr. MacDonald said most would fit E3, with some possible E2 cases. The largest concern in moving from E3 to E2 would be social licenses and environmental issues.

Commercial projects met the E and F axes at the highest levels, but were called reserves under conventional systems (under CRIRSCO or PRMS). Where non-commercial projects were not captured within the CRIRSCO system, the UNFC system allowed those volumes through the categories. The UNFC system used generic specifications as the minimum standard for reporting and its categories deduced the estimates that were required by CRIRSCO for disclosure. There are 20 different generic specifications covering a number of different issues from disclosure to defining the levels of project maturity. The UNFC expert group are experts in their own commodities with the goal to having UNFC rely on existing systems as much as possible, through bridging documents.

Mr. MacDonald said the UNFC system was a generic principle-based system which allowed some modification to make it more need specific. The system could be viewed as value added to the CRIRSCO system and could be suitable for application to seabed mineral resource, having the E and F axes and the ability to subdivide the F4.

The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) – Classification Code

Pat Stephenson, AMC Mining Consultants, Vancouver, BC V6C 1S4, Canada

Dr. Stephenson, who made the presentation on behalf of Dr. Harry Parker, incoming Chair of CRIRSCO, said that the CRIRSCO was a very simple system, well understood by the world's mining and finance industries. He noted that CRIRSCO is the commercial arm of the UNFC, managed under a separate authority than the CRIRSCO Committee. CRIRSCO, as an international coordination and advisory body in the area of Mineral Resource / Reserve classification and reporting, Dr. Stephenson said, relies on its constituent members to ensure regulatory and disciplinary oversight at a national level. It promotes uniformity, excellence and continuous improvement in the public reporting of Mineral Exploration Results and Mineral Resources / Reserves, and represents the international minerals industry on Resources and Reserves issues with other international organizations. Its member countries are Australasia, Canada, Chile, Europe / UK, Russia, South Africa, USA and

Mongolia. Mining companies listed on stock exchanges that use CRIRSCO-type reporting standards account for over 80% of the listed capital of the world's mining industry.

Dr. Stephenson said that the indicated and inferred boundary was the most important separation in the CRIRSCO system, because it dictated what could be converted to mineral reserves. The CRIRSCO international reporting template (IRT) initiated in 2003 and its recent version in 2013 endeavors to promote **best practice** in mineral resource and reserve estimation and classification. The template could easily be adapted to seabed nodule reporting with the inclusion of clauses, after extensive discussion with interested groups on issues related to seabed nodule mining. Materiality, transparency and competency were the three principles that underline national reporting standards in all the CRIRSCO countries and the CRIRSCO template. The principles provide extensive guidelines with the **competent or qualified person** making his or her own judgment as to what is appropriate and applicable in the particular situation and taking responsibility for it.

The 'Competent Person' in Mine-Site Evaluation and Responsibilities for Study Design, Management and Findings

Matthew Nimmo, Golder Associates, Australia

Mr. Nimmo said that the CRIRSCO template describes the 'Competent Person' (CP) as having three primary principles - transparency, materiality and competency. Being transparent is about providing clean, concise and accurate information that did not mislead the investor and that was clearly understood by the reader. Methods of sampling and procedures detailed, lab assays and repeats, storage, maintenance, verification and security of the data in the public report subscribed to transparency. Materiality meant that all relevant information in the report that a reader expects, like QA/QC to be there. The competency is where the CP comes to work. CP would be minerals industry professional with experience in the mineralization type being addressed and who follows a code of ethics. The CP's role is to try and help extract the value out of the deposit, identify gaps in information and/or data and estimate it into a particular category to allow for economic assessments on that estimate.

For any project, a large number of competent people from project related aspects may be required, but there would be only one technical report containing all information related to the project. A competent person would need to visit the site, observe the sampling and verify the database recorded in the Assay certificates and, its suitability for mineral resource estimate and write it in the public report. A CP needed to understand all aspects of the resource estimate, the risks involved, the parameters that could affect the estimates, and the assumptions applied to it. In the public report, the reasons for prospects for economic extractions must also be stated. The CP has to build trust by performing the estimates using the best practices. In the end it is CP, not the company, who is legally responsible at the sign off the report.

Best practices – General and Specific Guidelines from CRIRSCO and its Member Organizations

Pat Stephenson, AMC Mining Consultants, Vancouver, BC V6C 1S4, Canada

Dr. Stephenson presented a paper by Debra McCombe about best practices in two categories – (i) public reporting of exploration results and Mineral Resources/Reserves and (ii) estimation, classification and monitoring of Mineral Resources/Reserves.

He said that the first is achieved by: (a) the provision, in Table 1 of most mineral industry reporting codes / standards and the CRIRSCO International Reporting Template, of checklists of all important criteria to take into account when estimating Mineral Resources / Reserves; (b) publishing separate Best Practice guidelines (Canada); (c) publishing monographs that provide up to date, peer reviewed technical papers on best practice (Australia); and (d) the general body of mineral industry publications in this area.

The second is achieved by publishing and keeping up to date each of the CRIRSCO member countries' mineral reporting codes / standards, and the CRIRSCO International Reporting Template. These provide a minimum standard for the public reporting of Exploration Results and Mineral Resources / Reserves, ensuring that public reports on these matters contain all the information that investors and their advisers would reasonably require for the purpose of making a balanced judgement regarding the results and estimates being reported. They are supported by mineral industry regulatory bodies in the CRIRSCO countries, and underpinned by the Competent / Qualified Person system. This commitment to best practice in the mineral industry has contributed substantially to the improved confidence that investors now have in the estimation and reporting of Mineral Resources/Reserves.

Identification of Special Aspects of Polymetallic Nodule Deposits of the Area that Should be Addressed in Reporting Standards

Matthew Nimmo, Golder Associates, Australia

Mr. Nimmo said that the CRIRSCO code or the NI43101 was more than adequate and the differences were not significant enough to warrant a new code. Going through Table 1 of the CRIRSCO template, he demonstrated that while there are differences they are not significant enough to warrant major changes and could be well accommodated within the code. He said TOML had paved the way through the Canadian system, so it was possible for anyone else to do the same.

Identification of any Issues Arising from Differences in National Reporting Standards to which the Authority Should Respond

Paul Kay, Offshore Minerals, Geosciences, Australia

Giving an example from Australia, Mr. Kay said that in the annual national inventory of Australia's mineral resources, information from the Australia Stock Exchange is used because the material is certified with the Australian code which has an absolute mapping capacity with CRIRSCO and with UNFC. The national or jurisdictional inventory was about aggregating the resources of individual deposits by having a national inventory; a regular evaluation of resources would be available in the foreseeable future for mineral development. Individual deposits have inherent characteristics that need to be amalgamated and that once the assessment has been made on what an economically demonstrated resource is, one can then move toward reporting a number nationally. He said the whole issue was mapping to a universal template, harmonizing the various systems and working how to compare world inventories. He said that although CRIRSCO did not have as much granularity as UNFC, the two were interchangeable and could map from one to the other. Summarizing Australia's terrestrial experience, Mr. Kay said it provided background in terms of how the JORC, CRIRSCO, UNFC systems could be incorporated to make a national or jurisdictional inventory.

Activities of the IOM Within the Scope of Geological Exploration for Polymetallic Nodule Resources.

Tomasz Abramowski, Interoceanmetal Joint Organization

Mr. Abramowski said IOM signed the contract in 2001 and located the most prospected areas in H11 and H22. He informed participants that in the H11 area 21 ore deposits from 66 ore fields had been identified using geostatistical model equations including Kriging. He said that one of the most significant parameters for delineation of nodule fields was the slope angle, because the collector device needed to overcome different slopes. He told participants that IOM areas have slope angles of more than 4°; 7° and 10° and based on calculations of the collector as well as information from scientific papers. He said that IOM selected 7° but was optimistic that mining collectors could reach 12°-15°. Another uncertainty would be buried nodules.

He informed participants that IOM had initially had opted to produce four million metric tonnes (4Mt) of wet nodules per year for the commercial phase, but now it preferred to consider an approach based on the analysis of various alternatives. Mr. Abramowski recommended that discussions on parameters affecting mining, such as design of ship and production rates; some kind of collaboration between contractors and the Authority may be useful.

The Concept of the Russian Exploration Area Polymetallic Nodules resource and reserve categorization

V. Yubko and I. Ponomareva, Yuzhmorgeologiya (Presented by Sandor Mulsow of the ISA in Ms. Ponomareva's absence)

The Russian Exploration Area (REA) incorporates an Eastern and a Western territory with assessed cumulative resources of 448 million tons nodules. The SSC Yuzhmorgeologiya used a Russian classification of mineral reserves and resources, developed by a competent organization - State Commission on Minerals. It identified four levels of resources, in order of decreasing knowledge (A, B, C1, C2) and three categories of 'prognostic' resources (P1, P2, P3). Resources of categories A and B were identified only in areas of detailed study for confirmation of C1 resource estimates.

In September, 2010 FGU "GKZ" and CRIRSCO agreed to a document which took into account the Guidelines categories of resources and reserves of hard minerals stipulated by the Russian classification and applied by Yuzhmorgeologiya to polymetallic nodules and the CRIRSCO Template.

Yuzhmorgeologiya demarcated deposits based on photo, video and acoustic surveys at 3 – 6 km spacing, and one sample per 36 km². Assessed resources and reserves in the studied areas were: P1 category (Inferred Resources) 414.3 and C2 category (Indicated Resources) - 144.2 Mt of wet nodules. It was expected that at the end of the contract, cumulative polymetallic nodules reserves with regard to C1 + C2 categories would reach 180 Mt, including C1 category of 36 Mt. Yuzhmorgeologiya qualified such reserves as sufficient for future mining enterprises processing 3 million tonnes of dry (4.3 Mt of wet) of nodules per year in the course of 20 years and the first 5-year period of the mining contract respectively.

Status of Korean Activities in Resource Assessment & Mining Technologies

Dr. Yoo and Dr. Hong, KIOST

Dr. Yoo presented the resource assessment activities of Korea and Dr. Hong described its miner Robot, *MineRo*. Dr. Yoo said that from 1992 to 2010, Korea focused on resource assessment and environmental baseline studies. During 2011, high resolution topography and acoustic seafloor surveys were carried out and environmental data for benthic impact experiment gathered.

He also said that sampling with free fall grabs (4 at each site) and box corers showed average abundance of 7.5 kg/m² at 4800-5100m depth. The slope gradient was less than 5° in 90% of the contract area. The shear strength of the sediments was between 10 cm to 40 cm and 87% of the total area has over 5kpa. It was easier to operate the miner robot - *MineRo* in southern blocks covered with consolidated sediments.

Kriging and the conditional simulation methods showed that the differences in areas of low density data when compared with high density sampling data were less than 5%. Therefore, available resource data could be described as indicated to measured mineral resource.

Dr. Hong said that a tentative production plan for nodule mining of 3 million tons/year for 30 years had been selected, based on previous studies. He also said that Korea's priority mining area was estimated as 18,000 km² with about 188 M ton of mineable resources. Dr. Hong said that delineation of the mining area was directly coupled with mining technology. He elaborated on Korea's pilot mining robot, *MineRo* which had undertaken two at sea trials in 2012 & 2013 at 130m depth. He noted that its collecting efficiency had been verified at the laboratory as 95%. Dr. Hong said that the seafloor miner should be limited to high-tech robotics to enhance nodule pick-up, crushing, and discharging performances. He told participants that the ongoing technological development of 20 years would end next year.

COMRA'S Activities in Resource Assessment

Jincai Jin, Secretary-General, COMRA

Dr. Jin informed that COMRA's western license area has lower grade, and the eastern area lower abundance. He said that the block with potential deposits were divided into six parts. The eastern part had 5 kg/m² abundance, about 1.8% grade and about 5° slope, at 9.8km x 9.8 km sampling grid.

An area of 217 km² with flat terrain was chosen for future environmental impact assessment together with equipment testing. Dense sampling and AUV measurements were carried out in this area in 2013 and will continue into 2015. He said that resources in the western part of COMRA's contract area were categorized as inferred, indicated and measured resources using the China (GT 1776-1999) that was based on UNFC 1997 with different categories of resources: 331, 332 and 333.

Dr. Jin said that the resource classification between COMRA and CRIRSCO were comparable; and that COMRA was in the stage of pre-feasibility studies. He mentioned the LTC chairman report in 2006, where the need to establish mineral resources/reserve classification system for the Area was expressed and discussions around system with global applicability, e.g. the UNFC. Mr. Jin presented COMRA's proposed mineral classification system.

Polymetallic nodule resources evaluation: how are we doing?

Masatsugu Okazaki, DORD

Dr. Okazaki informed participants that DORD's first generation mining area was approximately 6,000 km² with high abundance. A prefeasibility study had been conducted in the area for a 20-year mining operation. He said that with an average abundance of 10 kg/m² and an annual production of 3 million tonnes, DORD would have to produce 10,000 tons/day for 300 working days/year, with about 300 km²/year coverage, totaling 6,000 km² in 20 years. Additionally, he said that DORD had also conducted a detailed survey in its proposed mining area using an AUV for nodule distribution, detailed topography and continuous photography.

He told participants that DORD constructed its abundance map by applying Kriging to free fall grab (FFG) samples and had used a continuous deep sea camera (CDC) for the photographs to estimate coverage, number of nodules, and abundance. The areas of mineable resources had less than 5° slope gradient, 12.31 kg/m² average abundance, with 92.5% of the total mineral resources being mineable. He said the mineral resources drawn from the FFG were inferred, and from the FFG and CDC were indicated resources.

Dr. Okazaki concluded that DORD's mineral resources were now more than inferred but not accurate enough for the indicated category. He said statistical treatment of this data was necessary to decide the criteria of the indicated category.

Polymetallic Nodules Resource Classification: French Effort 1970-2014

Yves Fouquet, Ifremer

Dr. Fouquet informed the workshop that Ifremer moved to large scale exploration in the CCZ during 1975-76, it had its first diving operation in 1989 using a manned submersible, and from 2001-2004 did environmental, economic and geochemical studies and near-seafloor geological mapping and photography. In 2012 the eastern section of the Area was surveyed by a multi-beam system. Ordinary Kriging and conditional simulation was done on the slope and then the density of nodules on the seafloor and mineable areas were defined.

Dr. Fouquet told participants that Ifremer also worked on mining and processing technologies and techno-economic studies. Its next step, he said, should be pilot mining and prefeasibility studies. He said that Ifremer envisioned mining about 1.5 Mt of dry nodules every year in areas with an abundance of about 14 kg/m², for about 50 years, requiring about 30,000 km². With inferred resource shown to be capable of supporting decades of mining, Dr. Fouquet said upgrading this level of knowledge for the whole area was not necessary at this stage.

Indian polymetallic nodules programme

M. Shyam Prasad and Dr. TRP Singh, INDIA

Dr. Prasad informed participants that India had identified its first generation mine site (FGM) in 2009-2010 and subsequently a test mine site – a single block of 1/8 degree in 2013. He said over 2,500 stations were sampled mostly by free fall grab (5-7 at each site). Starting from a grid of one degree, it sampled at 14 km and 7 km grids in 18,400 km² area. He told participants that India undertook 76 expeditions for resource estimation and mineable area identification.

Dr. Prasad said that single beam and multi-beam echo-sounding mapping was done for seabed topography to relinquish areas. Sampling at 0.125 degree grid, baseline environmental data at 64 stations in five candidate tests and reference sites was done and a simulated mining experiment was conducted in 1997. For a first generation mine site to sustain production for 20 years, 20% of the area was sampled at 7 km grid, with sufficient topographic information to eliminate adverse topography and areas of steep slopes. Dr. Prasad informed participants that in 2010 India developed an underwater collector and crushing system and underwater mining machine, for mining nodules in 500 meters depth, and an unmanned ROV and *in-situ* soil tester for 6000m water depth. The integrated mining system for mining of nodules up to 6000m depth was still in progress.

Dr. Singh advised that 15% of the grade qualifies for a measured category and that 10% of the Area (75 000km²) will have sufficient resources for 20 years mine life.

CCZ Nodule Projects:2013 Mineral Resource Estimate per N143-101 Tonga Offshore Mining Limited [TOML]

John Parianos, TOML

Mr. John Parianos said that the TOML license has six blocks (A-F), returned (to ISA) by the Pioneer Investors. Area E and F have few samples, so were not included for classifying resources. Mr. Parianos informed that for going through the code NI 43-101, TOML had done data verification by obtaining public data and preparing a completely independent data set. Similar results were obtained by interrogating the model picture with the International Seabed Authority's 2010 map; using colour codes and comparing it to TOML's estimates model.

TOML took a block model approach in 10km x 10km, did Kriging and simulation for the purposes of an inferred resource. Mr. Parianos said the TOML reported a range of results and used abundance as a cut-off, along with a grade/tonnage curve. He said the grade barely changed although the abundance, which is the key economic variable, did; and that the appropriate cut-off at this inferred stage was not known.

Lead up of the Polymetallic Nodules Project and Context

Jacques Paynjon, GSR

Mr. Paynjon informed that the company signed the contract in early 2013. It has done a cruise in the Area for 55 days and while at the site, the group noticed that there was some sort of mechanism to define the presence/absence of nodules on the seabed and were able to confirm it with the box corers and dredges with cameras on board. He showed some sampling graphs.

WORKSHOP RECOMMENDATIONS

There was general consensus amongst members of Working Group 1, to continue discussion of potential collaborative efforts associated with pilot mining tests and environmental impact studies (benthic impact experiments) associated with collectors, as it was too early to identify where standardization was required in regards to collector systems. This working group recommended that the Authority:

- Accepts and make public the State-of-the-Art of the contractors collector development program;
- continue discussion of potential collaborative efforts with pilot mining tests and environment impact studies (benthic impact experiments) associated with collectors, amongst the State Owned Contractors;
- continue to support collaboration amongst interested contractors with regards to pilot mining tests and environmental assessment efforts as a means of helping contractors, reduce risk, reduce cost, share/develop technology, and reduce collector related environmental impact. Such support might include: Future workshops, Working Group I meetings, coordination of collaborative pilot mining and environmental impact assessment;
- provide to the contractors in a timely manner copies of the draft rules and regulations, for the transition from exploration to exploitation, and for exploitation;
- supports the recommendation of counsel and facilitate the review and release of the CCZ environment management plan taking into consideration the relevant proposal from the Netherlands

Working group 2 began its work with the draft revision of the CRIRSCO International Reporting Template and added clarity to the concept of “mineable areas”, applying the definition used by the UN Ocean Economics and Technology Branch of that area where, nodule abundance and grade is above a pre-determined cut-off and the topography is of unacceptable nature. The group found that resources of the mineable area correspond to the ‘mineral resources’ category of the CRIRSCO template, including inferred, indicated and measured categories.

This working group recommended:

- the terms “proven, probable and possible reserves” refers to the CRIRSCO categories of measured, indicated and inferred mineral resources and, if the pre-feasibility or feasibility studies supporting conversion of resources to reserves have been applied by the contractor, to proven and probable reserves; materials that do not qualify as CRIRSCO mineral reserves or resources may be classified within appropriate categories of the UN Framework Classification;
- in the application of the modifying factors listed in the template, the categories of weather, transportation, underwater topography and international benefit sharing should be considered;
- in the case of non-Public reports to the International Seabed Authority, the “Competent Person” requirement to belong to a professional association with disciplinary power was not applicable. The resource classification may be undertaken utilizing several competent persons with expertise in different areas.
- The modified template of CRIRSCO should be made available to the Legal and Technical Commission for its consideration for use by all contractors.

Working group 3, summarized that most contractors were already following existing CRIRSCO or UNFC classification systems and recommended that the Authority should prepare guidelines for resource classification as soon as possible although such guidelines should not refer to cut off values as it would depend on geological, technological and economic factors and should be defined by the contractors. The working group also advised that in their discussions the contractors agreed to use the resources classification scheme issued by the ISA in their practice and in the reports to the ISA (annual, after five-year periods and upon expiry of the contract).

PART I: MINING TECHNOLOGY FOR THE
CLASSIFICATION OF POLYMETALLIC NODULE
RESOURCES IN THE AREA

CHAPTER 1: International Standards for Resource and Economic Evaluation: Applications for Deep Seabed Mining

Caitlyn Antrim, Center for Leadership and Global Diplomacy,
Virginia, USA

Dr. Antrim's presentation provided an initial framework of standards as required by different stakeholders. She informed that at the beginning of the century mineral results were reported succinctly as proved, probable and probable reserves. By the early 21st century, governments applied two and three dimensional taxonomies to categories resources by economic value, technological feasibility and geological assuredness. The United States Geological survey published during 1976-80, known as the "McKelvey Box", which served as the basis for the modern public and private systems in use today.

Evaluations are required to be conducted by "competent" or "qualified" experts subject to professional discipline by their peers. Industry standards and best practices provide guides for evaluations and the national societies working together as the Committee for International Mineral Reserve International Reporting Standards (CRIRSCO) established a common template that could be adapted for use by other countries. Where the CRIRSCO standards addressed the resource assessment needs of developers, investors and regulators, a parallel development addressed needs of public resource managers. The United National Economic Commission for Europe undertook to develop a common "Framework Classification", known as the UNFC, for energy and mineral resources. UNFC added a third dimension that separated technical feasibility from economic factors to provide a more rich understanding of a national, regional or global resource endowment. Collaboration between CRIRSCO and the UNECE provided links between CRIRSCO's categories of Proven and Probable Reserves and Measured and Indicated Resources and the related UNFC boxes in their three-dimensional matrix. Dr. Antrim said that the CRIRSCO "Template" could provide the basis for conforming mineral reserve and resources reports required of Contractors to the Authority with the international reporting standards. If reports made by Contractors to the International Seabed Authority are consistent with the CRIRSCO standards, they will meet the needs of all stakeholders on one hand and mineral management and planning functions that may be undertaken by the Authority on the other.

Introduction

My goal for this morning is to provide a framework for discussion of resource evaluation by all the experts here today from the World Bank, from UNECE, from CRIRSCO and from all the contractors and people who actually are engaged in this work as a profession. So I am going to give you the framework that brings all this together with a little bit of history and then when it comes to question time I am not going to be shy about turning to people who know more than I do, so be ready for that.

Standards and Stakeholders

First we have the issue of identifying standards for mineral evaluation. Standards are required by different stakeholders, each with their own needs and objectives. We need to address an accurate presentation within limits of the data available on what the seabed mineral resource is and what it means in terms of an overall economic analysis. We need to identify assumptions, to be sure that we understand uncertainties as well so that we can just take a number as if it is the divine word of what may or may not be economically exploitable.

We need to do this in line with accepted international standards and best practices. Deep seabed mining has for a long time been viewed by itself alone as its own industry, but it is not. As long as the idea is to sell metals on the market analysts have to realise that it is part of the mining industry as a whole and that the standards have been developed over decades, even over 100 years, apply equally to seabed mining and there is a lot there that will be useful to deep seabed miners - both in the management of the seabed resources and in its exploitation by the private contractors. And we will try and get some vision of that in our meetings today and tomorrow.

Resources and Reserves Assessments

The three groups that are most interested in having evaluations of the resources include, the governments and organizations that are responsible for management of the resources to assess supply vulnerability, encourage development, promote research and develop conservation policies. In the United States, the US Geological Surveys [USGS] gathers information about resources and uses that to support informed decisions by the government and private users as to what the requirements are for that development and what that would mean to fitting in to broader world markets.

Mineral developers need to know what the resources means to them in order to plan development of individual deposits and guide investment decisions and to do that in conjunction with the mining part and with the technology development, and use it to plan ahead on what they are going to do next. The third group are the people who put the money into making this happen - investors and securities regulators to prevent misleading or false information from disrupting stock exchanges and securities markets - those groups that depend on making educated decisions. They need to have assurance that the information they are getting is valid and is tested according to industry standards. These standards also respond to problems in the past where misreporting of information led a loss of confidence in evaluations by the lenders, investors and securities exchanges minerals industries.

Milestones

Just to give you a bit of history – almost 500 years ago in 1533 the first discussion of importance of assessing mineral resources and reporting was done by Agricola specifying that if people wanted to know what the mineral investment was, they needed to check it out and not just take the word of the seller or promoter.

In 1909, Herbert Hoover, later to be president of the United States, was a mining engineer. In the system he employed he only referred to reserves and categorizing them as proven, probable and possible reserves. This later became the US mineral categorization system and it is still used by the US Securities and Exchange Commission even though the rest of the world has become more sophisticated in mineral evaluation and categorization.

National supply concerns lead to new taxonomies. In 1976 to 1980, the US Geological Survey (USGS) developed a mineral classification system illustrated by what came to be called it the “McKelvey Box.” Minerals were classified both in terms of geological certainty and economic feasibility. This was done for larger areas, as applied to minerals in the United States, and most of the world. After some problems in public reporting on nickel deposits and gold mines, national codes for the reporting of minerals came into being. This led the Australians and Canadians, joined by other countries along the way, to develop a common code that now represents 90% of the world’s stock

holdings in mineral industries. It became almost impossible to finance a mine without being subject to the codes and, if not directly applicable, investors still required developers to follow those rules.

Forces for Change

Things have forced this development along. One is that it costs a lot to open major mines. Scale of investment capital required to develop the new mines we are talking about is on the order of \$3 to \$5 billion dollars. Some people get discouraged when they think of these numbers for seabed mining but if you want to open a new nickel laterite mine or a new copper porphyry mine in an area that does not have infrastructure in place, you are still working on that scale. That means you will have to have a lot of financing. No single company is going to provide that amount. The role of Securities Exchanges in financing mineral development is important since most companies will seek bank loans, stock market financing and capital investment and these groups want the assurance that they have access to honest information about the deposit and the venture. Because they have a regulatory role, securities exchange commissions and stock markets are able to require companies to follow these rules. As a result, when rules governing mineral evaluation and categorization are established, developers must abide by them.

Another area that maybe applicable to some of the seabed mineral contractors is the concept of the "junior exploration company" in which a company goes out not to mine the minerals but to find a deposit and to develop it to a point where they can then provide it to another firm to exploit. When they do that, they need to lay out and explain the value of that deposit by using the same processes required by investors for determining the reserves and resources, measuring them and following the standards developed and recommended by professional societies in the minerals sector. For governments there are two things that drive this. First, after World War II, which had been very much a logistics war - a war over resources and a war by resources, the major governments at that time spent considerable effort to develop mineral and material policies that assured that they had access to minerals for international development, particularly as their economies became more and more dependent on uninterrupted supplies of metals. So that was one driver - and the second, more broad in its definition, was the importance of developing raw materials as an integral part of development and economic growth. So improved characterization of mineral resources and reserves at both international and the intergovernmental level was needed and those needs led to changes in classifications.

Commercial focus on Resource Classification

Commercial stakeholders are closely involved in the focus on resource classification. Stakeholders include professional societies in geology, in mining, law, industry and accounting. With support and encouragement from mining and investment securities groups on the stakeholders' side, development of a common template that the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) has developed a Template based on work with the countries that had been doing most of the work in this area and it has reinforced regulation in line with Australia's Joint Ore Reserves Committee, Canada's National Instrument on the subject (NI-43-101) and other members. CRIRSCO members have all formalized these processes.

Industry Best Practices

While specific rules and codes govern the evaluation, much rests on adoption and implementation of best practices based on professional judgement. Some of the main points are discussed here. These standards revolve around the trust put in a professional (or in a group of professionals since no one person has the full breadth of expertise in all of the related fields, including mining, processing, and marketing. It creates standard definitions of resources and reserves and rules and requirements for the design of a resource database. For geological interpretation and modeling, one may gather many data points about the seabed but intermediate points must be interpolated. It is not feasible to sample every section of seafloor that will be mined, so it is necessary to have to have trust in the interpolation methods. For land based deposits, the CRIRSCO systems have rules and guidance on mineral resource estimation and on application of modifying factors that allow one to move from having a confidence in that there are minerals in a region of the seafloor to assurance that they are really going to be present in the specific area a nodule collectors traverses.

Reporting standards define what you are allowed to say to the public and what you aren't. There is also a need for reconciliation between the projected categorization of reserves and resources with actual results Those are the types of things that industries expect to be incorporated into the codes required by the various stakeholders.

Industry Resource Definitions

Thanks are owed to the International Seabed Authority and to the many people who have worked on the development of a mineral resource model of the Clarion Clipperton Zone nodule province - this is a public evaluation of the inferred mineral resources of the Clarion Clipperton Zone.

The categorization of "inferred resources" means that there are a number of data points from which estimates have been extrapolated as to what is likely to be found in the region. That does not mean that if you drop your collector down to the bottom, it will find exactly the resources projected by the model. Much more work is needed to ascertain the indicated resources and measured resources with their higher degree of assurance. The movement to reserves is a increasingly more stringent analysis of economic, legal and other factors beyond abundance and mineral content. For a mineral resource, there is high potential for future economic exploitation. For a mineral reserve, there is greater assurance that the minerals are economically viable and the available information is sufficient to develop a mine plan for exploitation.

Modifying Factors

I just mentioned modifying factors. I will leave deep discussion of these factors for other speakers to fill in. These factors include understanding of the technology and understanding of the regulations and environment and social requirements, government regulations for mining operations, ship safety, investment and operating costs, commodity markets and mineral sales everything you do may not be able to control the market so you need to have not just a best guess about what markets are going to do, but alternatives so you can see what would happen if you overestimated or underestimated market prices. Modifying factors will also include provisions for sharing of contractor's financial benefits.

Government and Industry Interests

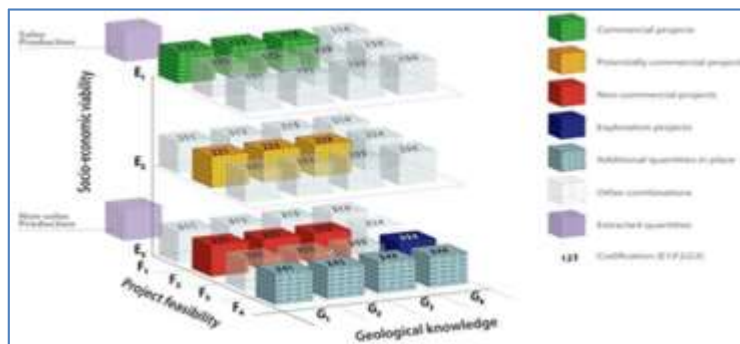
National governments have interests in maintaining a national inventory of mineral resources and the ISA needs to know the location and on what is available in the area. Information related to land use planning, economic development, and infrastructure are needed to support mining from land deposits. The same information is needed for seabed mining but in a different way because much of the infrastructure is mobile. Environmental regulation and various aspects of social impact, such as technology transfer, training, and the benefits of a stable metals market, are addressed in the Law of the Sea Convention. National economy and security issues must be considered as well since seabed mining has the potential to produce metals that are important to both high technology and economic development - cobalt, nickel, copper and zinc all of which are considerations in national and international planning.

Cumulative Production	IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES	
	Demonstrated		Probability Range	
	Measured	Inferred	Hypothetical	Speculative
ECONOMIC	Reserve	Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves	Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources	Inferred Subeconomic Resources		
Other Occurrences	Includes nonconventional and low-grade materials			

The 'McKelvey Box'

For a governmental perspective we go back to the McKelvey Box published in 1980 by the USGS to support government policymaking on resource management and security of supply. The diagram is named for Vincent McKelvey, who was director of USGS before he

retired to become the senior scientific adviser to the United States delegation to the Law of the Sea Conference where helped develop some of the provisions.

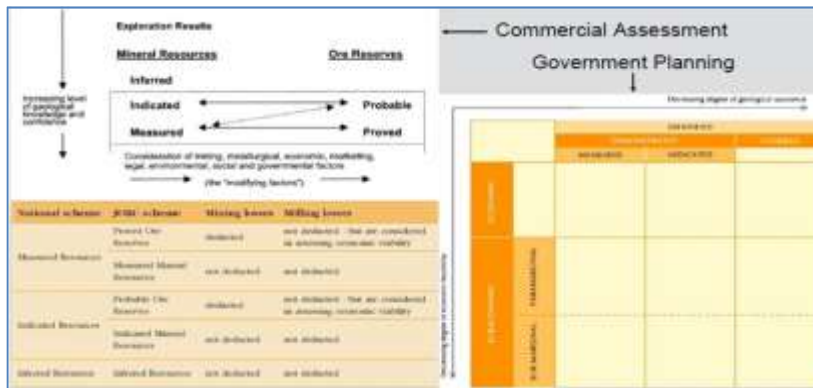


UN Framework Classification

The UN Framework Classification adds a layer of insight the earlier two-dimensional approach of the McKelvey diagram. With regard to seabed minerals, the world is now looking at three categories (nodules, sulphides, and crusts) and the Japanese have raised the possibility of exploiting sediments rich in minerals. There are other

minerals that may come be discovered and this could be a useful tool if those minerals are prove to be of economic interest. There is room for both the commercial perspective and the resource manager perspective in the UN Framework classification since the reserve and resource classifications of the CRIRSCO system correspond to specific boxes in the UNFC.

Two paths of Resource Assessment



In this case I have a diagram created by CRIRSCO which brings inferred, indicated, measured resources together with proved and probable reserves. On the right is the Australian governmental classification very much in the tradition of the McKelvey Box and they are shown together so it is clear that

both of these approaches may be used together but they each offer their unique perspectives so I expect the presenters to follow me will be discussing how these fit together. And I am not going to try and step in on that and take it away from you.

Resource Reporting Systems and the International Seabed Authority

We can relate all this to the ISA. First the industry and government approach to mineral resource categorization are different but compatible. The CRIRSCO taxonomy and the UNFC are both in use and the ISA has interests in both what the individual companies do and industry responsibility for managing this vast area by the resources of the area so we may well see something develop out of both of these systems, instead two of them. I could easily see that as a necessary tool for the ISA rules.

Four takeaways

Four takeaway issues are:

- (i) Reserves and resources are not just a mineral determination, they are financial measures that reflect a comprehensive commercial assessment. They are an international accounting standard and as such can be implemented by the Authority;
- (ii) The critical components for this include - understanding the current industry standards and best practices and hoping our contractors and our people who are experts in preparing these reports will go much more in-depth with that;
- (iii) The resource database - the ISA maintains a resource database, as do individual contractors. As additional information is gained, the database will be expanded to include information about environment and living resources. It is a geospatial database and that those are the core elements in a resource database but needs to be fleshed out. The work on developing the taxonomy is critical to that. It will be essential to expand the databases so that when contractors submit information they do so in a format that not only brings the information in the categories but also reflects degrees of uncertainty about it so that you don't just get a number and trust it to be safe - this number is plus or minus some degree of confidence;
- (iv) The competent person - I am glad to see we have a presentation focused on the competent person coming up tomorrow because that is what makes the classification system work. You can have a lot of data but you have to have somebody who understands how it needs to fit into the system. The qualities expected of a competent person in evaluation of deposits for

commercial potential also reflect reliability of information at the government resource management level.

Standards and Practices for Deep Sea Minerals

Some of the key standards that will apply to the industry, guidance for sampling and interpolation for example, may be expanded upon within national codes. For example, the Canadian guidelines provide details related to evaluation of nickel laterites deposits and on appropriate frequency of sampling. Uniform application of the evaluation guidelines provides consistency across evaluations of different but similar deposits.

The projection of mineral or metal prices - there is probably no variable within an economic analysis more critical than getting the price right. A 25% swing in metal price can determine whether commercial exploitation is highly profitable or a dead issue. The 2008 ISA workshop workshop in Chennai was during a period of rapidly rising nickel prices - due in part to China economic growth. The economic situation one year later forced those prices down and they have remained much lower than we would have projected in 2008. Mineral evaluations must address the possibilities through alternative assumptions and scenarios.

Environmental standard and practices in seabed mining have to be developed before their impact on evaluations and be determined That uncertainty has to be taken into account when preparing evaluations of resources and reserves because the determination of reserves rests a lot on how much it is going to cost to get minerals into the market place.

Finally there are matters of cost engineering and estimation of mining, transportation and processing systems. There is a whole discipline in that needs to be incorporated into the economic analysis process mentioned earlier.

The Resource Database

In addition to the competent person and the industry best practice standards - the third key point is the resource database. The main feature for the resource database for minerals is that it is a geospatial database giving you locations associate with measured data on minerals, topographic soil properties and all things related to the mineral and biological environmental resources. The database also includes inferred data. The statistical methods for determining out what the values are between the measured points is a sophisticated process in mineral assessment and that is a key part of the database and understanding of the methods of interpolation assures understanding of the levels of uncertainty in the database.

The Competent Person

The Competent Person is a critical feature of the CRIRSCO evaluation system. The Competent Person is a member of a professional society that is recognized by an appropriate national authority and has enforceable disciplinary processes including the powers to suspend or expel a member. If the person does not follow the rules or fails in his professional responsibility, he can be disciplined and lose his certification which in turn means he can no longer work in his or her field. A minimum

of 5 years' experience related to a specific type of mineralization or type of deposit under consideration and in the activity that the Competent Person is undertaking is required. That is, experience in evaluating copper porphyry deposits does not qualify a person to assess nickel-laterites or some other minerals, though it may make it easier for you to get up to speed on them.

Resource Reporting

The core of the commercial standard is resource reporting. ISA regulations require submission info about reserves and resources estimates at the end of the contract, so that's one form of public reporting. There is national legislation regulation; and I assume that it likely that the public reports prepared in accordance with international standards will work for the Seabed Authority as well.

CRISCO provides a template guiding preparation of these reports to promote compatibility, to implement industry best practices and to draw on the expertise of experts. Quality of Reports depends upon Industry Best Practices and oversight by competent professionals in fields such as geology, mineral processing and cost engineering.

Next Steps

The next step is to integrate the modern view of resources and reserves into the ISA Regulations defining reporting on reserves and resources.

The second step is to identify that the industry best practices applied seabed mineral resources. Involvement of mineral industry professionals will be part of the process to develop new guidelines applicable to seabed minerals and to specialized seabed exploration and exploitation technology.

A third step is to promote professional competence in exploration and evaluation of seabed mineral deposits through development of criteria and professional education. I hope that some of the professional societies will start offering courses to explain seabed minerals to land-based experts so they have a better understanding of that

A fourth, and very important, step is the development and adoption of a common taxonomy for seabed mineral Resource Databases, including mineral, biological and environmental factors, and integrate Industry Reports into an ISA Model of Seabed Mineral Provinces of the Area, so that when data is transferred it is done easily and without error from contractor databases to the Authority.

And finally a lot of the contract reports can contribute to the global expansion of the ISA mineral resource database that presently focuses on the CCZ , first with the addition of nodule deposits in the Indian Ocean and the Peru Basin and creation of a database for polymetallic sulphides. These expansions are an important aspect of maintaining the ISA as the knowledge centre for anyone wanting to investigate opportunities of seabed mining and these databases will be growing part of that.

Summary of Discussions

A participant asked the difference and the relationship between resource assessment and resource classification. Dr. Caitlyn replied that the classification would be actually putting one sample into one particular box according to the rules that had been set for determining whether something is

resource or reserve, whether it has been measured or indicated, proven or probable. The assessment is a more general term.

Another expert added to this that the resource assessment or resource estimation is the process through which the data collected is interpreted, and the geological framework to come up with an estimate, in this case abundance, in land based deposits - usually the tonnage. The estimation is managing the interpretation of all that information, of the quality and quantity of that particular mineral. The classification relates to the confidence in that estimation. Start at the lower category of resources such as inferred, and improve the confidence in estimate of quality and quantity with more knowledge and progress to the indicated category and eventually to the measured category. Another expert added that the key thing to keep in mind is that every assessor of volumes is not about the worth their own unique evaluation but the quantities associated with that. Two individuals looking at the same prospect at times, come up with different numbers because of the skill involved in the assessors doing this, and also the experience the assessors have. The other key issue is that each individual looking at the modifying factors and how they apply the assessments also come up with different value, this can depend on which stakeholder is making the assessment. An individual who is working the business from an industry making an assessment of a project would have different risk factors on those modifying factors with someone working for the state government or whatever national government, because they may have different views on both legal and environmental issues associated with development of that project. There can be confusion in estimates when they are viewed from different types of views by different stakeholder groups. A business can only view what they will develop within their entitlement whereas the government will want to look at full rights of exploitation of the profits. And we can get examples of the difference in estimation on the assessment side. Even with very clear assessment rules, there may still be big differences in numbers.

Comment was made about when we talk of seabed, particularly for nodules, the focus on extracting metallurgy from metal extraction does not get the kind of attention that it deserves. In this case with the nodules, one has to look beyond the ocean, for what is to be done from extraction and what the infrastructure to be recreated, and what kind of programme are planned to make the integrated project viable. Without the extracting processes becoming viable, the nodule will never be a viable process.

Dr. Antrim agreed to this and added that while doing the scoping study in the late 70s, they did an integrated project because there was no immediate market for nodules. But for now the evaluation has to look at the processing, since generally the economic assessments have shown half of the capital costs that need to be in the processing side. You have to evaluate for the whole system between the seabed and the market place, and can't set an arbitrary number in between.

A participant commented on the role of a competent person. Dr. Antrim said to also bring that up in the discussions of the competent person. Dr. Antrim said that if there is a role for the Seabed Authority in fostering that education and interchange among people who are, or wish to be confident in seabed minerals. How can professional societies provide that, or can business provide that as a professional training course so all of these things will help and make it available for all people.

Another comment was that is this evolution from accounting standards into resource management, and on the stakeholders – it's government, organizations, developers, investors and securities.

Looking forward, one of the forces for change is society who is the end users of this information in the stakeholder pool.

Dr. Antrim said that the social aspect in the near term, would be incorporated inside regulatory process where sometimes the social operate brings in to the evaluation process or at least the regulatory process. What it going to take to get a resource developed into market, that becomes one aspect of it. The other - the ISA, to her, has three main objectives - develop the resources in the Area, protect the marine environment and share the benefits. The industries will get some benefits of a wide diverse and stable marketplace. Developing countries get access to technological experience and education to training and related benefits and to experiences. There's a core principle within the ISA that becomes part of the resource management - the resource has to be managed with society as one of the stakeholders. So it is apparent in the ISA's stake in mineral development.

Dr. Howorth, the chairman of the Legal and Technical Commission (LTC) added that the Commission has two immediately related but separate issues on its agenda, one of which is the current pioneer investors have come to an end of their 15 years of contract in the early part of 2016. The regulations require that any applications for extension of the contracts must be before the Authority by September 2015 (6 months); the paper but must go before Council no later than July next year (2015). So that's one task for this workshop in India must be done, otherwise the legal implications at the end of the contract will start to become a little complex, and the standard clauses in the contract will start peaking. The second point which is urgent before the Commission is the drafting of the exploitation regulations, which takes you from the resources and reserves to the financial implications.

CHAPTER 2: Nodule collector subsystems-organization of the OMI pilot mining test programme and its use in collaborative tests by contractors

Ted Brockett, President, Sound Ocean Systems Inc. Redmond, Washington, USA

Mr. Brockett presented the Ocean Management Inc. [OMI]'s collective development programme, which was a consortium in the 70s with four primary partners. In 1977, OMI conducted a test of high speed exploration with a 30 kHz side scan sonar based on a back scatter system. In 1978, it completed a pilot nodule mining test (PMT) project in the CCZ in 5,400m depth, aboard SEDCO 445. The primary collector for the OMI PMT was an incredibly simple passively towed runner sled, called the 2M hydraulic collector, which had an active width of 2m and four independent dredge heads. Two submersible pumps, installed in line with rigid type riser system, were used while testing the collector and 40 metric tonnes nodules an hour was expected. The moving water was used to separate the nodules and sediment from the seafloor, to transport the nodules within the collector both vertically and transversally, and to introduce the nodules into the riser system.

Two key parameters had a big impact on the development of collectors - (i) nodules were considered to be a surface deposit only, (ii) a Monte Carlo approach to mining the mine site had significant impact on the collector designs. Mr. Brockett said that another issue (to consider) would have been the active width of the collector for increasing the collection efficiency. The bow waves have a very significant adverse impact on collector's efficiency. More is needed to be done to eliminate or minimize bow waves, to reduce the bearing load even further, and to investigate a steerable collector design with options of side by side mining tracks.

Mr. Brockett said that OMI favored hydraulic designs, and the key to success was the Collector's reliability.

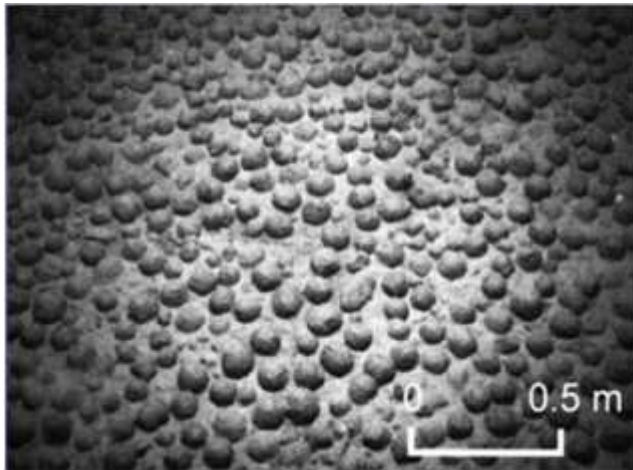
Background

My talk today will be about the OMI collective development programme. In the way of background - Ocean Management Inc. (OMI) was a consortium with 4 primary partners: INCO US, Inc., - a subsidiary of the Canadian International Nickel Mining Company; AMR - a German consortium; DOMCO a Japanese consortium; and SEDCO - a Texas based drilling service provider.

In 1978 OMI completed a very successful pilot mining test. We were in the CCZ area in about 5,400m of water. During that time we put over 600 tons of nodules on the deck of the mining ship. It was the culmination of a 4-year program and basically proved the technical feasibility of mining the ocean floor.

Resources

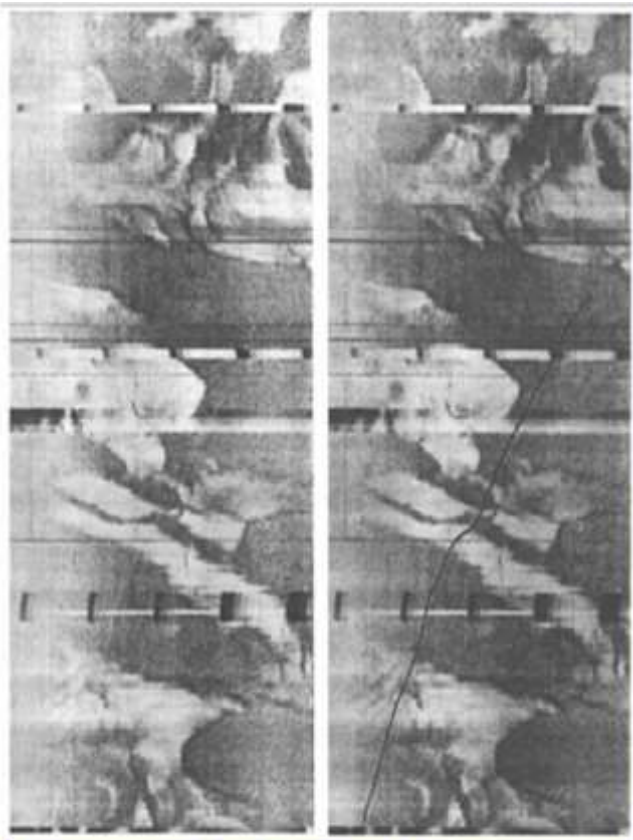
I don't think I need to show many photographs about the resource itself, you all have seen ones like the first one below. However you may not have seen one like the second image - I doubt that other than one or two people may have seen this image before.



High Speed Exploration System

In 1977 OMI conducted a test of high speed exploration system. This was a 30kHz based side scan sonar back scatter system and the imagery that came out of these tests truly changed the thinking, at least amongst the people within our consortium, about the abundance or distribution of nodules on the seafloor. They surveyed about 165 sq. km during this system test. The illustration you see here is the back scatter image that represents the deposits of the nodules on the seafloor surface.

There were many within our group that didn't believe this very mottled appearance was truly representative of nodules, but this particular slide proved that to be the fact. It's probably very difficult to see but if you look very carefully at the image on the left hand side you can –see there is a very light line that traverses from the upper right down to the bottom right. The right hand image is the same except that the light line has been darkened so you can see it better. In 1976, the year before this survey was completed, we conducted a deep sea collector test in this area and that very light line that shows up on the left was in fact the collector track of one of the passes that was made in 1976.



HSES Image (1977)

OMI Team Approach

OMI took a team approach to collector development. In fact they took a team approach to the whole ocean mining project. The PMT (pilot mining test) was divided into tasks and each of the partners

was given the responsibility of certain tasks and the other partners were generally given assistant roles. INCO the company I worked for had the responsibility of collector development and therefore we did the project management and internally to INCO we developed hydraulic and passive collectors design concepts. We designed and built a land-based collector test facility where fully assembled test collectors could be tested. Additionally we wrote test programs, test plans and conducted the at-sea tests. Our Japanese partner also participated by developing a hydraulic collector design and they participated in both on-land and at-sea tests. Our German partners did the same thing except their focus was mechanical collectors as opposed to hydraulic designs.

Two key Collector Design Parameters

I want to mention two key parameters that had a big impact on the way we developed collectors. First is we considered nodules to be a surface deposit only. We gave no consideration at all to nodules that may have been buried or otherwise below the seafloor surface. Second we planned to take a Monte Carlo approach to actually mining the mine site. What that meant was we would not be mowing the lawn with adjacent successive mining tracks or collector tracks. It was more or less a random first selection so if you envision a mine site as a large diameter circle - start anywhere in the circle for e.g. in the middle. Randomly select a compass reading and head off mining in that direction until you reach the boundary. When you get to the boundary you spin the roulette wheel and that tells you what heading you go to next. You then turn around and move in that new direction until you again reach the boundary and then you repeat the process. That had significant impact on the collector designs in that we did not have any type of active steerage control on our collectors and none of our collectors were self-propelled. All of the collectors developed throughout the OMI programme were passively towed collectors.

Phased Collector Development

We followed a typical phased approach to the collector development program. We started with conceptual designs. We then did laboratory size testing of the key critical components. We then did the detail design, fabrication and assembly of the test collectors. This was followed by land based testing. We then went through a design refinement phase for the in-situ test collectors. We then tested those collectors at-sea. This phase was followed by another design phase, this time for the pilot mining test collectors. The final phase was the pilot mining test itself. One of the interesting factors is that those first three items were conducted simultaneously by three different organisations in three countries and coordinated by us.

Laboratory and Tow Tank Tests



This is an example of one of the smallest laboratory tests that we conducted. During the laboratory testing we tested for such things as nodule settling velocity, jet sheet nozzle flow, the movement of nodules up inclined ramps and ducts, horizontal nodule transport, entrainment ratios, hydrodynamic model testing and towing stability tests.

Land Based 'Mud Pit' Tests

INCO constructed a temporary collector test facility approximately 200 ft. long x 12 ft. wide, measuring about 12 ft. deep at the bottom deep. This was a very cost effective facility that allowed



us to test fully assembled collectors. It was very inexpensively constructed by literally digging a trench with a bulldozer in a local gravel pit and then spraying the walls of that trench with concrete. We had developed a formula for simulated sediment which we used to fill the bottom of our trench. We also developed a formula for simulated nodules that we spread out in the bottom of the trench on the simulated sediment and occasionally we threw some real nodules in just for comparison purposes.

In this test tank we tested two passive collectors including a device called the rhombic rake and one known as the passive inverted plow. We also tested a number of active collectors including the electro-hydraulic, active inverted plow, the one that we simply called the DOMCO collector that was another hydraulic design, and then three collectors developed by our German partners, all of them mechanical. Two of them were cutter drum style machines and one of them was a cutter blade scraper. In these land-based tests we right away eliminated the passive devices as just not being appropriate for further consideration and we also eliminated the CDZ design.



1976 In-Situ Deep Sea Collector Tests

We followed the land-based tests with in-situ deep sea tests of the collectors. The testing was done aboard the German research ship Valdivia, in the CCZ area. All of the collectors were tested on the end of a tow cable. We didn't have a riser, therefore the collectors were configured to collect the nodules and put them right back down on the seafloor again. During the deep sea tests we tested the EH and the active inverted plow design as well as the DOMCO design and the cutter blade scraper. The CDM collector was on board but never was tested. Both the DOMCO and the EH design - again both hydraulic collectors - showed a lot of promise. The DOMCO design actually had some beneficial features that the EH design did not have. Therefore, we chose the DOMCO design as our primary pilot mining test collector and we also took out on the pilot mining test the cutter blade scraper design.



1978 Pilot Mining Test



In 1978 we conducted the pilot mining test aboard the SEDCO 445. We tested submersible pumps and air lift based mining systems. - The tests were conducted in the CCZ in about 5,400m of water using 9-5/8" diameter drill pipe. At the end of that rigid riser we had some cast lead dead-weights, a dump valve, a vacuum relief valve, and depending on which collector was being tested we had 8" or 6" diameter interface hose. On the very end of the hose we had one of the three collectors we took out to sea.

This is a picture of the SEDCO 445 which is a standard drill ship with one major modification - we eliminated the fixed derrick and replaced it with a gimballed rig floor and mast assembly.

Submersible Pumps and Air Lift Systems

We tested both submersible pumps and air lift systems. We had 1,000 horsepower KBS German submersible pumps. They were contained in caissons and the caissons were installed in line in the riser system. We used two pumps when testing the 2M collector and we expected 40 metric tonnes an hour using that machine and that lift system. We would then put three pumps in line if we were using the larger 3M collector and anticipated up to 60 metric tonnes per hour. When we tested the airlift system we injected the air at about 2000m depth. We had 3000 psi compressors on the deck and we were going to test the airlift air injection system using either the smaller hydraulic or the cutter blade scraper design.



Riser Systems Components



Our riser was a rigid type about 5350m in length. The upper 950m section was thick wall heavy weight pipe. The middle section only about 450m long was medium weight and the majority of the length of the riser was light weight thin wall pipe about 3960m long. We had high strength rotary tool joints on the ends of each joint of pipe. The dead weights were 8100 kg each, and we could put up to 6 of them on the end of the riser. The only purpose of the dead weights was to keep the riser straight during towing operations as a means of trying to minimize the bending stresses in the riser.

We had a dump valve in the bottom and the purpose of dump valve was to allow means for the nodules to get out of the riser or discharged from the riser if the pump system or an injection lift system failed. Similarly we had a vacuum relief valve down there so that if the collector or interface hose became clogged we could get clean water into the bottom of the riser and continue to lift the solids in the riser so they did not fall to the bottom and jam it.

Interface Hose



We had an approximately 250m long interface hose connecting the end of the vertically oriented rigid riser to the horizontally oriented collector on the sea floor. We had 8" hose we used for the hydraulic pumps and 6" hose for the airlift. The sections of the hose were about 40 ft. long. 250m of hose allowed us the flexibility to mine excursions of plus or minus 90 meters of bathymetric water depth without having to change the length of the riser. We used off the shelf Uni-bolt connectors [shown in the photograph] to join the links together.

Air/Sea Interface



I show this slide for no other reason than to remind people that we sit at our desks in our offices comfortable and warm and we tend to think about pictures like the one on the left. That is a work basket under the grid floor where we attached all the various power and communication cables to the riser as we were deploying. The picture on the right is the same work basket - just to remind us that things aren't all as calm as we would like to think they are.

2M Seafloor Collector



Our primary collector for the OMI PMT was called the 2M hydraulic collector. This was an incredibly simple passively towed two runner sled device. We had basically one moving part on that machine, and that was a 20hp electrical motor. We literally put an outboard motor propeller on the output shaft of that motor, put a duct around the outside of it, and that was our hydraulic power source.

The 2M collector had an active width of 2m consistent with its name. It consisted of four independent dredge heads which you can see here in this lower picture. The dredge heads were allowed to float a little bit relative one to the other and the lower limit of that movement was fixed by a cam.



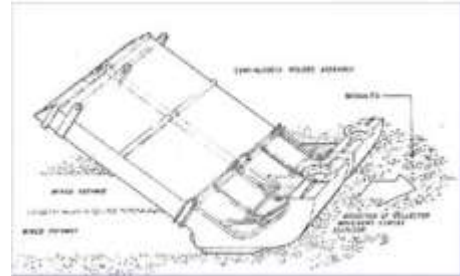
Another important consideration for our collectors is that we tried very hard to make sure that the bearing load of the collector on the seafloor was less than one half of one psi. We also used another very simple passive device, a cloth sail. The sail was used for hydrodynamic stability during the deployment and recovery operations when towing and it was critical when landing on the seafloor because it meant that the bottom of the runners would be facing forward and we would always land right side up.

The 3M collector was essentially identical to the 2M collector except that its active width was 3m and therefore we had six of the floating dredge heads as opposed to four. Otherwise it was essentially the same design. One significant difference was the 2M pump was an electric motor with a propeller on it and the 3M pump was a commercially available axial flow pump that was more efficient. We actually used the same 20hp motor to drive it and we drove it at more like 25 or 30hp.

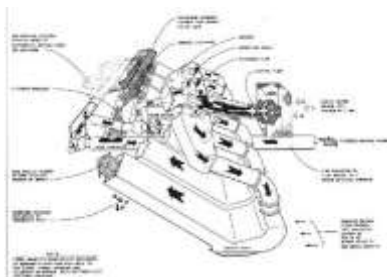
OMI Collector Functional Concept

This is a concept sketch showing a couple of dredge heads. Again I can't emphasize enough how simple the functionality of these collectors were. The moving water is the only thing we used to do all the work and the water came from that pump. The moving water was used to separate the nodules from the seafloor and to eliminate the sediment that was removed with the nodules. It was used to transport the nodules within the collector both vertically and transversally and it was used to introduce the nodules into our riser system. Reliability is key and our opinion at that time and mine today is that simplicity equals reliability. We followed the 1960s US Navy KISS principal which stood for Keep It Simple. Again I am a strong believer and I emphasize how simple our design was with that one moving part. And also I mention that moving part, the propeller, did not come in contact with the seafloor, or the nodules or the sediment, so wear and abrasion associated with this simple design was actually quite minimal.

This is a detail showing the water flow pattern within dredge head. Water from the propeller pump came into a header that was used to form jet sheet nozzles. The effect caused the flow output of the nozzles to follow the shape of the dredge head. Water scoured, lifted and entrained nodules and sent them up the ramp. Additionally we entrained water, so we had more flow coming out of the discharge of our ducts than what we put in through the nozzles. The nodules were transported up the inclined ramp or duct portion of the dredge heads. The flow was very turbulent and therefore the sediment was washed off the nozzles and discharged out the top within seconds. The nodules were also raised up within the collector which then allowed us to transport them horizontally.



We rejected oversized nodules in two places, one at the bottom of the dredge heads and one at the discharge of the dredge heads. Across the back of the machine we had a hopper that we used to eliminate the sediment and transport the nodules to the centre. We had 3/8" openings that were enough to let the sediment dirty water pass through but redirected the nodules down into the hopper where the bottom contained jet sheet nozzles used to transport the collected nodules to the centre of the machine. There were some gravity operated dump doors on the back of the hopper that would allow us to get rid of jammed nodules in the hopper should that condition exist.



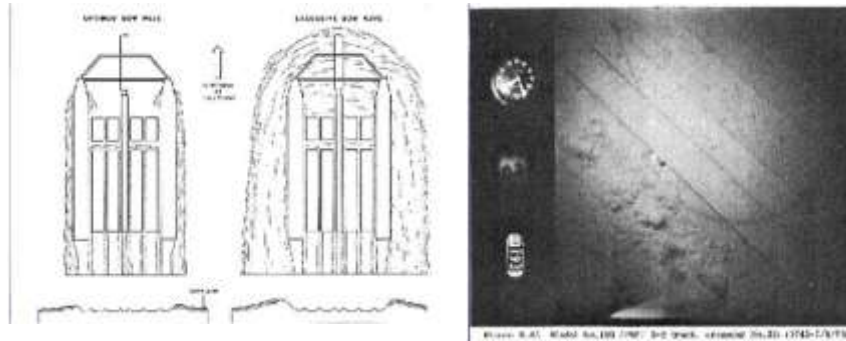
The figure on the left shows the flow pattern in the 2M design. You can see the hopper and you can see the flow from the simple motor split going into the four dredge heads. Additionally water was supplied to the header in the bottom of the hopper. There were a couple of simple eductors used to increase the flow.

The next figures illustrate the 3M working fluid flow. The 3M collector functioned the same as the 2M collector with the difference being we used a little more sophisticated, higher efficiency and higher horsepower pump to drive the machine. Hydraulic collectors work. They have a proven track record. There were more than 600 tonnes of nodules delivered to the deck that year as proof.



Bow Waves Can Impact Efficiencies

I want to just quickly mention bow waves because bow waves can have a very significant impact on the efficiency of the collector. The sketch on the left shows a collector with a small bow wave while the right hand sketch shows a large bow wave. The photograph on the right shows an actual windrow that was formed by a bow wave. The bad news is these bow waves act as plows and drive the nodules off to the side of the collector and therefore make the collection much more inefficient.



Remember KISS

As I wind down here I want everybody to remember the KISS principle. Keep It Simple. OMI hydraulic collectors embodied the KISS principle. We used sea water to perform all of the collector tasks. They require minimum horsepower, basically only 10hp per meter of active width. They use a simple reliable design, with only one moving part. That part was not in contact with solid materials. They used a very simple approach to make them land right side up at the bottom.

They had very good collection efficiency, as long as there were no bow waves. We did not have good collection efficiency when there were bow waves. We performed sediment rejection down at the seafloor as opposed to bringing it up to the surface. We had something on the order of 1% of the flow in the riser that was sediment or little bit less than 1% that made its way all the way up to the ship. Collector bearing load on the seafloor was kept to about one half a psi or less. And we rejected the oversize materials in a passive way.

Opportunities for Improvement

While the OMI PMT was considered to be very successful, that's not to say there aren't opportunities for improvement. We did have problems. More reliable submersible pumps would have allowed us to operate longer and to put a much larger quantity of nodules on the surface. We could have used redundant critical components like the submersible motor. One opportunity would be to improve the active width of the collector so that it equals the total width of the collector, right away increasing the collection efficiency. I think more needs to be done to eliminate or minimize bow waves. More can be done to reduce the bearing load even further thus reducing penetration depth into the seafloor and reducing bow waves. With regards to sediment rejection, even if we had less than 1% on the surface, we can do better. You might consider a steerable collector if your mining concept of operation does say you want to "mow the lawn" and have side by side parallel mining tracks. There is a potential alternative way to do that without necessarily driving the collector with screws or tracks. And just a comment on the state of the art - the computers, the sensors, and the other instruments we used in the 70's are archaic compared to what's available today, so there is room for significant improvement.

Conclusions

The conclusions are pretty straight forward. We were very successful in what we did. We believed and followed the KISS principle. OMI favored hydraulic designs. We proved the technical feasibility. I want to mention again the fact that we considered nodules only as surface deposit and ignored anything below the surface. We found out the hard way that collector reliability is key. It's a long way away. I would suggest that you need to be prepared to lose equipment. I did not mention it in my talk but in 1972 - we lost a collector, 25,000 feet of umbilical cable and collector instrumentation due to a winch failure. In 1976 we lost another collector, its cable, and instrumentation. In 1978 during the third PMT cruise we lost a mechanical collector, an interface hose, and cable because of the hose fitting failure. There is a saying 'don't put it in the water unless you can afford to lose it'. Be prepared. Have adequate spares and a good contingency plan.

Summary of Discussions

Following a question by a participant wanting to know how to measure the collector's efficiency, Mr. Brockett replied that most of the proved collection and efficiency that he measured were done in the test phase on land. The deep sea tests and the subsequent mining tests were more qualitative analysis, based on what they thought was distribution and the density of the nodules on the seafloor.

When asked about whether the efficiencies were higher in areas of lower nodules or higher nodule densities, Mr. Brockett said that he did not have a real answer to that. He continued that the biggest impact on collection efficiency was the bow waves. Even though they had cameras in front of the machine, it was often difficult to record the mining environment and because they weren't able to see any nodules in front of them, everything was based on the measurements system. He said one excellent way to determine nodule throughput was to use a hydrophone because the nodules going through the hydraulic collector made a lot of noise and they were able to tell whether they were delivering nodules or not just by listening.

Another participant commented that during the last 20 years – changes had been made from 'simple stupid' [of Keep it simple and stupid - KISS] to 'simple and smart', to get more nodules from the seafloor, in the sense that the ability of the collector was indispensable to get much more area to harvest the nodules on the seafloor. He wanted to know about slow slurry flow and if there were any serious problems in the pilot mining test in 1978 and direct introduction of the nodules to the lifting pipe, whether it raised technical problems.

Mr. Brockett said the easy answer to that question was no. There were no technical problems. However, on the second part of the mining test – while testing the airlift system, they did have a problem. The nodules that were in the riser fell back down when the lift system stopped. The nodules did not all exit out at the dump valve as expected and some of those nodules also went down the flexible hose and jammed the entire hose. So once they recovered the system it was a lot of work to get those nodules out. It took a full 48 hours to get the collector from the deck of the ship to the seafloor and it took 24 hours to get it back. So the idea of reliability is critical because a mining ship may cost \$250,000 a day (not indicative of the current price). He said no one wanted to be completely shut down for a minimum of 3 days just because of a part failure on a collector. He continued that it was three days - only if there was a standby collector ready to be deployed.

Mr. Brocket said for a commercial scale collector, one could design the collector, for example, a hydraulic designs, which could be sized for pilot mining tests. Assuming it was successful, that same collector device can be expanded and instead of having one collector, one basically had two identical machines. These might be 20m wide and maybe good enough for first production system or a pre-production system and that same system can be expanded again by simply ganging multiple units together. He did not know what the upper limit was but he did not see it as impossible and that it could increase to 40-45m. It was not likely to be able to launch and recover such a large assembly as a single component, as some assembly work would need to be done with the pieces in the water.

On the question of the diameter of the rigid hose versus nodule size, Mr. Brockett said he had no idea but he did not want nodules that were larger than 2" in diameter in the system because 3" could theoretically line up perfectly and jam up the riser. The commercial scale risers were going to be larger than the PMT riser. There were also anomalies like big nodules on the sea floor. In the claim sites in 1970s, the nodules were generally small and there weren't very many big ones.

On asked about defining other factors, Mr. Brockett said that he thinks it is going to be the size of the riser pipe and its ability to transport the nodules from the seafloor up to the surface.

PART II: EMERGING INTERNATIONAL STANDARDS FOR MINERAL RESOURCE EVALUATION

CHAPTER 3: Information needs of financiers, investors and resource managers

Michael Stanley, Mining specialist, World Bank, Washington

There continues to be a global shift regarding the practices that lead to sustainable mining, and the corresponding demands being placed on investors to insure mining activities lead to broader developmental outcomes. Financiers, mining companies, governments and civil society alike must assess investment opportunities viz. sector governance, and ensure not only full contractual and regulatory compliance, but also that the processes used to plan and execute mine development are guided by inclusive growth practices considering more strict levels of environmental & social performance. And, the social license to operate is increasingly earned through the degree to which communities not only share in decision making processes, but also in a commensurate stream of benefits derived from resource production. To this end, mining sector governance and investment risks are inseparably intertwined, forming the starting point for this presentation - an elaboration of what constitutes good sector governance and the attendant limitations regarding the ability to attract mining finance today. This presentation is based on the World Bank's experience regarding the policies and good practices for terrestrial mining, which may prove useful to those seeking to understand similar challenges for Deep Sea Mining (DSM). And core to the discussion is the need for resource planning to employ a resource classification system that explicitly considers not only the geological potential, and the technical and economic viability of the resource (project), but also the environmental and social issues that must align to allow sustainable outcomes.

The presentation concludes with summary of a pilot application of the UNFC 2009 Resource Classification System, applied to iron ore mining in Odisha State, India. This pilot application of the UNFC 2009 resource classification system illustrates the need for inclusion of environmental and social dimensions within a district having many complementary and competing land-uses, one of which is large scale mining for which the ability to attract financing has become overly problematic. The early results of the pilot demonstrate that the 2009 UNFC can be used by resource planners to prepare long-range development schemes, and this framework then allows for subsequent project-by-project examination of specific mine issues. It concludes by noting that the UNFC 2009 is aligned and reinforcing of more widely applied industry-standard reporting templates (which could include CRIRSCO).

Key Messages

This presentation has two key messages. Firstly, we have seen a profound shift in the mining industry starting about 1995 regarding what constitutes sustainable mining outcomes, in which mining activities are complementary to and mutually reinforcing of broader development outcomes. This presentation highlights the global shift in location and demand for sustainable mining operations, and while pertaining to terrestrial mining, the broad drivers for sustainable mining are more universal to mineral resource production and thus serve to facilitate a consideration of similar DSM related issues. Secondly, a message of the presentation is that financiers, investors and resource managers alike are challenged to operate beyond strict regulatory contractual compliance (that is full contractual and regulatory compliance on environmental & social issues), by ensuring socio-economic performance of mining operations. And so, to achieve this outcome, a resource classification system is needed that explicitly tracks and facilitates reporting on environmental & social performance. As a broad statement, strict regulatory contractual compliance of mining operations with environmental & social safeguards is necessary but no longer sufficient to attract the financial resources necessary to undertake major mining operations. In a highly constrained global capital market for financing, the set of premier mining projects having strong alignment

with broader development goals; and are underpinned by strong measures of inclusive growth at the community level.

Global Trends

The global mining industry today is a reflection of profound changes in the balance of supply and demand of mineral commodities,

with drivers that began just after the turn of the century. The world has experienced increased cyclic and volatile mineral commodity prices, and that volatility has dictated the pattern of new mineral supply. Certainly, high commodity prices have stimulated increased exploration and production, but the industry has also been negatively impacted by an increase in production costs for major commodity groups (ferrous and non-ferrous metals and energy minerals).

Moreover, despite improved exploration and production efficiency putting new mineral supplies into global markets (Figure 1), an expanding global population using the services of minerals for growth continues to draw-down resource inventories - the stock of minerals discovered and inventoried over past decades. The following graphs highlight the distribution of exploration expenditures and corresponding major discoveries in the western world – demonstrating that global growth continues to consume the stock of mineral resources that were built up from start 1900-1985.

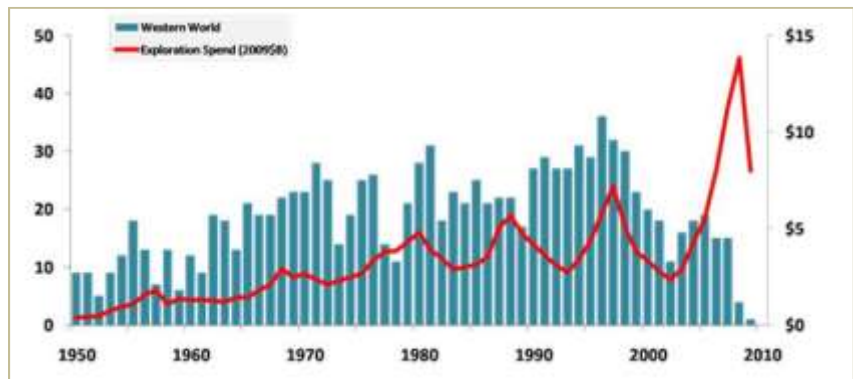


Figure 1: The commodity super-cycle (2000 – 2013) led to doubling of metallic prices with an attendant strong increase in exploration and production of key commodities. Source: McKinsey on Sustainability & Resource Productivity.

For an industry responding to highly cyclical prices, the challenges facing new mine development are many and complex. The foremost constraint for mine financing is access to capital for new mine development. Global capital markets remain shallow following the financial crisis of 2008 and the competition for financing new “greenfield” mining development is intense. As I will discuss below, there is a selectivity being applied to projects to identify those meeting not only the necessary regulatory and contractual compliance, but also the need for sufficient socio-environmental performance. And the intense scrutiny of environmental & social factors has become a proxy for measuring the social license to operate; which increasingly must be earned locally, sustained through continuous inclusive growth processes, and lead to a commensurate sharing of benefits across mine-impacted stakeholders. The financial risk of a proposed mine development not achieving and sustaining the social license to operate, all but eliminates that resource from the pool of new mine candidates.

A second material constraint is limited access to mineral resource lands. If one plotted mineral resource lands globally, that is those lands that were geologically perspective and available to investors in the period prior to 1980, the land area available for further terrestrial exploration and development is decreasing today. Much of this constraint comes from infrastructure gaps that could support new mining operations as the industry moves into the core of continents. Furthermore, the number of discoveries by region demonstrates that new discoveries are increasingly in non-western locations (Figure 2). Access to prospective resource lands has been increasingly limited by coincident non-

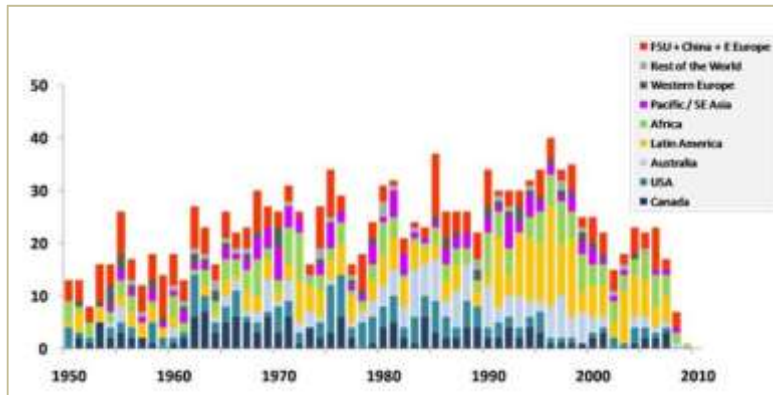


Figure 2: Number of discoveries by Region, Major deposits found in the World: 1950-2009.

geological dimension. Complex metallurgy in which the processing of an ore yields deleterious by-products restricts the commercial viability of certain deposit types, should moratoriums on the production of a particular metal and/or undue environmental impacts cannot be adequately mitigated.

Limitations in Mine Financing



Figure 3: Source: McKinsey on Sustainability & Resource Productivity

financing is now much smaller, the individual capital demand for each new mine is much larger, and the total number of new mining operations is expected to decrease. And moreover, as discussed below, associated infrastructure cost is now estimated to constitute about 60% of the total mine investment (investments into power, roads, ports, and rail to connect new resource areas to global markets). The end result is a material capital constraint to financing new mining operations, at a time when continued loss-of-access to prospective resource lands is unbaiting.

A New Global Trend: A Shift to Resource-Rich Nations

The geographic source of mineral supply is also shifting dramatically. The International Monetary Fund and World Bank Group track the nations in which resource production is occurring. This map from 2013 depicts resource-rich and resource-dependent nations (as a percentage of GDP and export earnings),

complementary land uses; resulting in “no go” areas and/or prospects for which new-mine permitting processes would be unduly lengthy, costly and complex. The need for improved spatial planning and consideration of complementary land-uses, is now everywhere, with the question being posed as to how the mine development can be reinforcing of broader development objectives. And oddly enough, integrated spatial planning now has a

And so the gap between investment needs and available mine financing can be seen in graph on the right, which was prepared by McKinsey Group last year (Figure 3). It estimates that by the year 2030, approximately \$17 trillion new investment will be demanded for new mining, oil and gas projects in the lower income countries. For the mining portion of that investment need, the capital expenditure needed to develop each new mine has increased from approximately \$500 million in the year 2000 to nearly \$3 billion today (as estimated for the bulk commodity iron ore). While the pool of available mine

highlighting a strong shift in mineral supply from developed OECD nations increasingly into developing nations. As recently as 2005 there were fewer than 40 countries classified as being resource-rich or resource-dependent, a statistic that had risen to over 50 countries by 2012. By 2018, depending on the long run trend of commodity prices, it is forecast that there may be more than 55 developing countries classified as resource-rich or resource-dependent. Importantly, as recently as 1980 many of these nations did not have major mineral production nor the professional capacities to properly and effectively govern the sector. This is for any one country a major shock to its ability to manage the impacts of mining, and cumulatively across many of these countries a global concern vis-a-vis the potential for resource curse.

The trend to resource-rich and resource-dependent nations has a second important driver that is less visible, the emergence of more engaged civil society demanding inclusive decision-making processes, and effective benefit sharing mechanisms with local communities. Absent prior informed consultation, protection of vulnerable community groups, and benefit sharing mechanisms, many mining investments within emerging economies have been undercut by a weak (or obsolescing) social license to operate. Despite having commercial viability, many mines have now been closed through inattention to achieving sustainable outcomes locally.

Key Challenge to Investors, Financiers and Resource Managers -- Governance

If one was to summarize the above challenges and constraints to new mine development, it would be that investors, financiers and resource managers face the same challenge - to operate mines where governance of the sector is stronger. And, as mining shifts into low income countries, the measure of governance is weak. As such, there is growing consensus that sector governance may well be the key determinant of the extent to which new projects are economically, politically, socially and/or environmentally viable. Where governance is weak, instability and lack of predictability often prevail, leading to heightened risk and uncertainty for all (citizens, investors, government).

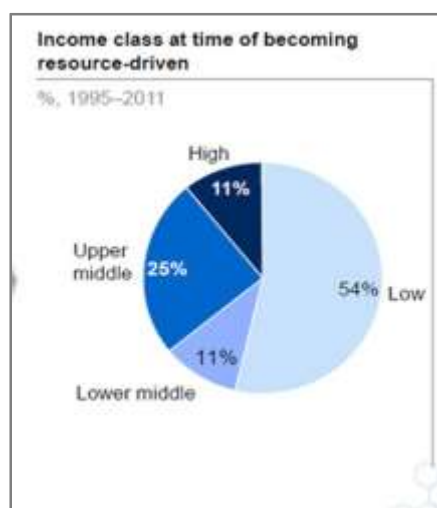


Figure 4: The trend towards increased mineral production in low governance countries. Source: McKinsey Global Institute (MGI)

What is governance? The World Bank supports interventions to strengthen mining sector governance by focusing on creating a clear set of rules, ensuring accountability by limiting discretionary powers, and enhancing prospects for predictability, stability, and prosperity for all stakeholders. Good governance mitigates mining investor risk, and the appreciation for the intertwined measure of governance and risk is increasingly being appreciated in capital markets, especially so in emerging economies. Some of the hallmarks of good governance are inclusive growth processes, informed prior consultation with the local communities, and a benefit sharing mechanism that is well understood and applied. It is commonly stated that risk and governance are “two sides of the same coin” within resource-rich and resource-dependent countries. For those countries - low average incomes, weak regulatory regimes and limited monitoring and reporting capacity translate to increased investor risk.

This shift to low governance countries can be seen in Figure 4, taken from McKinsey Global Institute showing that the resource-rich driven countries between 1995-2011 – has increased to 54% of the total contributing population of

mines. Indeed, in the 50 countries categorized by the IMF as resource-rich, more than 1.5 billion people live on less than \$2 per day. Far too often, the presence of an extractives sector does not translate into widespread wealth and prosperity and this only serves to undercut continued mine development.

What Do Future Resource-Rich Nations Look Like?

It is clear that the continued trend towards emerging economies will pull in island states having low gross domestic product and low Human Development Indexes (a holistic measure of the well-being of individuals and their advancement towards improved standards of living). Of the 7 world's lowest GDPs, 6 are Pacific Island Countries: FSM, Kiribati, Marshall Islands, Palau, Tonga and Tuvalu. And so, for these states there is a need to be sure that resource extraction is accompanied by strong benefits sharing and a social license to operate.

Challenges: Governance and Investment Risk are inseparably intertwined

A decade ago, the World Bank would conduct a survey of “what investors look for” when making an investment decision. While it has not been updated recently, there has been a remarkable consistency of responses over the years, and this can be quite informative. The first factor is geological potential - is there resource there of sufficient quantity and quality for a commercial operation? Thereafter, considerations relate to the fiscal regime, foreign exchange control mechanisms, security of tenure, clear roles and responsibilities at different levels of government, and an inclusive process for communities including formal benefits sharing mechanisms (Figure 5). Interestingly beyond the geological endowment measure, all other criteria are under control of the host government, and thus the overall governance of the sector in that country will determine the attractiveness to investors.

<u><i>What mining companies need</i></u>	
<i>Investment Decision Criteria</i>	<i>Instrument Available to the Government</i>
Geological Potential / Resource Certainty	Geological Survey providing basic geo-data and undertaking mineral resource assessment
Profitability of Potential operations – competitive fiscal regime, realistic foreign exchange controls	Investment Laws
Security of Tenure – clear, non-discretionary mining rights and title for permitting	Mining Cadastre
Consistency of Mineral Policy – clarity of roles & responsibility, stability of exploration / exploitation terms and conditions, mineral ownership (resource nationalism), social licence to operate	Mineral Policy Tax Legislation Community support
Stability of Legislation –predictable environmental / social obligations, non-discretionary transparent regulatory environment	Clear, consistent mining, environmental / social, and tax regulations
Availability of Infrastructure	Public Private Partnerships
Modified after (a) Transitional Islamic State of Afghanistan: Mining as a Source of Growth, Report No. 28231-AF, The World Bank 2004; and (b) James Otto – A Global Survey of Mineral Investment Preferences, Mineral Investment Conditions in Selected Countries of the Asia Pacific Region (United Nations ESCAP 1992).	

Figure 5: Source: “Mining - Prospecting, Exploration and Feasibility including Ancillary Infrastructure.” World Bank. Michael Stanley



Challenges: Sector Governance / Investment Risk: Sustainability Frameworks are Integrators

Figure 6 was created in the World Bank to illustrate the many factors that make up good governance, and it serves to illustrate the transition from regulatory compliance measures for a mine (largely on the left side) toward sustainable development outcomes (largely on the right side).

Figure 6: The many dimensions that constitute good mining sector governance

Challenge: Major Deficiencies Regulatory & Safeguard Compliance Monitoring

All mine development is guided by a series of widely shared and applied safeguard policies. The World Bank Safeguard Policies are designed to guide World Bank investment operations, but more broadly many governments have adopted and modified key safeguard instruments (i.e. resettlement action plans) for domestic use. Additionally, the IFC Environmental & Social Performance Standards represent a second set of mutually reinforcing norms applied at the project level, widely used by companies to ensure inclusive growth processes and sustainable outcomes of specific investments. While the performance standards are relevant to IFC investments, they too have become more widely cited and applied in many other investments (for which the IFC is not involved). Collectively these instruments clarify roles & responsibilities, provide guidance on how to identify risks and impacts, and help to avoid, mitigate or manage these risks.

The Equator Principles are a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. The Equator Principles, reinforced by the above WB Safeguard Policies and IFC Performance Standards, have greatly focused attention onto social/community standards including robust consultation with locally affected communities within the Project Finance market.

Key challenges going forward – Use of the UNFC 2009 Resource Classification System

In consideration of the above, and again appreciating that good governance and investment risk are two sides of the same coin, it has widely been debated as to an appropriate framework that investors, companies and resource planners alike could use to assess the environmental & social elements relating to a proposed mining development. Let me walk you through a brief case study that the World Bank has been supporting in India, to test an appropriate resource classification framework. While India is well endowed with natural resources, in particular coal, iron ore, and bauxite, ongoing mining sector development has become contentious in many states. Across India, mining-driven conflict is emerging around social and environmental factors that were long neglected by regulatory agencies, not captured

under sustainable mine planning and at odds with broader development plans across states. By 2013, companies and resource planners alike were at a loss as to identify those resource assets that could be put into productive use, in consideration of complementary and competing land-uses. There was no framework that could make an accounting of the environmental / social hot spots and identify practical remedies.

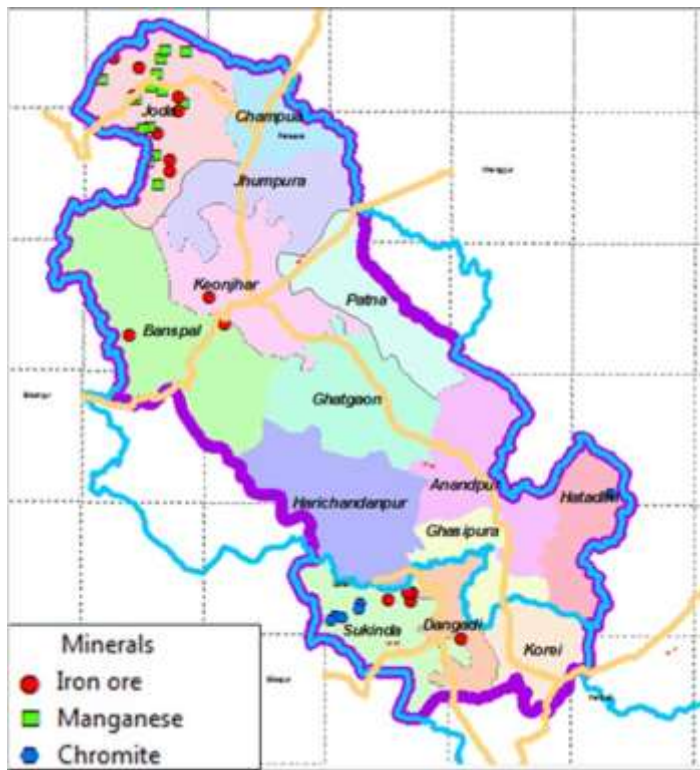


Figure 7: The pilot of the UNFC 2009 resource classification system within the Keonjhar District of Odisha State, India

Against this backdrop and absent adequate regulatory oversight, the Indian judiciary took actions to reduce mining operations through widely indiscriminately applied moratoriums. In response, the Government of India initiated a number of actions to modernize the mining sector through improved regulations and large-scale changes in the administrative structures; with the objective to develop the sector in the broader context of sustainable development. Core to these actions were to make an accounting of the economic, environmental and social impacts of mining using an inclusive, integrated planning methodology. Given the complexities of mining development in India, the World Bank mobilized a program of assistance to assess mineral resource potential using iron ore as a demonstration project. Odisha State, a major producer of many mineral commodities, was selected for this demonstration using the Keonjhar District, a mining-impacted area having

environmental and social conflicts that had all but immobilized continued mining development (Figure 7).

At the center of the Odisha pilot was to assess the viability of the United Nations Framework for Classifications (UNFC 2009), to demonstrate that it would improve understanding the underlying social and environmental landscape, prioritizing resource development within an integrated spatial planning framework. The UNFC 2009 classification system was chosen as it considers not only (a) the geological potential, and (b) the technical and economic viability of the resource (project); but also (c) the environmental and social dimensions that must align to achieve good practice mining. Moreover, the pilot was designed to assess application not just for one mine but for a resource-rich production across the Kheonjhar area. And, the UNFC 2009 resource-classification system was also selected because of its' inclusiveness of environmental and social dimensions, which were reinforcing of the geological and economic measures.

In the course of implementing the pilot, it was appreciated that the strength of the UNFC 2009 classification framework was that it was process-based, by allowing for identification of deficiencies (i.e. a particular social or environmental concern) and the measures to correct the deficiency using integrated spatial planning. The framework lent itself long-range resource planning, while also having

great utility to individual mining projects within the planning area to convey their consideration of geological, economic, and “socio-economic” (environmental & social) factors. If there were two deposits of the same quantity and quality, but having different socio-economic landscapes, then Indian planners would be able to identify which resource would more likely offer sustainable mining outcomes.

Early indications of the pilot suggest that the UNFC 2009 is a superior process for resource classification and resource planning. The environmental /social challenges that impede mineral resource development could be more accurately identified and solutions sought to lead to more sustainable outcomes. Application within the state-owned mining enterprise Odisha Mining Corporation is ongoing to select preferred resource lands whose development would be more aligned with broader development objectives. But early indications suggest that it is preferable to begin with UNFC 2009 as a broad resource planning tool (for integrated spatial planning), while retaining the flexibility to migrate project-specific information into industry-standard reporting templates (which could include CRIRSCO).

Summary of Key Messages

Mining sector governance and investment risk are intertwined – good governance lessens risks of poor mining outcomes and thus governance is a useful measure for resource planners, financiers / companies, and civil society alike. Global mining trends underscore the migration of mining into weaker governance, emerging economies; and a concurrent shift towards financiers, investors and resource planners moving beyond necessary regulatory compliance into sufficient performance-based evaluation systems. Such holistic development perspectives are essential given limited capital availability and the increased application of performance standards and principles for sustainable development. These trends are thought provoking when considering DSM more broadly.

To this end, investors and resource planners have need of a resource classification framework that explicitly considers not only the geological potential; and the technical and economic viability of the project; but also the environmental and social issues that must align to allow sustainable mining outcomes. A pilot application of the UNFC 2009 Resource Classification System applied to iron ore mining in Odisha State India underscores how it can be inclusive of environmental and social dimensions, in addition to the geological and economic measures. The pilot underscores that the 2009 UNFC is a process that can be used by resource planners to prepare long-range development schemes that then allows for a project-by-project examination of specific mine issues that would then be reported out using industry-standard reporting templates.

Summary of Discussions

Discussions

One expert remarked that the UNFC had strived early on in the development to account for social and environmental impact in the classification system. However, they were a bit weak at the moment, and a working group within the EGRC was actively endeavoring to enhance and expand the guidance on social and environmental issues. Mr. Stanley said that the UNFC was a great starting point.

A participant asked Mr. Stanley to elaborate on (i) implications of social licensing, (ii) sustainable development in context with the deep seabed mining regime to which Mr. Stanley said that in his opinion, the social license to operate could be brought into deep seabed mining. The sustainable development part was most immediately probably going to be a part, be an effective benefit-sharing

scheme. He said that for a small island state, that is undertaking deep seabed mining, there would need to be clarity on how the revenue was to be used. He continued that nations that have done very well at mining (i.e. Australia and Canada) have all gone through a transformation where the economy becomes more diverse.

Another expert advised that there was a time in the history of the law of the sea (LOS) negotiation when it was thought that developed countries would try to push policies on developing countries. So there is one reason why we make decisions by consensus so that everyone can have a say including the NGO.

The ISA Secretary-General explained that the Authority was not engaged in which country gets a license. There was a royalty and there was a payment made by the contractor. He said the Authority takes that royalty or payment and sets up a system to distribute it. He said that during the time of the conference (LOS), the idea was that there would be land-based producing states that would suffer as a result of deep seabed mining. Contracts that were given out by the Authority had nothing to do with the size of the country. They could be small island states or states the size of China or India. The Secretary-General said he was not sure what the social benefit was but that he thought it had nothing to do with the island state. He said the state would have to show that the entity that was going to undertake the activities was qualified in terms of its technical and financial capabilities.

A participant cited the a development aid programme in Papua New Guinea as an example, saying that the country that was heavily-dependent upon resources and there were analogues with the situation in the ISA's considerations. Mr. Stanley said that he was trying to bring this transparency initiative, which was a terrific analog to what was being done at the workshop because participants needed to look at definitions of payment type, definitions of materiality, in the name of the system of the government framework.

Secretary-General Odunton pointed out that the ISA was established to administer the global commons which were territories including those which have mineral resources that are beyond the jurisdiction of any State. The ISA, through its membership and its organs, are responsible for the rules, regulations and procedures governing the prospecting, exploration and exploitation of these mineral resources. He emphasized that the ISA does not get into individual States and their practices. In our case at the workshop, he said the issue was the fact that the resources being reported to the ISA was done on an annual basis. Among the work that has to be done in terms of the reporting was the provision of information on the resources in Areas to which members states are allowed to conduct these activities. He said there was no part of the work of the ISA that required it to look at the details of the governments of any individual states. Mr. Stanley said that he agreed with what was being said but that these mining companies are in a different space because they have to go to the same global markets as the terrestrial mining companies for financing.

The Secretary-General commented that the resources in the deep seabed are reported to ISA and the biggest problem was that various contractors were not reporting on these resources in a standardized format. He was trying to find a way to utilize as much as possible, the practices of land-based mining to get better reporting and more information on the resources of the global commons. He continued that he wanted to keep the framework intact and that if he could take the practices of land-based mining and make the necessary adjustments for these resources, he would be quite pleased as he has a little

over a year to be able to get an extension to exploration contracts that the ISA is not happy with what is being reported to the organization. He said the governments and everybody who has participated and who gets an exploration contract should provide the ISA some information. He continued that he was trying to get to a point of getting everybody to agree to some standards and draft a good template as the beginning of a process to get there. He said he hoped such a process of taking an existing template and modifying it to allow it to be used for the reporting of mineral resources of the global commons. He said although he recognized the work of the individual nation states, he did not have the power to go to that extent.

CHAPTER 4: Purpose, design and content of scoping, pre-feasibility and feasibility studies

Caitlyn L. Antrim, director, Centre for Leadership and Global diplomacy, Virginia, USA

Dr. Antrim addressed the issues of mining in a commercial environment. She identified two broad categories: i) technical reports, and ii) integrated economic assessments. An integrated economic assessment involves factors such as geology and resources of the property, infrastructure, management and labor, environmental and permitting requirements and overall project economics. Integrated studies include the technical and economic scoping study on the potential viability of mineral resources at the introductory level, the pre-feasibility study to assess the likelihood of a viable operation, a key decision-making full feasibility study and an engineering study, using the best design approach.

Dr. Antrim stated that the scoping and feasibility studies are economic assessments and serve both design and decision functions. These studies may become public documents to inform investors and regulators and be governed by national reporting laws and international codes. The same rules would apply to a seabed miner wanting to be a part of the mining industry

Introduction

I want to address the issue of reports and I hope that this addresses a lot of what you want to hear in terms of identifying the different types of reports that are expected from anyone who wants to move forward with mining in a commercial environment.

Mining studies and Assessments

From Agricola on, we have 450 years of addressing mineral issues. This year is the 35th anniversary of the UNCLOS application of a sea bed minerals scoping study,, the first public and open-source scoping study that the examined sub-levels of the integrated assessment of a mining operation. We have two broad categories of studies: i) technical reports – those that look at one element, say, the nodule collector; and ii) integrated economic assessments – (that is not an formal term) that integrate all the factors involved in development and does it through an economic lens). It puts everything together into a measure of internal rate of return. There are many other measures, but IROR is a key measure used to compare how one project stacks up against other development opportunities.

Factors in Economic Studies

These are the basic factors that go into doing an integrated economic assessment:

- i. Information about the property; where is it, what are its dimensions.
- ii. The geology and resources – what are the minerals there that we want to develop and what are their situations in that region? How would we recover them?
- iii. What is the mining approach?
- iv. What is our processing approach for the ores?
- v. What is the infrastructure you need? If you have an ocean mine you have to have ports to receive the minerals.

- vi. Management and labor – are you going to hire people, how are you going to house them? What are the labour requirements and legal issues under both international and national law?
- vii. What are the products you are going to produce? What are the markets? What are you likely to make in sales?
- viii. What are the environmental and permitting requirements;
- ix. Financial issues – how much do you have to pay both to the national government and the international community;
- x. What are the development costs and schedule – schedules are very important. The “time value of money” is why we look at the internal rate of return rather than just simple payback period or rate of return;
- xi. How do political and social conditions work into the decision;
- xii. Overall project economics. These are the measures that result when you try to bring all of this together to see what the mining opportunity looks like.

Integrated Studies

There are four levels of study:

1. The Scoping study - which is the very introductory level. It uses technical reports and industry studies as well as general assumptions about mineral resources. It is more than a back-of-the-envelope calculation but it is limited in the accuracy of the information that it can draw upon. It won't necessarily draw on (in seabed mining cases) detailed assessments of abundance and grade in an area. It is just a general number that represents what resources area has, based on the general information. It could begin within the ISA model of mineral distribution in the Clarion Clipperton Zone. It does provide an integrated economic assessment and reports on internal rate of return. It is used to decide whether to move forward with more detailed studies and assessments and in what direction to move. It helps you choose between alternatives - where to put your next quantum of development capital, where you need to put your time and what expertise you need to bring in. It is one of your first opportunities for course corrections on your way to a real development program.
2. The Pre-Feasibility study is where assessment begins to get really serious. It evaluates a workable design with substantial resource and environmental data and it contrasts design alternatives. Pre-feasibility studies uses numbers from seabed exploration (your sampling results) and you need to decide how often you need to sample to be able to interpolate information. You need geographical and bathymetric information to know what your likely mineable area is but you are still working in some degree of generality. You need to have a definition of technology. It may not be your final technology, it may not be your best technology, but it is technology that you are confident will work.

Pre-feasibility studies are an opportunity to compare alternative approaches. Perhaps an alternative processing route doesn't give you quite as much recovery of one particular metal but improves recovery of another; I am thinking some of the metallurgical processes for nickel laterites that might be applied to nodules, some of which get fairly low recovery of cobalt while other designs get a higher recovery.

Currently the newer designs could take more time and effort to be running at their best. This is a time to choose among your technological directions if you are examining one technology but are still looking for better alternatives; a pre-feasibility study gives you a cautious approach that is based on sound cost-estimation practices.

3. The full Feasibility Study evaluates a near final design with greater resources and environmental data available leading to greater accuracy of estimates. You are settling down on a particular design and asking “if we do this, should we move ahead?” You are still getting the economic assessment, you are getting a lot more detail and you are using much more finely-grained results from the mineral resource that you are going to use more closely in developing a model. You can lay out a mine plan and decide how you want to move your collector through the region to be your mine area for the first years of operation.
4. The final type of study is an engineering design study – this is a detailed study of the final design, where you take the results from the feasibility study and how you plan to implement it and figures out how much the whole project is really going to cost - it involves talking to vendors, getting specific numbers for costs, using the best design approach you have, and adapting your detailed plan for the system, for construction and for initial operations.

Scoping studies/Preliminary Economic Assessments

These are order of magnitude technical and economic studies of the potential viability of Mineral Resources that includes appropriate assessments of realistically assumed “modifying factors” together with any other relevant operational factors that are necessary to demonstrate at the time of reporting that progress to a Pre-feasibility Study can be reasonably justified.

Here are a few details that provide a little more depth in defining scoping studies. This definition is available on the CRIRSCO website. It is an order of magnitude study; it is a technical and economic study on the potential viability of the mineral resources including the assessments of realistic modifying factors. If you don’t find the results of the scoping studies satisfactory you might just quit and go to another property or you might decide to modify your design and circle back around to do another scoping study based on those changes. One of the principal techniques for determining costs at this stage is a factored approach in which you identify the major pieces of equipment and then use common engineering factors to work that up into an assessment for an installed and integrated system. If you know that you are going to have a roasting oven in the process then you take the cost of that unit and apply the appropriate factors to work up to estimate the cost of it installed with all its related support systems or you may have a similar, though smaller or larger system you can use to estimate costs through common scaling factors. That gives you a range of accuracy that in the mining area seems to average around 45% up or down. The scoping study is to give you a general sense of detailed response. It assumes ore values; it does not require you to have completed all your data collection, just enough to have a reasonably confident estimate of the grade, abundance and extent of the ore. It takes the best information you have and applies it as an input into your design assumptions and your economic calculations. It is not used for reporting reserves or resources in large part because it is not based on a sufficient quantity of accurate data. You cannot determine reserves or resources just by scoping studies. The cost of doing a scoping study (this is a rule of thumb) should be about 0.1% to 0.3% of the estimated capital cost of the project.

Pre-Feasibility study

This is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable

assumptions on the “Modifying Factors” and the evaluation of any other relevant factors which are sufficient for a Competent Person, acting reasonably, to determine if all or part of the Mineral Resource may be converted to a Mineral Reserve at the time of reporting.

A pre-feasibility study is where you start getting more definitive estimates. It is a tool for conducting a comprehensive study of options. You can go through and say “what happens if the metal price is 25% above or 25% below the original estimate?”. “What happens if we use a high pressure acid leach instead of an atmospheric pressure acid leach processing system?”. “What happens if we use two smaller mine ships instead of one large mine ship.?” You get a chance to go through and do a sensitivity analysis and make choices based on the technological factors and other assumptions. It is sufficiently accurate to be used to estimate a mineral resource (but not to estimate mineral reserves). The accuracy of the cost estimates are in the range of 30% plus or minus. The rough rule of thumb on the cost of conducting a Pre-Feasibility Study is 0.2% to 0.8% of the capital expense. Since we are talking of possibly a \$3B integrated operation, we are not talking small change here – the estimate is just to give you a rule of thumb of how much work you have to put in to get to this stage. This is one of the essential decision points in the project. If you provide the Authority with information about the extent of resources such a study could demonstrate that you have determined that an operation can be profitable. That is the goal – to determine whether there is a high likelihood of a viable operation.

Feasibility Study

A Feasibility Study is a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analyses that are necessary to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a developer, investor or financial institution to proceed with, or finance, the development of the project.

The feasibility study is the key “go” or “no-go” decisions. It is based on much more precise estimates of costs that go through a specific design and cost it out. It is based on much more detailed sampling of the seabed and developing a model so you know the resource and with much higher confidence. In some cases it is called a bankable feasibility study. It is not an official term but it gives you a sense of what this can be used for. You can go to your lenders with this and have a high degree of confidence that it is reasonably accurate. In this case the accuracy is generally about 15% up or down. It is more expensive to conduct than a pre-feasibility study; running about 0.5% to 1.5% of the capital expense but when you have done this you are ready to start making agreements for the funding to commence development and construction and you are planning to make a return. The Feasibility Study is the third of the principal three studies leading to a decision to develop. The final engineering design study, which follows the Feasibility Study provides greater detail to guide development and is generally conducted after a decision to move forward is made.

Case study

I want to take you through a case study of a scoping study. This is one that was done for the National Oceanic and Atmospheric Administration [NOAA] to help address issues and policies for seabed mining in the late 1970s. This became a tool for LOS negotiators to develop the financial terms of contracts and was used to find a balance between the views of the western industrialized countries and the African States to find a compromise that would not be overly burdensome to developers but would also provide a significant share of revenue. It was developed initially to evaluate design changes - regulatory

constraints of seabed mining operation. It was done through factored estimation approach and by taking comparable systems from existing operations, scaling them up and putting them into the models. It was a basic estimate based on data and assumptions obtained from developers and from independent research. Its estimates could be considerably high or low so alternatives were handled by doing sensitivity analysis on its assumptions. It used the resource assessment provided by industries. In this case it used about 1.3% nickel, 1.1% copper, 0.24% cobalt, and did not recover manganese.

Case study, Part 2 – 10 Sectors of the Model

The model of technology and costs broke the design down into 10 sectors:

- i) Preparatory cost – the R&D that was done and the continuing exploration programme required to get those numbers to move forward to a pre-feasibility study.
- ii) The mining system.
- iii) The marine transport system to move from the mine site to shore processing (which turned out to be much more expensive than had been anticipated). Then when on shore the minerals had to be transported over land to the processing plant and then, at a later point, to take the processing waste out of the processing plant to a waste disposal site. These require both:
- iv) Ore discharge terminal.
- v) On-shore transport.
- vi) The processing plant, which is the major cost item in this model, ran close to 50% of the total cost. It is a big, complicated project in itself. It has its own infrastructure requirement so cost estimation takes a lot of work. Until and unless a seabed mineral processing industry is developed to purchase and process ore, the seabed mining project will be a mineral processing project as well.
- vii) Waste disposal – after metals are recovered there will be between one million and three million tons per year of waste for which there is no current use for so there will be costs of disposing of it in a dedicated landfill. The processing plant may not be near a suitable disposal site so waste will have to be transported, probably by slurry pipeline.
- viii) There will be costs for marine support activities for operations 1,000 or more miles from shore that are able to take supplies out and rotate replacement crews that were estimated to be in the millions of dollars.
- ix) General Administration - this is not limited to the physical plant; there is a corporate office monitoring operations, managing sales, overseeing operations and providing corporate leadership and many other tasks that add to overall expenses.
- x) There are continuing preparations for upcoming activities, including a continuing exploration program, assessments of improvements to designs, and replacement of capital components.

Case Study, Part 3

The next step of the study was to evaluate and improve upon the initial model. This was done two ways. The first was to bring in industry and other experts for a technical review workshop. Based on expert comments, improvements were made in the system components and, particularly, in the development schedule: how many years more exploration and development are needed before you can begin constructing your plan. How long will your construction take (between three and five years were used

in the model) and how much will you spend in each of those years. How long will you operate? How long will it take you to ramp up a full operation? How effective will you be? Examples were drawn from land-based processing for a lot of these questions. That information and other guidance provided improved baseline numbers to be incorporated into the model. The second step was to assess the impact of changes in assumptions. A series of iterations were made that asked, for example, what if we are wrong on commodity price. What if we underestimated our capital costs by 50%? What if we under- or over- estimated our operating expenses. We looked at variations in prices for individual metals. We looked through a whole range of variables to identify the issues and assumptions to which the model was most sensitive and then put more work into those most sensitive assumptions. The result was the study that came out in 1978 and was presented to delegates and observers at the UN Conference on the Law of the Sea and then used as an analytic tool in the assessment of proposals regarding the financial terms of contracts in 1979. By using a group of six scenarios, the model, which was functionally equivalent to a scoping study, covered the issues that appealed to the different interest groups in the negotiations.

Increasing Study Details

The model was revised again in 1984 with much greater detail and, except in regard to the grade and abundance of the nodule resource where the model still relied on assumed values of the minerals, it approached being a full pre-feasibility study. The National Oceanic and Atmospheric Administration contracted an analysis of a nodule processing plant that was used to refine the model's estimates of costs in the processing sector. It took about 8 years to progress from the initial graduate research to the production of the final enhanced model.

Closing Points

The closing points I want to make are:

Economic measures are used to bring all the system components together. In many ways the social issues in seabed mining are brought in as economic terms, through the costs of revenue sharing, training programs, and technology transfer as well as the costs of meeting environmental standards and requirements. There are a number of aspects to social impacts but regarding the basic decision as to whether seabed mining will take place, they are measured in terms of whether social and environmental costs will change the economic viability of the project. This incorporation of social costs in the economic assessment is particularly valuable for regime design and development.

Scoping and feasibility studies serve to aid the design process – are we doing the right thing? Do we want to go this way or another? The decision function – are we going to go ahead? — is the single most important for all parties. If you can invest \$10M in doing studies and it says you are only going to get 9% return on investment any time in the feasible future you probably are going to look for a different place to put your money. If estimates project a return of 20%-25% then investment would probably proceed. When you do these studies you need to examine what happens if you are wrong on one of the assumptions and look at alternative outcomes. It is easy in these studies to incorporate one's own biases, so making assumptions explicit in a study or model makes it possible to determine whether a change in a particular assumption can change decisions.

If you go to the internet and start searching for sample pre-feasibility studies for mineral development you will turn up many examples. There is a lot of guidance if you want to see what actually is done for a scoping, pre-feasibility or feasibility study and what information from such studies becomes available to

the public. To a degree that these are used to justify investments of hundreds of millions, even billions, of dollars, the information is likely to be publicly accessible. These studies will be required by investors and lenders, by national securities regulators and by the ISA in the approval process for exploitation contracts.

Summary of Discussions

A participant commented that, “the return of 15% is an adequate return for business”, and said that according to him this is a very risky business and no one in the industry would support that 15%. Dr. Antrim replied that with the different levels of certainty and study 15% on a detailed feasibility study is more attractive than 15% on a pre-feasibility study or scoping study because those range of errors make you nervous.

CHAPTER 5: United Nations Framework Classification (UNFC)- how it works in practice and its application to seabed mineral resources

Charlotte Griffiths, Senior Economic Affairs Officer, UNFC and
Resource Classification

Ms. Griffiths introduced the UNFC. It is the UN framework classification for fossil energy and mineral resources. It's a global generic, principle based system, based on three fundamental criteria, represented by three axes. Ms. Griffiths said that the UNFC has a powerful numerical codification system. The fundamental principle of the UNFC is that resources are classified as a series of projects with differentiation on each of the three axes of the system; the social and economic axis, the project feasibility and field status axis and the geological knowledge axis. She said that the three criteria or axes are the most real and are therefore found in most other classification systems either as implicit attributes or as direct criteria. Ms. Griffiths advised that because the UNFC is direct on all three, it provides the framework through which other classification systems can be compared and harmonized, thus making the UNFC an extremely powerful tool. UNFC and the CRIRSCO Template are directly aligned, with the Template providing the solid minerals specifications for the UNFC.

The UNFC is managed by the Economic Commission for Europe (UNECE) and has a global mandate because of the UN Economic and Social Council (ECOSOC) decision adopted in 2004. She said that the work on energy and on resource classification is one of the flagship activities of UNECE. UNECE's work focuses on the development of regulations and standards, best practice guidance, and conventions. The Commission provides a neutral platform for stakeholders to work through an open and transparent process.

She also said the UN had developed the UNFC because of a demonstrated need for a common system for solid minerals and mineral commodities. She noted that the work on this resource management tool started in 1992 and that it had been developed in a transparent and inclusive manner, resulting in a solid and robust volunteer system that was approved in 2009, and that became operational in 2013.

First of all I would like to thank our hosts for an excellent dinner last night. I would also like to thank both the International Seabed Authority for the kind invitation to present on the UNFC and the Ministry of Earth Sciences of the Government of India for kindly hosting the workshop. As advised by David McDonald, who is the Chairman of the Expert Group on Resource Classification, we decided that it would make more sense and provide you with greater clarity if we combined our presentations.

Contents

The presentations will cover the following:

- i. an introduction to the Economic Commission for Europe and why the UN is involved in resource classification;
- ii. what the UNFC is and how it works;
- iii. the UNFC specifications;
- iv. an overview of the bridging documents;

v. summary and important observations.

First of all, I would like to underline that when we talk about the UNFC that implicitly means the CRIRSCO Template as well. The CRIRSCO Template is part of the UNFC as it provides the commodity specific specifications for solid minerals. We cannot talk about the UNFC without talking about the CRIRSCO Template, the two are part of one package. I need to emphasize that it is not a question of either or – the two are aligned. UNFC, which is a powerful resource management tool, has been developed over a long period of time through an inclusive and transparent process that has taken over twenty years involving all the relevant stakeholders. I would like to emphasize that UNFC is a solid, powerful and robust system. I understand a resource classification system is being sought for seabed minerals. UNFC with its alignment to the CRIRSCO Template offers you an option. There is no need for you to duplicate the efforts that have already been done by creating your own system.

I would now like to briefly introduce the Economic Commission for Europe which I am sure many of you may not have heard about, and then I will explain why the UN is involved in resource classification, the global mandate under which the UNFC has been developed and a bit about the history and the development of the UNFC.

Introduction

The UN splits the world into five regions. I work for the Economic Commission for Europe [UNECE] which is one of the larger regional commissions. ESCAP in Bangkok looks after Asia/Pacific. UNECE shares the Central Asian member states with ESCAP. ESCWA is based in Beirut and looks after Western Asia. ECA is the Economic Commission for Africa based in Addis Ababa. Finally, ECLAC which looks after Latin America and the Caribbean, is based in Santiago.

The UN covers the world through these five Regional Commissions.



Figure 1: UN Regions



The UNECE, which is where I work, has fifty-six member states. UNECE encompasses all of Europe – Eastern, Western, and Central Europe – the CIS, Central Asia, USA and Canada.

Colleagues from the USA and Canada are always interested to see the UN includes them in the Commission covering Europe!

The core work of UNECE is the development of regulations, norms and standards, best practice guidance, and conventions. For more than 60 years UNECE has helped countries to come together and to cooperate, even under the most difficult circumstances during the cold war, with remarkable results in a broad range of areas that have a direct impact on people's lives. When you put a child in a safe child seat in your car, buy fruit, vegetables or a piece of meat, drive a car or truck across Europe, enjoy the fresh air or the forests, engage in improving your environment or build an energy-efficient house, you benefit from the hundreds of policy recommendations, standards, conventions that have been developed under the auspices of UNECE. Global goals and policy discussions have been turned into practical standards and guidelines that are used by countries all over the world. UNECE turns sustainable development into global public goods. Last week I participated at a meeting at which the Secretary-General of the UN, Ban Ki-Moon was present, and he described the Economic Commission for Europe as the undiscovered pearl of the UN system because we do so much important work behind the scenes that makes an impact on the daily lives of citizens around the world. And the work on resource classification is also seen as one of the UNECE flagship activities. In the area of energy more broadly, UNECE has a wide range of other activities ... for example on energy efficiency, renewable energy, on cleaner electricity production, on coal mine methane and on gas, including for example development of best practice guidelines to reduce gas leakages from pipelines.

Why the United Nations?

So why is the UN involved in resource classification? There are still some one in five people in the world that currently don't have access to electricity and more than double that number still rely on coal and biomass for heating and cooking. Sustainable development is not possible without sustainable energy. The UN places significant importance on sustainable energy development with 2014 being the start of the decade of Sustainable Energy for All. SE4ALL has three global objectives, universal access to energy, doubling the share of renewables in the global energy mix, and doubling the rates of improvement of energy efficiency – all by 2030. UNECE's work on resource classification and resource management delivers on all those three goals. You cannot improve or manage what you cannot measure.

UNECE provides a forum for governments to develop practical instruments – the conventions, regulations, norms and standards that I mentioned earlier. Importantly, UNECE provides a neutral platform for its stakeholders, it offers a stage that allows others to develop global solutions through an open and transparent process. The convening power of the United Nations is unrivaled; there is no similar forum that exists. The UN was able to offer a platform to all the different stakeholders involved in resource classification and resource management to develop the globally applicable system that we are presenting to you today. We convened governments, the financial community, the private sector, international organizations and professional societies and associations. They all came together in a neutral setting at the UN to develop the UNFC. Importantly, I need to stress that the UN Framework Classification is a voluntary system – it is not mandated by the UN. It is up to countries or companies if they want to mandate the system. The UN is not there as an enforcer and that is a very important part of the process. There are a number of companies that use the UNFC and we have received feedback that they find it a very valuable resource management tool for internal purposes. There are also a number of countries around the world that have legislated the UNFC. The UNFC of 1997 which applies to solid minerals only is the version that has been legislated – the 2009 version has only just become operational. There are though many countries around the world that are now considering adopting the UNFC of 2009 as part of their national legislation. Even though UNFC is managed and developed under the auspices of the Economic Commission for Europe, it is global in nature.

UNFC and ECOSOC



Figure 3: UNFC and ECOSOC

ECOSOC is the UN Economic and Social Council. ECOSOC adopted its Decision relating to the UNFC in 2004. The important words to note from this Decision are that ECOSOC invited the member states of the UN, International Organizations and the five UN Regional Commissions to consider taking appropriate measures for ensuring worldwide application of the framework classification. That is very much the work that the Expert Group on Resource Classification has been undertaking, ensuring global outreach and application to deliver on the ECOSOC Decision.

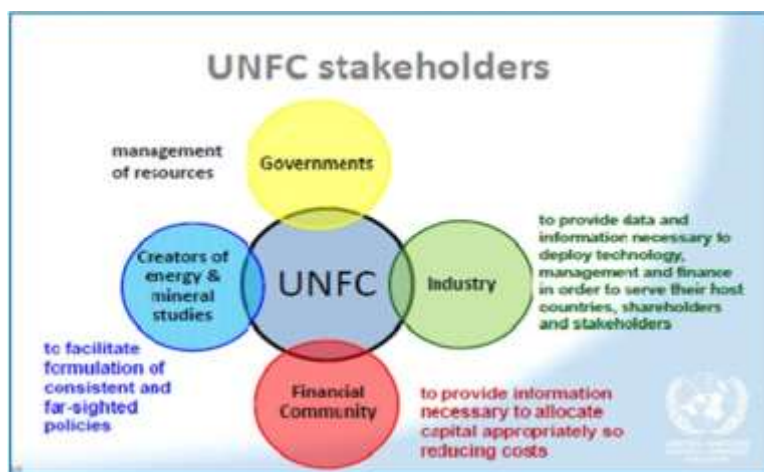
This slide shows where the Expert Group on Resource Classification actually fits in the large and complicated UN system; as I mentioned, the Economic and Social Council operates at the same level as the General Assembly, the International Court of Justice, the Security Council. The five UN regional Commissions operate under the Economic and Social Council and they are intergovernmental in nature. The Committee on Sustainable Energy reports to the Economic Commission for Europe; it is also intergovernmental in nature. The Committee is a decision making body in which governments are represented. The Expert Group is an advisory body that reports to the Committee on Sustainable Energy. The Expert Group works on consensus and would need to go to the Committee on Sustainable Energy, its parent body, if consensus cannot be achieved and a decision needs to be taken. Within the Expert Group – thanks to the excellent chairmanship of David MacDonald and his predecessors – we have been able to arrive at consensus on all but one occasion.

Expert Group on Resource Classification

I will briefly inform you about the governance of the UNFC. It is governed and developed by the Expert Group. All the key stakeholders are represented in the Expert Group; it is an inclusive body. All of you here are welcome to join and we would be very happy for you to do so and to attend the annual meetings held in Geneva in April/May. The solid minerals, uranium and petroleum are all represented in the Expert Group and now because of the importance of sustainable development, the renewables sector also. The application of UNFC to renewable energy is a priority for member States. Broadening the application of UNFC to cover both non-renewable and renewable energy projects has been greeted with a great deal of interest. The Expert Group is currently working on the documentation that would be needed to apply the UNFC to renewable energy resources. And that will make the UNFC an even more powerful tool and of greater interest to governments for their national resource management. To be able to have a tool that allows you to understand the total non-renewable and renewable resource base on a comparable basis is extremely powerful. As previously mentioned, the Expert Group cooperates extremely closely with CRIRSCO; CRIRSCO is represented on the Bureau of the Expert Group where it has a standing seat. There is an equivalent body to CRIRSCO for petroleum called the Society of Petroleum Engineers and this body has similarly developed the commodity specific specifications for application of the UNFC to petroleum. There is three-way alignment between the petroleum system, the solid mineral system and the UNFC as will be explained later. The Expert Group also collaborates extremely closely

with the International Atomic Energy Agency on uranium. The Bridging Document between the UNFC and the IAEA and Nuclear Energy Agency uranium classification system that some of you may know as the “Red Book” has recently been finalized. This means UNFC is now aligned with and fully applicable to uranium.

As I mentioned, the Expert Group works on consensus. Whilst it has taken many years to develop UNFC because of working by consensus, this process has made the system more robust. More stakeholders have been involved and deeply engaged during the development process. The Expert Group has a five year mandate which is unusual within the Economic Commission for Europe. Expert Groups normally have two year mandates. This five year mandate is in recognition of the long-term nature of classification work and also of what has been achieved to date by the Expert Group. UN Member States see value in the UNFC and the work of the Expert Group.



UNFC Stakeholders

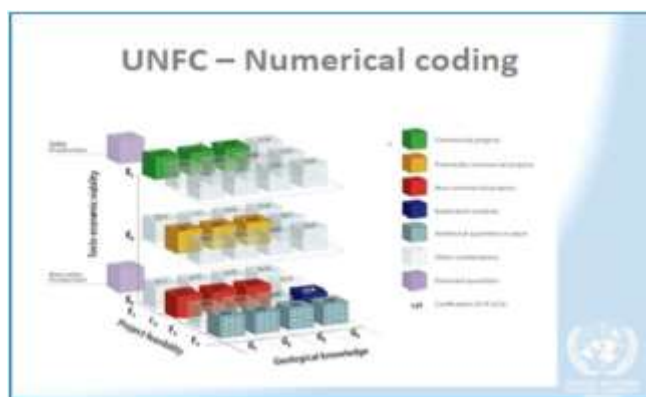
I will now focus on the UNFC stakeholders. This slide shows all the UNFC stakeholders. Governments are represented in the Expert Group. The UNFC assists Governments with management of their resources; industry is also represented and the UNFC assists to provide the data and information necessary to deploy the technology, management, and finance in order to serve industry's host countries, shareholders and

stakeholders. Industry is very well represented in the Expert Group and has been critically involved in the development of the UNFC. Also, we work with those organizations such as the International Energy Agency that develop those all-important mineral and energy studies. Formulation of consistent and far-sighted energy scenarios requires reliable and coherent data. We also work very closely with the financial community; UNFC helps to provide the information necessary to allocate capital appropriately, importantly reducing costs.

What is the UNFC?

UNFC stands for the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources. Interestingly, the only time that the word reserve is mentioned is in the title of the system. UNFC is a global generic, principle based system. It is based on three fundamental criteria. We talk about the three axes of the UNFC but the focus should be on the three criteria: economic viability (E), technical feasibility/project maturity (F), and knowledge of the geological endowment (G). Because of the way the system has been designed, UNFC has a powerful numerical codification system. UNFC enhances global communications because it overcomes all the language barriers through this numerical codification. UNFC is also applicable to both solid minerals and fluids. As I mentioned, UNFC is fully aligned with the CRIRSCO Template and the Petroleum Resource Management System and other classification systems can be aligned with UNFC, for example the uranium “Red Book” system that I referred to earlier. We are now working with the Russian Federation to develop a bridging document between the new Russian Federation petroleum classification system and UNFC. We are additionally

developing the documentation to broaden the application of UNFC to renewables and finally we are looking at the application of UNFC to injection projects, principally for the geological storage of carbon dioxide.



UNFC – Numerical Coding

In this slide you can see the numerical coding that will be explained to you in more detail shortly. The fundamental premise of the UNFC is that resources are classified as a series of projects with differentiation on each of the three axes or criteria. These three criteria in the UNFC are the most real and are therefore found in most other classification systems either as implicit attributes or as direct criteria. But because the UNFC is direct on all three, it provides the framework through which other classification systems can be compared and harmonized. This makes the UNFC an extremely powerful tool.

Why is the UNFC needed?

There is a need for a common global language for energy and mineral reserves and resources. I am sure if I was to ask each of you in the room what you understand by the word reserves there would be a variety of answers. Take the minerals and the petroleum sectors, the word “reserves” has a different meaning in both sectors. Very simplistically, in mining, there is a tonnage of rock (or ore) containing the mineral or minerals of interest that is estimated to be recoverable at the surface. This surface recovery is defined as a tonnage of ore with an average grade of mineral content. This is what the minerals sector calls “reserves”. Coal is an interesting exception, as this sector reports both “reserves” which are pre-beneficiation and “marketable reserves” which are equivalent to sales quantities. In the oil and gas sector, it is the sales quantities that constitute the reserves. An estimate of the “wellhead” quantities is made first – what is recovered at the surface – and then this is followed by on-site processing to separate the oil and gas, and remove impurities if necessary. The sales quantities or “reserves” are then exported from the project. And then in the public domain you can hear people talking about “recoverable reserves” or “in place reserves”. “Reserves” is widely used and widely misunderstood word. Because of the misunderstanding over this word in the UNFC the use of the term “reserve” is avoided.

The UNFC is also needed because of the increasing overlap between the mining and the petroleum industries in relation to unconventional resources. The CRIRSCO Template was designed for solids and the Petroleum Resource Management System or PRMS was designed for fluids. For example, applying the CRIRSCO Template does not work very well for fluids produced through wells such as in situ uranium leaching and for which, PRMS would work much better.

And finally there is an increasing need to be able to compare renewable energy resources to non-renewable energy resources on an equivalent or comparable basis and the UNFC will allow this.



Turning to the history of how the UNFC was developed. The UN has developed the UNFC because there was a demonstrated need. As I mentioned this is not something that the UN has imposed; countries came to the UN and said we want to develop a common system for solid minerals and mineral commodities. So that started in 1992 and in 1997 after five years of work the UNFC for solid fuels and minerals commodities was issued. A number of countries around the world, including India, applied the UNFC of 1997, and then once that system was in place, a number of countries came to the UN and requested to see if it would be possible to extend that system to encompass petroleum and uranium.

That work started in 2001/2002 and then in 2004, we developed what was essentially a draft system of the UNFC applicable to solid fuels, uranium, oil and gas. In 2005 -2006, we started co-operating with the International Accounting Standards Board – this is mentioned in the background document prepared for this event. The IASB was looking to develop an international financial reporting standard for all extractive activities as one doesn't currently exist. Very simplistically, under the auspices or umbrella of the UNECE, CRIRSCO and SPE PRMS worked together to align their systems; and as a result of that co-operation we found that in order to achieve the closest alignment that we now have between the systems, the UNFC of 2004 needed to be slightly modified. So in 2007 there were proposed modifications to the definitions as well as some other fundamental changes to the system to ensure that there could be the harmonization that was needed. At the end of 2009 the UNFC was approved and it was published in 2010. The Expert Group then started work on the rules of application or specifications to ensure consistent application of the system. We worked for two to three years on development of the specifications through a very inclusive, transparent robust process; a number of surveys were undertaken, the draft texts were issued for public comment, and the final generic specifications were agreed upon at the Expert Group meeting in April 2013. Following this, they were submitted to the Committee on Sustainable and they were approved at the end of 2013. The UNFC finally became operational at the end of last year (2013). That was a significant achievement or milestone for resource management around the world.

Thank you for your attention.

I am pleased to hand over to David MacDonald who will continue the presentation.

Summary of Discussions

There was no discussion, as Ms. Griffith's talk was combined with that of Dr. David MacDonald in the following chapter.

CHAPTER 6 : Resource classification – Comprehensive Extraction and the Importance of Environmental and Social Issues

David MacDonald, Chair, Expert group on resource classification of the United Nations Economic Commission for Europe (UNECE)

Mr. MacDonald described the UNFC as a framework classification that captured, measured and quantified reserves and resources. He said that it is based on a set of definitions for different categories; a list of specifications gave detailed application guidelines around these definitions with a series of bridging documents, that acted as guidelines and existing specifications for different commodities.

Mr. MacDonald said that the UNFC system is based on three criteria represented by E (economic and social viability), F (feasibility) and G (geology) axes. Each of the axes is sub divided. The E axis has three categories and the F and G axes each have four major categories. In the UNFC system therefore, 111 would mean level 1 on the E, F and G axis and it would be the highest level of achievement. In the case of composites being discussed at the workshop, Mr. MacDonald said most would fit E3, with some possible E2 cases. The largest concern in moving from E3 to E2 would be social licenses and environmental issues.

Commercial projects met the E and F axes at the highest levels, but were called reserves under conventional systems (under CRIRSCO or PRMS). Where non-commercial projects were not captured within the CRIRSCO system, the UNFC system allowed those volumes through the categories. The UNFC system used generic specifications as the minimum standard for reporting and its categories deduced the estimates that were required by CRIRSCO for disclosure. There are 20 different generic specifications covering a number of different issues from disclosure to defining the levels of project maturity. The UNFC expert group comprises experts in their own commodities with the goal to have UNFC rely on existing systems as much as possible, through bridging documents.

Mr. MacDonald said the UNFC system was a generic principle-based system which allowed some modification to make it more need specific. The system could be viewed as value added to the CRIRSCO system and could be suitable for application to seabed mineral resource, having the E and F axes and the ability to subdivide F4.

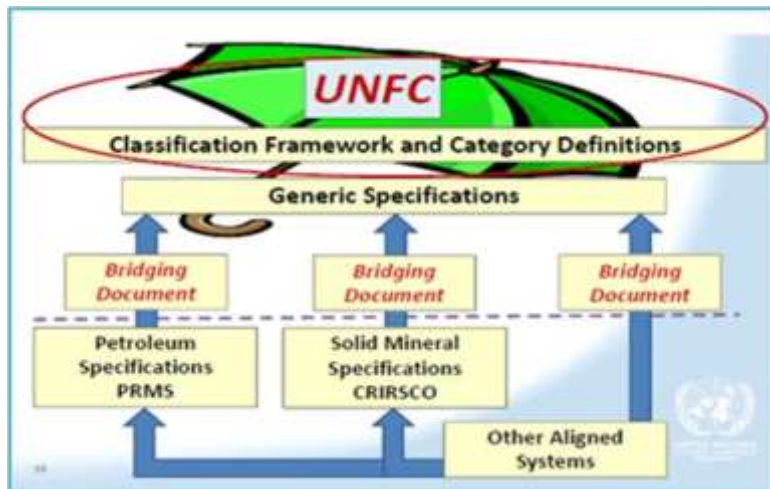
Introduction

I would like to start with a short quiz: see if you can identify these companies:

- A famous company misrepresents its reserves with collusion of the board of directors
- Application of revised rules significantly alters management's previous estimate
- Risk mitigation not in place results in revision of field reserves
- Management found to be trading shares prior to release of reserves estimates.

These were four situations which were discussed in a presidential address to the London Institute of Mining and Metallurgy. The interesting thing about this is that this address was given in 1911. The reason I put this up is to show the issues around reserves and this is very similar to the presentation Caitlyn Antrim gave yesterday – there is no change, we have the same issues today, that we are

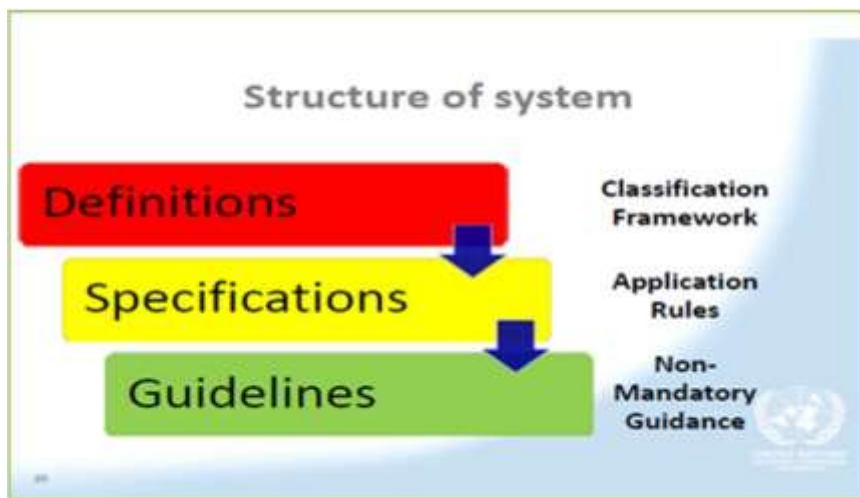
debating around reserves, and they are going to go on for a long time to come. The reason is that there are different stakeholder groups that are interested: people want to have reserves represented in different ways and frankly people use reserves as a commercial and legal framework representing their volume and we need to keep this in mind. The other reason I like to put this slide up when I give talks such as this is to make it clear to that you should not think you are going to completely resolve the situation here today or even next year; this is something that is going to be an issue for the ISA for many, many years. It is going to continue to develop with time. What we need to do is work together to get to a better place. Hopefully the discussion today will put us in a framework, in a place where we can reach that.



The UNFC is the framework classification that allows us to capture and measure and quantify our reserves and resources. The framework classification is based on a set of definitions for different categories. Seated underneath that we have a list of specifications which give more detailed application guidelines around these definitions and then coming up underneath those are a series of bridging documents to act as guidelines and existing specifications for different

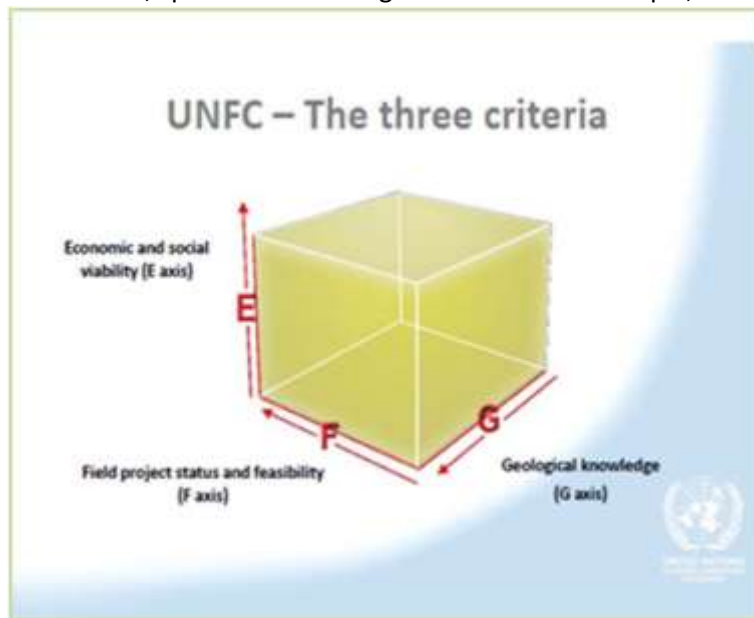
commodities. We have a petroleum specification based on the Petroleum Resource Management System (PRMS) of the Society of Petroleum Engineers and the solid mineral specifications are based on the CRIRSCO Template. You can see that the UNFC is actually founded on these other specifications and in fact these are not the only two that link into the UNFC, you could have many, many other alliances and as Charlotte mentioned we are just about to publish the International Atomic Energy Agency's Red Book as an underlying system. We are working very closely now with the renewable energy world in developing a series of renewable energy estimates of reserves and resources, and we continue to have interest from people working in groundwater and a variety of other commodity types that we could put into the UNFC.

UNFC is based on three principles and actually if you look at different classification systems throughout different industries, such as the electronics industry, aerospace, the best systems for classification of any commodity or any issue seem to follow the same three tiered structure. A great deal research was undertaken on this as we were putting together the UNFC in 2009. It seems that following these three tiers of definition allows you to have much more clarity in applying the system and understanding how it works.



So the first level is a set of definitions, and this is really the classification framework so when people talk about what is the UNFC 2009 system I would say most people are referring to these definitions. This is the classification framework; it is that cube of little cubes that you can see on the screen. But that is just really the start of what the UNFC is. Sitting underneath that are generic specifications

and commodity specific specifications that provide the rules of how you apply that framework to any individual commodity. There is a set of specifications that are generic across all commodities and there is another set of specifications for individual commodities, whether it be minerals, petroleum, or renewable energy etc. Then sitting beneath that is how the rules should be used and interpreted in general application. And the guidelines that sit underneath them are non-mandatory and provide assistance to users. Some of the other classifications systems tend to muddle up these three issues: definitions, specifications and guidelines. As an example, in the Petroleum Resource Management



System there are plenty of places where there are definition, specifications and guidelines, sometimes even in the same paragraph, and that is ok, but it does become difficult for people sometimes to identify what is actually mandatory, what you actually have to do, versus what is a good idea to do in following the system. And that is where you can have confusion I think in the application. So simply put, you think of that definition though, these are actually defined, as these are kind of more than mandatory, this is actually the law of how something is set up. Specifications are the mandatory rules that need to be in using the system. If you want to apply it you have to do this,

and the guidelines are just good ideas, good practice, and best practice on how to actually implement the system.

The UNFC is based on three criteria, and is generally presented as a cube. But in reality, if you don't think in 3D, if you are a seasoned geologist or just a mining engineer, generally in this sort of environment you can do pretty well in 3D but a lot of people don't, you don't have to use it, think about it this way, people can think of this as just 3 separate criteria by which our reserves and resource estimates are measured. So there are three categories, using E, F. and G as the letters.

E axis category definitions	
Category	Definition
E1	Extraction and sale has been confirmed to be economically viable.
E2	Extraction and sale is expected to become economically viable in the foreseeable future.
E3	Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability.

F axis category definitions	
Category	Definition
F1	Feasibility of extraction by a defined development project or mining operation has been confirmed.
F2	Feasibility of extraction by a defined development project or mining operation is subject to further evaluation.
F3	Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.
F4	No development project or mining operation has been identified.

G axis category definitions	
Category	Definition
G1	Quantities associated with a known deposit that can be estimated with a high level of confidence.
G2	Quantities associated with a known deposit that can be estimated with a moderate level of confidence.
G3	Quantities associated with a known deposit that can be estimated with a low level of confidence.
G4	Estimated quantities associated with a potential deposit, based primarily on indirect evidence.

The E category stands for the economic and social viability, all concerns that go into the commerciality of the project, so it's not just a financial issue, not just your internal rate of return, these are issues that are about how are you going to affect the environment, how are you going to affect the social issues of communities around you, all the issues that go with the commerciality of the project.

The next axis F relates to the feasibility or the field status and feasibility of that project. The key point here is that the UNFC is not defining the reserves associated with the field or project, you are looking at the individual projects, we would classify an individual project, we need to define what that project is going to be, if you are going to be ultimately recovering, the process that we're going to go through, in reaching that recovery. The UNFC also has space in the full geologic endowment, so you will also capture those lines that will not be recovered by any projects that you may have in place. But principally the UNFC is a project based system, and that is really fundamental as not all systems are like that, the Mckelvey box for example, is not a project based system; the Mckelvey box is about taking the volumes that are in place for a given deposit and just sub-dividing them across the different boxes. UNFC is about taking a project and what process we are going to need to put in place for that project to move it from wherever it sits in the UNFC system, move it through to production. As we said yesterday, that is ultimately our goal in all these processes.

The final axis is the G axis, geological knowledge. Now this axis actually operates slightly different from the other two axes, it is really an uncertainty or a certainty axis if you want to think of it that way. It is where we measure how much we know about our deposits and although it is used in G as geology, there are other issues that go and come into uncertainty, how well a project is going to function, how well are you going to be able to capture these nodules, you put a number of different mechanisms in place and add some things to capture the nodules, how well are they actually going to work what's their capture efficiency, is it going to have 70% efficiency? Are they going to be 50% in actually capturing things? That will go into this category here under the geologic axis. So it's pretty easy to remember, E, F, G, Economic and social viability, Project feasibility, Geologic certainty or knowledge associated with it.

When we use the UNFC we always report the values of these axes in order, E, F, and G. Each of the axes is sub divided into a number of categories. So the E axis, for example, has three categories, the F axis and the G axis each have four major categories. So we always report our values that we put into the UNFC with three digits, a name effectively, so 111 will mean that you are sitting at level 1 on the E axis, level 1 on the F and level 1 on the G. Each of the axes is set up so that there are levels of maturity as we move through them, from the highest level of maturity on each axis #1, the lowest and the lower will have higher numbers. So 111 would be the highest level of achievement on all three axes.

Each of the axes has a set of definitions. This is an example of what the three category definitions are for the E axis; E1 is extraction and sale confirmed to be economically viable. And again we are using the phrase economic here to mean the full commerciality of the project and that includes the social and environmental issues as well, so it is fully viable and makes sense. E2, is saying the project is expected to become economically viable in the foreseeable future and we do get some assistance on interpreting

what is foreseeable means, how far off is that in time. And finally E3 is not expected to become economically viable in the foreseeable future or at a too early stage in that determination. I would say many of the composites we are discussing here, are going to fit probably E3, in some cases they are possibly E2, and we certainly should be working ourselves towards where we understand that.

Now I would say probably the largest concern that you are going to have in moving from E3 to E2 is going to be looking at social licenses and environmental issues. I mentioned yesterday that we are spending quite a bit of the time now looking at these social licenses and environmental issues, we have a working group that is doing that right now, they are looking at taking the E2 category and subdividing that to describe in more details the different categories of issues that we have for environmental and social license issues.

The F axis or the project, feasibility axis here is subdivided into four categories and as you can see here F1 is the highest level of project maturity, something that has been defined as fully feasible, we understand how it works, and we can put it in place. F2 is saying that we need to do some further evaluation on the project, F3 at the moment can't be evaluated, it's going to need technical data and afterwards, we haven't yet identified a project to put it into place. This is that category F4 where I said we'd put the total endowment so you are not throwing away volumes, I'm associating it with reservoirs here, you can put every volume that is associated with that deposit, it is going to go somewhere in the cube. And this is what makes it unique from many other classification systems. The CRIRSCO Template for example, is about reporting volumes externally to give exposure to markets, to investors and it is only talking about volumes that are associated with projects which are planned and implemented. Whereas here we are allowing you to capture the full volumes so you can really understand and describe the reserves and resources.

And finally the G axis which I said is an uncertainty axis, you can see G1, G2, G3 are associated basically with high medium and low confidence in understanding of those volumes, the description of those volumes, so you could think about this either as levels of uncertainty, so maybe you want to think that you have a 90% chance of reaching or exceeding that volume estimate or you have a 50% chance or 10% chance of reaching the volume estimates. G4 are volumes that are associated particularly with deposits that have only been based on indirect evidence, you think of these as kind of exploration you might not



have penetrated as there is no actual measure for data, it's all based on indirect intervention. So these are the three axes and definitions associated with those and these are the base category definitions. There are also some categories sitting beneath these that can also be used optionally to give additional details and description of the reserves and resource associated with each of these categories.

So we put it all together and you wind up with the UNFC cube which you have all seen. Perhaps as an example we could just work through one particular category in the system, so perhaps, on the E1 axis we have a project and I'm going to evaluate it and I've determined that it is fully economically viable, meets all the requirements I need to put his project in place, so we meet that definition there, the F1 category is a project that is fully feasible, I can put it in place, I know how to do this project makes sense and finally the G1, it's at level G1 on the

UNFC – 2D representation

Total commodity initially in place	Extracted	Sales Production			
		Non-sales Production			
		Class	Categories		
			E	F	G
			1	2	3, 4, 5
	Future recovery to commercial development projects or mining operations	Commercial Projects	1	1	1, 2, 3
	Potential future recovery by contingent development projects or mining operations	Potentially Commercial Projects	2	2	1, 2, 3
	Additional quantities in place associated with mineral deposits	Non-Commercial Projects	3	3	1, 2, 3
	Potential future recovery by successful exploration activities	Exploration Projects	3	4	4
	Additional quantities in place associated with potential deposits		3	4	4

Each class is uniquely defined by its code

G axis and here it means I have a high confidence, I understand the volumes associated with it. If you read those three categories together, you read those three definitions, I think you will see that that sounds very much like the CRIRSCO definition of proved reserves and that is exactly what it is, so that is UNFC class 111 and that would map to the proved reserves classification in pretty much any resource system. So this is how we put together the three different categories to come

up with that one system. By being able to break any category into these constituent parts on the three axes – economic, project feasibility and geologic uncertainty, we are able to get a lot more granularity and information about the barriers to progressing the volumes, and that is really the key to applying UNFC and the power that it has.

However once you have mapped that system into the different categories you can start doing interesting things with them, start cutting and slicing and looking at different rows and planes of the system and you can flatten the cube if you choose to and this is the way we suggest you flatten it within the UNFC-2009 document however there are other optional ways you could choose to do so. So you see that taking different categories combinations under E, F and G and I call those different, I have given them different class names, so commercial projects are those that meet the E and F axes at the highest levels, things are fully economically viable and I understand the project, they are highlighted in green, and are known as “commercial projects”. If you were to look back on the cube you would see that it is the upper three cells, those are the volumes that are the commercial projects and under conventional systems are what we call reserves. So those are basically reserves, proved, probable, possible reserves under the CRIRSCO Template or PRMS. We further categorize things into commercial projects, non-commercial projects, exploration projects, and we also – which I think is unique in the UNFC – recapture these additional quantities and volumes in place so we are looking at the whole endowment in the deposits.

Alignment of systems (schematic)

	UNFC-2009	CRIRSCO	PRMS
Total commodity initially in place	Sales Production	Extracted	Production
	Non-sales Production		
	Class	Class	Class
	Commercial Projects	Mineral Reserves	Reserves
	Potentially Commercial Projects	Mineral Resources	
	Non-Commercial Projects	Not reported	Contingent Resources
	Additional quantities in place	Not reported	Unrecoverable
	Exploration Projects	Exploration Results	Prospective Resources
	Additional quantities in place	Not reported	Unrecoverable

By flattening the system we can then uniquely take these different categories or project material thresholds and we can map them directly to the CRIRSCO Template and this is where the mapping and bridging between the documents comes into place. You can map the mineral reserves, mineral resources and we can do the sub division as well and add exploration resource under the new CRIRSCO Template of November 2013 which does

define these results. Now you see there are a lot of places where however, non-commercial projects and those additional quantities in place aren't actually captured within the CRIRSCO system, and this is why we think that you should be using or looking at the power of the UNFC in addition to simply doing your external disclosure. UNFC allows you to look into the total resource base and allows you to come up

with mechanisms to progress those volumes through the categories. If you use the UNFC, and you do categorize the UNFC into categories it is very straight forward to produce the estimates that will be required by CRIRSCO for disclosure. So if you are using the UNFC it is a relatively easy step to move to before going on to the CRIRSCO Template. The volumes have all been estimated under the guidelines which would be required for CRIRSCO disclosure, so it is just a matter of how you choose to present those to the market. There really is no technical work required at all, it just a matter of taking the individual mapped categories, representing the different CRIRSCO Template categories, and similarly you have the same sort of mapping for the PRMS.

How can we use alignment?

The real value of this alignment between the systems is that you can make the estimates using the CRIRSCO standards and then you can simply report those under whichever system you choose. I can report volumes under UNFC categories or I can report them under the CRIRSCO categories if I choose to do that. But the same quantities are being reported under either of the two systems, absolutely independent of commodity type as well which is a powerful outcome.

One of the interesting things is the different coloured boxes here are effectively the CRIRSCO categories and they are presented in that way, but there are other cells on here that are not coloured in and I have quite a bit of interest in those. Looking at the UNFC, what falls into the F1, E2 areas is what I personally find most interesting. Think about what that means, E2 means they are volumes that I have an economic barrier to progressing them and they are not fully viable economically. F1 however means it is a project that is fully feasible, I understand that project, I know how to implement it, it means the only reason this cannot be called a reserve is I have some sort of a commercial barrier that needs to be overcome. And that is something that we often forget as most of us in the room are technical people, we want to look at everything as a technical issue but actually often times the progression of volumes is not a technical issue, it is a commercial, legal, and/or social issue. That set of blocks has highlighted that this is an issue that I can take forward and move forward from a technical point of view and it is only being delayed because of other softer commercial issues, often these days they are not soft at all, they are actually the hardest ones to move forward and I think it is a very important set of criteria for this group, in particular to be thinking about. What are the social issues to move forward? What are the economic issues to move forward, what are the environmental issues to move forward. If it is just a commercial barrier, a financial issue stopping us moving forward, that is an interesting sub-set of volumes to know – you could have discussions with your state to see what the governments could do potentially to incentivize you to address those issues. For example, does the government give tax breaks? We do see that sort of behavior in many circumstances where a nation wants to progress volumes in a certain region. It is interesting to have those discussions and to use the granularity of the UNFC system. Those issues are highlighted much clearer than when using a system like the CRIRSCO Template for management of volumes – the CRIRSCO Template is the right choice to use for disclosure of volumes but the UNFC will allow you to manage the volumes better.

Specifications

We talked about the three levels in the UNFC: definitions, specifications and guidelines. We have covered the definitions. We can now look in more detail at the specifications or application rules. The UNFC is set up around a system of generic specifications. The UNFC is very clear on specifications about which things are absolutely mandatory, when we see the word shall in the UNFC that means it is

something you absolutely have to do, should is something that we might be recommended to do, it is preferred, you don't have to do it but we suggest you do and may is used to indicate one of many alternatives, but again it may be best practice to follow. We do set a number of generic specifications as the minimum standards for reporting and we expect that all commodity systems would have similar type of requirements. For example, a basic one would be effective date, so if you are going to report volumes you need to advise the date on which you made this estimate and that is of course particularly important when you take into account commercial issues such as price, which will obviously impact your classification. It will not necessarily impact the total volume but it may impact which classification you fall into. Another thing that is important about the date is how much you have already produced – reserves and resources and remaining quantities – I need to know how much I produce by a certain date i.e. the effective date, which is one of the UNFC generic specifications. Another one is reference point: where is the point where you are actually making this estimate of reserves, it will change at different stages of processing through your system, there may be losses associated with these dates, so knowing where I am at that stage, what is the reference point that I used in making that measurement is important.

Generic specifications

In total, UNFC actually has 20 different generic specifications which cover a number of different issues:

- Mandatory disclosure issues
- Project maturity
- Distinction between categories
- Aggregation
- General obligations
- Optional additional sub-categories and labels
- Extracted quantities that may be saleable in the future

From disclosure issues to defining the levels of project maturity through issues of adding additional clarity around different categories, how you aggregate volumes etc. And also how you deal with different commodities, for example, you may have many different commodities contained in one deposit and how you present that is an important issue.

Specification S: Classification of additional quantities in place

One specification I think might be of particular interest to you is on classification of additional quantities in place. In some situations you are going to want to actually classify those volumes that are additionally in place and to understand what are the issues associated with them. You can have sub-categories and the F4 category relates to those volumes that are additionally in place. There are three sub-categories for F1 and F2. If, for example, the F1 is the technology to recover these points under active development, it is something that could fit in with what you are doing here. F2 is defined as the feasibility of extraction by a defined development project is subject to further evaluation. A successful pilot study has yet to be undertaken. I would argue that you don't fall into that category because you have some clear pilot studies in many cases. Finally F3, which is defined as feasibility of extraction by a defined project cannot be evaluated due to limited technical data. Where things might fit into F2 or F3 in relation to polymetallic nodules might be some of the volumes that you are leaving behind. If there are volumes being left behind, how do you make sure you are scraping up every last piece there is. This

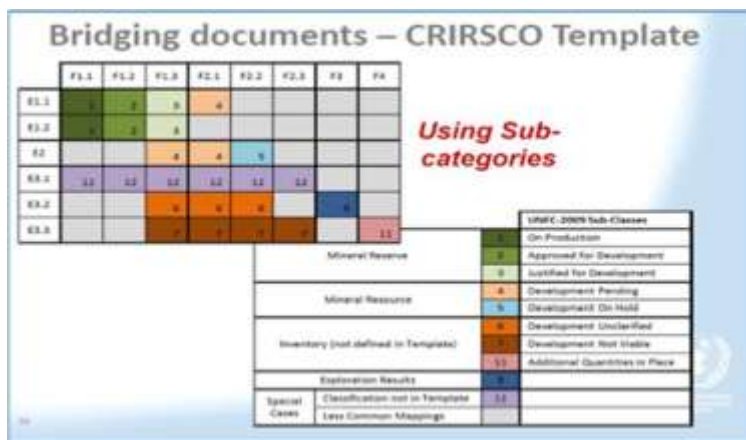
is an illustration of the level of detail that you can go into with UNFC i.e. to capture and quantify all the volumes you have.

Bridging documents

“A document that explains the relationship between UNFC-2009 and another classification system, including instructions and guidelines on how to classify estimates generated by application of that system using the UNFC-2009 Numerical Codes.”

Within the Expert Group on Resource Classification, there are experts across the range of commodities. The goal is not to reproduce or create a new classification system. We want to have the UNFC rely on existing systems as much as possible and we do this through what we call bridging documents. So these are systems which have been aligned to form the basic commodity specific specifications for each of the commodity types, so for minerals we use the CRIRSCO system, for uranium in particular we use the IAEA system. Again even those two systems within the UNFC, you could classify them by using the CRIRSCO system, we need to make sure that they are aligned so whichever system you choose to use you would end up at the same place.

So we have a bridging document for aligned systems. For solid minerals we are using the CRIRSCO Template, for petroleum we are using the PRMS, for uranium the Red Book system and we are looking at other systems now for renewables. We are also looking at perhaps taking the Russian classification systems for both minerals and petroleum and bridging that into the UNFC and we have started to have discussions with China to see if we could perhaps take the Chinese system for reserves estimation and map that into the UNFC as well.



Here is an example of how we bridge between the systems. The two axes that are presented here are the E axis and the F axis i.e. the economic and sociability criteria and the project feasibility criteria. Effectively we are looking at one plane through the system and what the plane is coming out of is the G axis, with geologic uncertainty.

The reason I have chosen not to do explain that axis is because I think you all understand uncertainty pretty well; you understand that there can be high,

medium, low estimates of uncertainty. I think that it is actually the easiest for us to capture and probably the most important category to understand, sometimes it is pure geology and sometimes it is the math that is taking the plane in that direction. So what we are technically looking could be considered a macro commerciality of the project, looking at the economics of it and the feasibility of it. So I slice it through, these are each of the categories and sub-categories of the different projects. The numbers just refer to the colours and they match. The colours are associated with the project maturity of the CRIRSCO system, so mineral reserves are broken up into levels 1, 2, 3, whether they are around production, approved for development or justified for development and you can see where those would map within the UNFC system. So we have direct one to one mapping – what goes into each of the categories of the UNFC system will map directly into one of the categories in the CRIRSCO system. This

is why I advised you that recording is relatively easy. If I mapped everything into the UNFC, I simply have to go into this table and see how I would translate those volumes into the CRIRSCO system directly, there is no additional work required. I could write a simple programme to do it if I have got everything in an EXCEL spreadsheet. So I am getting the power of understanding my reservoirs and my deposits and I have got the power to go ahead and report that wherever I choose to do so. The E2 F1 category is number 4 here and it appears in quite a few different places i.e. mineral resources development pending, which is probably much like inferred or indicated resources under the CRIRSCO Template. They can be at that stage of maturity for a number of different reasons, such as technical issues or commercial issue However, just looking at the number I cannot tell what the reason is but the UNFC gives me a little more insight into those numbers to identify. The sub-categories showing here are the standard sub-categories used by the UN system, and they are consistent in each of the commodity types. However, we do say in the UNFC document that the sub-categories are optional and you have the right to develop your own sub-categorization. It may be something for ISA to consider. If you are going to request the people to use the UNFC system, perhaps you could arrive at the categories associated with deep sea mining. I am not a domain expert, so I cannot give you assistance on this issue, but it might be something to consider and we would be happy to work with you. Do reflect on this point, as there may be a slightly different categorization system that would provide you more insight. UNFC is about providing information and assistance and progression.

As I said UNFC is a process. It is about understanding the deposit, developing the project and testing the social/economic impacts. That's the way you do every project that you develop, we do this all the time. Any geo-engineer will follow these three steps, it maps back to the UNFC, it is an extremely logical system, it reflects the way we go through our analyses every day.

What is the goal?

I would now like to focus on the commercial issues and environmental aspects, the E axis. The goal of stakeholders varies, ranging from businesses, governments and all other stakeholders whether they be investors or NGOs, or the financial community. Every stakeholder's goal is different. However, there is one principal goal that all stakeholder groups do have in common and that is the issue of sustainability. Look at businesses, their goal really is not only to make money but to be sustainable so they can pay dividends this year as well as next year – the longer term goal of the business is sustainability. A lot of other cultures and western culture has been saying this for a long time. We want to have that longevity, companies celebrate being around for a long time. Sustainability is the key, every group wants to be able to count on a return on their investment. We should be capturing that. Sustainability is the bottom line.



Corporate Responsibility and the Triple Bottom Line

Proposed by John Elkington, California Business Review 1994, he wrote a book called the Cannibals with Forks, the principle behind was that it takes more than corporate responsibility. A business cannot just say they it is going to be responsible. It is not only about corporate responsibility, you have to change the way of

the company and how it looks at its work. And by looking at it in a new light, a new paradigm you can start to get improved performance and optimize the enterprise.

It is suggested you need to look at three things here, the three axes that he is proposing are financial, social and environmental axes, the triple bottom line. You have to look at all three all the time to make sure that you have got them balanced. You cannot just say this is a technical issue and I am not going to bother about anything else, ignore the other issues. They are just as important in reaching the solution and taking things forward in a positive way. You must look at all three in balance and at all times work on all three.



Sustainable Development Fundamentals

What about the fundamentals of sustainable development. Comprehensive extraction i.e. disturb the ground once and don't leave anything behind. The social license to operate and working with communities. The principle of environment and zero waste, making sure that you are not damaging the environment. These are the three principles of the triple bottom line and they line up closely with the three axes of UNFC. When we look

at all the ideas people are having around how to develop things in a moderate, socially and environmentally responsible way, in fact we all are doing the same thing but we are just looking at the different principles through different lenses. It is really important to understand that if you try and go too far on one round without looking at the concerns of the other points on the triangle you will not have the most optimum development strategy. You must keep the balance. There is no right or wrong answer on this. The exciting thing, I think is taking the principles of this triple bottom line and seeing what your key performance indicators are. Companies like KPIs.

Key Performance Indicators

Typically we look at things such as net reserve values and return on investments but there is a lot more now we can focus on. We can start to look at building long term partnerships with our communities, how are we going to be able to do that? We can incentivize communities to work with us. It is not a matter of having competing issues with groups, we want to work together to find out what is the best way to solve things. Maybe we will find that doing a project in a certain area just isn't the right thing to do. You need to balance those issues and have discussions with partners. There are lots of different ways that we could look at how we actually measure success for a company, at the end of the day it is going to be about having the finances to do business because we have to pay our shareholders, being able to do that sustainably might mean having to take a slightly lower rate of return to be able to meet these other requirements and to be able to make the needed developments.

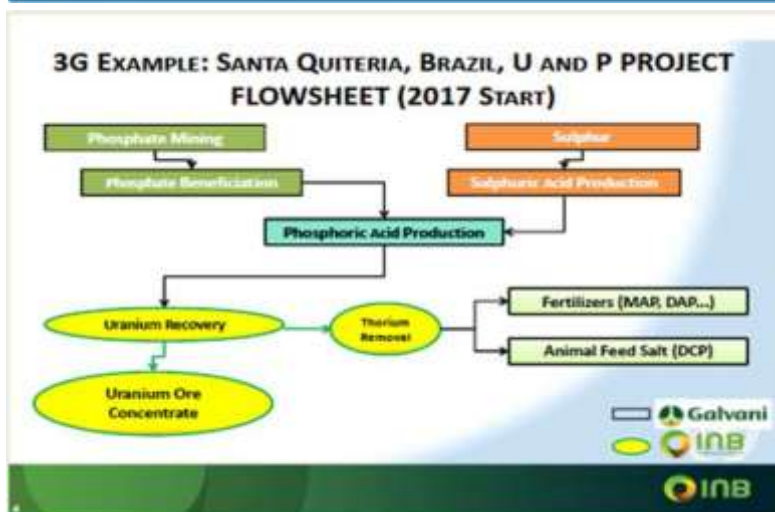
Uptake of Comprehensive Extraction

Issues around comprehensive extraction are very interesting. It relates to producing multiple minerals at the same time. The concept came out of work in the 90s in Russia and China and was focused on uranium as a bi-product of phosphate production. The oil industry has been doing this for a long time, the oil industry always produces oil and gas but often they also produce things such as helium. They

additionally sell CO₂ as a by-product. Comprehensive extraction is something that also has a lot of potential for the mining industry as well. So it is not just the primary resources but also secondary resources; there is a significant amount of mine tailings around the world that have huge resource potential for a variety of commodities. It gives us a chance to really rethink the balance sheets, the value of our deposits and also the flow sheets or the process by which do things, how we actually are going to put projects in place to optimize development.

Comprehensive Extraction Methodology

The methodology around comprehensive extraction needs to be looking at full life cycles. You need to think about all available resources of the various projects; if you are going to look at developing a project and think I am only here to develop the phosphate associated with it, I'm here to develop the phosphate so I can make fertilizer. If I just go in with that mind set and I don't think of all the other things that are there, I might lose or develop the deposit in a way that is not optimum to develop all the resources at once. So having this idea of thinking of the primary and secondary resources as a single deposit and putting together a blue print so I have zero waste, I only disturb the ground once and so minimize the impact both to the environment, the communities and for ourselves. And from a business point of view we only want to have to do things once.



Resource assessment for comprehensive extraction (CX)

Comprehensive extraction does actually require discussion about the resource assessment, because I need to not only know where my base resources are but I also need to think about all these auxiliary resources, the secondary resources that might be associated with it and make those estimates. Some of them are going to be more economic at a given point in time than another so coming up with the total project base resources can be quite complicated. I would argue that something as simple as the McKelvey path cost, for example, doesn't meet the needs of the situation. However as you may guess, I am going to say that the UNFC does meet the needs because of the 3D framework around the E, F and G axes. UNFC does allow us to take multiple commodities and to classify our project bases through these

different axes. So a single project can have different commodities at different levels of commercial maturity and by having this international cooperation across diverse stakeholder groups, I think the UNFC is uniquely placed to deal with these issues around comprehensive extraction.

I would like to share two examples. The experts who work with comprehensive extraction around the world like to use technology metaphors for these types of projects, they use the same terminology that we use for mobile phones. They liken to this what we call a 3G-third generation example (see above) of combining uranium and phosphate production in a single flow sheet. I will share an example from Brazil. Basically they are trying to produce fertilizer so it is very easy to go from phosphate mining straight to the fertilizer. They are able to change the flow sheet at the same time coming out with the uranium and the phosphate or modify the process. This is what they call the 3rd generation example of taking the ideas of comprehensive extraction and working out a way to use everything that is in that reservoir system.

4G Extraction

The real goal they have is what they call 4G so 4th generation extraction, that is really looking at a full basin, not just using the output from a single mine but looking at “how can I go into a basin and identify the oil, gas, all the minerals that are there and actually developing the entire basin with one fluid pass so it is an integrated management strategy process, disturbing the ground once and getting all the resource potential out in one pass”.

Summary

In summary, the key points are that UNFC is a generic principle based system which allows you some modifications and specialization to make it more specific to your needs. That is a key point, the UNFC is flexible enough to meet the needs that you have here at ISA. We are happy to work with you to make it useful for you. I cannot emphasize enough the importance of the linkage that we have with CRIRSCO. We never talk about the UNFC without talking about CRIRSCO because it is the basis of the system for solid minerals, we actually call it the keystone and foundation of the system. UNFC could be considered as value added to CRIRSCO, providing a little more insight into the numbers but you do have the ability to report on that system as freely as you can. UNFC gives you a clear way to communicate the value of your volumes.

Observations

A couple of observations: UNFC is suitable for application to seabed mineral resource, having the E and F axes and the ability to subdivide the F4 is really important to you/ISA. Until the economics of the deposits can be evaluated, the classification should be E3.2 - economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the exploration phase) i.e. no inferred resources. Once resources become more “mature” e.g. commercial extraction agreements are in place you can then classify with UNFC and disclose with the CRIRSCO Template. Governments are well placed to continue with UNFC for national reporting purposes.

Contacts

Some of the contacts are:

Hari Tulsidas [t.harikrishnan@iaea.org]

Roberto Villas Bôas [villasboas@cetem.gov.br]

Julian Hilton [jhilton@aleffgroup.com]

David MacDonald [david.g.macdonald@uk.bp.com]

Summary of Discussions

A participant commented on the issues the ISA faced that had parallels with national reporting even though it was a jurisdiction and not a nation as such. He asked whether Dr. MacDonald was suggesting that aligning specific categories could possibly be something that could specifically benefit the ISA and its contractors because basically if one knew exactly what one needed to do, then there would be a limited amount of additional technical input that would be required. He said that he supported getting together to confirm if there was a need for some sort of alignment of special categories and getting over any hurdles that might come in the way of implementing this system, so that the ISA not only have reports that give information on the areas in question but that can all be joined together to give a jurisdictional report and a clearer picture of how much resource and how much commodity was available.

Dr. Macdonald said that the word economic did not just mean financial issues. He said something cannot be economic unless it contained all the issues that were required to progress forward, so it does implicitly include issues around social and environmental issues. He continued that if one went into the UNFC documents, there is a footnote that clearly states that economics include social and environmental issues as well. He continued that if he had to write the 2009 document over, he would make it much more explicit that to cover all other issues. Dr. Macdonald said that a work programme was in place to expand the guidance and specifications around the E axis and the experts working on it could provide quite a bit of additional information on guidelines and how to actually apply the UNFC. He was of the opinion that the experts were going to suggest that the E2 category be broken up into a number of sub categories and would be more explicit on what the barriers were progressively, because understanding that something is an environmental issue or community based issue is going to be quite important in moving things forward.

On a question about technology, Dr. MacDonald said the project feasibility axis subdivides the issues and subdivides the category looking at maturity of the project. He said this was an area that would need some specifications and guidance from the ISA, specifically on the value of deep water minerals. He said there needed to be a consistent application between the contractor groups, for example how they make their estimates, and what the maturity of different project types were. He said the Expert Group on Resource Classification would be happy to provide some technical assistance on producing that. He said the the general framework of the UNFC allows that but most classification systems don't have that flexibility. He continued that one was basically in a situation where one needed to choose to put something together for a specific reason but then lose the comparability and the international acceptance by using the framework and the specifications underneath it.

Another person was interested in how systems were developed if people wanted to take advantage of both the UNFC 2009 and the CRIRSCO system, in order to understand resource and reserve classification. He continued that the system tried to use an umbrella to cover all of the state systems or local systems and in this instance, requirement of the group application of petroleum and mining industry. He said although UNFC had the advantage of having well-defined categories and

specifications, CRIRSCO had the advantage of being easy to use and widespread. UNFC has well defined the axis level, tier one, tier two; F1, F2; G1, G2, the main categories and top categories. CRIRSCO uses completion of terms to describe the tier 1, tier 2; B1, B2; and use continuity for geology, confidence for geology. So I think, in fact both UNFC and CRIRSCO have three axes, UNFC has geology, feasibility study and economics. CRIRSCO also has three axes, geology, modification and economics. So if we do some mapping we can get a clearer concept of each category, the meaning of each category, the classes based on the category. So this mapping should be more precise; so that is my view and I am just making some recommendations.

Dr. MacDonald offered one comment on the issues surrounding terminology when referring to classes or categories. He said the problem with developing the current UNFC 2009 was that the SPE system for petroleum was inconsistent in its use of classes and categories with the CRIRSCO system, so it was never going to be possible to have them exactly the same. What he was looking at was to map a way to move from one system to the other, and avoid issues around terminology as much as possible. He agreed that more work could be spent on guidance and how to make the applications and critical case studies were needed at this point in time.

The same speaker remarked that UNFC never used resource but that CRIRSCO does and that he understood why the system may need to be extended into other fields, or other resources.

Dr. MacDonald said that he did not use the word quantity. He had actually tried to use relevant terms but it was challenging as he was more of a petroleum person and he responds to fields and deposits. He continued that the renewable energy people don't like these terms either.

Another expert commended Dr. MacDonald on making an excellent case for a large comprehensive classification system. He appreciated the mapping of the CRIRSCO standard but in the long term, he said the Secretariat would have to address more than three times the minerals and bring that into coordination with national planning. This system, in the short term, in the next five years, will have to narrow its focus so that the contractors can focus on a couple of specific items and the Secretariat can get its minimum required, which is, to use the current terminology, proved probable and possible reserve, that really maps to CRIRSCO standards. He wanted to be sure that Dr. MacDonald felt that if work is done now on getting reports on the CRIRSCO standards, or if the systems are compatible and that it can be taken on, step by step, getting broader and more integrated .

Dr. MacDonald said that was possible and that he would propose a slight alternative solution to that. He said participants could adopt the UNFC system, with the required disclosure of certain categories within this, and then choose the categories that match directly to the CRIRSCO system, so that one is actually recording and asking for the same information, but asking with the UNFC terminology. He said he would actually write it out in such a way that the presentation of the requirements would be that these are the categories that are consistent with CRIRSCO disclosure. He said this would enable one to then quite clearly write “being guided” stickers because it goes along with the UNFC categories, and it would be easier to expand in the future, internally within the contract. He said other categories could also be looked at for a management system because if he was a contractor group, he would actually want to be using the UNFC because it would give him more insight.

CHAPTER 7: The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) - Classification Code

Pat Stephenson, past Co-chair, CRIRSCO (2005/06), director, AMC
Mining Consultant, Vancouver, Canada

Mr. Stephenson, who made the presentation on behalf of Dr. Harry Parker, incoming Chair of CRIRSCO, said that the CRIRSCO International Reporting Template (IRT) was a very simple system, well understood by the world's mining and finance industries. CRIRSCO, as an international coordination and advisory body in the area of Mineral Resource / Reserve classification and reporting, Mr. Stephenson said, relies on its constituent members to ensure regulatory and disciplinary oversight at a national level. It promotes uniformity, excellence and continuous improvement in the public reporting of Mineral Exploration Results and Mineral Resources / Reserves, and represents the international minerals industry on Resources and Reserves issues with other international organizations. Its member countries are Australasia, Canada, Chile, Europe / UK, Russia, South Africa, USA and (as of today) Mongolia. Mining companies listed on stock exchanges that use CRIRSCO-type reporting standards account for over 80% of the listed capital of the world's mining industry.

Mr. Stephenson said that the boundary between Indicated Mineral Resources and Inferred Mineral Resources is the most important separation in the CRIRSCO system, because it dictates what can be converted from Mineral Resources to Mineral Reserves.

The IRT was initiated in 2003 and its recent version in 2013 endeavors to promote best practice in Mineral Resource and Mineral Reserve estimation and classification. The IRT could easily be adapted to seabed nodule reporting, with minor modifications and the inclusion of seabed nodule-specific clauses, after extensive discussion with interested groups on issues related to seabed nodule mining. Materiality, Transparency and Competency are the three principles that underline national reporting standards in all the CRIRSCO countries and the IRT. The principles and other text in the IRT provide extensive guidelines for the Competent or Qualified Person making his or her own judgment as to what is appropriate and applicable in the particular situation and taking responsibility for it.

Introduction

I am going to give a presentation on CRIRSCO and the International Reporting Template (IRT). There has been lots of talk on this topic so far during this workshop. Hopefully I can lay to rest some of the perceptions, clarify them and demonstrate that CRIRSCO really is a very simple system that is well understood by the world's mining and finance industries. I think it is a very useful standard for where the ISA needs to go next.

I would like to say following David's talk that his description of the relationship between CRIRSCO and the UNFC was a very good summary. That is the way we see it. The CRIRSCO Mineral Resource and Mineral Reserve categories occupy the market-related reporting area of the UNFC. The UNFC is managed under a separate authority (UNECE) from CRIRSCO.

I am representing CRIRSCO here although I am not currently a member of CRIRSCO, because the entire committee is in Mongolia this week holding its AGM. I am happy to advise that, as a result of the meeting in Mongolia, it has become the latest country to join the CRIRSCO list of member countries. I

am giving this presentation on behalf of Dr. Harry Parker who apologizes for not being able to be here today.

Since I am not a current member of CRIRSCO I think I should give my credentials. I have been in mining for 43 years now. Most of that time has been related to Resource and Reserves estimation and classification. We mentioned JORC a few times in the recent presentations. It is the Australasian reporting standard and it was developed in the 1980s. I was a member of JORC for 18 years and Secretary or Chairman for 12 of those years. I was co-Chairman of CRIRSCO in 2005 and 2006. That was a fairly important time, because it was when we had key discussions with the UNECE regarding the UNFC, and with the International Accounting Standards Board (IASB) and other international bodies as well. I am now a resident of Canada having moved from Australia seven years ago, so I am very familiar with NI 43-101 as well. I have authored over 20 technical papers on Resource classification and reporting. I have been and currently am an expert witness in more than one litigation case that involves Resource and Reserves estimation, classification and reporting.

Presentation Outline

My outline will be:

- an overview of CRIRSCO
- an outline of the IRT
- a discussion of how the IRT caters for certain commodities or deposit types that require some special clauses
- and finally a recommendation for a way forward.

In my opinion the IRT can be very easily adapted to seabed nodule reporting with the inclusion of a few clauses that relate specifically to the special issues to do with seabed nodule extraction.

CRIRSCO - Principle Objectives

Just some background on CRIRSCO – its principal objective is to promote best practice in international public reporting of Mineral Resources, Mineral Reserves and Mineral Exploration results. It is an umbrella body of the National Resource and Reserves Committee in each of the countries that are members of CRIRSCO. The IRT is based on those individual national reporting standards. There are two representatives from each of the committees in each of the countries that form the CRIRSCO committee. It recognizes the truly global nature of the minerals industry these days.

Through the IRT and continuous communications, CRIRSCO endeavors to promote best practice in Mineral Resource and Reserve Estimation, Classification and Reporting. The latest version of the IRT is dated 2013. CRIRSCO represents the international minerals industry in certain international negotiations, including the ones I mentioned earlier on. We will also talk about the Competent or Qualified Person system. CRIRSCO encourages the international reciprocity of the Competent or Qualified Person system. In other words, it promotes international cooperation and agreement between countries to facilitate Competent or Qualified Person reporting in more than one jurisdiction.

History

CRIRSCO's history is that it was formed as a sub-committee of what used to be called the Council for Mining and Metallurgical Institutions, which died a fairly untimely death in 2002. There was an accord reached in Denver in 1997 and the member countries at that stage were Australia, Canada, USA, UK / Western Europe and South Africa. That year, an agreement was reached on uniform definitions for Mineral Resources and Mineral Reserves and the subdivisions of those that would be common to all of the reporting standards in those countries.

As Charlotte and Dave have already mentioned, CRIRSCO reached an agreement with the UNECE in 1999 for the CRIRSCO definitions to be the market-related component of the UNFC. CRIRSCO in its current form was formed in Cairns in 2002 at a meeting of the CMMI where the decision was taken to disband the CMMI. The IRT was initiated in 2003 and the latest version is 2013. CRIRSCO was granted observer status of the ISA in July 2014 for which we are very appreciative.

CRIRSCO - ICMM

The ICMM is not the same as the CMMI, or the CIMM. It is the International Council for Mining and Metals. When the CMMI was disbanded in 2002, CRIRSCO essentially had no parent body to support its activities. Negotiations took place with the ICMM leading to CRIRSCO becoming a task force of the ICMM in 2007. It is now a strategic partner of the ICMM. That is just to explain a bit about the ICMM because a fair bit has been mentioned here about the importance of social and environmental aspects of the mineral industry and that is quite right. This is the remit of the ICMM - in the governance area and social / environmental, and just general good practice. It is a CEO-led organization and includes the CEOs of most of the major and mid-tier mining companies of the world. It plays a leading role in the promotion of good practice and performance internationally. The statement of principles of sustainable development is part of the charter of the ICMM. Since CRIRSCO is a strategic partner, it is exposed to the ICMM's aims in that area. There is a clear linkage between CRIRSCO and the principles of sustainable development.

CRIRSCO Members and Potential Members

Current members of CRIRSCO are Australia, which is the JORC committee; Canada- that is NI 43-101 and CIM; Chile - its code is called the Certification Code; UK and Western Europe is a member and it has a code called the PERC code; Russia joined a few years ago – that is the NAEN code and there is also a mapping document between the Russian and the IRT, which was developed as part of those negotiations; South Africa through the SAMREC code; USA is a particularly interesting situation – the CRIRSCO type of standard is not accepted by the Securities and Exchange Commission (SEC) in the USA – it is the only major regulatory body in the western world that doesn't accept the CRIRSCO type of standard. It has been a thorn in the side of CRIRSCO and American professional societies (and American companies) for a long time, but I am pleased to say that finally there are negotiation between the SEC and the American Society of Mining Engineers.

Securities Regulators' Recognition

Securities Regulator	Main CRIRSCO-Type Reporting Standard Recognized
ASIC / ASX / NZSE (Australasia)	JORC
Securities Commissions, TSX (Canada)	NI 43-101 (incorporating CIM)
Santiago SX (Chile)	Certification Code
ESMA, AIM (Europe & UK)	PERC, all CRIRSCO-aligned standards
Hong Kong SX	JORC, 43-101, SAMREC
NYSE & NASDAQ (USA)	None (SEC Industry Guide 7)
JSE (South Africa)	SAMREC
Moscow (Russia)	NAEN

These are the securities regulators that recognize CRIRSCO-style standards. I will re-emphasize that NI 43-101 is a CRIRSCO-style standard, so is the JORC code, the SAMREC code, the PERC code, the Chilean and the Russian. Australian regulators recognize the main CRIRSCO style reporting standards. The Toronto Stock Exchange in Canada uses NI 43-101, which incorporates a document called the CIM Definition Standards. That

document is more or less equivalent to the JORC code. Other regulators include the Hong Kong SX, Singapore SX and AIM.

Importance of CRIRSCO-type standards to the international mining industry

The mining companies listed on those stock exchanges that recognize or use CRIRSCO-style standards account for over 80% of the capitalization of the world's mining industry.

CRIRSCO – Petroleum Industry and International Accounting Standards

CRIRSCO entered into negotiations with the petroleum industry (mainly Society of Petroleum Engineers, SPE) and created a mapping document under the auspices of the IASB. We were asked to work together to produce this document so that the IASB could be properly informed about standards that might apply to future accounting standards for the extractive industries. That was a very useful exercise. I believe the IASB accepted the main conclusions arising from those discussions, and agreed that there was no need to impose a unified set of definitions on the minerals and oil / gas industries because the existing systems were well understood by each of those industries and they could be mapped to each other. So the IASB was comfortable at that time with the idea of a new accounting standard referencing Resources and Reserves at a fairly high level encompassing both the CRIRSCO standards and the SPE standards. CRIRSCO and SPE are both recognized in the UNFC for commodity-specific standards guidance.

Relationship of CRIRSCO categories to UNFC

CRIRSCO Template		UNFC-2009 minimum Categories			UNFC-2009 Class
Mineral Reserve	Proved	E1	F1	G1	Commercial Projects
	Probable			G2	
Mineral Resource	Measured	E2	F2	G1	Potentially Commercial Projects
	Indicated			G2	
	Inferred			G3	
Exploration Results		E3	F3	G4	Exploration Projects

Another way to look at what David had in his talk – it is a simple mapping of the CRIRSCO IRT categories to the UNFC [indicating slide]. You can see the Mineral Reserves Proved category, which is the highest category, is essentially category 111 in the UNFC; Probable is 112 and they are described as commercial projects in the UNFC. Under Mineral Resources, the Measured category, which is the highest

category, is 221; Indicated, which is the middle level, is 222; Inferred is 223. Exploration results sit under 334.

I was thinking when David was speaking of another way of looking at how CRIRSCO relates to the UNFC. It could almost be looked on as a pyramid. If the ultimate aim is commercial exploitation of a particular commodity, then if you like the apex of a pyramid is the CRIRSCO definitions, because that is where we would like to get to. We are trying to get to definitions that are recognized in the marketplace by most lending institutions and by the regulators of stock exchanges and by the mining companies worldwide. It is another way of looking at the relationship between the two.

CRIRSCO Executive

Chairperson: Edmundo Tulcanaza (IMEC - Chile), Past Chairperson: Deborah McCombe (CIM - Canada), Deputy Chairperson and incoming chairperson: Dr. Harry Parker (SME - USA), Secretary: Ian Goddard (JORC - Australasia). They change every couple of years. The Executive is elected for a two year term, and the Secretary's term may be extended for continuity. So it is truly an international committee.

CRIRSCO and International Reporting Template [IRT]

Each of the countries that is a member of CRIRSCO has a reporting standard that is has already developed. These reporting standards have been developed by the industry in each country, not by government or regulators. Some of them have stood the test of time very well. The IRT is really a document that pulls together all the best, the common parts of all those reporting standards and ensures that it stays up-to-date with best practice in each of those countries.

CRIRSCO is an advisory body, it is an umbrella body with mainly a coordinating role, but the IRT is based on well accepted national reporting standards. In the case of the JORC code, which I was heavily involved in for 18 years, the first JORC code was released in 1989 so you can see that has been around for 25 years. It has stood the test of time. It has been modified through that time and during that period the CIM standard definitions came into place, which were then referenced by NI 43-101; the SAMREC code came in; the PERC code came in and the other countries that are now part of CRIRSCO. What has

been incorporated in the IRT, which I think would be a very good model for where ISA wants to go in the immediate future, is now very well established. We have gone through some intensive learning periods in that time that the ISA would not need to go through again, at least certainly not to the extent that we had to go through them. I think there is a real benefit, as with the UNFC as well, of taking advantage of years and years of development to get these standards and systems to where they are.

The IRT is not something that takes precedence over the reporting standards in each country. It is deliberately called a template so that it is clear that it is not a code, not a standard that has any force. It is an advisory document that can be taken by another country that wishes to develop a reporting standard of the CRIRSCO type. They can just take the IRT and adapt it as required to their circumstances. Another point to mention about the IRT; the reporting standards it is based on have been deliberately being kept relatively non-prescriptive and fairly wide in scope in order to be able to cover the very wide range of mineral deposits that we encounter. This makes it very valuable to the ISA in this situation because I would say that 95% of the IRT could be directly applied to seabed nodules with no change.

IRT- Principles

There are three principles that underline the national reporting standards in all the CRIRSCO countries and also underline the IRT: Materiality, Transparency and Competency. The standards are for reporting, they do not set standards for how you estimate. They set standards for how you report what you estimate.

Materiality means that you report all the information that somebody who is reading the report, and who wishes to make an informed decision on the basis of that report, can reasonably require, that you are not withholding anything that could be influential in affecting that person's decision.

Transparency is related to materiality but it basically says that whatever you report must be reported very clearly in an unambiguous way so it is not capable of confusion or misunderstanding.

Competency brings in this very important concept of the Competent Person. In Canada it is called the Qualified Person, in Chile it is the Competent Qualified Person, but it is all the same. It is another reason why these standards work as well as they do, because they don't try to specify in detail how you estimate Resources and Reserves; they leave that to the judgement of the Competent Person. They provide extensive guidelines as to the things to take into account, but in the end the responsibility lies with the Competent or Qualified Person to make his or her own judgement as to what is appropriate and applicable in the particular situation and take responsibility for that.

Public Reports



This is a summary of the type of public reports that we are referring to when we talk about the CRIRSCO standards like the JORC code, NI-43-101. They relate to the public reporting of explorations results, Mineral Resources and Reserves. They don't dictate how a company reports internally. A company can report in any way it likes internally, but they do dictate how a company reports to the market and stock exchanges. The public report for the purposes of CRIRSCO and its related standards is really a report that is designed primarily to inform investors or potential investors. It is a fairly broad application.

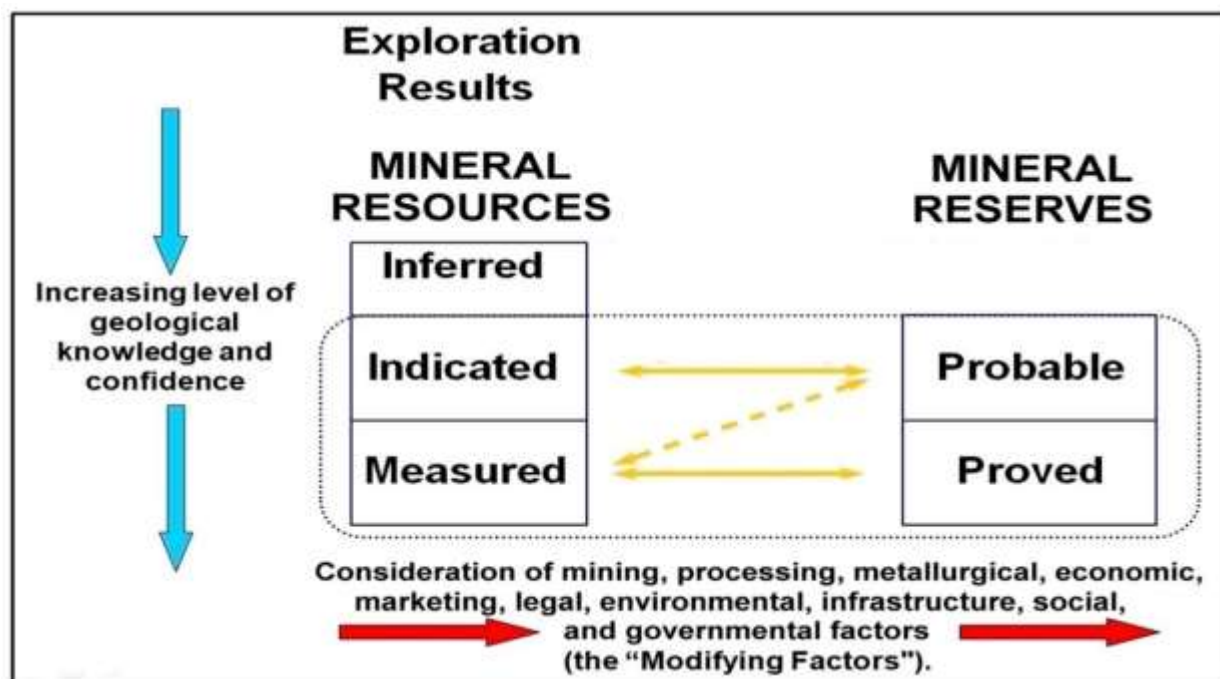
Standard definitions

There are a number of definitions in the IRT and I have listed them all.

- | | |
|-----------------------|-------------------------|
| • Public reports | • Measured Resource |
| • Competent Person | • Mineral Reserve |
| • Modifying Factors | • Probable Reserve |
| • Exploration Target | • Proved Reserve |
| • Exploration Results | • Scoping Study |
| • Mineral Resource | • Pre-Feasibility Study |
| • Inferred Resource | • Feasibility Study |
| • Indicated Resource | |

These definitions are there already, they are developed, and they are available for applications to seabed nodules. There may be a need to do a bit of adjustment here and there, but in general they are fairly broad definitions that are intended to apply to a wide range of deposit-type situations.

Fundamental Framework (Figure 1 from IRT)



This is a diagram that you have seen before and it shows how the categories of Resources and Reserves relate to each other. We start at the top with exploration results, which is the least amount of information. You may have, as David and Charlotte have explained, information that predates the CRIRSCO categories or is not appropriate for public reporting that you want to classify. That is where the UNFC has a role to play. When you are in a position to report publicly for the prime purpose of attracting financing, Figure 1 is the diagram that applies.

Exploration Results

Exploration results are at an early stage where you have exploration information and you want to report it. There are certain things you should and should not do so you do not mislead investors.

Mineral Resources

Mineral Resources apply when you are able to make an estimate of the quantity and quality of the deposit that you have - in seabed nodule terms, the abundance and the grade. Inferred Resources is the least confident estimate, and then moving to Indicated Resources and then to Measured Resources, which is the most confident estimate. You can see there is a vertical axis in Figure 1 that relates to geological confidence and knowledge. It is usually on the basis of increasing information. As you get more information you are able to make more confident estimates of quantities and qualities. It is important to note that Inferred Resources – the uncertainty that surrounds Inferred Resources is such that it cannot be converted to Mineral Reserves. It needs to be upgraded first to at least the Indicated category before it can be converted to Mineral Reserves.

Mineral Resources must have reasonable prospects for eventual economic extraction. Eventual in this situation – there is guidance in the IRT for the word eventual. I think this is very important to seabed nodules. Eventual is explained in the IRT that it could be in the order of up to 50 years for bulk commodities like coal, iron etc. Obviously seabed nodules were not contemplated at that time. When you are looking at eventual economic extraction, you are looking at a reasonable time frame; you are not just looking at what might be extractable in the next year or two. That is where you get into the Reserve - it is what is extractable under the conditions that apply today or immediately in the future.

The Measured, Indicated and Inferred Resource categories – the words are not necessarily the best. If we had our time again in developing something like the IRT, we would not necessarily use the words, particularly Measured and Proved as they tend to imply 100% certainty; and they are not. They are subject to uncertainty. There is no international agreement as to what the uncertainty might be, but in general it can be said that Measured or Proved is probably somewhere between 5% and 15%; Indicated and Probable perhaps anywhere in the order of 10% to 25%. You can see there is still uncertainty in the estimation.

The Indicated and Inferred Resource boundary – that is the most important separation in the CRIRSCO system because it dictates what can be converted to Mineral Reserves. Inferred Resources cannot be converted to Reserves; indicated Resources can. The Indicated to Measured Resource boundary can be an important one depending on how you are looking to finance your project. Some banks require you to have a certain percentage of your Reserve in a Proved category, but that is related to your finance. The critical separation is between Inferred Resources and Indicated Resources.

Modifying Factors



The Mineral Resource categories relate purely to the information you have and the confidence you have in the estimate of the quantity and grade. In order to convert Mineral Resources to Mineral Reserves you must consider a number of what are called modifying factors.

The modifying factors are indicated on the slide [indicating slide] and are: Mining, Processing, Metallurgical, Economic, Marketing, Legal, Environmental, Social, Infrastructure and Governmental. It is important to see that they include social, environmental, governmental and all the “non-technical” issues that would normally be taken into account. Some of these also apply

to Resources, although they may not be specifically stated there; but because of the principle that there must be reasonable prospects for eventual economic extraction, if for example, you found a deposit that sits under a national park in a particular country, and the government has decided that it will not allow mining in the national park, then you cannot classify your estimate as a Mineral Resource. It doesn't matter how well you know it, it doesn't have reasonable prospects for economical extraction.

Mineral Reserve

A Mineral Reserve is the economically mineable part of a Measured or Indicated Resource. It includes dilution and losses. The simplest way I think of a Mineral Reserve is, if you have a treatment plant as part of your process, it is what you intend to feed to the treatment plant. The quality and quantity of the material you intend to feed to that plant. Whatever dilution you are going to incur on the way to doing that and whatever you might lose on the way to doing that, they have to be taken into account.

It is now becoming accepted in all the CRIRSCO countries that, in order to convert a Mineral Resource to a Mineral Reserve, you must have undertaken a study that is at least a prefeasibility study. That is defined in the IRT and describes the type of work you have to do in order to convert a Mineral Resource to a Mineral Reserve.

The Measured category of Resources, if it satisfies the modifying factors, can be converted to Proven Reserves. You can actually convert Measured Resources to Probable Reserves in situations where one or more of the modifying factors has significantly increased the level of uncertainty in the estimate from where it was at the Measured Resource stage. Again, remember that these categories relate to the confidence in the estimation of the quantity and quality. Indicated Resources can only be converted to Probable Reserves, not directly to Proved Reserves.

Going back to what Caitlyn was saying in her speech yesterday about the early stages of these classifications schemes – basically the proven / probable / possible reserves which are still referenced in the ISA – it is only in the early 1990s that most of CRIRSCO countries did away with the category of Possible Reserves. It did exist up until that time, but it was decided that it really didn't make sense to have an economic equivalent to the category of Inferred Resource, which has a high degree of uncertainty attached to it. So that category was removed – it no longer exists in any of the CRIRSCO standards.

Competent Person

Competent Persons have to be a member or fellow of a professional body or professional association with an enforceable code of ethics. This is so that, if Competent Persons acts in a way that is not consistent with their responsibilities or in a way that is illegal or outside the normal standards of industry practice, they can be brought to account. They can be made to explain their actions in front of the professional body. The body can, if necessary, discipline them by imposing a fine or by suspending their licences to operate. They must have at least five years of relevant experience in the commodity and situation they are reporting on. The relevant experience issue will be an interesting discussion with respect to seabed nodules, but I think it can be resolved.

Competency, that is whether or not you are a Competent Person, is largely a self-declaration. In other words, I can say that in my opinion I am a Competent Person for seabed nodules. I would not say that because I am not, but I can say with confidence that I am a Competent Person for reporting on gold deposits. Some countries do not like the idea that a Competent Person declares whether or not he or she qualifies as a Competent Person. Those countries maintain registers of Competent or Qualified Persons. There are challenges with the register system as well, but it depends really on the culture of the country which system you adopt. The disciplinary system of the Competent Person is important.

Reasons for success of CRIRSCO-style reporting standards

Simplicity is absolutely paramount when you are reporting to potential investors. They will not lend their money to you if they do not understand what they are being told. What we found is that the two-dimensional presentation of the CRIRSCO definitions is a simple one – three dimensions like the UNFC is too complex for investors. Because there are only five Resource / Reserve categories in the CRIRSCO system, it is simple to explain, simple to understand. The IRT and the similar standards avoid as much possible overly prescriptive requirements. That is part of what makes them applicable to a wide range of deposit types, and potentially to seabed nodules.

These standards all have regulatory backing, in other words the stock exchanges also accept them. All these standards were drawn up by the minerals industry in each country. I think that is very important. It means that they are friendly to the industry and to the processes and practices that mining companies actually go through. They are not standards that the government or the regulatory body has imposed on the industry that don't relate in some way to the practicality of what we do in the industry. The commitment to ongoing improvements and communication is critical as well.

Each of the standards is updated every few years. The JORC code was updated in 2012; CIM in 2013; the SAMREC code I believe is being updated next year. They are kept current and, because they are all members of this umbrella organization and they cooperate with each other, there is a degree of leap-frogging that happens. If for example, the SAMREC code comes out and it has some improvements in it, next time the JORC code is revised, it will look at the SAMREC code and will include the improvements. Usually the latest of the standards is the best of them. That is where the IRT encapsulates the best of them as well.

Special clauses in International Reporting Template

I am getting to where the IRT can easily be applied to seabed nodules. I am highlighting here the fact that, although the IRT and all the reporting standards it is based on are kept very generic so they can be applied to a wide range of situations, there are some commodities or deposit types that require special clauses. The IRT has those clauses. They cover coal, diamonds and industrial minerals. I will not go through the details of what the special clauses are, but they can be summarized as being mainly related to terminology, deposit characteristics and market-related issues.

In some cases there is a terminology that has traditionally been accepted, and which does not cause problems in reporting to stock exchanges. For example, the coal industry uses a category called marketable coal. It is very well recognized by the coal industry and coal investors. It would not make sense for a reporting standard to disallow that style of reporting because you do not want to make it more difficult for investors to understand what they are being told – otherwise they will take their money elsewhere.

The characteristics of deposits might be an issue that needs special clauses – diamonds for example. There are certain issues with diamonds that are a bit different to most other deposit types. Seabed nodules fall to some degree into this category.

For some commodities, market-related issues can be very important – in particular coal and industrial minerals. For these, ensuring that you have a secure market into which to sell your product is a key issue.

Some potentially “special” aspects of polymetallic seabed nodules

I have listed here from my reading what the special issues relating to seabed nodules include:

- Seafloor topography, particularly for Reserve estimation
- Estimation of quantity (abundance) is more challenging than estimation of quality
- Some of the techniques that are currently in use, such as photography and FFG sampling, are known to underestimate abundance
- Quality assurance / quality control (QA/QC) issues, which are very important in assuring the quality of the data that is used in Resource and Reserve estimates, particularly when we are dealing with seabed nodule data that goes back 30 years
- Competent Person experience
- How to judge reasonable prospects for eventual economic extraction. I think that is the key issue to be discussed here. I know there has been discussion about mining and processing, and challenges in those areas. As I understand it, none of the proposed mining methods has yet been proven on a full commercial scale operation. With processing, you may have successful bench scale tests, but what is your confidence in the scaling up of those bench tests to a commercial level? Note that, with respect to reporting Resources as opposed to Reserves, the uncertainties of how exactly you would extract and process the minerals are not as critical as for Reserves, as long as you have reasonable expectations of eventual economic extraction.
- Different legal and tenure situation.

There may be special environmental conditions.

Application of International Reporting Template to polymetallic seabed nodules

Although extensive discussion is required with all the interest groups, which includes all the groups represented here, the extension of the IRT to cover seabed nodules would, I believe, be relatively straightforward. It is recommended that it be done. CRIRSCO is very willing, if it is asked, to coordinate and manage that activity, together with experienced representatives in their particular areas.

A suggested take-away from this workshop is to appoint that sub-committee or group. Its charge would be to produce recommendations on the extension of the IRT to polymetallic seabed nodules. In my presentation on best practices, I will suggest that a second component of the charter of that group could be to develop best practice guidelines to cover seabed nodules. That is a bigger job, but it has been accomplished for other commodity types.

Summary of Discussions

A participant wanted to know if an area of 75,000 sq.km sampled by free fall grabs (FFG) within 10% accuracy in abundance and in grade, could be considered as measured?

Mr. Stephenson said that there were several aspects that could be taken into account when classifying. For example the quality of data that underpins the estimate was very important. One could not, for example, have detailed drilling in a particular area and estimate on that basis within 5%-10% in your own judgment. The more intense sampling data generally was, the higher the category of the resource.

Another participant noted that the CRIRSCO was a good system, simple to use and accepted by security exchanges worldwide. All the mining companies in the world used the CRIRSCO system. However, in case of seabed minerals, there was a problem. All the categories defined by CRIRSCO are active. Resources and reserves should be active. Resources have potential economic variability; reserves have present variability. One could not guarantee the resources would be active to mean that we should have exploration or mining activities as UNFC has in its categories.

A participant noted that the boundary between inferred and indicated resources were critical and asked if there were any regulations in the CRIRSCO standards for that?

Dr. Stephenson said that this called for long discussions, however, it did rely on the judgment of a person based on experience, which may differ from person to person. This was one of the things that concerned people about the 'Competent Person' system. There is sufficient guidelines in the template and in good practice the guidelines that exist are pretty confident that there should not be major differences of opinion between experienced CPs but it is certainly not a black and white issue. There are no sharp boundaries, it is a judgment call.

A person wanted to know whether there were registers in some States to bring out the qualifications of a competent person and how the registers worked?

Mr. Stephenson replied that countries like Chile, Indonesia, and perhaps Russia, have such registers although he personally did not know how these worked. However, the main challenge (which may not apply to nodules), for the register would be to have to specify the type of deposit, situation and the activity. There are registers so it's being made to work, but he was not sure how effectively they worked. To go back to the application of seabed nodules, Mr. Stephenson said were in an area where people talk about one specific deposit type with variations on the theme, but basically about nodules on the sea floor. He said there was an opportunity, to have some role for the ISA, perhaps in recognizing the people who have the appropriate experience and skills, in order to be recognized as a qualified person. This was an opportunity where a register of some sort with recognition, could actually be made to work.

On the question of whether some societies had special categories for professionals and if all organizations had that in the SME, Mr. Stephenson said in Europe, one of the professionals may have that. The reason that was brought in, to be was because the SME was not structured as an organization that could discipline its members. For an organization to meet the requirements, it must have the ability to bring its members to account. All the organizations that are recognized within the CRIRSCO group of companies already have that mechanism in place. For seabed nodules, the matter of being a member of an appropriate professional organization that has that capability is also important and that organization should be asked to verify. It could also discipline the person if they were to be in breach. In the past a whole lot of organizations have been added to the list without anybody ever going over and saying would you actually discipline persons in that situation. Some don't even know they were on the list, so obviously that doesn't work. But it could be made to work.

A participant asked which persons were in a position to judge the technological readiness for proven technology and whether the mining technology is proven or still probable in the state and in the petition of CRIRSCO and who was in charge of such technological judgment. Mr. Stephenson replied that that it all comes back to the competent person who is dominating, for example the competent person for reporting on mineral resources would probably not be the competent person who is responsible for recording the mineral reserves. The reporting of mineral reserves usually involved several competent

persons or qualified persons, with each taking responsibility for an area of its particular importance. He said not every single aspect of the estimation of reserves was subject to a competent person but that critical ones usually were. The simple mining technology in this case could be one and processing another. He said he couldn't really answer the question but he thought it was one that needed to be discussed at the workshop. He continued that in order to convert a resource to reserve, one had to go through at least a prefeasibility study, that sets out the guidelines as to what was expected to be done which would then need to be taken into account when forming a view as to what degree mining recovery technology would need to be proved in order to allow it to be reported as reserve. He said he thought that was one of the questions that definitely needed to be resolved or addressed.

Another expert added to the above that a lot of the definitions around reserves and resources in terms of technology is now based on the principle that are generally accepted generic principles and generally accepted practices. We don't have any generally accepted practices here, so what you really need is a group like, I think the ISA, or a group or deep sea mining industry need, that's why you need the guidelines to see that assessments are being made consistently. The competent person really only needs interpreting the guidance, that is being given consistently. One concern I have about why I think guidance is important here, let's make sure that we are being consistent here, if we were to relax the principles behind reasonable expectations that something is going to happen for this commodity, this type of process for acquisition of a commodity would be consistent with other commodities that the company has, it's a risk of having a portfolio without balance.

Mr. Stephenson agreed with the above statement and further added that it is a general guideline that eventually might mean up to fifty years, in my experience; is generally not in terms of that way in most cases. In retrospect that is probably a guideline that could have been written a bit more tightly because it does leave quite a bit of scope for almost abuse of the guideline, but my experience has been that so far I haven't seen any abuse, not deliberately anyway.

CHAPTER 8: The ‘competent person’ in mine-site evaluation and responsibilities for study design, management and findings

Matthew Nimmo, Principal Geologist, Golder Associates, Australia

Mr. Nimmo said that the CRIRSCO template describes the ‘Competent Person’ (CP) as having three primary principles - transparency, materiality and competency. Being transparent is about providing clean, concise and accurate information that did not mislead the investor and that was clearly understood by the reader. Methods of sampling and procedures detailed, lab assays and repeats, storage, maintenance, verification and security of the data in the public report subscribed to transparency. Materiality meant that all relevant information in the report that a reader expects, like QA/QC to be there. The competency is where the CP comes to work. CP would be minerals industry professional with experience in the mineralization type being addressed and who follows a code of ethics. The CP’s role is to try and help extract the value out of the deposit, identify gaps in information and/or data and estimate it into a particular category to allow for economic assessments on that estimate.

For any project, a large number of competent people from project related aspects may be required, but there would be only one technical report containing all information related to the project. A competent person would need to visit the site, observe the sampling and verify the database recorded in the Assay certificates and, its suitability for mineral resource estimate and write it in the public report. A CP needed to understand all aspects of the resource estimate, the risks involved, the parameters that could affect the estimates, and the assumptions applied to it. In the public report, the reasons for prospects for economic extractions must also be stated. The CP has to build trust by performing the estimates using the best practices. In the end it is CP, not the company, who is legally responsible at the sign off the report.

Pat actually covered a lot of what I was actually intending on saying so I’m actually going to try and change my talk up a little. I’ll use the same slides but I’ll speak a little bit differently and just speak more from experience and try to talk about some examples of what I had to do as a competent person. The term competent person, competent - I think I’m competent, I hope I’m competent, and a person – I’m obviously a person, I think I am, I might have looked twice in the mirror. But the term Competent Person actually has a rather strict term in context with the code, loosely called code. When I mean the code, I’m talking more about the CRIRSCO template. NI43-101 and JORC 2012, they are the two codes that I’m actually familiar with. I’ve been spending pretty much the last two decades doing resource estimation under those two codes. I’m fairly familiar with what a Competent Person is supposed to be and supposed to do.

The CRIRSCO code, as Pat quite nicely alluded to has three primary principles. The first principle being **transparency**. Now what does transparency actually mean? From the competent person’s perspective, that’s about providing enough information so that the person reading the document can understand what you’re talking about. Being clear, clean and concise with what you’re talking about. Be balanced. What I’m talking about here is providing information that is



both good and bad. If you're talking about exploration results you don't want to exclude the bad situation where you've gone out on your boat and you've dropped a few box cores over and they fail to pick up nodules. You explain that in your report. That's balanced reporting. Because you don't want to give the perception that everything is rosy, everything is good. Because you face them and "look, like wow, fantastic, we got this deposit that is perfect" when in fact it might actually not be. You need to be unambiguous, that is, not trying to mean something else than what you are actually saying. So you want to be clear about that, you want to say exactly what you mean and be clear about it. I mentioned clear quite a few times; being clear, concise and accurate, not misleading. So you don't want to be talking about something like the red herring that has absolutely nothing to do with resource estimation and yet you spend most of your time talking about it, misleading the investor along a path that doesn't make any sense, that doesn't matter. So don't mislead the investor in your public report.



The next principal is **materiality**. This is probably another important principle, and one that sometimes gets a little bit misunderstood. It means all relevant information that the third party reading the report can understand the report and expect what they expect to be in the report.

In the industry there are certain things that go into a report that investors look for. If you don't include that information, such as a description of the geology or a description of the method you used for collecting your

samples or what you have done about QAQC. If you don't include that then you are not following the principle of materiality. You are leaving out points that should be there, that the investor expects. It's about judgement and sometimes that judgement can be very, very, very difficult to do. You can look at something and go is this material? I don't know. If you are asking yourself and telling yourself and you are not sure about whether it's material or not then put it in. It's not "if in doubt leave it out". It's more "if in doubt put it in".

It's about transparency as well. If you are not sure about it put it in. State it, unless for instance, if an item happens to be for trade secrets. There are some, particularly under the NI43101, that lays out if you have trade secrets then you don't necessarily have to provide all the details. You just have to be transparent enough to allow the investor to understand where you are coming from and what you are doing; how you are reporting your resources and reserves. You have got to include it or think about how it is going to affect the public. If I include this material or not include this material in the report how is it going to affect the perceptions of the third party? How are they going to read and understand the report? If you leave something out they may actually get the wrong impression about what the Mineral Resource is about.

A certain value; this is probably one of the biggest parts of materiality. I'll give you an example. If company X has say 50 resources and they are reporting resources for one of those deposits and they are talking about an assumption of a particular parameter that is used in estimation of resources and if it is out by a certain percentage, it could mean that they've got no resource or they have a resource. So we're talking about a binary selection of 100% resource or 0% resource. That company, let's say a percentage change is 100% and they in turn could save a million dollars. That company has 50 deposits

each worth several hundred million dollars and total value of let's just say a billion dollars. So if their resource is 100% wrong, it doesn't matter to the company, it's not material to the company. Now if another company, say company Y, has that same resource and that's the only resource they have then in this instance, it is extremely material because it means if that it is right they have a resource, if it's wrong they can be in serious trouble financially. So materiality is not just about information that gets used in the resource (estimate), it's also about what the company has, the materiality of the company. So you've got to think about those aspects as well, and although it's not described in the code, it's sort of more or less implicit, when we do work.



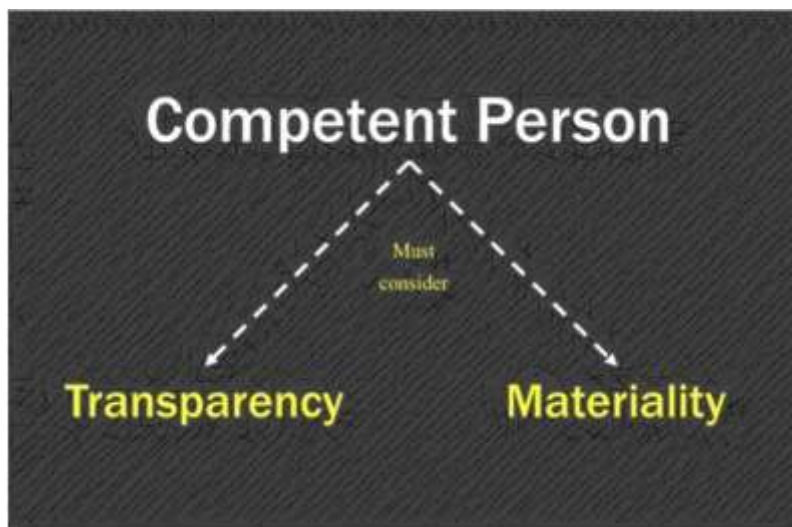
The third is **competency** or **competence**. And this is where the Competent Person actually comes into work, and this is a very, very important aspect to the code. Without the Competent Person basically the code would not work. The Competent Person has to be qualified and qualified is a relative term, and it's related to the role of the Competent Person. So for instance, for me I'm a Competent Person. I think I am; I hope I am. But I'm a Competent Person in relation to Mineral Resource estimation that is. I'm qualified to do Mineral Resource estimates.

I'm a qualified geologist. I've been working in the minerals industry for nearly two decades. I've been doing resource estimates for nearly as long as that and I've gained that experience. But am I qualified to be acting as a qualified person for say the Mineral Reserves? I can't; because I'm not qualified. I don't have a mining engineering background. But I might actually be able to do the mining aspects. I might be able to do scheduling or something like that, but it doesn't mean that I can sign off on that. I might be able to do the work but I am not the Competent Person to be supervising that work and signing off on it. It doesn't stop me from doing the work, but I would need somebody else's help.

Experience; it comes down to the experience, and as Pat said, you do need 5 years. I've got another slide that covers that. Experience is an important aspect of competence because without experience, you don't know what you're actually doing. You might have gone and listened in to a lecture and found out "oh I have to do a resource estimation – I can do that"; being told that it is easy to model a resource for instance, kriging is a good way to go, but without the experience of actually applying that, you don't realize what could actually go wrong. So you could apply it and get it woefully wrong so that's where the experience comes into it.

Membership. That's also a very, very important aspect of it (the code). Without membership (of a recognized professional organization) you're not a Competent Person. Membership is basically, you have to be a member of any of the registered professional organizations listed, by say the British Columbia Securities Commission or the ISA. They have maintained a list of all the organizations which if you are a member of one of those, then you can qualify as a Competent Person or Qualified Person, it doesn't mean that you will or are. But it means that the chances of you becoming a Competent Person is much higher. And for instance, for me, I'm a member of the Australian Institute of Geoscientists (AIG). That's on the list of both the ASX and also the NI43-101, in fact it is also listed for the same CRIRSCO templates and probably a couple other codes as well. The reason why AIG is on a lot of the listings is because of the membership requirements. To actually become a member of the AIG, you actually have

to have 5 years industry experience before you can even be a member. Now a lot of other organizations don't require that, in fact, like the AusIMM (Australian Institute of Mining and Metallurgy) recently got knocked off the list for the NI43101 (as a member). In fact they bumped the membership grade to fellow. Principally, because the membership requirements to get into the AusIMM is less than the AIG. You don't need 5 years' experience. In the AIG you also need two people to vet your CV. They actually need to know you, need to work with you and also be members of the AIG. This means that the Competent Person, if he were part of the AIG, then you know that they've got 5 years' experience. You know that they are qualified to be and act as a Competent Person, because of the membership requirements for that organization. It's not necessarily the case for all of them (registered professional organizations), I can't speak for some of the others that are listed. But when we were doing the TOML (Tonga Offshore Mining Ltd) technical report, I needed two others competent persons to sign off on the aspects of exploration, because I wasn't competent enough to sign off on that. I needed a couple of prominent people to bridge that gap and in order to bridge that gap we brought in two others: Charles Morgan and Davey Banning. They had a wealth of experience in exploration, in nodule geology. They knew what went on, they knew about sampling, they could actually bring that to the table, but they didn't have membership (of a registered professional organization) and so we had to actually help them to get that membership, and they got it through the AIG but it was a difficult process. So it's not easy, but it can be done. The membership also comes with a code of ethics. So when you become a member, you've actually got to abide by that code of ethics. It's quite a long list so I couldn't tell all of what that code of ethics is about. Generally its behaving appropriately and professionally and not to actually try and mislead or do fraudulent activity; and if you did that, then you'd be ejected out of the AIG or whatever other organization you're in and as a result you wouldn't actually be able to work in the industry again. And as I alluded to before, there can be more than one competent person and in general there is usually more than one Competent Person. The only time that you have just one (CP) is early on in the exploration phase where you might have a Mineral Resource but that Competent Person can also sign off on the data. It doesn't always happen and in a lot of the cases what we do is we get a Competent Person from the company to act as CP, to sign off on the exploration of data. They sign-off on the exploration data aspect; as the Competent Person they have often dealt with it (data). We come along and do the resource estimates but we also do the checks and balances on that data. We are not going to necessarily take them, the Competent Person from the company's word for it.



The **Competent Person** must take into consideration transparency and materiality; that's a very important triangle there - they're the three main principles of the code. The Competent Person should always keep in mind: am I being transparent? Am I including everything that's material to this estimate in the public report? Am I being clear and concise? These are things that you should consistently keep thinking about, you can never get away from these principles.

So who is a Competent Person? Here I am, I'm one at least. I've been a Competent Person for iron ore, for nickel, for copper, for gold and now nodules. I'm a Competent Person for Mineral Resource

estimation, not for the mining side and not for exploration but at least I've got quite a few commodities that I can sign off on.

Who is a Competent Person?

A Competent Person is a minerals industry professional...

... with a recognized Professional Organisation and appropriate membership class...

A Competent Person must have

A minimum of 5 years relevant experience

In style of mineralisation or type of deposit

And activity which the person is undertaking

Appropriate membership and class of a Professional Organisation

Appropriate qualification (Geology, Mining Engineering, Metallurgy,)

I'll just go through the actual meaning of a Competent Person as listed in the (CRIRSCO) framework, the code that Pat briefly touched on. The Competent Person is a minerals industry professional, that is, somebody who actually works in the profession. It's not a scientist. It's not a geochemist that works in the library. It's somebody who works in the mining industry

It's somebody who has that recognized professional organization, they're a member, as I alluded to, and that's really important. If you don't have that you are not a Competent Person. Usually the various regulations (stock exchanges and government) that are backed by the various CRIRSCO Code and NI43101 have their own lists of organizations of which you should be a member. If you are not a member of any of those on that list, you are not a Competent Person or a Qualified Person who can actually sign off on the resources for that jurisdiction. Case in point, Charles and Davy were members of a professional organization but that organization was not listed in the Canadian system, so they couldn't actually act as a CP for that organization, so they had to go somewhere else.

A Competent Person must have five years' experience. You can't have 2 years, 3 years or 4 years and 6 months. It has to be at least 5 years, and that experience is in the role or in the type of mineralization that you're addressing. Although this can be a little bit flexible. The code sort of allows you to cross your experience from one commodity to another as long as the type of deposit you did in one, like gold, is

similar to for instance working in copper. So you've got to be able to compare and make sure that that experience is very similar to what you're trying to act as a Competent Person in. The main point is actually the activity in which you are performing your role, as I said before, you want to be a Competent person in say you've chosen Mineral Resource estimation, you need to have the experience in Mineral

Resource estimation. You can't try to do Mineral Resource estimation if all you have is 5 years in exploration; it doesn't work. The more important aspect is actually the 5 years' experience in the activity under which you are actually acting as CP. So if you do Mineral Resource estimation, 5 years' experience in Mineral Resource estimation. If you are on the exploration side of it, it's 5 years in exploration data. In the same way, if you're doing environmental, it's 5 years environmental, legal and so on; again, appropriate membership and appropriate qualifications. So you might know how to do Mineral Resource estimation but you're not a geologist so you are not familiar with interpretation, the sampling and statistical and variographic analysis for instance, but you might have experience in actually performing that (Mineral Resource estimation) but you're not qualified and that's not necessarily stated in the code, or generally considered a requirement. You don't get a geologist to do Mineral Reserves. You don't get a mining engineer to do Mineral Resources. You don't get an environmental scientist to do exploration for instance. You get the right qualified person for the right job.



And before I go on I want to just mention that the Competent Person is not your enemy. It's somebody there to try and help you extract the value out of your deposit. They are there to try and get the deposit estimated into a particular category hopefully Indicated (Mineral Resource), preferably sometimes Measured (Mineral Resource), so that allows you to perform economic assessments on that estimate. So we are there to help, we are there to guide you, we are there to identify gaps in your information or in your data.

I'll tell you all straight up now that no one here probably would probably have Indicated Mineral Resources unless they have the appropriate QAQC. That's the one major problem that I had when I was trying to estimate resources for TOML.

I got the data; looked at it; it had no QAQC, what were the samples done what was the method? Box core or free form grabs? No idea. Location information, on the certainty of locations – no idea How were the locations measured? No idea, and so on and so on. There was so little information on the data that I really struggled to even get to Inferred (Mineral Resource). The problem was the data did not have the back-up information (metadata). And I stress it to everyone here, make sure that you collect that information and record it please because it really does make a big difference to whether a CP like myself will come in and say "no you don't actually have a resource, you can't get it any further (apply a Mineral Resource category) because that data is just numbers, there's nothing backing it up". And that's a very important aspect for resource estimation. Without that (metadata) I can't help you. All I can do is come in and say "ok, we like this information what can we do to verify this data? And I struggled with this for TOML. I thought about this question for a very long time. This was an issue that bugged me for weeks and it was something I knew there was a solution to and I made sure I just kept thinking about it and working at how can I get around the fact that I don't have the data, I don't have that information.

The way I took it was basically, I looked at the CCZ as one deposit not each individual country's area as individual deposits. I treated the whole CCZ as one deposit. That makes a big difference in how I verify the data. Because then I could actually take the data and split it up into all the different contractors and

there were at least 6 or 7 data sets there for each individual contractor. I knew or assumed that they used different collecting methods, different assaying and sampling methods. So I took that and thought well, OK, I can utilize that assumption and then compare all of the data, split it up and compare it with each other. What that allows you to do is basically treat it like twin data. You know you can actually compare different data sets and give the indication of the accuracy of it (data). Luckily a lot of the results were very similar; the distributions were remarkably similar, the variance of the assays is very low which gave me confidence that the data was suitable for the purpose (of Mineral Resource estimation). It was something I had to argue with the regulators who had a few issues on that. They sort of thought OK, you don't actually have a resource, but we thought, now hang on, we do because we can compare these data sets. So even though you might not have the information there are ways of going about verifying the data and making sure that you can get a resource estimate.

So that's what as a competent person, we do. We do that all the time, we try to think about, OK, what are we missing? What do we need? How do we actually get around what we're missing? Maintaining the integrity and transparency, between the materiality and doing the estimate to best practice. And it is not always easy, it can actually take some time to actually figure out.



But the question I'll ask all of you is: Are you a competent person? So think hard about that, can you act as a Competent Person? What role could you be acting as a Competent Person? What would you need to do to become a Competent Person? Is all I actually need to do is go and join an organization as a member? Go and find somebody who actually is (a member of an appropriate registered organization) and start the process so you can become a Competent Person?

For a project there are a whole swag of different roles that a Competent Person can take on, there's legal, environmental, social, mining, geology, exploration, marketing, metallurgy, process engineering, engineering design, and probably a few others. So there is probably a large number of Competent People that are required for a project. In the NI43101, which to some degree is not too bad because it describes a particular technical document and that technical document has sections for each area which would be regarded as necessary, you would have the legal, environmental, marketing and so on. And in generating the first report generally what you do is you fill in the geology, the introduction (reliance on other experts, property description, accessibility and climate, history, deposit type, exploration, drilling, preparation analyses and security, data verification), maybe a mineral resource and then there's only one technical report. That technical report keeps getting updated as you actually get more information. So then, if you do have a Mineral Reserve, that mineral Reserve goes into the section for Mineral Reserves and you update the technical report so you only have one technical report. All the information relating to your project is in one report and you keep updating it. And sometimes you feel like you are repeating yourself and putting the same information out but you're required to, the technical report needs to stand on its own. You take the original one and you just add in an extra section and you re-issue and so on. So if you do a preliminary economic assessment, after you've done the resource

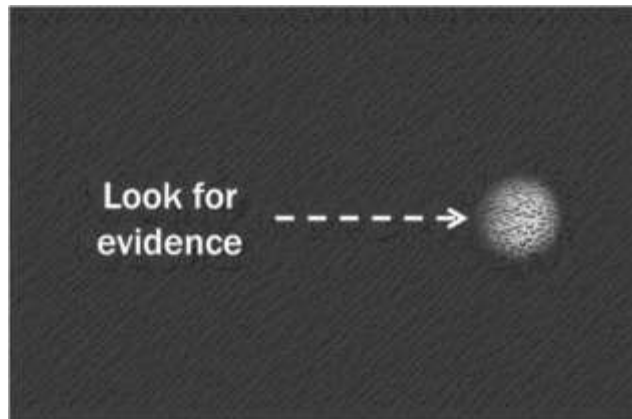
estimate and you fill in those sections on metallurgy, processing, mining engineering scheduling and so on.

In a fairly general basis, it's basically a self- assessment, it's up to you to decide if you are the Competent Person. No one else can decide for you. You can ask your regulator; I've actually done this. They'll send a letter back saying it's up to you, simple as that. You make that choice and it's not an easy choice. It's a choice that takes time.

In the case of the TOML; I was sitting there and I asked do you want to do this resource estimate for nodules? I thought about that for quite a while because I had actually been involved in deep sea estimates in the Solwara project. I was familiar with the nodule and I was familiar with the deep sea project and so I had to think, OK, what aspects of being a Competent Person is related to this project? I'm qualified, I've got 5 years' experience minimum (in Mineral Resource estimation), a lot more than that in resource estimation, I've got experience in the commodities nickel, copper, cobalt. What I didn't have was direct experience in the deposit. That was the hard part, to bridge the gap. And one way to get past that is actually to have other competent people come on board, and as I said, Davy Banning and Charles Morgan, they helped with me understanding what was required, what went on, how the deposit was sampled, the geology of the deposit, the differences, the similarities and so on, what issues I needed to be aware of when I'm estimating the resource. They proved to be quite valuable so they helped me bridge that gap. So the thing is if you're not quite there with being a Competent Person you ask the same question. Can I get somebody else that can help bridge that gap? Maybe there's someone that can, that may help you but you've got to try, you've got to look for that. If you find somebody, fantastic, you can go forward. Now bear in mind that even though you made that self- assessment, it's up to the peers to keep you honest, not that they will necessarily call you out but they can and sometimes they do. So you need to be aware of that even though you say "oh I'm a Competent Person" you have got to be aware of "OK do my peers think that I'm a Competent Person?" So in the case of the TOML CCZ, I actually went around and asked my peers in Golder. I asked "do you think I've got sufficient experience to cover this? And the answer was yes and in a lot of cases these people that have got a lot more experience than I have and have been in the industry for more than three decades, thirty odd years. I asked 2, 3, 4 people the same question, do you think I'm a Competent Person for this role, for this deposit. They looked at me; OK yeah you've got the commodity experience, but you do not have the direct deposit experience but you do have experience in bulk commodities, I did with the iron ore and the nickel laterite and bauxite. So we utilized that as well to help bridge that gap. You've just got to think about what's needed and how I can actually bridge that gap.

A competent person needs to visit the site. This is a very, very important aspect of it (the code) and it's one actually that almost stopped us (Golder) from issuing the technical report for TOML. The site visit, it was a very, very difficult aspect to cover for the NI43-101. NI43101 requires that you have to have visited the site. They used to actually specify a six month period that you had to visit the site within six months. But luckily they dropped that requirement just as we were reporting the technical report. So they had actually taken that out, which is to our benefit. So what we actually did was got somebody that had been to that site but twenty-five years ago. It didn't matter (how long ago it was) because it (the code) didn't actually specify anymore the time frame. We actually put some qualifying words around why we thought that the site visit was still relevant because we knew that the geological process was so slow and long and it hardly ever changed. Basically if you go to the site what you are going to do is see that, the ocean or the sea. There is not much actually to see when you do go to visit the site. So the site visit here, we thought, well even if I go to the site am I actually going to see anything worth seeing? And the answer in this case – probably not. The site visit, even though it's a pre-requisite for

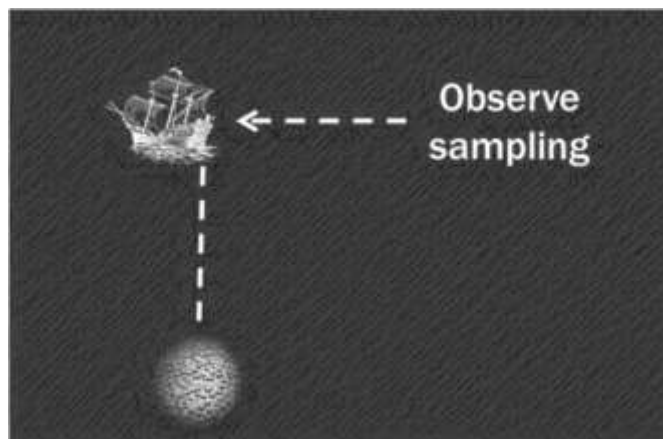
NI43-101, is actually not a requisite for JORC but on the basis of if not why not. If you didn't do it you have to explain why you didn't do it. But the site visit doesn't necessarily mean that you are actually going to get anything out of it. Because for nodules rather than terrestrial based deposits, on site there is not much to see, what you do normally is you look for the evidence of mineralization or in this case evidence of nodules.



If you go out into the ocean in a little boat what you are going to do is see water, endless expanse of water, you are not going to see any evidence of nodules unless you get into a deep submersible and travel like 5km down to the bottom of the ocean. I don't think anyone is going to do that. I think there's only one person who has actually travelled down to that depth and there is probably only one sub that can do that. Looking for evidence of nodules from a site visit perspective is actually difficult so what you actually need to do is be on the boat when they are sampling the nodules and in the case of TOML,

they hadn't had that plan for years and the cost of crews as you are well aware is pretty expensive. You don't want to just set up a cruise just to get a Competent Person out there to see it. So the site visit, even though it is prescribed on the NI43-101 as a requisite it is very difficult to actually comply with that. We struggled for quite some time to actually comply with it even though we knew that sending me out

on a little boat was going to prove nothing.



Observe sampling. The other aspect of the site visit basically is observing the sampling. So really you want to actually have that site visit when you are going out there on a cruise sampling. And in this instance it's actually very important to consider getting a Competent Person early on in your exploration phase, even before you even consider doing the resource estimate because it could really help the site visit. It means that the Competent Person has already been to the site, has already observed the sampling, is familiar with that sampling and can sign off on that sampling.

Verify data ... check 5-10% of the data

Rec	Ni	Cu	Abundance
34	1.21	1.04	6.4
115	1.05	1.33	9.8
233	1.16	0.98	12.5

Database

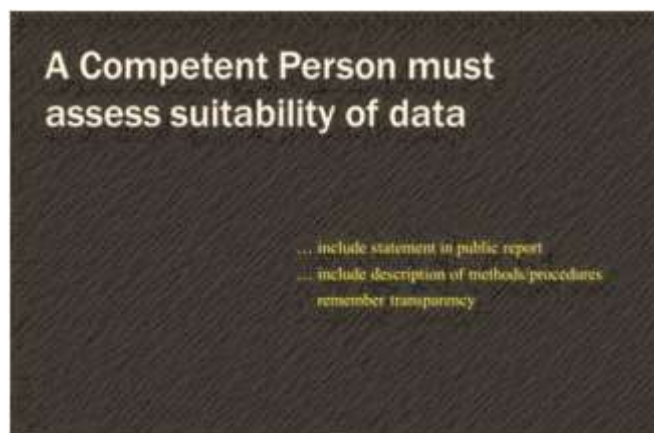
≠

Rec	Ni	Cu	Abundance
34	1.21	1.04	6.4
115	1.33	1.05	9.8
233	1.16	0.98	12.5

Assay certificates

Verify data. The other aspect of going to site is... I tend to do it a few times, I don't enjoy doing it, but verifying the data. It's a rather thankless, tedious, boring task, that if you are lucky you give it to somebody else. But it is an essential part of it (Mineral Resource estimation). Normally most commercial based deposits had their data (stored) on site. When you go to visit the site you actually go and check the data. You go into their data room and have a look at; well you check 5-10% of the

data. It is to verify that what you've got in the data base is actually what has been recorded in the assay certificates, the physical records of the sampling. So for instance you check through the data; you just basically randomly pick various records. I've got just a couple of examples (on slide), just me randomly typing in some numbers as an example. You check that database against the assay certificates and whether they are equal or not. In this case I intentionally made sure they were not equal, so basically we identify how many errors were in the data base. If you get one or two, that you found erroneous out of thousands that you've checked then the data base is fairly good. In one instance I went to a project site for a copper deposit and I was checking the data and that data had actually been audited by another consultancy before. So you think maybe this data should be pretty good. Don't assume because it wasn't. When I started checking through the data I realized that the copper was switched with the gold and so what was in the data base was gold for copper and copper for gold. And I also found other instances where in the data bases recorded as parts per million mixed in with percentages, so all the magnitude out. Sometimes, generally what we do is we scan through the data base, pick the outlines with the worst data, the most extreme data, because we assume that probably they are wrong, and then go and check them against the physicals (assay certificates). In the case of the TOML where we didn't actually have any of that (no original assay certificates) we had absolutely no idea what the error rate was. So please keep hold of that sort of information as well, because it is very important from the Competent Person's perspective to verify that data and you need to actually state in the public report that you have verified that data. How much of a percentage of that data base have you gone through and checked?



A competent person must assess suitability of data. At every stage a competent person must assess suitability of the data. This is critical, in fact in the NI43-101 you actually have to state the suitability of it (data). You have to do that. You have to say at the end of the section for verification of data for instance this data has been verified and is suitable for purposes of Mineral Resource estimation or the other is no the data is not suitable and we can't use it. We were almost at that point with the TOML (technical) report. We were almost at that point where "no we can't use it because we can't verify". In which case it would have been out. We would have had to put in a statement that this data is not suitable for the purpose. But we worked out other ways to verify (the data). So you have to include it in your public report. You have to include descriptions of the methods of the sampling and procedures and always, always remember transparency.

Data. The next aspect from a Competent Person's perspective is the data. That's the most important part of a Mineral Resource estimate. This is what goes into the estimate;

what you are basing your estimate on. You have to check the quality assurance, quality control information, and again I'll harp on this till the cows come home basically you need that (QAQC)

information and you need the quality control and it's a little bit different than normal scientific practices. You might take a few samples and check samples but a quality control quality assurance data for resource estimations is what the minerals industry expects and is quite substantial. We expect check samples, we expect field duplicates, we expect lab assay repeats and so on. We expect blank assay standards, we expect normal standards going in to check the veracity of the data. If you don't have that, please start doing it now because you need to have that data verified by a Competent Person.

You need to describe your methods of how you collect that data, how you crush the nodule and how you measure moisture. The weight of the nodule, how you even calibrate your machine that you use to weigh the nodules. You need to describe the assaying methods, the lab, how it was crushed at the lab, the actual method the lab used, what was the procedures the lab used to control quality and so on. You need to describe your procedures, field procedures, that's how we do the sampling. In the storage of the data you need to understand that even though you collect the data it can actually become useless if you don't store it correctly. Storing it in an excel spread sheet is insufficient because the columns can be switched and parts of the spread sheet can be sorted independent of each other and you lose confidence in the data. So storing in an access data base for instance is one starting point. You'd also need to consider maintenance of the data, who looks after it? Who protects it? Who manages it? The verification of data as I've expressed before and security (data), security in the NI43-101 is actually a very big issue. You need to understand and document, how the sample passes from the boat to the lab and every step in between. You have to understand who can access those samples. Limiting the number of people having access to those samples improves security. It's all about fraudulent activity, some people can come along and actually swap the sample. They can do that in gold, copper, it can happen and has happened and that's the reason why the NI43-101 has come along and said we need to know the security procedures. How do you actually protect the samples between when you collect it and when you assay it?

**A Competent Person must
adhere to the Code and
Government regulations**

A competent person must adhere to the code and Government regulations. A competent person has to follow the code, as part of the code, cause it's written in the code, you have to follow the code, you have to follow and go through table one of the CRIRSCO template.

The competent person in the case of mineral resources supervises or estimates mineral resources. The Competent person doesn't actually have to perform the estimate they just have to be there to supervise that estimate.

Sometimes the company might estimate the results but we can come in and do an audit, check the results, check the data check everything and then sign off on it (the Mineral Resource estimate).

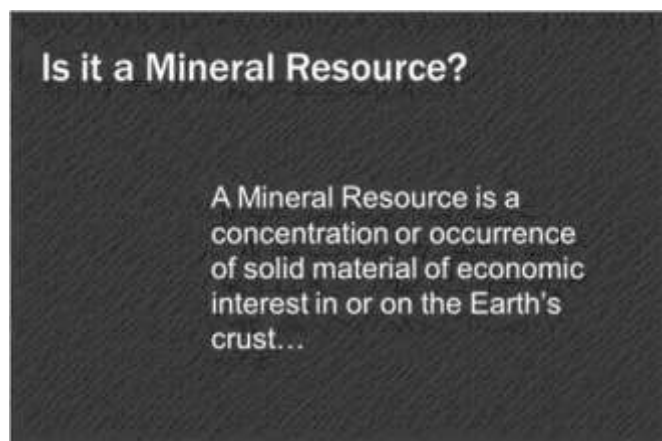


A competent person classifies mineral resources and ore reserves. A competent person classifies mineral resources and ore reserves. The company doesn't do that. The company representative doesn't do that. It's the Competent Person; it's the decision of the Competent Person; it's solely up to the Competent Person to make that choice. A lot of the times the company will try to say we want Indicated (Mineral Resource). The Competent Person will push back and say "no, you just got Inferred (Mineral Resource)".

Because, at the end of the day it is the

Competent Person who takes responsibility for that Mineral Resource estimate, not the company. It's the Competent Person; the person who is signing off on it (the Mineral Resource) and so you have to actually take that responsibility seriously because it is a legal responsibility. Because not only can you get kicked out of your membership but you could also get taken to court; you could also find yourself in jail.

Classification in this case, is Inferred (on slide). During the classification (of Mineral Resources); actually it's not an easy process; it can actually take quite a long time. It takes sometimes longer than the actual estimation process. The reason for that is you've actually got to understand all aspects of that estimate. The risk involved. What parameters can change and how those parameters can affect the estimates. The assumptions that you have applied to it, whether the confidence on those assumptions is adequate for a particular estimate. You need to take into consideration modifying factors; you need to also not report everything (no lower reporting cut-off value). This is a distinction, you're not reporting everything. Say for instance you have a deposit and some of that deposit is categorized as an environmental reserve; no chance ever of being able to mine it. You can't report it, you might want to but you can't unfortunately.

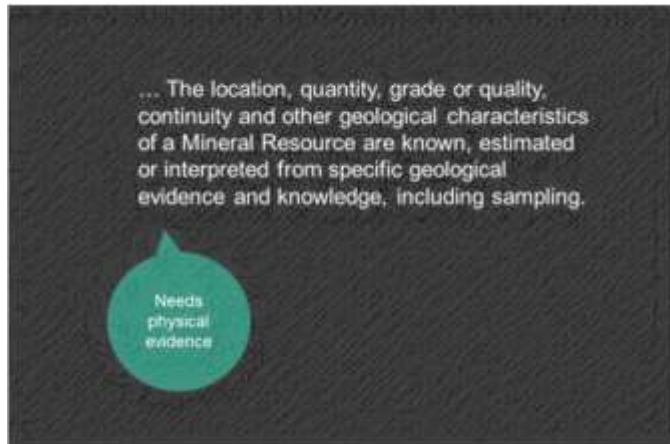


Is it a Mineral Resource? So that comes to the term is it a Mineral Reserve? The first choice in classifying it is, OK, have I actually got an Mineral Resource as defined by the code?

Bearing in mind that as a Competent Person we have to follow the code, whether it is JORC 2012 or NI43-101, we still have to follow the code and also the regulations wrapped around that code. Let us say, the ASX listing rule on public reporting of Mineral Resources requires us to following the JORC code. A Mineral Resource is a concentration of material of economic interest. So in a sense of course

most deposits fall into that category.

The next part of the description "in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction", and that Pat pointed out, it's that eventual economic extraction you actually have to take into consideration before you classify as a Mineral Resources. If you



know for instance with gold and it's refractory and you know that there is no way you are going to get the gold out then you can't classify it as a resource. You don't have a resource even though you might have fantastic gold grade. Can't get it out forget it. The same with nodules. Know you've got rare earths in there and you know absolutely, unequivocally that the processing to get the rare earths out is not there yet and probably never will be then again you can't classify this as a resource. Again this is the responsibility of the Competent Person, not the company.

The CP makes that choice, and it must be stated in the public report. There must be a statement in there saying why the Competent Person believes there is reasonable prospects for economic extractions for these reasons, A, B, C, D.

Also you have to understand the location of the estimate is known, estimated or interpreted from specific geological evidence, you can't make it up. You can't say "oh we've got a couple of resources sitting on the moon". It has to be done from physical evidence, nodule samples, and I don't know whether video actually falls under physical evidence or not at this moment. Because maybe the regulators might accept it or not. Because video and remote sensing methods detect nodule percent coverage and then from there you actually go to then determine nodule abundance. It's not a direct sampling of nodule abundance so it's not necessarily physical evidence. Yes there's nodules there but as it relates to abundance, maybe not, we are actually using a formula to derive that, it's not necessarily sampling.



So when you come to classifying the resource there's a number of aspects you've got to consider. First geology; continuity of mineralization, the dimensions. Basically, we know the CCZ is actually massive so the dimensions are not an issue. The (geological) domains, in the case of the TOML, we considered the CCZ as one domain, one massive, big domain. Domaining for resource estimation is a little bit different to domaining from the scientific perspective we're only interested in domains of continuity of grade and tons.

You have three different facies and all have the same grade, it's one (grade) domain.

Continuity; this is the aspect that the regulators had nearly had heart attack about. They struggled with the consistent 20 kilometer spacing. It is a very long way in respect to mineral resources; 20k is a lot. A lot can happen in 20km so the regulators had real trouble with that. We actually had to explain to them that yes in relation to the size and dimensions of the deposits it's actually not a lot (distance).

Data; we've also got to consider the data. As I mentioned, QAQC quality and verification security and so on of the data. You have also got to consider the modeling techniques, how we actually did our

estimates, we must state the technique. The code doesn't prescribe how we do the estimates. It's up to us, the CP; we make that choice. We can choose whether we use multiple indicator kriging, ordinary kriging, inverse distance, nearest neighbor and so on or we can just take the average.

We have to determine relative accuracy in the estimate, recently that has started to become more of a bigger component. In the NI43-101 there's a much stronger requirement than under JORC 2012. But it

is basically stating how accurate you think that estimate is. Generally, that usually means you have to perform conditional simulations to understand the relative accuracy. We also have to describe the method of course being transparent you've got to describe how you've actually come to your conclusion and also all those modifying factors and there's quite a lot of them. I've mentioned a few of those: mining, processing, metallurgy, environmental, legal, marketing, social, government and so on.

The Competent Person needs to actually understand each of those modifying factors, they don't have to be competent in each of them. They just need to understand whether there's environmental regulations that could kill the project. They have to understand the governmental situation, whether the government is going to say no, we haven't got the resource. You have to understand that even though you are not competent you've still got to take that into account.

A competent person compiles a technical report. You must consider table one of the code and it's an "if not why not" process. So you have to start there, if not why not? Transparency, materiality; it is always there, can't get away from it. Transparency, materiality; keep saying that to yourself.

Statements, Competent Person's statements. There's quite a few of those, I've got examples. First the sign off.

Basically you have to put your signature to your resource (estimate), to the technical report and on the NI43-101. You've actually got to sign the report and submit it to SEDAR (for reporting under NI43-101).



The sign-off

Competent Persons Name
Membership
Date

Sign Here

Competent Persons Statement in Public Reports

An example

This Mineral Resource estimate is based upon and accurately reflects data compiled or supervised by Mr Matthew Nimmo, Principal Geologist, who is a member of the Australian Institute of Geoscientists and a full time employee of Golder Associates Pty Ltd. Mr Nimmo has sufficient experience that is relevant to the style of mineralisation and the type of deposit under consideration and to the activity which he has undertaken to qualify as a Competent Person as defined in the 2004 edition of the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves, and as a Qualified Person under NI43-101.

The competent person's statement. You could actually grab the TOML technical report and see the example of a statement made by the Competent Person. Basically, they say (statement) I'm a Competent Person, I'm a member of the AIG, and I have sufficient experience to be qualified as a Competent Person. You have to make that statement.



And the consent; a company can't actually release the information without the consent of the Competent Person. Basically you can find examples of that (consents) in the TOML report. Basically these consents; normally they are provided for every public release and they are not provided necessarily with the (public) documents. But every time they, TOML, releases a statement on resources they have to get me to sign off on it.

Role of the competent person. I'll just run through this quickly just to sum up. Follow the code; consider transparency and materiality, compile the technical report, assess suitability of the data at every stage, consider every modifying factor and observe (collection of data and site visit). The Competent Person actually has to observe the collection of the data, the sampling and so on and even at times we go to the assay lab to observe the lab preparing the assays. So it's actually a really good idea to get a Competent Person on board early on so that they can actually observe those things. They have also got to consider risks, all risks and sometimes you don't necessarily



identify all of them. It's hard to identify all of them. Sometimes after you've done the resource estimate that's when you go "arr..", there's another risk there, it's not material but it's another risk.

Gap analysis; this is somewhere where you might not have a resource but I can come along and go, OK,

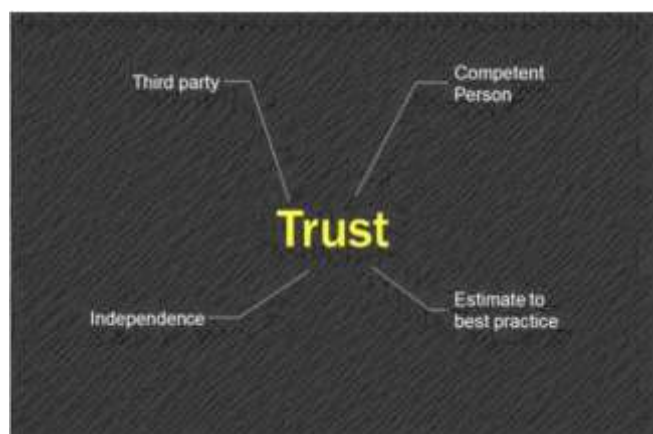


what do you need to get to a resource? How many samples, samples spacing? Are you missing QAQC? What do you need? I can help with that? A Competent Person generally does that as part of the resource classification and estimation. I will have an understanding of what is missing, I'll go "you got Inferred (Mineral Resource) but from what you've indicated this is what you need to do".

Responsibilities of the competent person. Resource estimate; you sign off on it, take responsibility for it. Technical report; you sign

off on it, take responsibility for it and for all the content that is in that technical report. Public statements; you sign off on it, take responsibility for that as well. Membership; you've got to make sure your membership is up to date, so it's your responsibility, no one else tells you that you need to maintain membership.

And consider the "If not why not" principle. So basically when you are compiling the technical report you've got to go "well ok, I don't have this so why not?" You have to describe why not; I haven't gone to the site, haven't done a site visit why not? Why have I not gone?



Trust; the final word of the day and this is probably the reason we've done this. I can trust this estimate. The Competent Person is actually the one that gives this and the trust also comes from performing the estimates following best practices.

Independence; the CRIRSCO Code doesn't actually state that the CP needs to be independent. But is actually, the industry these days is actually going towards more competent people are independent. It builds trust. If you

have a Competent Person signing off on the resources, part of a company, how do you know that the Competent Person is actually acting independent of the company and acting in the role of a Competent Person? He may be controlled by or dictated to by their employers saying "we want Indicated (Mineral Resource), you give us Indicated (Mineral Resource)" you've got no choice. But being independent a consultant can come along and say "no, you can't get Indicated (Mineral Resource)".

Summary of Discussions

A participant noted how important it was to get a competent person onboard, who could be like GOD to the project. He said the only thing needed was to do as much upfront work related with data etc. as possible to help the CP do the job.

Another participant wanted to know (i) at what stage of the project the competent person should be brought in and (ii) which organization or association could certify an expert as competent person. Mr. Nimmo replied by giving ISA's example as a starting point, which was; take the list given by the Toronto Stock Exchange, the NI43101, because it was fairly comprehensive and has gone through the process of looking at each of the organizations. The ISA would then need to accept that list and ratify the fact that the list has been used, so that if the Canadian system changed, so does the list. That was one way.

Another was to use the CP essentially as a guide, who could help in the transition from an exploration phase to getting a resource inferred, resource indicated and possibly measured. The case of deep sea nodules mining, might be extremely difficult to get to measure, as there were multiple requirements, but it was always a good idea to at least nominate a lead CP to get involved with the project early on, so they understood the processes, and observe from onboard the ship, generally, just slightly before doing the resource estimates.

CHAPTER 9: Best Practices - General and Specific Guidelines from CRIRSCO and its Member Organizations

Pat Stephenson, past Co-chair, CRIRSCO (2005/06), director, AMC Mining Consultant, Vancouver, Canada

Mr. Stephenson presented a paper by Deborah McCombe about best practices in two categories – (i) estimation, classification and monitoring of Mineral Resources and Mineral Reserves, and (ii) public reporting of exploration results and Mineral Resources / Reserves.

He said that the first is achieved by: (a) the provision, in Table 1 of most mineral industry reporting codes / standards and the CRIRSCO International Reporting Template (IRT), of checklists of important criteria to take into account when estimating Mineral Resources / Reserves; (b) publishing separate Best Practice guidelines (Canada); (c) publishing monographs that provide up to date, peer reviewed technical papers on good practice (Australia); and (d) the general body of mineral industry publications in this area.

The second is achieved by publishing and keeping up to date each of the CRIRSCO member countries' mineral reporting codes / standards, and the CRIRSCO IRT. These provide a minimum standard for the public reporting of exploration results and Mineral Resources / Reserves, ensuring that public reports on these matters contain all the information that investors and their advisers would reasonably require for the purpose of making a balanced judgement regarding the results and estimates being reported. They are supported by mineral industry regulatory bodies in the CRIRSCO countries, and underpinned by the Competent / Qualified Person system. This commitment to best practice in the mineral industry has contributed substantially to the improved confidence that investors now have in the estimation and reporting of Mineral Resources / Reserves.

Introduction

In my first presentation, I outlined CRIRSCO, the IRT, UNFC those kinds of things. There is a whole wealth of industry knowledge, guidelines there to assist the Competent and the Qualified Persons. What I'm going to describe now is what is generally called best practices, I think it would be better to call them good practices, because it would be hard to say something is the best, but best practices is an accepted terminology. I'm presenting on behalf of Deborah McCombe, who is the past chair of CRIRSCO and who is in Mongolia with the rest of the CRIRSCO Executive. She prepared this presentation and sends her apologies for being unable to attend.

I'll talk about best practices in two categories. The first one essentially is what I spoke about already, which is best practices in public reporting. Now we're still at that apex or corner if you like of the UNFC, where we're talking about market-related reporting, i.e. the commercial end of the spectrum. Then I'm going to talk about best practice in estimation, classification and monitoring of Mineral Resource and Mineral Reserve estimates, because it is very important to recognize that the IRT, and the codes and standards that it's based on, are all to do with reporting, they do not govern estimation. The estimation of Resources and Reserves is the responsibility of the Competent or Qualified Person, as Matthew has just described. It's a very important distinction to remember. The IRT and the codes / standards do contain a lot of guidance for the Competent or Qualified Person, and there are other areas where this guidance is provided.

I'll then talk about Canada's and Australia's additional activities. They are the two main countries that have additional areas where they provide guidance to the Competent or Qualified Person. I'll end up with recommendations.

Note that although exploration results are also part of the IRT and of the codes and standards on which it is based, I'm concentrating here on Resources and Reserves.



The slide is titled "CRIRSCO Members and Potential Members". It features a table with two main columns: "Current Members" and "Potential New Members". The "Current Members" column lists: Australasia (JORC), Canada (NI 43-101, CIM), Chile (Certification Code), Europe & UK (PERC), Russia (NAEN), South Africa (SAMREC), and USA (SME). The "Potential New Members" column is divided into two sub-columns: "Argentina", "China", "Indonesia", "Mongolia", "Peru", "Philippines", and "Turkey" in the first sub-column; and "Scandinavia" and "Colombia" in the second sub-column. The slide also includes the CRIRSCO logo and the text "COMMITTEE FOR MINERAL RESERVES INTERNATIONAL REPORTING STANDARDS" and "ICMM".

Current Members	Potential New Members	
Australasia (JORC)	Argentina	Scandinavia
Canada (NI 43-101, CIM)	China	Colombia
Chile (Certification Code)	Indonesia	
Europe & UK (PERC)	Mongolia	
Russia (NAEN)	Peru	
South Africa (SAMREC)	Philippines	
USA (SME)	Turkey	

I won't go over the description of CRIRSCO again - I think we had enough of that in the first presentation. Again these are the current members, and as I mentioned, Mongolia has just been made a member. Some other countries by the way, the Philippines and perhaps Indonesia for example, do have a CRIRSCO-style reporting standard. It's just that, as I understand it, they haven't requested at this stage to become a member of CRIRSCO.

Best Practice in Public Reporting

Just to summarize from my first talk, best practices in public reporting are represented by each of the CRIRSCO-style reporting standards. The main purpose of those standards is to provide a minimum standard for public reporting of exploration results, Mineral Resources and Reserves – this is really a repetition of what Matthew has already said. They are underpinned by the Qualified or Competent Person system. I should also clarify that, when Matthew was talking about the public Technical Report and what is required under that, he was very specifically talking about the Canadian system. Australia doesn't have a public Technical Report system equivalent to the Canadian requirement. However, Australia introduced in 2012 a requirement to publicly report against Table 1 of the JORC Code, which I mentioned a moment ago, on an "if not, why not" principle. So even though we can talk about a Technical Report that's required to support public statements on Mineral Resource and Mineral Reserve estimates, it's not required in all the CRIRSCO countries - it can differ from country to country.

Best practices are also underpinned by Competent or Qualified Person system, which is based on concept of 'Responsibility with Accountability'.

Best Practice in Estimation; Classification and Monitoring of Resources and Reserves

Ok so going on to best practices in the estimation, classification and monitoring of Mineral Resources and Mineral Reserves, it's achieved really in four broad ways: (a) Table 1 of most mineral industry reporting codes / standards and the IRT (The CIM Definition Standards don't have a Table 1, because Canada has developed separate best practice guidelines); (b) publishing separate Best Practice guidelines (Canada); (c) publishing monographs that provide up to date, peer reviewed technical papers on best practice (Australia); and (d) the general body of mineral industry publications in this area.

Table 1 of Reporting Standards

Sampling Techniques and Data	Sampling Techniques Drilling techniques Drill Sample Recovery Logging
	Sub-sampling techniques sample preparation Quality of assay data & laboratory tests
	Verification of sampling and assaying Sample security Location of data points
	Data spacing and distribution Orientation of data in relation to geological structure
	Audits or reviews
Reporting of Exploration Results	Mineral tenement and land tenure status Exploration done by other parties Geology
	Drill information Data aggregation methods
	Relationship between mineralization widths and intercept lengths
	Diagrams Balanced reporting } Other substantive exploration data Further work
Estimation and Reporting of Mineral Resources	Data integrity Site visits Geological interpretation Dimensions
	Estimation and modelling techniques Moisture Cut-off parameters
	Mining factors or assumptions Metallurgical factors or assumptions
	Environmental factors or assumptions Bulk density Classification
	Audits or reviews Discussion of relative accuracy/confidence
Estimation and Reporting of Ore Reserves	Mineral Resource estimate for conversion to Ore Reserves Site visits Study status
	Cut-off parameters Mining factors or assumptions Metallurgical factors or assumptions
	Environmental Infrastructure Costs Revenue factors Market assessment
	Economic Social Classification Audits or reviews Other
Estimation and Reporting Diamonds and Other Gemstones	Indicator minerals source of diamonds Sample treatment Carat Sample grade
	Reporting of Exploration Results Grade estimation for reporting Resources/Reserves
	Value estimation Security and integrity Classification

I apologize for how crowded these next couple of slides are going to be but, in some ways I've left it like this to emphasize the point that Table 1 in these standards has a lot of guidance in it for the Competent or Qualified Person.

So this and the next slide summarize Table 1 of the IRT. It's sub-divided into five general categories: (1) Sampling Techniques and Data; (2) Reporting of Exploration Results; (3) Estimation and Reporting of Mineral Resources; (4) Estimation and Reporting of Mineral (or Ore) Reserves; and (5) Estimation and Reporting of Diamonds and other Gemstones.

And under each of these categories we then have a series of headings (I'm not going to go through all of these so don't worry). For example, we have sampling techniques, drilling techniques, drill sampling recovery, logging, sub-sampling techniques etc. all sitting under Sampling Techniques and Data. Each of these in the IRT has a series of bullet points that are essentially memory joggers or reminders of things you should consider when you are thinking about sampling techniques and data, things that are important to bear in mind. The IRT doesn't tell you exactly how to do any of this, but it tells you that

these are the aspects that are important, that you must take into account. The same idea applies to each of the other four categories. Each of these categories supports the following one as well. So when we consider the bullet points under Reporting of Exploration Results, we also have to consider the bullet points under Sampling Techniques and Data. So you can see that Table 1 contains a wealth of guidance information for the Competent or Qualified Person. However, how the Competent or Qualified Person acts on those guidance points, it's up to his or her judgement and experience.

Best Practice Guidelines

For the next two parts of this presentation, I'll be concentrating on Canada and Australia, because they are the two dominant reporting standards in the world on which the IRT is based. The JORC Code was the first one - it came out in 1989 as I said, so it has stood the test of time for 25 years. National Instrument (NI) 43-101, the first version came out in 1997/1998.

For those who know anything about mining history, there was a major scandal in the world called the Bre-X Busang scandal, I can see some nodding going on. That was incredible and it's worth reading about if you don't know anything about it. Just go on Google and look it up. Major scandal where the samples were salted with gold apparently by the geologists on the exploration site. It created a stock market phenomenon in Canada that resulted in share prices rocketing upwards. When it was found to all have been falsified, share prices rocketed downwards and people made a fortune or lost a fortune; apparently the Chief Geologist of Bre-X fell out of a helicopter and various other things happened.

Anyway that's a sideline, but it boosted the finalization of NI 43-101. It was given an imperative at that time, because if that sort of thing happens in the industry and you lose the confidence of the markets, it has huge impact as it did in this case. It took years for the mining markets to recover. Funding was just not available for mineral projects during that time. So NI 43-101 is a Canadian legal document, it encapsulates the CIM Definition Standards for Resources and Reserves, and Matthew has described it



pretty well. It is probably the toughest regime in the world, the Canadian regime. The regulators are not easy people to persuade, so the fact that Golder was able to persuade them is a testament to its work.

These are the best practice guidelines that the CIM has produced to support the CIM Definition Standards and NI 43-101.

NI 43-101 encourages Qualified Persons to comply with these guidelines. It doesn't insist, because they are guidelines, they are not mandatory, but they do contain a lot of very good advice on things you

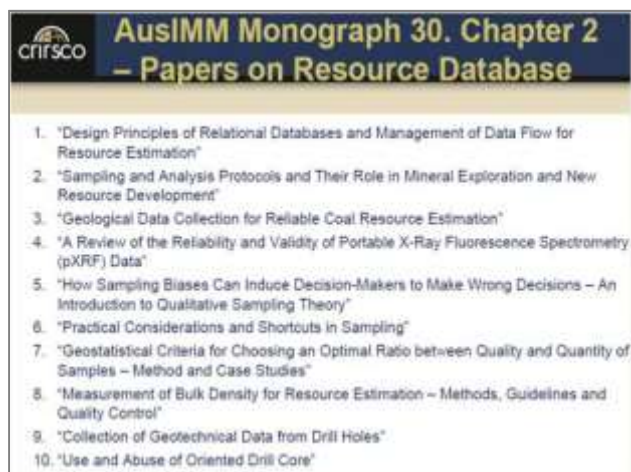
should consider. Again it's not a recipe book for how you do everything. It doesn't describe, for example, how you do geostatistical Resource estimates, it doesn't describe exactly how you might do sampling of gold deposits; but it does give you a lot of guidance as to the things that are important in those issues. This is where I think that eventually the ISA, or this body, could look at developing best practices guidelines for seabed nodules. The ones that CIM have are for Mineral Resource estimation,



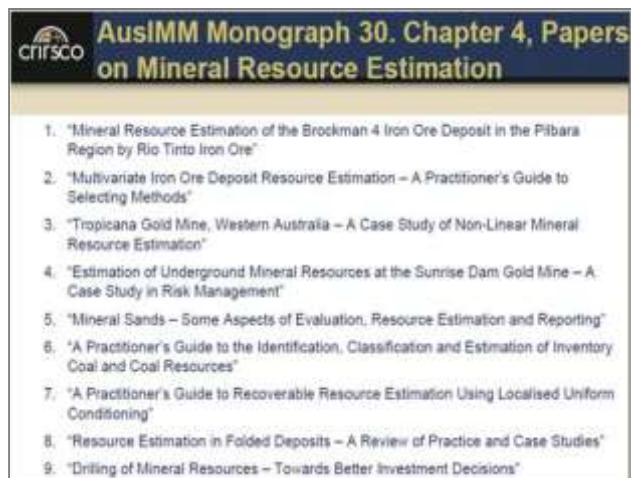
mineral exploration, mineral processing, etc., so the CIM has been very active in producing best practices guidelines.

The CIM is working right now on best practice guidelines for pre-feasibility studies and feasibility studies. I believe the drafts will be available by the end of this year. That could of particular interest I think, because the conversion from Resource to Reserve has to go through study under CRIRSCO standards that is at least at a pre -feasibility study level, so the more guidance that is available, the better for this group. In the USA the Society of Mining Engineers is in the process of preparing a best practices manual as well.

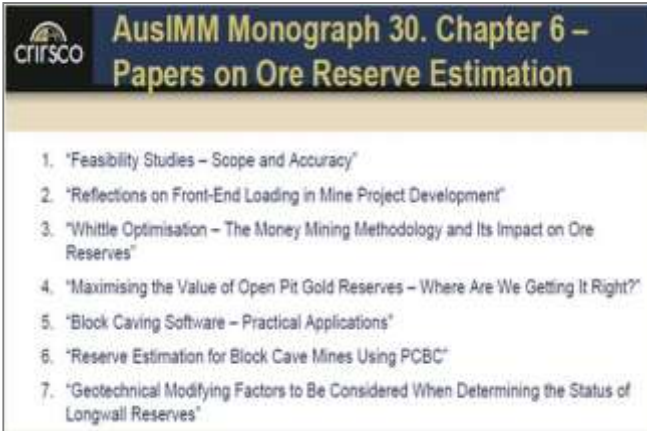
Good Practice Papers in Monographs



Another way of supporting best practice in the industry is to encourage industry production of monographs that comprise peer reviewed technical papers on good practice in Mineral Resource and Reserve estimation. That is the way that Australia has gone, instead of setting up separate best practice guidelines along Canadian lines. In Australia, mining professional societies have supported the publication of industry monographs by commissioning good practice technical papers from recognized experts in their fields.



Monograph 30 is the latest monograph that came out last year or earlier this year. The table of contents is shown on the left and, as you can see, it covers everything that we've been talking about here, that are important for the estimation, classification, monitoring and reporting of Resources and Reserves.



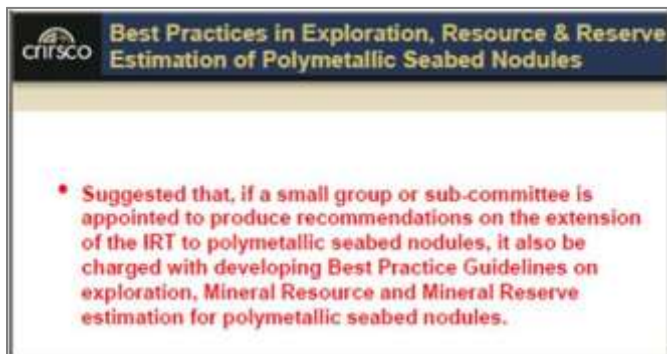
The top slide is a listing of the technical papers that are in that monograph. So just a quick look through, you can see that it's arranged into subjects that cover the different important technical areas. The idea is not to give everybody a recipe book for how you do everything, but to give some very good learning experiences from well recognized practitioners so that it adds to the wealth of knowledge that the Competent or Qualified Person can take into account. The next slide indicates papers on Resource estimation; and the third show papers on Reserve estimation.

When I was preparing these slides, one thing I noticed was that there are nine papers under Resources, seven under Reserves, and that there's a lot more words in the ones on Resources than in the ones on Reserves. I have to say, speaking as a geologist as well, that confirms what I've always known, geologists use far more words than engineers. I can't say whether it is a good thing or bad, it's just a fact.

Other Good Practice Activities

In Russia, the geology and mining practices integrate into the state expertise, I'm reading this verbatim because I didn't compile the slide. There are methodological documents on various types of mineral deposits that guide the estimation of Russian mineral deposits. Some other countries have similar approaches – for example, China, I understand. This type of specific guidance in a country's own system may sometimes almost dictate what you should do in certain situations to estimate the Resource and Reserves, and to explore. There is also a body of industry experience and technical papers that aren't necessarily part of the systems I've described, but that are available to everybody through various industry conferences and technical sessions workshops. Other activities that are undertaken or practiced around the world, include the encouragement in all countries for Competent or Qualified Persons to become proficient in their profession and in the skills they are seeking to acquire.

Summary



This is the wrap up slide for this presentation. What I'm suggesting is, if it's agreed that there should be a sub- committee or group appointed by the ISA out of this workshop, that the second part of its mandate should be preparation of best practice guidelines. Now I think that's not something that's going to be done quickly, it will require a lot of discussion including from experts in several different fields. I'm hoping that, as the discussions

continue in the next couple of days, it will become a bit clearer as to how that could be brought about.

In summary, I believe that extending the CRIRSCO IRT in the way that was described in my first talk, combined with preparation of best practice guidelines covering the estimation, classification and reporting of Resources and Reserves for seabed nodules, would provide the ISA with what it needs to go forward with the next phase of seabed mining, both in the Clarion Clipperton Zone and in other areas.

Summary of Discussions

A participant, citing India as an example, commented that in a government owned projects, all the upstream activities starting from exploration, mine planning, mine design, cost estimates, were done by an experienced consultant, and that was the basis for budget financing and approvals. A Registered Qualified Person approved the plan for the governmental managed project or a private set of projects. The same was true for the government run nodules project. In the government sector, the government is the shareholder.

Mr. Stephenson responded that it was a very good point to make, and emphasized once again that everything Mr. Matthew and he had discussed was in relation to the market related reporting, but they could and do exist side by side with government requirements.

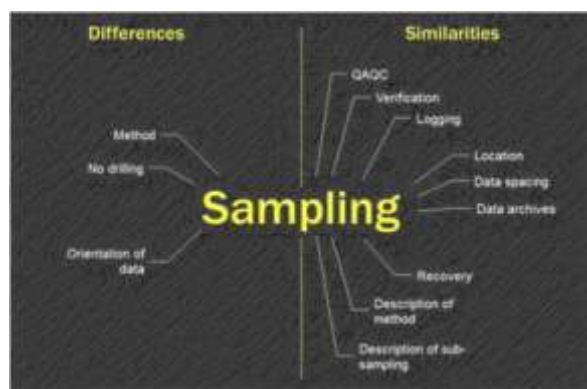
Another participant questioned whether CRIRSCO document could be modified for the Seabed Authority in regards to deep sea minerals, and how it could be done. Mr. Stephenson replied that he should never say something was easy, but identifying the areas which required some tweaking should not take too long. The drafting may take a bit longer, but the topics could be identified and the recommended wording for each would be the subjects of the clauses.

CHAPTER 10: Identification of Special Aspects of Polymetallic Nodule Deposits of the Area that Should be Addressed in Reporting Standards

Matthew Nimmo Principal Geologist, Golder Associates, Australia

Mr. Nimmo said that the CRIRSCO code or the NI43101 was more than adequate and the differences were not significant enough to warrant a new code. Going through Table 1 of the CRIRSCO template, he demonstrated that while there are differences they are not significant enough to warrant major changes and could be well accommodated within the code. He said TOML had paved the way through the Canadian system, so it was possible for anyone else to do the same.

The question of identifying aspects of polymetallic nodules being addressed in the code is a rather difficult process for me. I will probably divert quite a lot. And at the end of the day I say yes there are differences, but are those differences significant enough to warrant big changes or significant changes for a new code? In my opinion it is no. I don't think the differences are sufficient. I don't think the current code, the CRIRSCO code or the NI43101 is insufficient for the purpose (of reporting polymetallic nodules Mineral Resources). Reason being we have applied the NI43-101 code and we got it through the regulators (the Canadian stock exchange). It was a painful process but we managed to do it. So I think that the code as it is, is more than adequate. Although we may need some little tweaks here and there, and it is more from a wording perspective and I will go through that because Pat talked about Table 1. And I thought, well the best way to describe the differences is basically to go through Table 1 where I can show the differences and what is considered the same. This presentation is going to be fairly short because there is not a lot to actually say as I think the differences aren't significant.

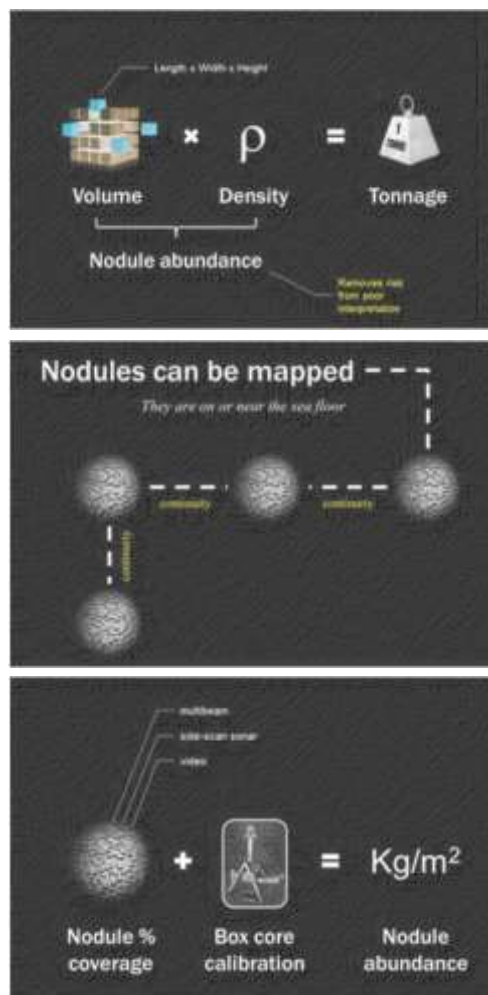


Sampling: This is part of *Table 1*. The method is a bit different so you won't really understand that you are not drilling and you are not obtaining individual samples where you need to go and interpret and use volumes. You actually get all that in your sample. You get the volume and density in the sample; the abundance. So the method is different, but is it different enough to warrant any changes to the code? I don't think so. In the code you describe the method, it doesn't matter how you sample it. Just describe it and so you still have to do that so there is

no difference there.

In the case for nodules *Table 1* describes drilling, we don't use drilling so I think maybe a little bit of wording change to that (is required). Instead of drilling we just mention that there's physical sampling. So just a little wording change. Description of the method as I mentioned goes under similarities (on slide) because we have to actually describe the method. Description of sub-sampling, the QAQC, we need that for every deposit that we do an estimate for. QAQC is a critical component that should not be overlooked, and if you're not collecting it then start collecting it. Verification of the sampling, that's the same regardless of the deposit type. Logging might be a bit different, you should actually be logging the shapes, size and description of the nodule as opposed to the lithology and alteration and mineralization.

But again, you just describe what you are logging so there is no real difference. Recovery method, although the amount of recovery, how many nodules you have recovered, and the sampling method; I haven't seen any information describing what that is. You can sort of get an idea of what it might be through point simulations but the sample recovery would be different for the free fall grabs to the box core. Your recovery of the samples is going to be different, you have nodules that you will lose and so you need to describe or discuss what (percent) you're losing. The location of the samples; we need to measure the location of the samples as accurate as we can. Data spacing; again is the same (regardless of deposit), we just basically describe what we've got, say for instance 20km spaced samples. The regulator might get really worried about that spacing but when you put it into context of the size of the deposit, it's not as big an issue, we still need to describe what spacing it is. Orientation of the Data; not relevant to this (nodules), so that's different (most terrestrial deposits require drilling which can intersect the deposit at different angles – the orientation of the drilling with respect to the mineralisation is important and determines the true width of the intersection). The data archives; how the data is stored, whether it's stored in the data base, how to secure it; that's the same irrespective of the deposit type.



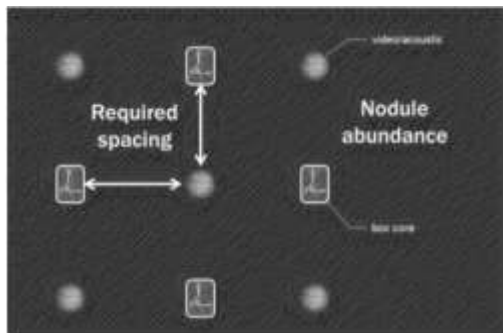
As you can see there is a lot more of the similarities than there is dissimilarities and the differences, they are just minor changes mainly to what is described in the Table 1.

Just a brief description on volume. For the typical (terrestrial) deposit we do (resource estimates for), samples are collected which we then do an interpretation of for volume. We then have to get samples to obtain density and that gives us tonnage. In the case of the nodules we get both (volume and density) in nodule abundance. So we don't actually have to worry about our interpretation of volumes, it comes explicit with the sampling. We have to worry about our interpretation of area. So there is a bit of difference there but does it actually make it significantly different to warrant that we would change the code? No, you just describe the method. As I said, it just removes the risk of interpretation but there are other risks to interpretation, not just volume.

The other big difference; nodules can be mapped. Pretty much 100% of the surface (sea floor); you can see them, you know that they're there and you can use remote sensing techniques, video, multimedia to map them. Obviously at different quality resolution than you would get from box core sampling but still they are used.

You can sample your nodules, take a video, and in between the sample locations that you might get box core, you might take some videos at the same locations. It's what happens in between (the sample locations), the continuity (of grade and abundance) in between samples. That's the same irrespective of the deposit. We always have to worry about what's between our sample points. In the case of the nodules we can actually define 100% what's going on between our sample points, using video, multibeam. The question is though, whether that sampling is regarded as physical

sampling because we are taking a representation of nodule, the nodule coverage, and then we have to express that in terms of nodule abundance.



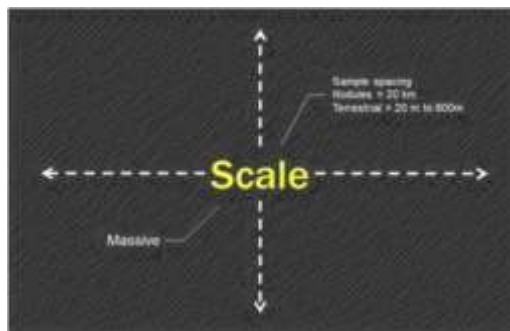
Nodule percent coverage; you can use multibeam or side scan sonar or video or even some other new technique we haven't yet developed. Add that with the box corers and get some sort of estimate of nodule abundance. And so we could probably use that to infill our box core samples.

So this is our grid with 20km spacing (on slide) for instance and infill those with abundance taken from video. The question is though, how can we utilize that information in resource estimation when this is not true physical sampling.

My feeling is possibly it can be used. We've had discussions with TOML (Tonga Offshore Mining Ltd) over this and we've considered the issue quite closely and I think it could be used as long as there are controls in place. Because it's open to fraud; you could easily manipulate the data without anyone actually knowing about it.

The controls in place, I would suggest maybe comes back to the Competent Person. Having an independent Competent Person present on the boat as you are doing the sampling to check-off (the sampling) to make sure that you are doing it correctly (that it is physically being undertaken at that location and not being substituted by false sampling) will overcome that. So I recommend that for the ISA. To say that, if you are going to use this recommendation, I suggest having an independent Competent Person. If you are going to do this we would like to see an independent Competent Person present on the boat as a control measure and then in that way you could overcome it easily.

I've also done a simulation exercise; my colleague has done a simulation exercise with my assistance, to identify and understand the level and spacing required to get to Indicated (Mineral Resource). Because that's the next step (Increasing a Mineral Resource from Inferred to Indicated Mineral Resource). The role of the Competent Person is to help guide them (company) to the next point (to the taking their resource to a higher resource classifications or to get it into a Mineral Resource to start with). What do we have to do to get Indicated (Mineral Resource)? We did some (conditional) simulations to figure out what that spacing is (for the TOML areas) and basically it comes down to requiring more samples points. If we can do anything to increase the confidence in the Mineral Resource estimate, we add additional samples although that cost of sampling can be quite high. So utilizing other techniques; video or multibeam to derive abundance will help to increase that confidence and increase the chances of getting to Indicated (Mineral Resource) because otherwise you may need significant amounts of sampling.



Scale; vertical and horizontal: It (the CCZ) is absolutely massive in terms of comparison with terrestrial deposits; there is no (terrestrial) deposit that would compare. The closest would be the iron ore and the nickel laterites, but you are dealing with at least a factor of 10 maybe 20 times larger (for the CCZ). By utilizing the scale, the dimensions of the deposit, the sample spacing is relative to the size. The regulators were very nervous about using 20 km of spacing. In the end we convinced them that it was adequate but it

took some time to get them comfortable with the scale. It is all about the scale. It is not just in the sampling it is also regards mining, also regarding the environmental.



Exploration Results: another section of Table 1. It is exactly the same say (for terrestrial deposits as for nodules).

Mineral rights, no difference. History, we did that (summarized the history of the CCZ exploration) in the technical report. It is a good way of acknowledging the past; the previous pioneers and giving them credit where credit is due. Describing the geology is no different although the deposit is different we still describe the geology. In fact I will go to a point; the nodule deposit is unique but so is the Witwatersrand (South Africa), so is

Telfer (a gold deposit in Western Australia). Yet what they have in common is the code that they were reported under. All three of those deposits are unique; there is nothing like it in the world. But it doesn't mean that they should have their own code because they are unique. The same with nodules. Yes they are unique, but they still fit under the code.

In Table 1 you have to describe the relationship between mineralization with intercepts; this is not relevant to nodules. So you can actually reword that or remove that section (or simply put not applicable due to...). Diagrams; you have to put diagrams in the report. The lawyers will go through the technical reports and check the diagrams. Balanced reporting; there is no difference there. Other exploration data; you might rely on video or multibeam. Further work; that is where the Competent Person will come in and say this is what we need to do to get to Inferred (Mineral Resource). That is a guidance to the contractor to know exactly what they need to do, what sampling spacing and so on, if there are issues to get it (the deposit) to Indicated (Mineral Resource), what needs to be done and what needs to be captured. The Competent Person helps you work that out. Obviously that is controlled by how much you are willing and able to spend as well.



Resource Estimation: the same approach in differences and similarities. On the similarities side we have... Database integrity; there is no way to get around that (just describe the integrity of the data you have). Geological interpretation; generally regardless of the deposit you can always interpret the domains. In the case of the nodules you have an approach where the whole area was one domain but that was Inferred (Mineral Resource). You can get away with that to some degree whereas going to Indicated (Mineral Resource) you have to go more into the

sub domains; so there is a little bit more interpretation if you have that information available. Some domains might only account for only 1% or 2% of the total area. In the case of an Inferred (Mineral) Resource it is not material. Dimensions; there is no difference. Estimation method; we can use industry standard methods that are applied. The industry is expecting you to apply the most common techniques such as ordinary kriging, which is a geostatistical method that is basically the best estimator. In the case of nodules the estimation method for grade; I have no issue, I can actually classify that as Indicated (Mineral Resource) but I have an issue with abundance. It is getting around that issue of abundance. How do we address abundance and how do we address that in the estimation method? I have put modeling method on a different side (on the slide) because it is a little bit different although it

isn't. It can actually go back to the similarities. At the end of the day in a technical report we just describe our modeling methodology. It doesn't matter how we do it; just describe it. There is no difference between the various deposits we just have to be open and transparent and present that information. In this case of modeling method it is basically two-dimensional. We don't do the typical interpretation for volume that we do for terrestrial deposits. We don't have to worry any more about density because density is factor into collecting the nodule abundance. In that case we need to understand more about how the weight of abundance is measured for QC (quality control).

The other difference is probably in the modeling aspect; is that we don't really apply domains because we consider the whole thing (deposit) as one domain. Although some will argue that there are different nodule facies; in the case of resource estimation there is only one grade domain. Moisture; we do need to describe moisture. It is one of those information that is lacking and hard to find. Bulk density; I put it on the side of differences because it is implicit in nodule abundance. Cut-off parameters; I see cut off parameters as different from typical terrestrial based deposits in the sense that normally when you are doing a resources on terrestrial based deposits you apply a cut off; being what you describe as waste from ore. In the case of nodules they are everywhere. What matters is the frequency in the nodules and changes and quite rapidly. So describing the domain in the sense of the cut-off, based on that, is nonsensical because it also comes back to how you are going to mine it. It might start off with the high nodule abundance zones and slowly work your way down to the lower (abundance) zones. The cut-off, in a sense, in the typical mining approach disappears. It is not the same you are not working with the fact that you are following an area because this is 6 km/m² where another one has 6.5 km/m². Mining and Metallurgy factors; just describe that so there is nothing different there. Classification; we still have the same classification schemes so we have to factor in risks, modifying factors and then the geology etc. Then the accuracy of the estimate.

There are still a lot more on the similarity side as there are on the differences and those that are on the differences they can actually be handled by the code. In that sense there are really no differences.



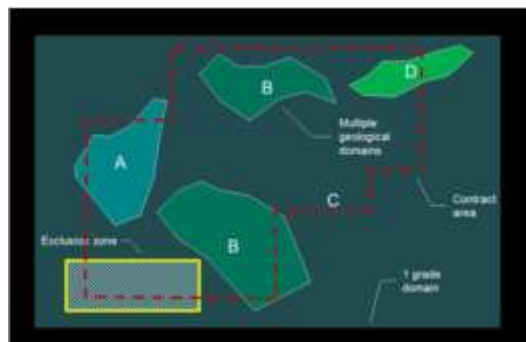
Domaining: We have geological domaining, that is the facies or any other interesting (geological) features that you might be interested in. You have the grade and statistical domains which you use in resource assessment; it can be similar, in most cases they are different. Also, you have metallurgical domains; this could be a factor of grades. In some areas you can have a higher cobalt, in other areas lower cobalt that may affect metallurgical recoveries (it may not be the low cobalt that affects recoveries but some other element that results in lower cobalt that does) or it may not

or we might have another area that is geochemically different (and results in different metallurgical behavior). In the case of terrestrial deposits you might have some geochemistry or other deleterious elements that you don't like (or want in the deposit that can significantly affect metallurgy). In the case of nodules it is probably not as critical (as there is unlikely to be any lithology or geochemistry that would impact on metallurgy).

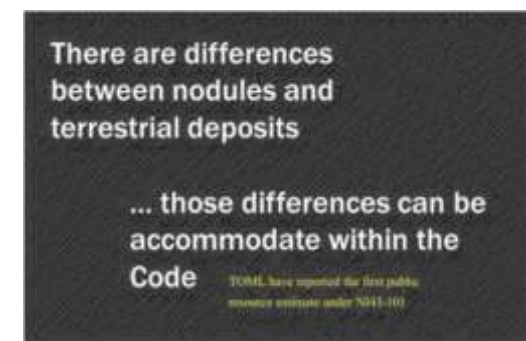
Environmental domains; they are mainly areas that are exclusion zones, they are areas that environmentally are buffer zones. As soon as you put a number there somebody is going to report it. I always exclude it from the resource estimate. License area; this might sound rather basic but it can be missed. When you produce a resource estimate you need to estimate only within your license area; it

becomes a domain essentially. Exclusion zones are another domain and they can be social. For instance you might have a shipping lane that is running in the area in which case you might consider that a no-go zone for a while until you have actually negotiated with the people who use that to access that area. It is not necessarily a complete exclusion of the resource but you might exclude it on the basis that you don't have access to it yet.

In terms of domaining I thought I would just throw out a picture to explain what I mean by it. You might have four different domains; multiple geological domains but one grade domain. From a resource estimation point of view where you just use a grade domain as opposed to the geological (domains),



although it is still built into the model. Then you have your license boundary, an exclusion zone. They become your domains.



As I said at the beginning there are differences between terrestrial deposits and nodules. I don't think those differences are significant enough to warrant any major change to the code. We have done it before (TOML technical report) so there is no reason why anybody else cannot. If you follow what we have done. In fact TOML paved the way through the Canadian system. We managed to some degree get them (the Canadian regulators) to accept and become comfortable with the aspects of nodules and so a second or third going through them, they would be more comfortable with. One of the questions from the regulator was "ok using your modeling method how do we know it is best practice in relation to the nodules"? We said we don't have a best practice (not yet) so we had to argue with them (using industry best practice for terrestrial deposits).

Summary of Discussions

A participant pointed out that for downstream activities, numerical values of densities may be needed. Mr. Matthew agreed that for knowledge of density, moisture was still an important factor for downstream processing.

Another comment made was that to determine nodule abundance, the bathymetric information was necessary. The nodules lying on the seamounts or the steeper slope areas, may not be possible for the mining system to negotiate, and these restrictive resource areas may not be accessible to mining technology for the next 50 years, but the information was important to identify such resources.

Mr. Matthew agreed and added that in the inferred perspective, the bathymetrical gradients where you know that you may not mine with current technology you may not necessarily exclude it but report it separately when you do decide to.

A participant asked why only industry experts could act as CP irrespective of whether he had gone to sea or seen a nodule, whereas an academic or exploration geologist who was at sea doing exploration work

couldn't. Mr. Nimmo replied that from a CP's perspective, you cannot have every aspect covered with the first estimate. You would need to rely on other experts, and utilize their expertise.

Mr. Matthew said that following the code there is a strict definition of what a CP actually is so if an expert had those requirement then they are CPs. If they don't have the requirements they may still be experts but they cannot sign off on the code.

Another expert expanded on Mr. Matthew's reply, adding that it was important to recognize the reasons for the CP concept. Under the CRIRSCO system, reports are made to the public and the potential investors, who hopefully would lend the money. There was a system where the experts have to make a lot of judgement calls and take responsibility. For that to work effectively there needed to be a way in which expert can be brought to account and/or disciplined, if the expert does something that is unacceptable. The competent person must belong to organizations that have the ability to discipline and who have agreed that they will. In theory, the experts that you are talking about could be competent persons if organizations they are members of, agree that they will discipline that person if s/he does not comply with the appropriate standards. The word CP was probably not a good one as it almost implies that someone is not competent. Usually you will see in a technical report, a table of the qualified persons who will take responsibility and then a list of experts who assisted them. Some of those experts may only be experts because they are not members of the professional body.

On the question of a contractor representing a sovereign state and whether a CP is needed, Mr. Nimmo was of the opinion that if it was internal reporting then a CP would not be needed. However, he said if it was to generate resources, then it would be advantageous to have the industry participate in the resources estimate and to try and get an industry player onboard. He said it was also very useful to have that estimate done to a particular code so that when that company comes along for an estimate we can actually answer. Otherwise if they are given a resource estimate without the code then they would have to turn around and assess the value themselves.

A participant questioned how a CP would be able to resolve a case of fraudulent abundance estimates. Mr. Nimmo said that it came down to the point that if the CP was not involved with the sampling and the CP was not comfortable with that sampling, the CP will not use it. Putting controls in place around it to prevent the likelihood of fraud occurring may increase the confidence that the CP could say it was useful. It doesn't necessarily say that fraudulent behavior will occur, it just means that it is possible. If a CP suspects tampering, you will have to state that the sampling was not secure. It can still be utilized but it would be reported as a risk. It is then up to the third party to make that decision. Mr. Nimmo added that if potential fraudulent activity was suspected, it should be stated. A CP had to be very careful and take the quality of the data, how, why and where it is collected seriously. The reason why the CP came into being was because there were a lot of fraudulent activities in the mining industry and it caused a lot of issues, so the regulators put some controls on it.

A participant noted that this kind of exploration was full of uncertainty, like patchy distribution and buried nodules and that a CP could not dictate terms to the exploration geologist. Another expert, Mr. Stephenson commented that everything Mr. Nimmo and he have been describing was to do with market-related reporting, where they report publicly to raise money from investors at a stage where there was huge potential for money to be won or lost in the stock market, because of fraudulent activities. He said 99% of industry professionals were honest people. Unfortunately it was the 1% that required rules of standards to be set in place to protect the public so that when a company goes to the stock market looking to raise money there were protections in place. Under the QP there is a person

who has taken personal responsibility for reliability of information. So it was not a matter of questioning the honesty or reliability of people who do the prior work, it was the report to the public protecting the public from potential fraud. Stock markets too have their own role in protecting the investors.

Mr. Parianos of TOML added to the above discussions by citing the example of how TOML had more than one person from the geology and legal background onboard to compliment the CP, to get maximum confidence.

One contractor expressed apprehension about adopting this methodology and hoped that if the CRIRSCO methodology was adopted by the ISA, some balance would be brought in by the experts.

CHAPTER 11: Identification of Any Issues Arising from Differences in National Reporting Standards to Which the Authority should Respond

Paul Kay, Manager, Offshore Minerals, Geosciences, Australia

Providing an example from Australia, Mr. Kay said that in the annual national inventory of Australia's mineral resources, information from the Australia Stock Exchange is used because the material is certified with the Australian code which has an absolute mapping transfer capacity with CRIRSCO and with UNFC. The national or jurisdictional inventory was about aggregating the resources of individual deposits by having a national inventory; a regular evaluation of resources would be available in the foreseeable future for mineral development. Individual deposits have inherent characteristics that need to be amalgamated and that once the assessment has been made on what an economically demonstrated resource is, one can then move toward reporting a number nationally. He said the issue was mapping to a universal template, harmonizing the various systems and working to compare and potentially amalgamate world inventories. He said that although CRIRSCO did not have as much granularity as UNFC, the two were interchangeable and could map from one to the other. Summarizing Australia's terrestrial experience, Mr. Kay said it provided background in terms of how the JORC, CRIRSCO, UNFC and other systems could be incorporated to make a national or jurisdictional inventory.

Identification of any issues arising from differences in national reporting standards to which the Authority should respond. So we are moving beyond what we talked about in the commercial context. Frankly, the talks today have been excellent – explaining the circumstances with the commercial and “competent person” requirements. I worked as a geologist for ten years in commercial polymetallic ore resource reporting, however, subsequent roles in government have not required certification, though I am a Fellow of the AusIMM. The competent person certification is a mechanism to allow for commercial resource reporting and the mitigation of commercial risk in project development.



Figure1: Slide with an airphoto of Geoscience Australia's facility in Canberra

I am here at the Workshop representing Geoscience Australia, an Australian Commonwealth Government organization. Geoscience Australia currently has about 600 employees, much smaller than comparable United States Geological Survey, but for Australia a significant organization. Figure 1 has an air photo of Geoscience Australia's facility in Canberra, the capital of Australia. The purpose built facility has geoscience laboratories and sample storage, providing a dedicated geological resource for the nation of Australia. I have recently taken on responsibility for Offshore Minerals at Geoscience Australia. The Commonwealth Government has an interest in industry engagement with offshore minerals in Australia. The International Seabed

Authority Workshop on Polymetallic Nodule Resources Classification was convened, so I am involved on behalf of Geoscience Australia.

Looking at the outline of the presentation, every year we do a national inventory of Australia's mineral resources. How do we get that? The government does not have the resources or enough employees to

be on the ground working this out. Nor does the Australian Government have a direct role in commercial mineral exploration and development. Geoscience Australia uses information derived through Australia's Stock Exchange (ASX), other stock exchanges and other forms of company reporting. In general the information is certified for Australia through the Australian Joint Ore Reserves Committee (JORC) Code. However, that has an absolute mapping capacity with the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) and at the same time the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC) system. In some ways the debate that we are having is not that necessary because each of these codes translates to the other. Provided you can interpret between the codes and map between them, you can use one to move your understanding into the other system.

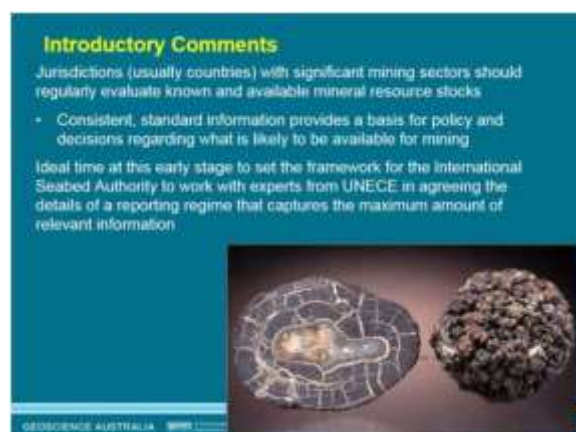


Figure 2: Pre-feasibility assessment provides the marker before some formal reserve is established for a resource

Importantly for this Workshop, and the Secretary-General has attested to this – it is much like a national reporting situation with the International Seabed Authority (ISA) because it is a jurisdiction. The ISA is not a commercial entity seeking investors' funds for commercial investment and eventually profit taking. ISA is a regulatory authority leasing out areas in order to have interested commercial or government entities come in to do the geological and scientific mapping, along with project feasibility; hopefully getting to the point that there is some sort of commercial activity. So the parallel I am drawing here - and I hope everyone appreciates the comparison - is that the ISA is much like a national authority - it is a jurisdiction. In Australia we use the word jurisdiction for states – New South Wales, Victoria, Tasmania etcetera, so if we are talking about jurisdictions in Australia it is much the same effect. Australia is a Commonwealth or Federation, but there are also jurisdictions within that. The last paragraph in Figure 2 reinforces that it really is the ideal, if not critical time with these first contracts coming up in 18 months or so. Agreed reporting systems need to be in place well before the contracts end so that the ISA has the equivalent of a national reporting system with consistent information.

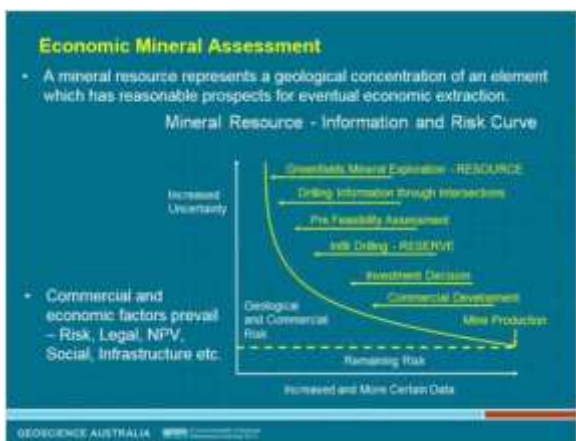


Figure 3: Slide showing form of a polymetallic nodule and recognizing the importance of timing with regard to the reporting regime for ISA resources

The Workshop has effectively been through a number of the slides I had prepared in the earlier discussion but others, so hopefully I can save you from “death by PowerPoint”, and reduce unnecessary duplication. I have kept quite a few slides that may very well cross over with what has already been said, and I apologize for this.

The point with Figure 3 is that pre-feasibility assessment provides the marker before some formal reserve is established for a resource. You have increased uncertainty going up this way, and there is an

increased and more and more certain data across going that way. We have a long way to go before we get to the point before we get a resource that we can exploit – which we can actually mine. There are a whole lot of facts and reasons underpinning this, particularly the need to increasing certainty as large scale investment gets closer.

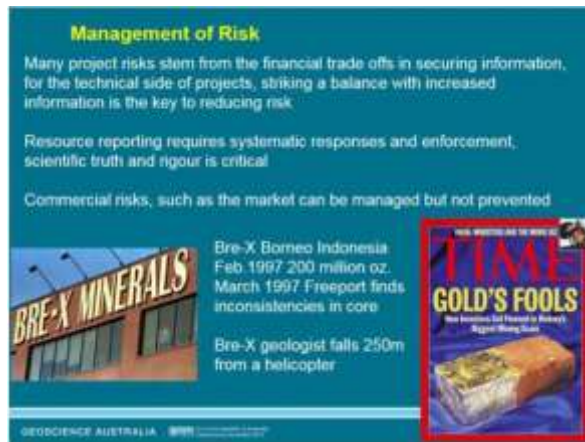


Figure 4: The Bre-X scandal captured global public and media attention

A key issue that has come up again and again today is represented on Figure 4 through the Bre-X references. The minerals sector and related fields have rarely captured wide scale public and media attention, however, this did happen with Bre-X and was reported on the front page of TIME Magazine.

This was such big news at the time; it was worth going back and double checking the unfortunate turn of events. The resource geologist's name was de Guzman, apparently after the events were reported he fell 250m from a helicopter and his body was only found months later and identified by a thumb print. The point here is the pressure financial and professional – and that is the sort of pressure that somebody putting themselves forward as a

“competent person” could potentially find themselves under.

The competent person (or persons in a team situation) is effectively the “point man” or “point team” if something should go wrong. Everything is on line, your reputation, your job and your livelihood so you want to make sure that you did it as right as you possibly could. The Bre-X story might not be positive, but it is better to tell that story and be transparent than to end up in similar situation. The fallout from Bre-X did precipitate a range of activities at the time and subsequently in terms of improving the commercial reporting of mineral resources and reserves.

In the case of the International Seabed authority, however, we are not strictly talking about commercial reporting, a closer analogy would be country or jurisdictional reporting. So, the question here is, what do countries or jurisdictions report and how do they amalgamate this information? We are all aware that USGS produces an annual statement; something comparable to what Australia does. Australia has something called Economic Demonstrated Resources. These are largely the four main categories in CRIRSCO. There are a couple of other sort of historical artifacts that sort of creep into those estimations. The point here that is being raised by David and others is that CRIRSCO has the absolute granularity necessary for the commercial reporting at the reserve stage, but as it stretches out to the longer term the granularity fades. UNFC as I see it, connects here with CRIRSCO to help incorporate some of the granularity.

UNFC has ‘development pending’ and ‘development on hold’ which could potentially provide a sub division allowing for better guidance for ISA.

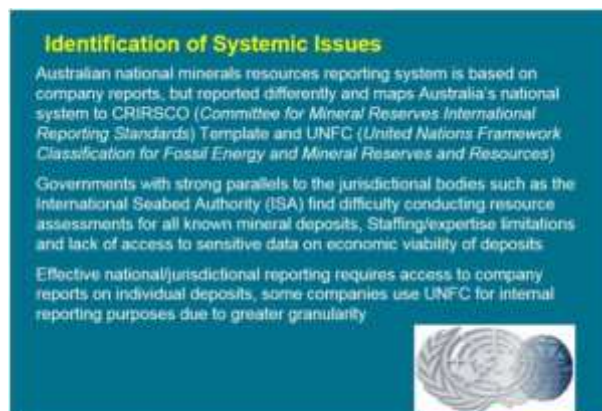


Figure 5: Some commercial entities use UNFC for internal



Figure 6: Australian experience in collating national data for Economic Demonstrated Resources (EDR)

facilities and roadways; whether or not decisions need to be made by governments to try and establish towns and other infrastructure to support the sector. If a resource has been identified with some certainty, then the government has a higher level of confidence in putting highly sought after government resources into shared facilities that could be utilized by rapidly growing industries in mineral sector dependent regions.

Geoscience Australia resources are what have reasonable prospects for economic extraction. The Economic Demonstrated Resources (EDR) – Geoscience Australia publishes this annually in, Australia's Identified Mineral Resources. Companies in Australia report publicly basically using the CRIRSCO (in Australia the JORC standard). The aim of the GA resource estimation is look at the next 25 years or so; the foreseeable future. The McKelvey system and inferred resources would not fall into Economic Demonstrated Resources (at this point in time) because additional work is required to better establish economic viability.

The main point to recognize in Figure 5 is that some companies use UNFC for internal reporting, due to the availability of greater granularity.

So now we move to more detail on to the Australian experience and this described in Figure 6. Basically, Australia followed on from the USA (USGS) McKelvey Grid experience. Australia started to use a system similar to McKelvey in 1975. At that time the Australian Government had an almost parallel situation to what ISA currently faces. Australia had a very high incentive to work out mineral resource potential and identify minerals that required more exploration emphasis. Looking back, mineral resources have become an increasingly important part of Australia's economy and export capacity. I do wonder whether it was at least in some way the outcome of this initiative and work done around 1975 that has played out in terms of the understanding of Australia's mineral resources and the subsequent development of the Australian mineral sector.

The work done on mineral resources provided the technical basis for Australia to have an understanding of long term potential resources, which in turn helped in national planning for infrastructure, port



with a national resource it is impossible to talk about the grade of that resource at the same time as you bulk altogether these individual deposits. There are a variety of individual deposits that have a lot of inherent individual characteristics that need to somehow be amalgamated. Grade cannot be incorporated in absolute detail through the amalgamation. The absolute amount of resource available needs to be calculated and then amalgamated on an absolute total basis. Information is protected because you have already made the assessment of what is an economically demonstrated resource. The information collated has already passed a number of hurdles and been proven to the extent that you have something worth considering economically before you then move to having a number that you report nationally.

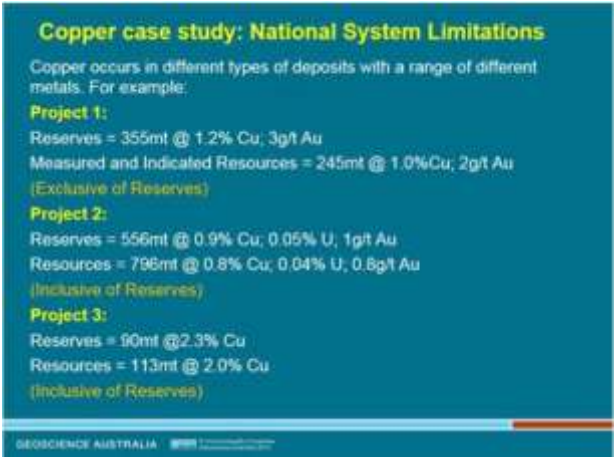


Figure 9: An example of the amalgamation process with three different copper deposits

Figure 9 provides an example of the amalgamation process with three different copper deposits. The first one you have is 355mt @ 1.2%. Next one: .9% in reserves and .8% in resources. Next one – 2.3% in reserves and 2% in resources. All of those are very different numbers. You cannot amalgamate those simply. What we do is take the bulk amount. We know it has met the criteria as an economically demonstrated resource and we bulk the cumulative metal together the main national resource.

What does Geoscience Australia report?



Figure 10: Reporting by Australia of the Economic Demonstrated Resource (EDR) in Australia's Identified Mineral Resourced

Geoscience Australia reports the one cumulative number, as the Economic Demonstrated Resource (EDR). Take the case of bauxite which is 6,464 million tonnes, a simple single amalgamated number. Then you have the JORC reserves that are substantially smaller component than the EDR. Take cobalt – we know we have a EDR, something that will be developed within the next 25 years and only 36 percent of that meets JORC criteria.

The key issue that we have been exploring through the Workshop is mapping to a universal template, enabling information to be expressed equally in each system. A harmony between the various systems described earlier and above is required so that we have the capacity to compare world inventories or in this case ISA inventories from different contractors.

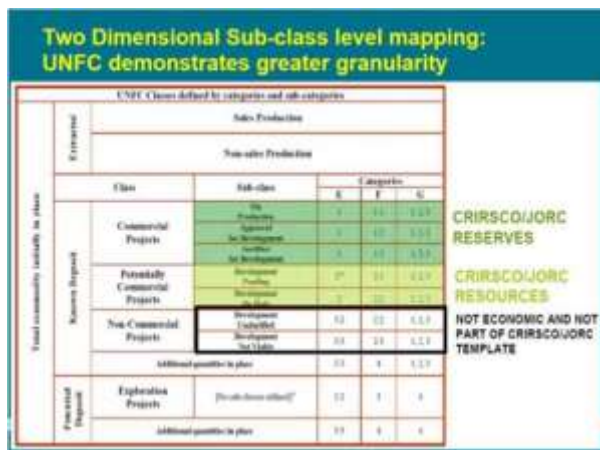


Figure 11: Mapping resources between the CRIRSCO, JORC and UNF systems

I came into this thinking that the best way was to go was to use the UNFC; it has the granularity and allows readily for mapping to other systems. Figure 11 demonstrates the means to map resources between the CRIRSCO, JORC and UNFC systems. The issue that has been expressed strongly through the Workshop is that we have people who are now using CRIRSCO. The various systems are not in a form of competition, but on the other hand there is a decision point about what method is employed.

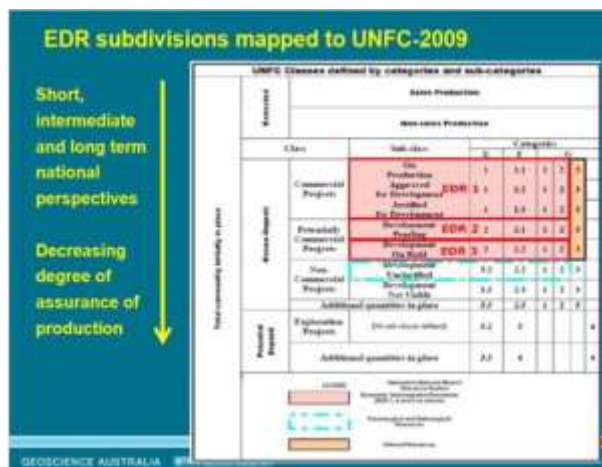


Figure 12: Mapping to UNFC at the jurisdictional level of Geoscience Australia

The Workshop seems to be embarking upon CRIRSCO in terms of the discussions today, and CRIRSCO works, it will do the job and it might well be a relatively simple solution. By comparison the mapping to UNFC at the jurisdictional level of Geoscience Australia is shown in Figure 12. The downside of avoiding UNFC is that the chosen system might be that it is not quite as elegant, because you don't have as much granularity as you do with UNFC. Having said that, the two are interchangeable to a large degree and you can map from one to the other in many cases.



Figure 13: Jurisdictions may have mandated commercial systems or adopt the UNFC (PRMS - Petroleum Resources Management System)

Before the Workshop discussion today, it seemed clear that UNFC would be the primary way to go, however, existing effort and record keeping needs to be accommodated. Figure 13 provides a summary where jurisdictions have mandated commercial systems and don't necessarily need to adopt the UNFC, though others may choose to use it. Basically, UNFC can be used; it is a tool that is available. The question is if you have already a

system that is working or almost working it is only the few modifications that we spoke about today at the Workshop that may well get us over the line in the months leading up to the cessation of the first ISA contracts.

Going back to Geoscience Australia's EDR as shown in Figure 12, there are current JORC reserves: proved and possible -111, 112 using the UNFC system. Following through with the detail, the 223 where a JORC inferred resource is expressed. That is not to say that reporting through CRIRSCO will ignore this category. CRIRSCO doesn't carry as many categories so the advantage with UNFC is that you are going to be able to have a finer resolution of those boundaries or categories.

The two-dimensional diagram shown in Figure 11 represents the mapping of the two systems, with the apparent complexity of the third dimension, providing another way of looking at the same matter. For Geoscience Australia, EDR which is the national or jurisdiction inventory – it uses proved, probable, measured and indicated. EDR does not incorporate inferred resources, which could prove a weakness for the resource estimation required by ISA. At the current point in time, inferred may be the most certain category available through information submitted to ISA by contractors.

What we are looking for here is a framework for all the contractors and we want to have a decision taken to ensure that contractors know what the rules are and know exactly where to go forward. I think we can do that through the next couple of days. Alternatively we set up further working groups to resolve any outstanding issues if we cannot get it done. Conceivably, a UNFC/CRIRSCO working group could be established under the auspices of the ISA, because the information or changes required are specifically for the needs of ISA.

Workshop discussion has gone into great detail about competent persons, as defined through the various reporting codes. Clearly this requirement is an issue, particularly for non-commercial contractors, but there are ways available to get around this issue. Processes required to incorporate definitions and other anomalous requirements into UNFC 2009 cover international reporting. Risk and uncertainty have impacts, as they might do in a commercial situation, however, the main goal of the national authority or jurisdiction is an estimate of the scale of a potential resource rather than preparation for an investment decision.

One thing that concerns me is until we actually have mining, until we had something pragmatic, we cannot – in the UNFC case for example – move to level one. At this stage of the game, resources could at best be inferred. The implication here also is that it would be impossible to meet the strict requirements of a competent person of this as yet unmined style of ore resource. This level of uncertainty is inevitable as we work to progress scientific knowledge through to a commercial outcome. The key point is that the national or jurisdictional inventory is about aggregating the resources of individual deposits. The mechanism or system through which we achieve this outcome is available and mapping to categories will achieve the key goals.

What will ISA get by having a national/jurisdictional inventory?

The International Seabed Authority will have a regular evaluation of what potential resources look like and what might be available in the foreseeable future for mineral development. This information will play into policies and the resolution of issues that arise deep sea mining proceeds. One issue that comes to mind is that the United States has not signed the treaty. If there is a better assessment of what might be available as some sort of encouragement to get the United States involved again perhaps that would be a good thing and you do that through information by measurement.

Summary of issues identified

Australia's terrestrial experience provides background in terms of how the JORC, CRISCO and UNFC systems can be incorporated and mapped to each other to build a national or jurisdictional inventory. Individual deposit data can be provided through scientific and commercial reporting to build the jurisdictional reporting. Amalgamating the individual and often quite unique information requires a systematic approach.

UNFC-2009 provides a universal framework for deep sea polymetallic manganese nodules and other seabed mineral resources; that can be collated and utilized in a consistent way by the ISA, without the requirement for a "competent person" as required in commercial reporting systems. UNFC-2009 allows for alignment of various national and commercial mineral reporting systems, reconciling the mineral resource assessments derived through these various frameworks. For commercial resources, the CRIRSCO template (and the other aligned systems) provides a means of incorporating seabed resources into the jurisdictional inventory system.

There might be a concern with commercial entities if there any forms of duplication of reporting required. The system needs to accommodate the reporting done by commercial entities or in some cases government (scientific) entities so that the information that comes in from the CRIRSCO or JORC reporting or the Canadian reporting system (National Instrument NI 43-101) can be amalgamated. Contractors to ISA do not want to find themselves in a situation where they have to expend additional money recalculating resources or presenting existing information another way.

Whether the Workshops chooses to convene an expert ISA/CRIRSCO/UNECE working committee to ensure that the reporting for mineral resources satisfies requirements for commercial and national reporting remains open. At this stage most of the knowledge base is at best available as inferred resources. There would be additional granularity available to describe the status of potential projects, should mapping to the UNFC be undertaken.

Conclusions

Jurisdictional mineral resource classification systems can be correlated on a broad basis with UNFC-2009 with CRIRSCO. CRIRSCO would result in the aggregation of some information available through the UNFC classifications because there is more granularity. To take full advantage of the available UNFC granularity the original resource data would need to meet the information hurdle. Use of the CRIRSCO bridging document provides to means to move this information across. Issues would remain with the competent person hurdle for QA-QC in international assessment reporting for mineral resources. There could potentially be financial implications if this is not correct from the outset. ISA wants the best system it can for it jurisdictional resource, and the means is available to provide this without having to reinvent processes at a later date.

The International Minerals Reporting Code Template provides general guidance that could be applied to deep seabed minerals, but agreement needs to be reached on specific parameters applicable to polymetallic manganese nodules. These specifics are likely to include, sampling techniques, abundance estimation methods (for example, wet kilograms/square meter), recovery technology methods and probable recovery efficiencies, rate of recovery and duration of mining, potential monetary value and

rate of return on investment. Individual contractors or commercial entities may not see a direct need to go beyond their existing processes, but the introduction of reporting through the consistent UNFC Mineral Resource Assessment Framework would provide a robust means of understanding and comparing the technical and economic potential of international seabed resources.

Summary of Discussions

A participant noted that the primary benefit of the UNFC was granularity that brought with it an increased level of effort to fulfill that granularity. He continued that in any case the CRIRSCO system does bring with it a set of rules that determine or help bring uniformity to the classification no matter which framework, so it was a given that something like the CRIRSCO system be expanded. In the long term the benefit of the granularity can be seen with one or two things that could be put into that increased granularity and which would take a tremendous amount of research. Dr. Kay agreed and said it was a perfect assessment.

Another participant remarked that the UNFC added value but if the values of the deposits were being truncated and the CRIRSCO system was used – it only had places to put volumes that have reached a certain place of maturity. There is a greater volume associated with these deposits that are not associated with projects identified today that will not be captured using the CRIRSCO system only. If one looked at the total value of the deposits, the concern was the deposits may be underestimated.

The Secretary General of ISA, Mr. Odunton commented that there was an objection by one contractor on a particular slide whereby the contractor disagreed with the term “competent person” and asked what would be the way to get around that situation. A participant explained that the UNFC was based on CRIRSCO, so for the estimation report, one needed at a point person like the “competent person” who would bear the weight. A “competent person” was needed in both the CRIRSCO and UNFC systems.

The Secretary General said that his concern was that the other contractors had not said anything in relation to the “competent person” and that he was still trying to figure out how he could move forward to get a system. He continued that there was also a question raised earlier about taking the template and making adjustments for polymetallic nodules to that template and he wanted to figure out whether to go ahead or return to the discussion after the contractors made their presentations. He said the workshop seemed stuck at a point based on an objection by one contractor.

That same contractor noted other contractors have not commented so he suggested that the experts move forward with the adjustment of the template then have it circulated to all contractors for their comments on how to proceed from that point onwards. Mr. Odunton added that these were the global commons and don’t belong to any State. I do hear comments that sound like “this is my resource”. I don’t understand what that means in the context of the global commons? People acquire rights to these resources. However, it is not theirs. They acquire rights and there are rules and regulations and procedures that they follow in relation to their resources. There are also, for example, exploration contracts - those are the contracts that we have currently in place. Our regulations ask for certain information and data from these contractors, in particular as they relate to the resources. We need something that enables us as the Authority to administer these resources. It doesn’t help if there is no commonality in the reporting standards nor in what we are reporting.

A participant added that the purpose of the “competent person” in the context of the CRIRSCO document was in the context of the public reporting where companies were primarily going to the stock

exchange to raise funds to carry out their work. In the case of the ISA, some companies now have exploration licenses, but predominantly the current market licenses are held by state or state entities who do not have to worry about this issue of the “competent person” because they alone are the judge of whether they put money into doing further work. He said some clarification was needed on the extent to which the issue of “competent person” did apply to those exploration contracts with the Authority held by states of state entities.

The Secretary General went on further to explain that an exploration contract was given out for 15 years. At the end of 15 years, the ISA needed to know something about the resources that have been identified and their categories. He said it was not obvious to him that because it is a state entity that information was not required. It is not within any national jurisdiction, it is the global common. The rules were very clear and contractors were all supposed to work by these rules, regulations and procedures.

Certain information are asked of contractors no matter their category regardless of whether they are state entities or commercial bodies. He said he would like to figure out a way to get around “the competent person”. He wondered if the systems available required such an individual and whether these were the international standards. He said he could not justify giving land to someone for 15 years at the end of which he has no information on the resource because it was a State or a State entity.

Another expert added that the QP and CP system provided a level of protection for the investing public. It was to do with reporting to the public where shareholder funds are raised and it is to conform with the stock markets own rules about protecting and informing the investing public. He said he thought it was a good point and a genuine point of discussion, the degree to which a CP system is required back down the chain like into a time period before the reporting is applicable at the CRIRSCO stage. The suggestion about quality and quantity was that it is done by experienced people who have sufficient knowledge and understanding to make these estimates and for people who use the estimates to have confidence in them. This did not require the CP system which has the added requirements related to public reporting. He said the principle still applied - if you do need people who know what they are doing in this situation and have experience in the activities they are undertaking. Many of the aspects of the “competent person” apply however you are reporting into the UNFC boxes where these are not yet ready to go into inferred resource or beyond. But certainly the requirements to belong to a national organization that can discipline you wouldn’t be one that would be required. I think it is thinking in a common sense way we can apply what the intent is without that additional regulatory.

Dr. Kay said this issue could be postponed until the mining proceeds under the hard terms, the understanding was the “competent person”, or do guidelines now that say that someone has a scientific understanding and doesn’t make the requirements?

Another expert added that an independent authority could be used and chosen to do whatever you want to on your own resource assessment. You could choose to adopt the principles of CRIRSCO. I think you will not be able to say estimates are based on the CRIRSCO template if you didn’t require a “competent person”. You would not be able to say “this is a CRIRSCO estimate” but you could say “this is an estimate that meets the ISA standards for reserves and resource assessment which is loosely based on the CRIRSCO template.

Effectively you are creating your own standard that is strongly coupled to an existing standard. If you do choose to come up with your own system based on CRIRSCO, with some modifications you could also look to add some of the specific categories within the UNFC, e.g. I think you would want to know the

total volume and placement of the deposits are. You wouldn't know this just from the CRIRSCO reporting. There are few things like that which would be very valuable to have and that would ease the transition to the UNFC adoption at a later date.

The ISA Secretary General said that as a first task – the ISA was supposed to get some reports from contractors regardless of whether they would be requesting extensions or not. He reiterated his suggestion to make the adjustments to the CRIRSCO template and have it up for discussion after the contractors' presentations to take up the objection to the term "competent person". Let us take up that conversation with a modified template from CRIRSCO. Immediately following the contractor presentations and go around the room with all contractors and see exactly how we proceed.

A participant commented that Tonga found a solution in the case of the "competent person". He said if the possibility existed there, why the same possibility does not exist for other organizations. The Secretary General explained that Tonga went ahead and utilized the standards that existed. There was no objection from Tonga, but another contractor had commented that the term "competent person" was not acceptable. The Secretary-General said he thought we should distinguish between the two things here because I see that the objectives of the workshop was that we try to support the LTC which would allow them to justify the extension of the contracts and I think this is a priority here. I have the feeling that now we don't have the time to adopt some kind of guidelines; I think it is important but we cannot solve that here.

Another participant commented that it was needed to define the objective on whether it was the contractor or the Authority who would do the public reporting. If the objective was internal reporting between the contractor and the Authority, the Authority had a uniformed basis of understanding what has been done by which contractor. A solution could be worked out where a competent person is not needed, and is replaced by a single requirement that is consistent with the general requirements of the system but not necessarily be mandated by the Competent Person's signature.

A participant commented that the ISA could not mandate how companies did their estimates for public reporting. That was going to be determined by whatever entity they were reporting to. Every entity that is collecting information can choose to make their own rules and a decision needed to be made on how that could be captured.

Secretary General remarked that it is the ISA that approved the contracts.

The person continued that in this case the contractors would report to the ISA. Therefore, the ISA needed to choose what information it wanted to gather and what governing structure it wanted to have to back up that report. The ISA could choose to set that structure however it wants. He cited that the petroleum industry did not have a requirement for a Competent Person but still needed to have a clear description of what governance was behind that estimate.

A participant noted that participants were assembled to discuss a classification system and the adoption of a classification system. That system would then consequently be used also for the extension of contracts for expiring contracts.

PART III: STATUS OF CONTRACTOR ACTIVITIES IN RESOURCE ASSESSMENT

CHAPTER 12: Activities of the IOM within the Scope of Geological Exploration for Polymetallic Nodule Resources

Tomasz Abramowski, Director General,
InterOceanmetal Joint Organization

Mr. Abramowski said IOM signed the contract in 2001 and located the most prospected areas in H11 and H22. He informed participants that in the H11 area 21 ore deposits from 66 ore fields had been identified using geostatistical model equations including Kriging. He said that one of the most significant parameters for delineation of nodule fields was the slope angle, because the collector device needed to overcome different slopes. He told participants that IOM areas have slope angles of more than 4°; 7° and 10° and based on calculations of the collector as well as information from scientific papers. He said that IOM selected 7° but was optimistic that mining collectors could reach 12°-15°. Another uncertainty would be buried nodules.

He informed participants that IOM had initially had opted to produce four million metric tonnes (4Mt) of wet nodules per year for the commercial phase, but now it preferred to consider an approach based on the analysis of various alternatives. Mr. Abramowski recommended that discussions on parameters affecting mining, such as design of ship and production rates; some kind of collaboration between contractors and the Authority may be useful.

Introduction

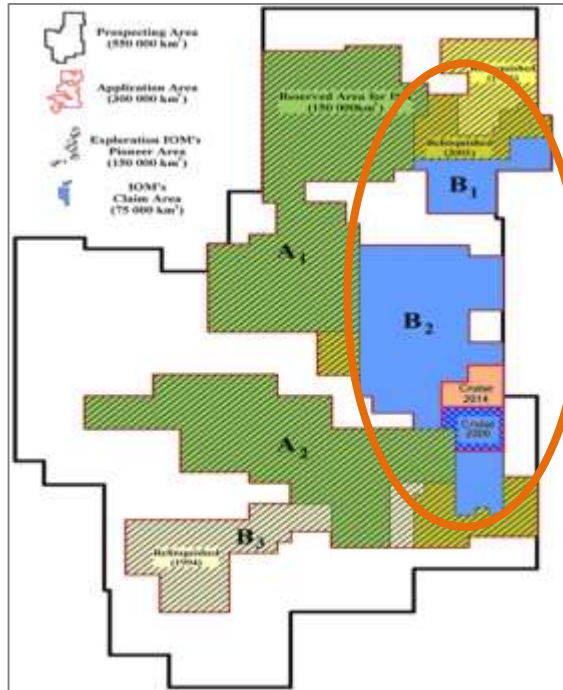
I will begin by thanking the Secretary-General, the ISA Secretariat and the Ministry of Earth Sciences, India. This is a very nice place and I think we will have very productive discussions here. I would like to present our activities and some of our results which perhaps for the future will be used before we move into the commercial phase of deep seabed mining.

Main objectives

The main objectives of our work in exploration are defined by the provisions of the ISA approved plan of work for exploration and the programme of activities for five-year periods. They include:

- Identification of nodule deposit resources that have the potential to be commercially mined as well as the delineation of nodule deposits.
- A pre-feasibility study in order to define the possibility of proceeding with the nodule mining project in Sector B2 of the exploration area. I will show it in a moment.
- The selection of potential mining areas/blocks within the delineated nodule deposits
- Detailed studies within the selected blocks in order to estimate nodule reserves for the first generation mining block and to develop more job-specific exploration technology
- Recovery of nodules from the selected mining block in order to conduct a processing technology experiment on larger samples as well as geological-engineering and geotechnical studies in order to collect data and information on nodules and sediment physical properties for carrying out mining technology research and development
- At the present development our work is based on the former regional exploration results. The outcome of our former work has allowed us to search and determine the polymetallic deposits in our exploration area. Within this Sector the estimation of nodule result and nodule metal content analysis has been carried out using the kriging method. Several orogenic fields were located. Detailed studies within the selected blocks in order to estimate nodule reserves for the first generation mining block and to develop more job-specific exploration technology

- Recovery of nodules from the selected mining block in order to conduct a processing technology experiment on larger samples
- Geological-engineering and geotechnical studies in order to collect data and information on nodules and sediment physical properties for carrying out mining technology research and development.



The present development of our work is based on former regional exploration results. The outcome of the former work has allowed us to search and determine the polymetallic deposits in our exploration area.

As you can see we started in the prospecting area (in white) and then each step allowed us to work in more and more detail. We have application area for pioneer investors and we have area for signing the contract in 2001, the area consists of B1 and B2. On the basis of the work we located the most prospected areas which we names as H11 and H22. Two of our cruises were carried out in those two areas.

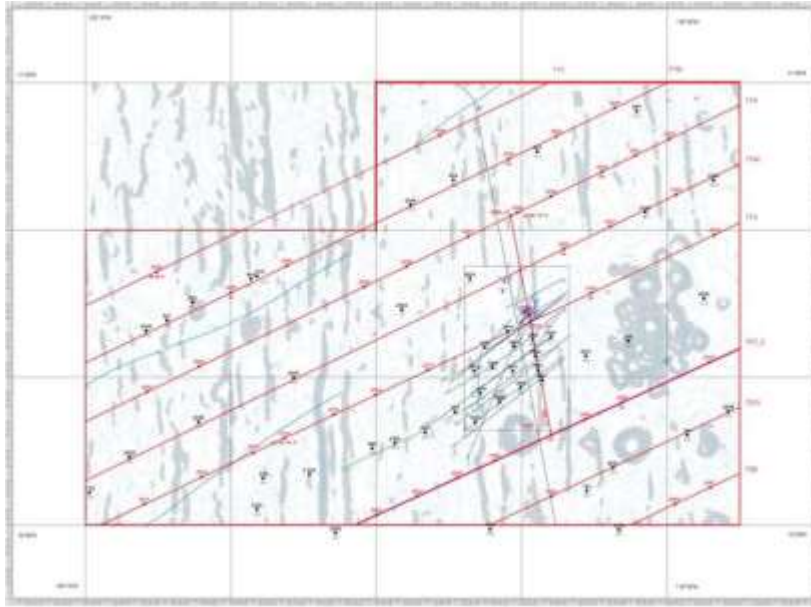
This is the summary of the 2009 exploration projects; the H11 area. In the south part of this selected area we did several transects. We had a lot of box corers located in this area.

Summary of the 2009 exploration project – the H11 area

The summary of our work is as follows:

- side-scan sonar surveys with acoustic profilo graph at 295.8km
- photo profiling (344.3km)
- sediment and nodule sampling with a box corer in 51 stations
- collection of a nodule sample of 740 kg for the research on nodule processing technology and a 40 kg sediment sample
- analyses of nodules, sediment, and its pore water samples in on-board laboratories
- collection of sediment samples for analyses in land-based laboratories as well as
- meteorological, environmental, geotechnical, chemical and computer analyses

2014 exploration project – H22 area – with BIE area in the center



This is our project which we just finished. We finished exploration work and there was a cruise in April and May. We used the same methodology for this as well. We used some transects from deep tow cameras. We did several samples with box corers. It was located together with a block of benthic impact experiment which we did in 1970. We have some interesting results from that cruise which are in connection with environmental work but that is for another workshop.

Some results from that cruise. The summary of the project tells us that :

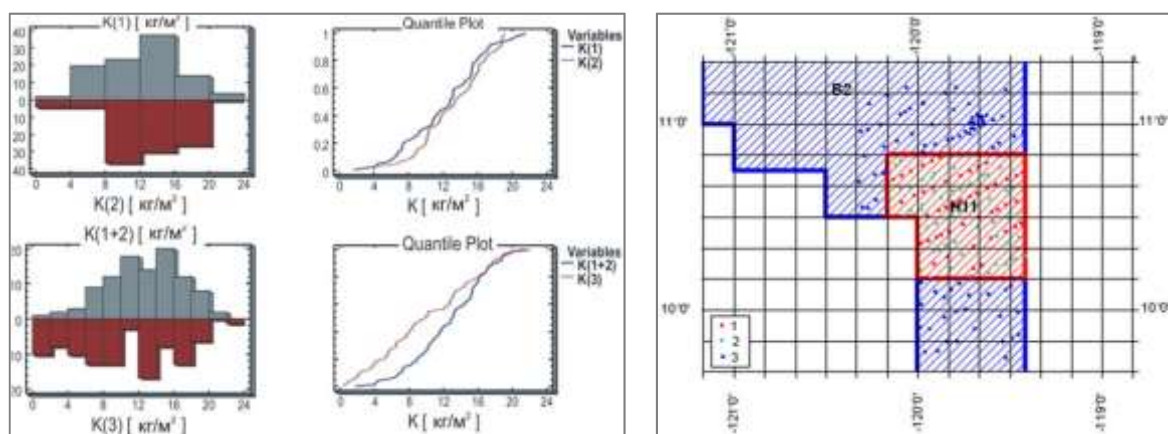
1. side scan sonars surveys with acoustic profilograph (60 km), and 585 km of photoprofiling.
2. Sediment and nodule sampling with box corers at 55 stations
3. Collection of nodule sample of 2.1 tons for the research on nodule processing technology and 60 kg sediment samples
4. Analyses of nodules, sediment and its pore water samples in on board laboratories
5. Collection of sediment samples for analyses on land laboratories as well as
6. hydro-meteorological, geotechnical, chemical and computer analyses

Resources of the H11 area have been estimated, the results from 2014 project are presently under processing. Most likely after the workshop perhaps taking into account some outcomes of the workshop and the results of standardization we are going to adopt, we will be considering re-estimation for the two united areas.

For the time being the results for H11 are ready for reporting. We have actually already reported those results in one of our annual reports. The information was processed using geostatistical methods, with assessment of resources of nodules and metals - manganese, nickel, copper, and cobalt. The analysis was based on sampling carried out in area H11 (5372 km²). We also used some stations we took in the cruise from 2004.

The data processed reflected the wet weight-based nodule abundance and contents of 4 metals (Mn, Ni, Cu, Co). We based the data on 101 samples. 51 samples were collected in 2004 and 50 samples were obtained in 2009; during the latter sampling campaign, areas with slope >7° were contoured.

For estimation the mean nodule abundance and mean metal concentrations as well as nodule and metal resources, the block kriging method was used.



The procedure takes into account the distribution of sampling sites relative to the mining block being samples relative to each other; shape and size of the block; structure of the variability of a parameter in question, as expressed with the geostatistical- variability model (semi variogram model).

In the area H11, a total of 21 ore deposits were identified. This comprised a total of 66 ore fields, a total area of 3800 km^2 . The parameters estimated using the geostatistical model equations applicable to ordinary kriging were:

1. overall resources of polymetallic nodules (wet and dry) and resources of metals along with relative standard errors of kriging
2. mean values of ore deposit metrics – nodule and metal abundance as well as percentage concentration of metals
3. resources of polymetallic nodules (wet and dry) along with estimation of relative standard errors
4. resources of metals for each of the 66 ore fields were identified
5. Mean metal concentration in percentage in each of the 66 ore fields were identified.

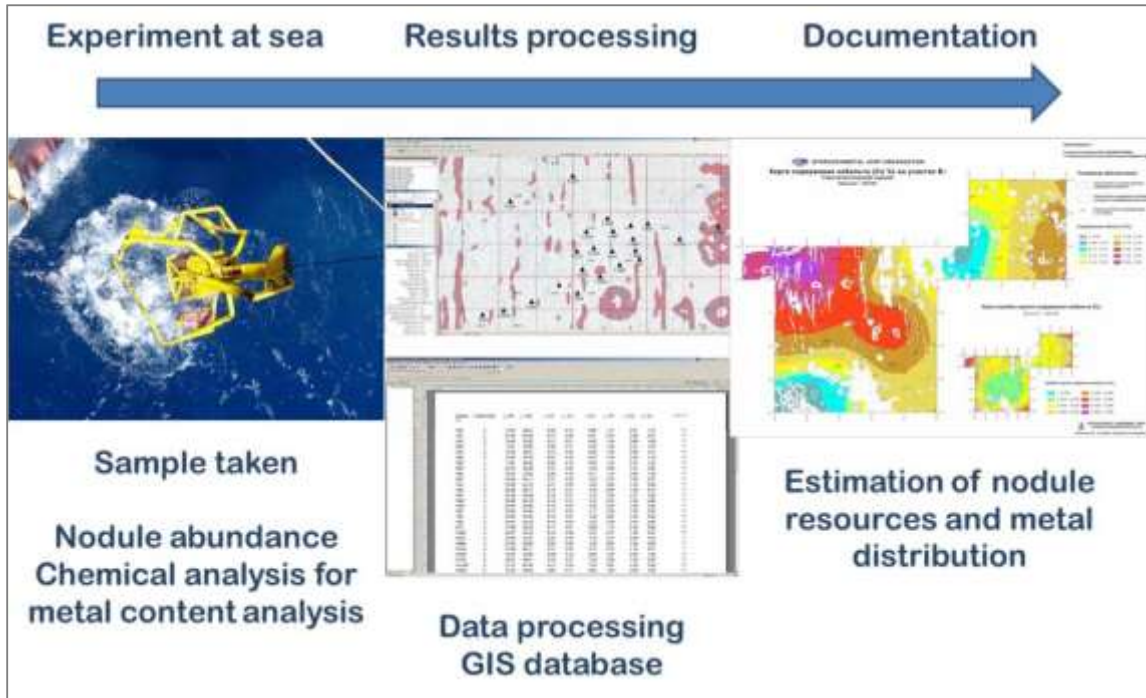
Resources of polymetallic nodules and metals in area H11

PARAMETER	RESOURCES	RELATIVE STANDARD ERROR OF THE ESTIMATE (%)
Polymetallic Nodules	33.7 MT tonnes (dry)	4.3
	48.1 MT tonnes (wet)	4.3
Manganese (Mn)	11 MT tonnes	4.5
Nickel (Ni)	$443 \cdot 10^3$ tonnes	4.6
Copper (Cu)	$435 \cdot 10^3$ tonnes	4.3
Cobalt (Co)	$53 \cdot 10^3$ tonnes	4.6

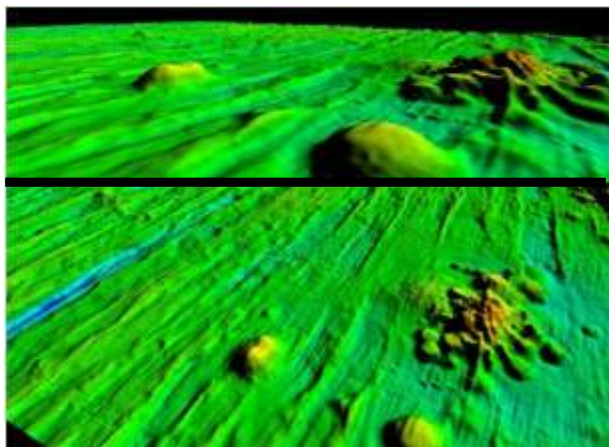
The mean abundance of nodules was estimated for blocks of different surface areas ($1 \times 1 \text{ km}$, $10 \times 10 \text{ km}$, and $20 \times 20 \text{ km}$), based on data collected at the first stage of sampling in area H11 as well as on the pooled data from the first and the second stage. The results showed the nodule abundance assessment to be sufficiently reliable for the basic $1 \times 1 \text{ km}$ blocks (relative and absolute relative errors of 2.9 and 12%, respectively). For the larger blocks ($20 \times 20 \text{ km}$), the reliability of assessment was increased (the relative and absolute relative errors of 2.5 and 5%, respectively).

In the area H11 this is the southern area of our exploration. We have identified here a total of 33.7 MT of dry nodules which corresponds with 48.1 MT of wet nodules. Then you have the quantities of manganese, nickel, copper and cobalt.

Exploration - information flow - connection between exploration and economic feasibility

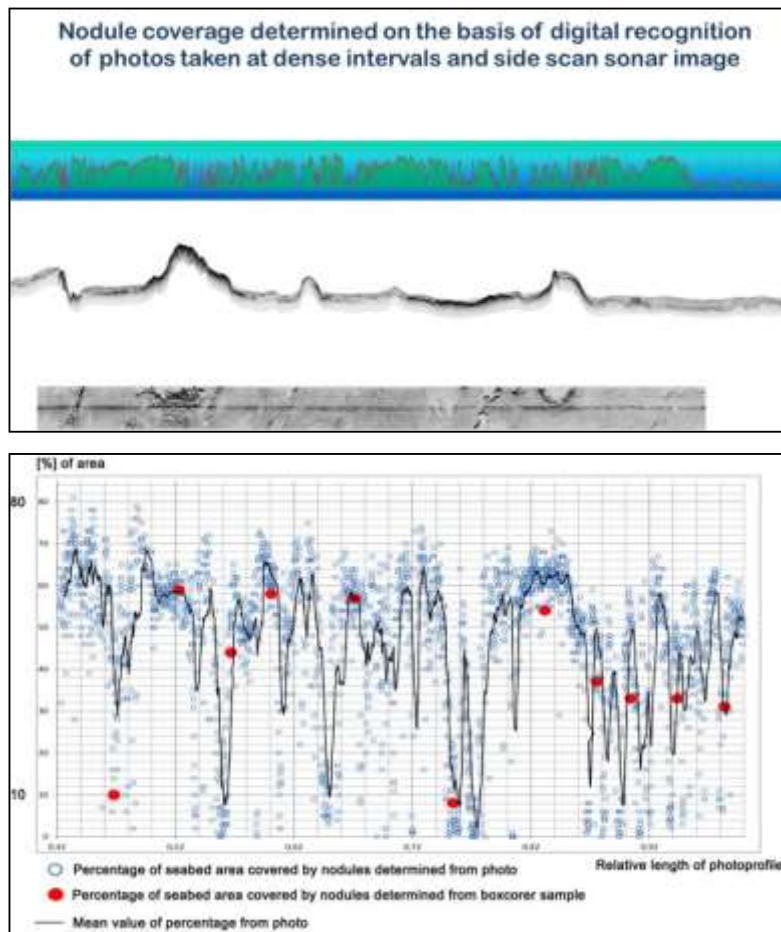


Our methodologies for exploration I think are the same as some other contractors. There are also some differences in some details. At first we do experiments at sea. Here we have experiments with the box corer, experiment from photo profiles and distant methods. We can then determine nodule abundance and we do chemical analysis of metal content, then of course data is processed and we put it into our GIS database and then on the basis of some statistical methods, we estimate nodule resources and metal distribution.



Bathymetry processing

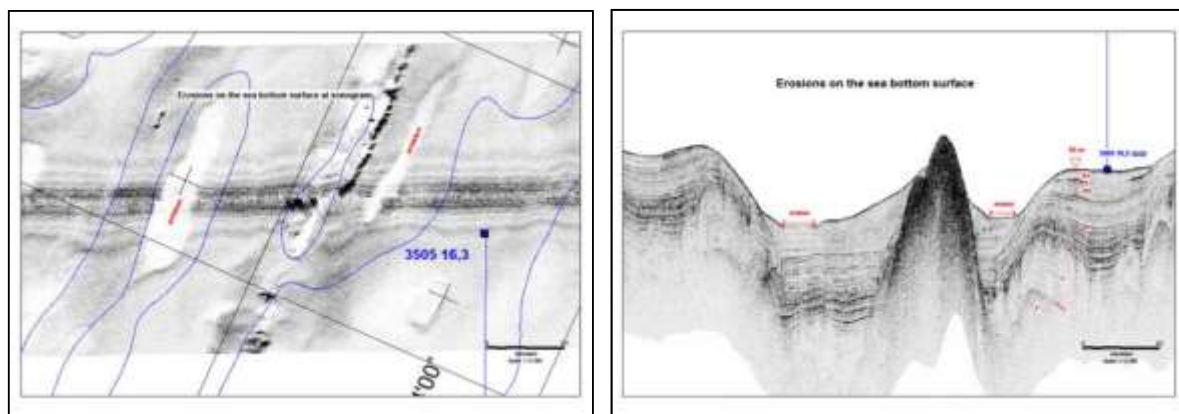
As you see we of course have to do some other measurements. Bathymetric processing is an important thing for delineation of nodule fields. Apart from box corers our methodology is now focused on distant methods because we see that the productivity of those metals are better so we do some correlation between the photo-profiling and transects of side scan sonars. Nodule coverage determined on the basis of digital recognition of photos taken at dense intervals and side scan sonar image



See we have a horizontal image and some vertical transects as well. This information is put together for the delineation of fields.

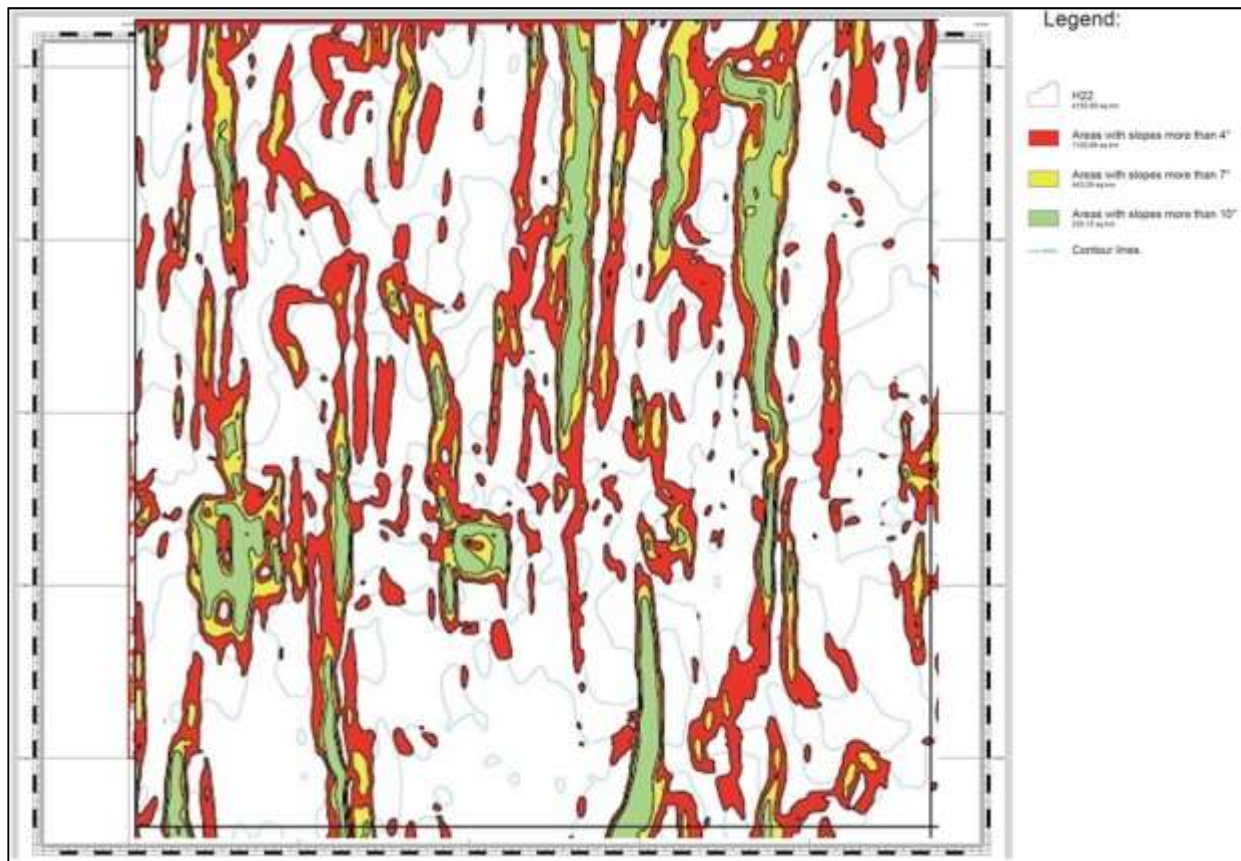
I think that a very important issue is to generalize our methods and to find some correlation and find confirmation as well between experiments we understood as samples taken by box corers and this documents which shows photo-profile and side scan sonars. As you see on this drawing you have some results from box corers and percentages of seabed areas covered by nodules. This is from box core samples and marked in red circles. Those small blue circles are interpretations of seabed covered by cobalt and nodules determined from photos. As you see the number of photos is quite big so we have to interpret quite efficiently. We do it digitally as it is impossible to do it manually as we have several thousands of photos.

When you see the results there is also mean value of percentage from photos marked in the black line and the correlation between box corers and the mean value is quite good. Of course we could compare exact photos located close to the box corer but I think that for some generalization we would like to know the changes of our nodule fields. It is better to present such correlation on the basis of mean value.



We can add some more information from bathymetry. There are two layers of information in the image above: the horizontal images from side scan sonar and bathymetry lines then we can compare with the

vertical information from side scan sonar and on that basis we can also add some information from box corers and confront it with some boundary conditions such as slope angles, obstacles and cut-off conditions if we are supposed to apply on the basis and delineate nodule field and nodule-free areas.



I would also like to show you some important information which might have some influence on mining areas. I think that this can be discussed in this group – we can talk about the problems of mining collector because I think that one of the most important parameters for delineation of nodule fields is the slope angle which is shown here. As you see on the right we have areas more than 4 degrees; in yellow they are more than 7 then in green which is more than 10 degrees. On bigger images we have 10 miles on each side. You can see the significance of this parameter. We have to decide how our mining collector can reach 4 degrees, 7 degrees and 10 degrees of slope. Our assumption here was to adopt 7 degrees. This is based on some calculations of the collector as well as some earlier information from scientific papers. We are optimistic here that mining collectors can reach about 12-15 degrees. I know that some contractors apply a value of 3 degrees which was for me was a surprisingly small value and I think they will have some problems with delineation. I asked on what basis and the answer was “just because.” This is a very strong assumption which I think we must discuss and we will never be able to confirm depth without pilot mining experiments. This will show the real values which can be some confirmation of this assumptions.

Uncertainty factors – buried and deposit covered nodules



This has already been discussed in our previous discussions. As you see we have some station on the photo which is nodule free and then we discovered that the abundance in the place was almost 10/ km². There are some situations in which nodule is visible and we still have some bigger values after the analysis of the sample.

Large sample abt. 2t – 2014 cruise



Another thing we did after our exploration cruise in 2014 was taking of the large samples and we did it with the use of dredge – a total of four dredges. We used about 2,000 nodules for metallurgical processing but I think which is good a confirmation of our resources. We understand that this sample is a kind of geological sample as well some empirical confirmation of the work we did.

Production rate

We were asked in the background document for this workshop to present some information of assumptions about our plans for the commercial phase. There were some parameters in question. First it was the production rate. These were critical questions; they were not easy to answer. At the very initial stage of research exploration, we adopted a value of 4 MT of wet nodules yearly. However, I think that now at that stage of research and market conditions we preferred to consider an approach that is based on analysis of various alternatives.

Production rate understood as an initial assumption is a parameter affecting both CAPEX and OPEX. So we start with production rate and on that basis we can assume, for example, such parameters as main dimensions of the mining ship. Main dimensions of the mining ship affect the CAPEX of nodules. We prefer to do it in some alternative designs. We already did it in some regression analysis, knowledge,

guessing at times and strong assumptions. We did some optimization results but I think that for real operations and with results taken from pilot mining experiments there will be possibilities to formulate a mathematical model where economic factors will be maximizing and the production rate being a design variable solution. I think this is such approach to the problems we have discussed before which is sustainable development. I think that the cash flow here is the biggest question.

Duration of the Project

In terms of geological exploration and various IRR and NPV resources should be indicated for the duration of 15-20 years. I think it is meaningful to present a good feasibility study for the mining project we can make such assumptions, of course there is an option to proceed to exploration when the production has commenced.

Cut-off levels

I think, again, this is another thing which is not very well described. I think they can change according to metal prices, so cut-off levels depend on the kind of random variable than depend on market conditions. This is for initial assumptions we were adopting 10 kg/m² but some analysis have shown that it is possible and even probable that such market conditions existed where it could be economically viable to reach 5.4 kg/m².

Conclusion

I think our organization has accomplished several exploration objective and we have sufficient information to formulate a report and comply with any international and professional standards that are to be adopted by the ISA for the purpose of contract extension. Everybody likes to be "KISSED"[keep it simple], so this proposed approach is welcome.

Exploration methods are mature enough to conclude that resources can be estimated with sufficient reliability and accuracy. I think some other contractors as well consider that some innovative techniques can even improve the process. There are some modern statistical methods which do not require regular grid and developments of exploration procedures like AUVs and laser scanning and digital recognition can even improve the efficiency.

But can we move up to reserves without a pilot mining experiment? Do the previous mining experiments from the 70s and 80s give us sufficient information? In my opinion the result of those experiments have proved explicitly technical and functional feasibility but that is not all. This does not allow us to move to reserves and there are several factors. I think the most important is that we do not have economic factors, especially in present market conditions. All financial information which must be provided for those experiments from the 70s and 80s are either insufficient or not up to date, so there is a problem. There are also factors in question like maneuvering of the mining collector on the seabed and the questions of the slope and angle assumptions.

In parallel to a mining experiment I see the real need for environmental monitoring system which can be designed and put into operation in parallel to a mining experiment. We see from the proposed standards that environmental concerns is one of the most important from the list of modifying factors, This is not our problem to decide that modifying factors are equally important . I understand that the list

of modifying factors can be like that one is more important than the other. I clearly see first the need to include environmental problems in the list and I can see that if we look at future mining operations and the pressure from environmental groups and concerns of human kind about the environmental feasibility of mining. I see there is real need for commencing it together with mining experiments.

At first we have to ask in the future perhaps, I don't think we have enough time at this workshop to consider, but perhaps some considerations about the definition and scope of a pilot mining experiment which can be widely adopted for a deep sea mining project. I would like to present some aspects which we can discuss – the problems of the design experiment methods for pilot mining experiment we can at least define expected productivity of the pilot mining test. It should be a fraction of the assumptions for the production of some constant value - I am not sure.

A very important thing is the duration of the pilot mining experiment; whether it should last for two weeks or one year -what value we will consider; maneuvering abilities and efficiencies of a collector; operational requirements and safety factors; size and type of affected area, I think there are some differences between the various skills in the CCZ; scope of environmental investigation – the monitoring system, various sensors should be placed around the equipment for pilot mining states and this should be considered in detail and of course reliability issues.

These questions are very important and contractors should move in some time to pilot experiment but some parameters have to be discussed before. Maybe some kind of collaborative work with contractors and the ISA. I had some discussions with others and they had different opinions – it is not so easy but it is not impossible.

Summary of Discussions

Replying to a question about the distance between the sites of box corers, Mr. Abramowski replied that it was about 6 miles. When asked if he was using the ore deposit or ore fields, Mr. Abramowski replied that he was a naval architect and would not be able to answer although he thought that it was ore field mining block.

On the question of when IOM would conduct a pilot mining test, Mr. Abramowski answered that IOM hoped to do a pilot mining test in the next five years, maybe in collaboration with some others.

A participant asked about the results of benthic impact experiments IOM had conducted in 1995. Mr. Abramowski said that they did some transects, some photo-profiles which were of some tracks and the photos showed that re-colonization happens very quickly. He said IOM did several trials to find those tracks in the seabed. The tracks almost don't exist, showing impact on the environmental results.

On the matter of a feasibility study, Mr. Abramowski said it was a document containing information which constantly changed. He said IOM had documents from 1989, which were the foundation and the basis for their next work. Looking at the proposals for regulations from CRIRSCO, for example, and other institutions, he said IOM could see that there were various stages and phases of feasibility studies with various information at various stages of experiments which should be included in the study. Full feasibility studies conducted for commercial projects will contain all the information in at least 4-5 main directions – mining, geology, environmental, law and will cover topics like processing on the production scale. Such a document on feasibility study, structured similar to the technical information presented by

TOML should be prepared, (though we think that our results are more detailed) perhaps which the ISA should control.

He said that IOM had developed three technologies for processing; hydrometallurgical, pyrometallurgical and a combination of pyro and hydro; and were going to carry out an experiment on large-sample metallurgy to have some economic information for energy consumption, material use and production.

When asked if getting out the metals through metallurgical processes and selling them into market was the real bucks and it should be a parallel processing exercise, Mr. Abramowski replied that according to their research, the cost of metallurgy processing would be twice as large as the mining technological cost if they were to build a new factory. He said possible considerations would be to use existing factors in existing plants and to consider adding some quantity of nodules to the processing of laterite nickel ores.

He said that the pilot processing experiments had similar problems as pilot-scale mining and he thought that it could be further defined using examples from land processing. Mr. Abramowski continued that instead of having problem with some methods (science or engineering), it could be a problem of scale of investments, because in his opinion the engineering was ready. He said there could be some environmental processing issues and market reaction.

A participant suggested that instead of production rate of 4 metric ton per year and then something smaller, there was also the possibility of doing something smaller and profitable and if the tons of Manganese was also utilized, its usefulness other than in steel industry should be sought. Mr. Abramowski replied that mining challenges was a revolution, and that another approach could be the evolution from pilot mining scale and small nodules processing using the existing technologies on land and then gradually increasing the production.

Replying to the last question if the estimation of 3MT was inferred, Mr. Abramowski said that he thought it was indicated.

CHAPTER 13: The Concept of the Russian Exploration Area Polymetallic Nodules Resource and Reserve Categorization

V. Yubko, I. Ponomareva; State Scientific Center
“Yuzhmorgeologiya”, Russia

The Russian Exploration Area (REA) incorporates an Eastern and a Western territory with assessed cumulative resources of 448 million tons nodules. The SSC Yuzhmorgeologiya used a Russian classification of mineral reserves and resources, developed by a competent organization - State Commission on Minerals. It identified four levels of resources, in order of decreasing knowledge (A, B, C₁, C₂) and three categories of 'prognostic' resources (P₁, P₂, P₃). Resources of categories A and B were identified only in areas of detailed study for confirmation of C₁ resource estimates.

In September, 2010 FGU “GKZ” and CRIRSCO agreed to a document which took into account the Guidelines categories of resources and reserves of hard minerals stipulated by the Russian classification and applied by Yuzhmorgeologiya to polymetallic nodules and the CRIRSCO Template.

Yuzhmorgeologiya demarcated deposits based on photo, video and acoustic surveys at 3 - 6 km spacing, and one sample per 36 km². Assessed resources and reserves in the studied areas were: P₁ category (Inferred Resources) 414.3 and C₂ category (Indicated Resources) - 144.2 Mt of wet nodules. It was expected that at the end of the contract, cumulative polymetallic nodules reserves with regard to C₁ + C₂ categories would reach 180 Mt, including C₁ category of 36 Mt. Yuzhmorgeologiya qualified such reserves as sufficient for future mining enterprises processing 3 million tonnes of dry (4.3 Mt of wet) of nodules per year in the course of 20 years and the first 5-year period of the mining contract respectively.

The Russian Exploration Area (REA), which is 75,000 km², (Figure 1) incorporates two territories; an Eastern territory (61,600 km²) and a Western territory (13,400 km²). The cumulative resources of the polymetallic nodules within the REA (as dry mass) are assessed as being 448 million tonnes [2]. The average concentrations of commercially valuable components in the nodule ore of the REA add up to (%): nickel – 1.39; copper – 1.1; cobalt – 0.23; manganese 29.3 [3].

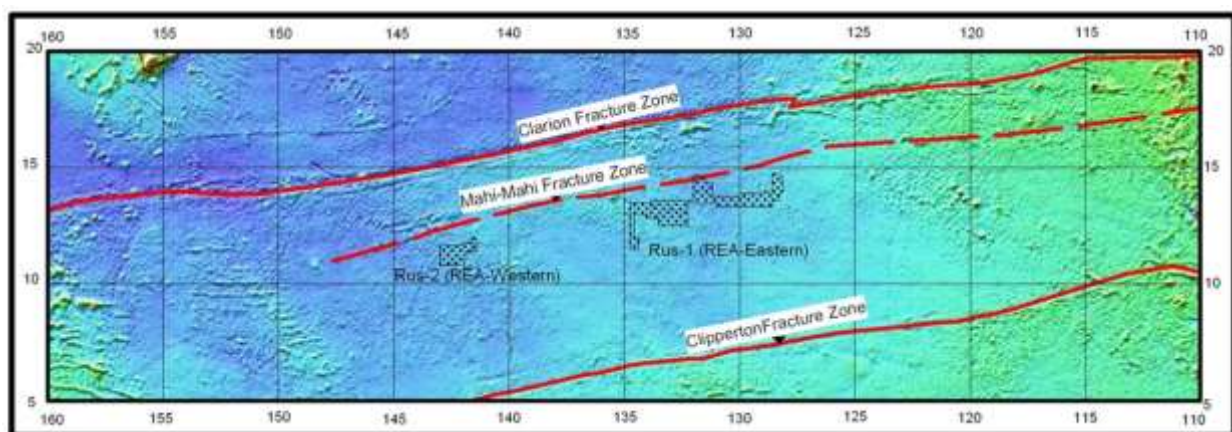


Figure 1: Location of the Russian Exploration Area (REA) within the Clarion-Clipperton Zone

The Contractor SSC Yuzhmorgeologiya used as a basis for assessment of the resources and reserves of polymetallic nodules of the Russian exploration area a Russian classification of mineral reserves and resources, developed by a competent organization - State Commission on Minerals.

According to the level of geological knowledge the Russian system identifies four levels of resources, in order of decreasing knowledge (A, B, C₁, C₂) and three categories of 'prognostic' resources (P₁, P₂, P₃) [1]. Resources of categories A and B are identified only in areas of detailed study for confirmation of C₁ resource estimates.

Prognostic resources of category P₃ provide for merely the potential possibility of discovery of deposits of one or other kind of mineral on the basis of favorable geological and paleo-geographic pre-conditions, discovered in the region being estimated. Their quantitative estimation is done without reference to any specific locations.

Prognostic resources of category P₂ provide for the possibility of discovery in a basin, or ore region, a site or field of new mineral deposits, the proposed existence of which is based upon favourable estimation of occurrence from large-scale (or in some cases medium scale) geological survey and exploration work on the mineral occurrences, and also geophysical and geochemical anomalies, the nature and possible prospectivity of which are established by single workings. Quantitative estimation of resources, opinions on the sizes of proposed deposits, on the mineral composition and quality of ores is based on a combination of direct and indirect indications of ore-bearing potential, on materials from single ore intersections, and also by analogy with known deposits of similar formation (geological-industrial) type. Prognostic resources expressed quantitatively associated with a local area form the basis for formulation of a detailed exploration work programme.

Prognostic resources of category P₁ provide for the possibility of extension of the spatial area of mineral beyond the boundary of C₂ reserves or delineation of new ore bodies at mineral occurrences, and for ore deposits which are explored or currently being exploited. For quantitative estimation of resources of this category, geological evidence based on the sizes and formation conditions of known bodies are used. Estimation of resources is based on the results of geological, geophysical, and geochemical studies of the area of possible location of mineral.

Reserves of category C₂ are identified from exploration of deposits of all complexity groups, and must comply with the following requirements:

- the size, form, and internal structure of the mineral body, and conditions of formation are estimated from geological, geophysical and geochemical data and confirmed by intersection of the mineral by a limited number of drill holes and mine workings;
- the outline of the mineral reserves is defined in accordance with the results of sampling of a limited number of drill holes, mine workings {e.g. trenches, pilot-scale pits}, natural outcrops or by their biota {indicator fauna/flora}, with consideration of data from geophysical and geochemical studies and geological structures.

Reserves of category C₁ constitute the main part of reserves of explored and mined deposits with the following basic requirements:

- the size and characteristic form of the mineral body, and main particularities of the conditions of formation and internal structure are explained; variability and possible discontinuity of the mineral body are estimated;
- the natural variation and the industrial (technological) types of mineral are defined; the general laws of their spatial distribution and quantitative relationships of industrial (technological) types and sorts of mineral, and mineral forms of occurrence of valuable and deleterious components are established; the quality of industrial (technological) types and sorts of mineral are characterized for all envisaged industrial parameters;
- the outline of the mineral reserves is defined in accordance with the requirements of conditions according to the results of sampling with consideration of data from geophysical and geochemical studies.

Reserves of category C₁ are the principal basis for planning and mine design.

Reserves of categories A and B are identified usually only in areas of detailed study for confirmation of C₁ estimates, and as a rule do not have any independent significance.

In September, 2010 FGU “GKZ” and CRIRSCO agreed document «Guidelines on Alignment of Russian minerals reporting standards and the CRIRSCO Template» [1], select the corresponding categories of resources and reserves of Russian and CRIRSCO classification systems (Figure 2). Taking into account this Guidelines categories of resources and reserves of hard minerals that are stipulated by the Russian classification and applied by us to polymetallic nodules are related to the categories of CRIRSCO Template in the following way (see Table 1).

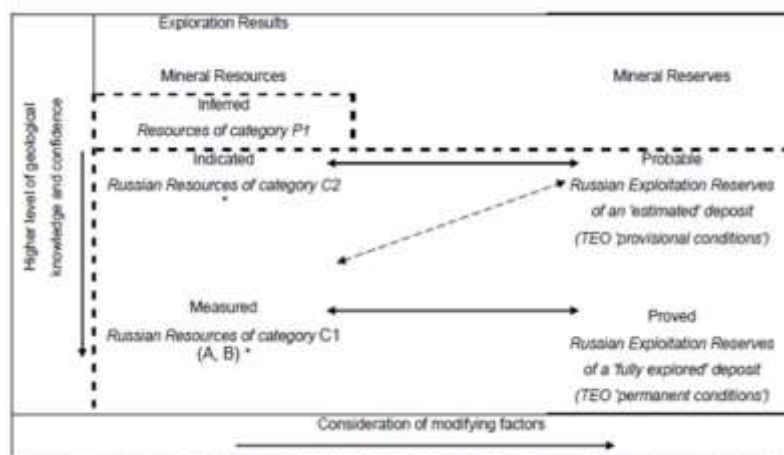


Figure 2: A mapping of the Russian and CRIRSCO classification (categorization) of Mineral Resources and Mineral Reserves [1]

Table 1

Categories of the Russian Classification	Categories for the CRIRSCO Template
Prognostic Resources of Category P ₁	Inferred Resources
Resources of Category C ₂	Indicated Resources
Resources of Category C ₁	Measured Resources

Before the exploration, provided in the Exploration Plan for REA, we supposed that a task of upgrading to better categories of provisionally Inferred Resources of polymetallic nodules, assessed at submitting to the Authority our application that was based upon the results of sampling along a relatively spaced grid of 50 x 50 km, would not be too difficult. This opinion was based on the concept of a simple pattern of spatial distribution of nodules comprising some relatively large accumulations of tens of thousands square kilometers on the bottom surface (Figure. 3). It was assumed that for the assessment of such accumulations of reserves with regard to category C₂ (Indicated Resources) it will be sufficient to perform sampling along a condensed grid and then to specify statistically average values of their tonnage and grade.

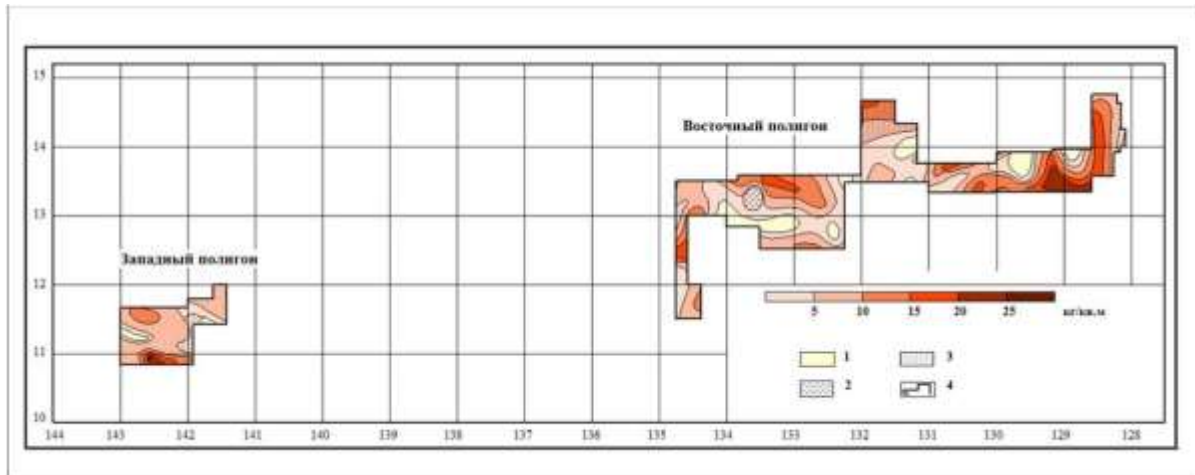


Figure 3: Early concept of a simple pattern of spatial distribution of nodules accumulations

However, upon the results of a period of more detailed surveys it became obvious that individual accumulations or, as we called them, ore deposits of polymetallic nodules happened to be substantially smaller and much more numerous than expected. Thus, according to our estimates, a number of ore deposits within the RAE is about 300 (Figure 4). The area of about half of them is less than 50 km², and the largest deposit is about 4000 km².

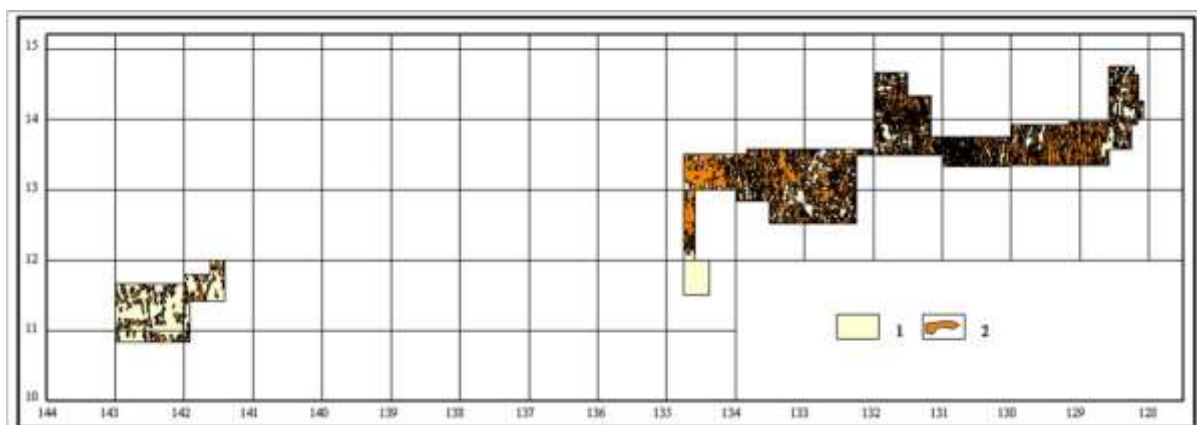


Figure 4: More real concept of nodules accumulations spatial distribution: (1) Ore free (2) Ore deposits

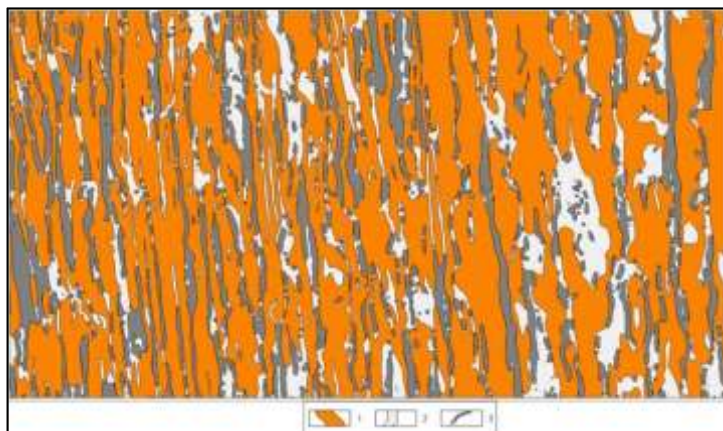


Figure 5: Example of a thoroughly studied fragment of the RAE (1) Ore deposits (2,3) Ore-free zone, connected with (2) zones of flattened bottom relief, (3) with zones of steep slopes

The provided example of a thoroughly studied fragments of the RAE (Figure 5) showing a typical sinuous form, small size of ore deposits and boundaries confined to steep slopes and trenches demonstrates necessity of taking into account of such aspects at the assessment of reserves of polymetallic nodules with regard to category C_2 (Indicated Resources). It is clear that such reserves should be considered as a sum of reserves of only those deposits, whose tonnage and grade are prospective for future exploration.

At the moment Yuzhmorgeologiya is solving this task. Demarcation of deposits is carried out based on photo, video and acoustic surveys along the sub-latitudinal lines with 3 – 6 km spacing. Sampling grid covering each deposit is regular with 1 sample per 36 km². Acquired practices of classification of ore deposits showed, that within those deposits that satisfy the above requirements, the abundance and grade parameters of polymetallic nodules are quite uniform (Figure 6).

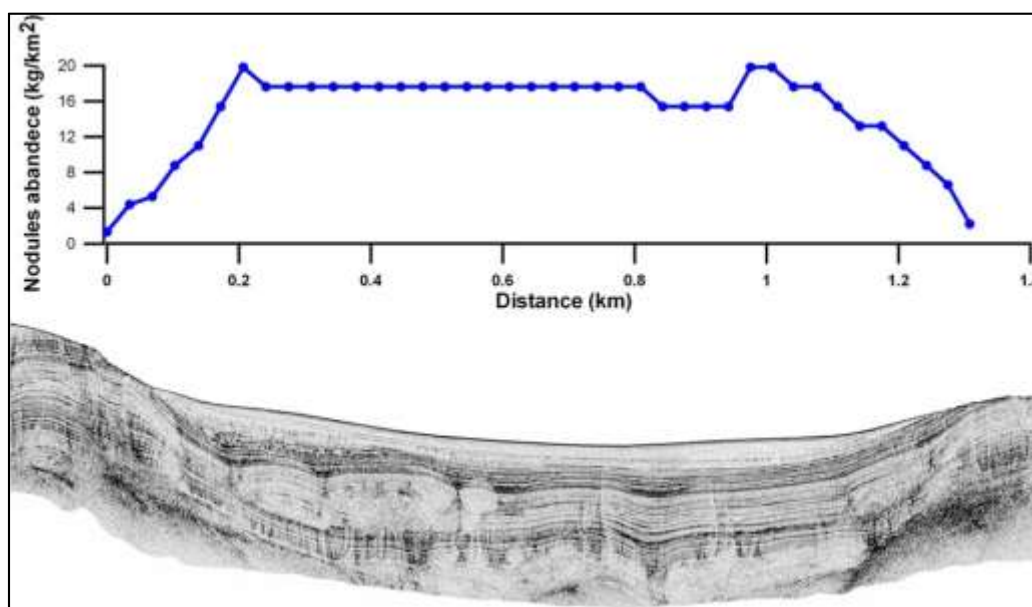


Figure 6: The schedule of nodules abundance variability (above) an acoustic cross-section of a sea bottom (below) across the ore body

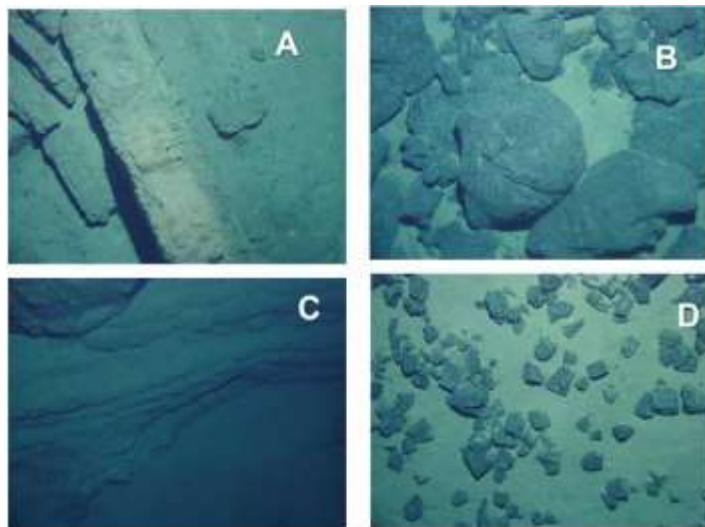


Figure 7: Types of bottom obstacles (explanations in the text)

It was discovered that within many of such deposits there are quite abundant zones of so called obstacles for their future development. The most significant obstacles are bottom outcrops of lithified sedimentary (Figure 7A) and igneous (Figure 7B) rocks, steep slopes and erosive trenches (Figure 7C), areas of potential slides of unconsolidated sediments (Figure 7D).



Figure 8: Assessed resources and reserves of the studied areas.

Figure 8 illustrates a current situation with the assessment of the resources and reserves of the REA. Pink color (2) shows those REA parts that are studied to a degree that is sufficient for the assessment of the P1 category resources (Inferred Resources), and yellow (1) of the C2 category (Indicated Resources). Dashed contour (3) shows a site that was specified for detailed studies required for the assessment of the C1 category reserves (Measured Resources).

Assessed resources and reserves of the studied areas are: P₁ category (Inferred Resources) - 414.3 and category C₂ category (Indicated Resources) - 144.2 ml t of wet nodules. It is scheduled that by the moment of the Contract completion cumulative polymetallic nodules reserves with regard to C₁ + C₂ categories will reach 180 ml t, including C₁ category of 36 ml t. We qualify such reserves as sufficient for future mining enterprises processing 3 million tonnes of dry (4.3 ml t of wet) of polymetallic nodules per year in the course of 20-year and the first 5-year period of the mining contract respectively.

References

1. Guidelines on Alignment of Russian minerals reporting standards and the CRIRSCO Template. [http://www.gkz-rf.ru/index.php?option=com_content&view=article&id=96:-crirSCO &catid=42:news-news&Itemid=55](http://www.gkz-rf.ru/index.php?option=com_content&view=article&id=96:-crirSCO&catid=42:news-news&Itemid=55)
2. Kozlovskiy, E. Marine and Oceanic Deposits of Mineral Resources. Industrial Bulletin, Q1 (in Russian). <http://www.promved.ru/articles/article.phtml?id=338&nomer=13>
3. Strategy for the Development of the Research Fleet of the Ministry of Natural Resources of the Russian Federation (in Russian), http://www.mnr.gov.ru/files/part/4412_kontseptsiya.pdf

CHAPTER 14: Status of Korea Activities in Resource Assessment and Mining Technologies

Chan Min Yoo & Sup Hong, Ministry of Oceans and Fisheries,
Republic of Korea, Korea Institute of Ocean Science & Technology
(KIOST)

Dr. Yoo presented the resource assessment activities of Korea and Dr. Hong described its miner Robot, MineRo. Dr Yoo said that from 1992 to 2010, Korea focused on resource assessment and environmental baseline studies. During 2011, high resolution topography and acoustic seafloor surveys were carried out and environmental data for benthic impact experiment gathered.

He also said that sampling with free fall grabs (4 at each site) and box corers showed average abundance of 7.5 kg/m² at 4800-5100m depth. The slope gradient was less than 5° in 90% of the contract area. The shear strength of the sediments was between 10 cm to 40 cm and 87% of the total area has over 5kpa. It was easier to operate the miner robot - MineRo in southern blocks covered with consolidated sediments.

Kriging and the conditional simulation methods showed that the differences in areas of low density data when compared with high density sampling data were less than 5%. Therefore, available resource data could be described as indicated to measured mineral resource.

Dr. Hong said that a tentative production plan for nodule mining of 3 million tons/year for 30 years had been selected, based on previous studies. He also said that Korea's priority mining area was estimated as 18,000 km² with about 188 M ton of mineable resources. Dr. Hong said that delineation of the mining area was directly coupled with mining technology. He elaborated on Korea's pilot mining robot, MineRo which had undertaken two at sea trials in 2012 & 2013 at 130m depth. He noted that its collecting efficiency had been verified at the laboratory as 95%. Dr. Hong said that the seafloor miner should be limited to high-tech robotics to enhance nodule pick-up, crushing, and discharging performances. He told participants that the ongoing technological development of 20 years would end next year.

I want to talk about the activities of Korea in resource assessment and mining technologies. My talk will contain a brief history of exploration activities in Korea; general characteristics of the contract area; resource assessment; the selection of mineable areas and priority mining area and the scope of future work. After that Dr. Hong will explain about our miner robot, Minero.

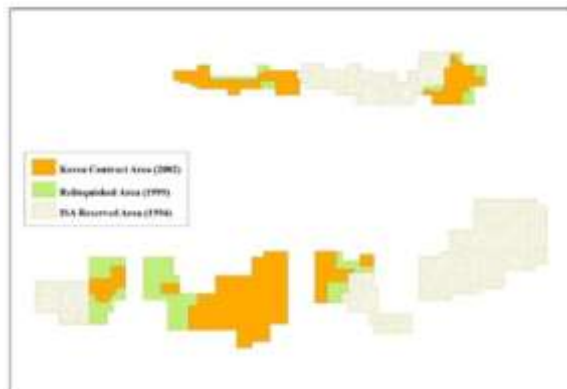
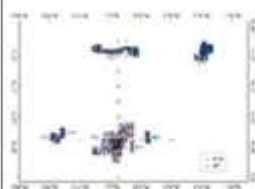
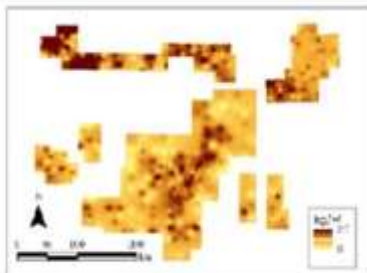
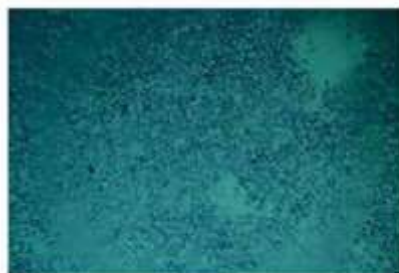


Figure 1: 1994 - Registration as a pioneer investor; 1997 -first relinquishment; 1999 - Second relinquishment; 2002 – Selection of final contract area

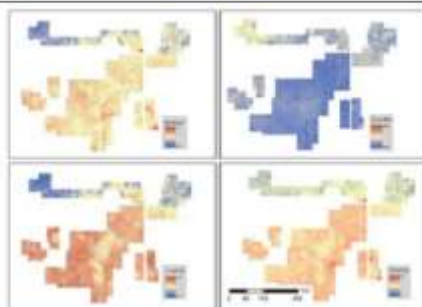
In 1994 we acquired 150,000 km² exploration areas as a pioneer investor in the middle of the CCZ fracture zone. We relinquished parts between 1997 and 2002. Our final contract area comprises areas totaling 75,000 km².

- **Stage I (1994-2010) :** Resource assessment and environmental baseline study
- 925 days (ave. 62 days/year)
- **Stage II (2011-2015) :** High resolution topographic and acoustic seafloor mapping in a prospective area and environment data collection for BIE (195 days)



- **Collection of Mn-nodule :** 1,354 sites (FFG 1,062 (4 deployments at a site); BC 292)
- **Average abundance :** 7.5kg/m²
- **High in north central (10.5kg/m²), and low in southwest (6.3kg/m²)**

- **Mineral resources are estimated from 451 samples**
- **Average contents of Ni, Co, Cu, and Mn are 1.19, 0.22, 1.02, and 27.7%.**



Variable	#Samples	Min.	Max.	Ave.	Median	S.D.
Ni	451	0.26	2.09	1.19	1.25	0.26
Co	451	0.07	0.65	0.22	0.21	0.07
Cu	451	0.22	1.64	1.02	1.09	0.31
Mn	451	4.7	47.7	27.7	28.7	5.1

and copper are higher in the southern blocks whereas the cobalt is higher in the northern blocks.

Exploration summary

We carried out exploration activities through two stages. From 1992 to 2010 we focused on the resource assessment and environmental baseline studies.

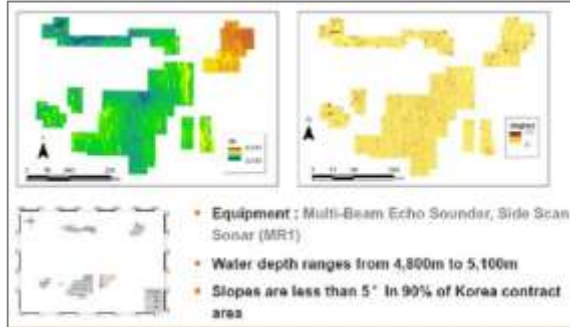
We carried this out over more than 60 days every year at sea. During stage two in 2011 we changed our strategy for exploration. We carried out high resolution topography and acoustic seafloor survey in our prospective area and gathered the environmental data for benthic impact experiment. These photos show our research vessel we used for exploration and the sampling equipment in there.

Nodule resources

The estimation of nodule resources was done by taking the samples from more than 1300 sites using FFGs and box corers. The four FFGs were deployed at sites for accurate estimations of the nodule abundance. We collected samples at the regular distance in all our contract areas. We estimated the average abundance at 7.5 kg/m². The nodule abundance is high in the north central and low in the southwest of our contract area.

Mineral resources

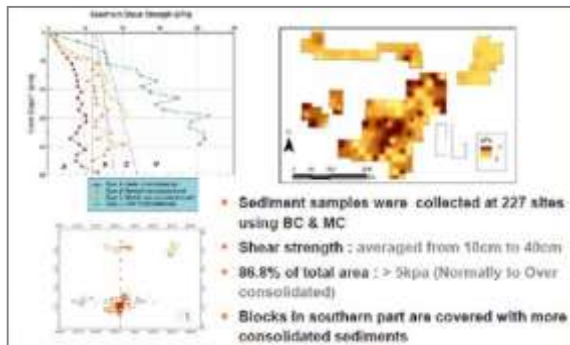
The mineral resources were estimated from 451 nodule samples. This table shows the statistics of metal content of the whole areas. In general the nickel



Topographic surveys

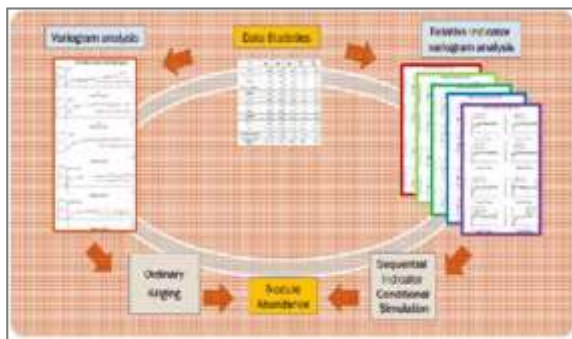
The slide above shows the seafloor topography and slope gradient of our contract areas. We got the topographic data by using multi-beam echo sounders and MR1 side scan sonar from the University of Hawaii. In most areas the water depths range from 4800m to 5100m. The depth varies at around the north to south direction.

The slope gradient is very important for mining operations. We measured the slope gradient from the topographic data and the slopes were less than 5 degrees in 90% in our contract area.



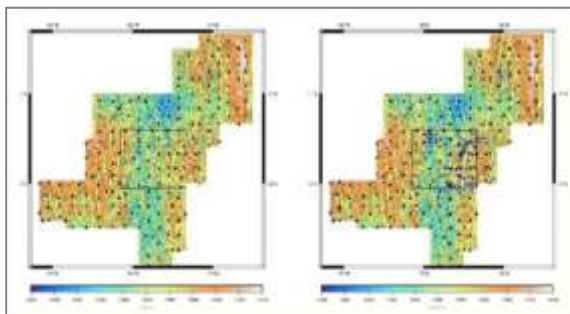
Sediment property – shear strength

We also collected sediment samples from 227 sites using box corers and multiple corers and measured the shear strength in centimeter intervals. The various shear strength averaged from 10 cm to 40 cm of the sediments. As a result 87% of our total area has over 5kpa. The blocks in the southern part are covered with consolidated sediments which is easier to operate our miner robot.



Estimation of nodule abundance

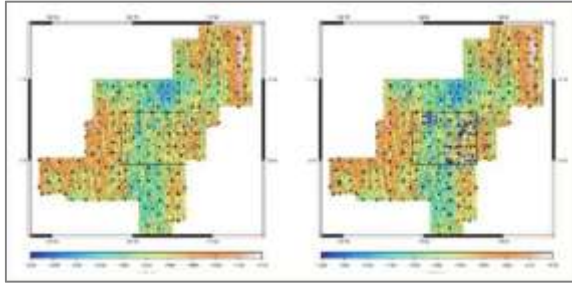
I will now talk about our resource assessment from the central data. We estimated nodule abundance using the ordinary kriging method and the sequential indicator conditional simulation method. We carried out the variogram analysis for the ordinary kriging method and our relative indicator variogram analysis for SIS method. As a result nodule abundance was the average result of both methods.



Nodule abundance of KR5 Areas

We collected the evenly-spaced samples in the whole contract areas. This shows the figures in the KR5 for us. In this case the average distance between samples is about 14 km. We collected more samples in a selected area to estimate the accuracy of our evenly-spaced samples. In this case the sample distance decreased to very close at 3.6 km. In order to generate

the necessity of more sampling in our areas of resource assessment we compared the nodule resources estimated from the low density data to high density sampling data in the selected areas.



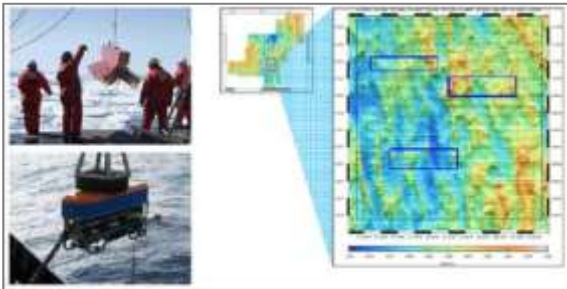
Nodule abundance of selected areas

This figure shows the blown up images of the best areas. On the left the figures show the low density data. It contains data from 32 points. The average abundance in this case is 8.0 kg/m². On the right side is the high density. It includes about 116 points and it estimates the nodule abundance is about 8.3 kg. The difference between the two data is about less than

5%. We think it is very similar. We believe this data tells us that our low density data is enough to estimate the resource assessment in our whole contract area.

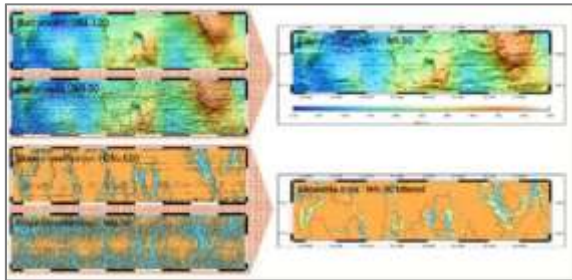
Although we did more statistics for the future our resource data could be described as the indicated to measured mineral resource category.

Mapping of mineable area – seafloor acoustic surveys

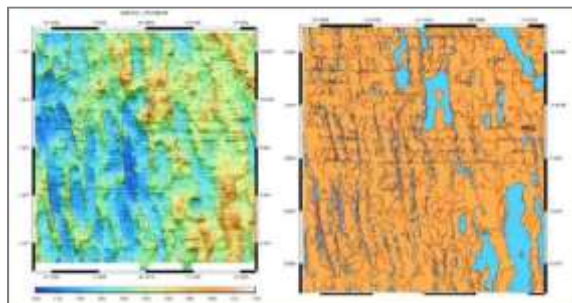


To select the mineable areas we did the seafloor acoustic survey in our key prospective mining areas. The site is about 1600 km². We used two high resolution deep tow side scan sonars, IMI-130 and DSL-120 from the University of Hawaii. Their resolutions are 25m and 5 m respectively. We collected the IMI-130 data in the whole prospecting mining area and the DSL-120 data from the three representative areas. We

expect to define the obstacles for miner operations and to construct our mining algorithm using these data in the future.

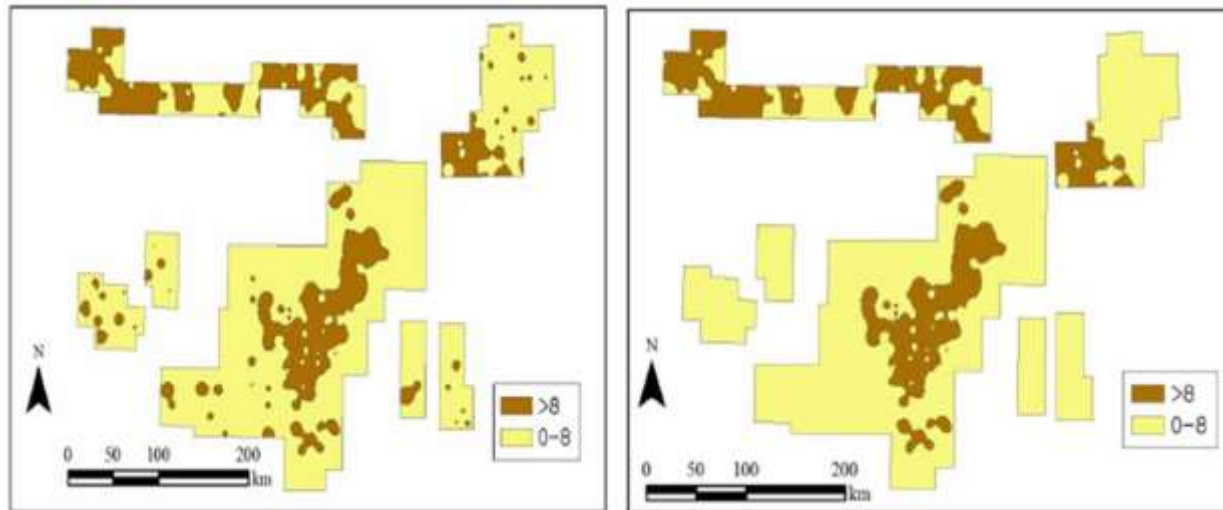


This is the processing of the data. We acquired this by using the side scan sonars (left). This figure is the topography acquired from the DSL-120; the second one from the IMI-30. The figure (middle) is more high resolution. We based all the high resolution topographic data and the filtered bathymetry maps from IMI-130 data. For slope gradient we used the same process. We defined the areas by obstacles, continuity or the slope gradient in more detail using these data, so the mineable areas are defined by the slope gradient which is less than 5 degrees and obstacle continuity.



This one is the filtered topographic maps using the IMI-30 data in the whole area. Using the filtered processing, we decided to estimate the mineable area taking into account the slope gradient and obstacle continuity which was about 75% in this area.

Selection of priority mining areas

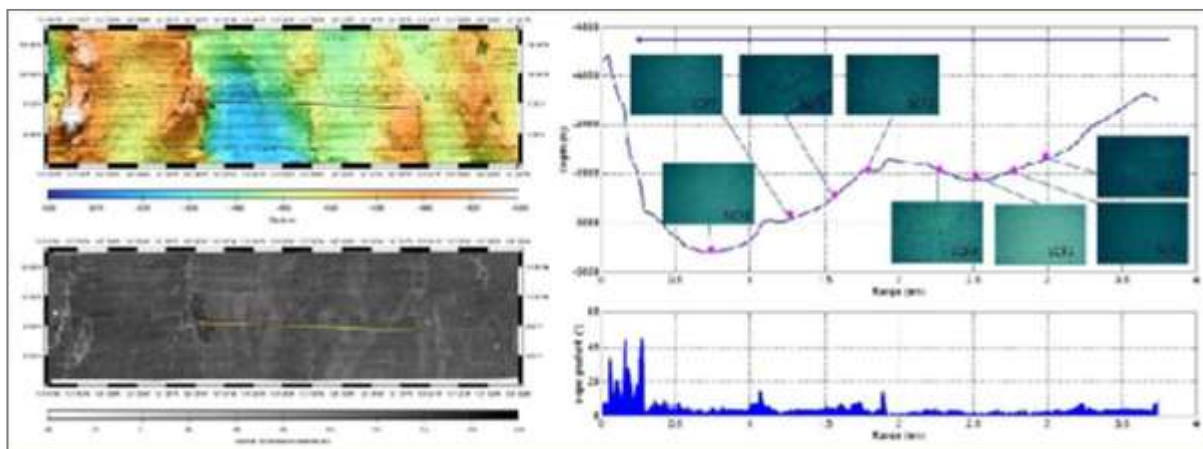


For selection of priority mining areas, we decided on a tentative production plan for nodule of 3 million tons per year for 30 years based on previous studies. To have this production rate we need to collect nodules in the area and the nodule coverage is about 8 kg/m^2 (shown in the brown).

Resources within priority mining areas

In considering the factors we discussed the previous three – the cut-off abundance (8 kg/m^2), slope gradient ($<5^\circ$) and continuity of the mineable area. We also considered the collecting efficiency of miners. Dr. Hong will explain this later. We estimated our priority mining area as the $18,113 \text{ km}^2$ and mineable there is about 188.4 M ton (avg. 10.4 kg/m^2).

Future work plan for resource assessment



This is the last slide showing the future work plan for resource assessment. For the next stage we will have continuous nodule abundance data in our representative area for more accurate resource assessment. For this we need to process the backscatter intensity image from the deep towed side scan sonar data. After that we collected more seafloor images using the deep-sea system and AUV and the

nodule data using the TV-guided box corers in the same areas. By comparison of the seafloor images and data we can make continuous nodule abundance map in the representation areas. We also made maps of the mining obstacles in the representative areas for the work of resource assessment.



Resource assessment and mining technology: safe and eco-friendly mining

Today I am here to share the status, understanding, knowledge and technology done by Korea. The above photo was taken of the pilot mining robot, MineRo, which had just recovered above seafloor after one set of sea test. It was done in 2013. For this kind of pre- pilot mining test we are spending 5-6 years from 2007/8 until now.

$MP = NC \times WC \times SC \times PE \times TE \times LE \times HE \times T$		
<i>MP</i> : Mining Production,	<i>NC</i> : Nodule Coverage	
<i>WC</i> : Width of Collector,	<i>SC</i> : Speed of Collector	
<i>PE</i> : Pick-Up Efficiency,	<i>TE</i> : Time Efficiency	
<i>LE</i> : Lifting Efficiency,	<i>HE</i> : Handling Efficiency	
<i>T</i> : Time		

I am very glad to talk about safe and eco-friendly mining. It took a long time to be able to talk about this topic. Similar to Tomasz Abramowski, my background is naval architecture and ocean engineering. I have taken charge of the development of the technology for mining systems for polymetallic nodules since 1994. I am being aged with this project.

Delineation of mining area is directly coupled with mining technology, in particular the performance of the miner robot which is crawling on the seafloor and its integrated controllability together with the lifting system.

In the phase of preliminary feasibility studies this simple equation gives mining production. Multiplication of several factors gives mining production. It is a very simple and beautiful equation – linear and non-linear but in reality it is not so easy. As we all know the mine site is not a flat soccer ground; it is filled with various kinds of obstacles.

How to sweep the nodules on the seafloor as much as possible is a question of mining technology. Sweeping efficiency if like say 100 tons are in a restricted area, then in sweeping, sweeping, sweeping only 20 tons is collected, this is very uneconomical. Therefore the terminology sweeping efficiency

represents the recovered amount of the resource by passing that area. The sweeping efficiency is a function of pick-up efficiency; it is recovering efficiency and area coverage performance of the collector or mining machine of any kind. Therefore mineable resources are the same as mining technology.

Because of the weak and soft seafloor sediment property any kind of operation will generate very severe sediment plumes. So because of the sediment distortion you can imagine that you will see nothing. So the manual operation of the mining system is, in principle, impossible. I therefore would like to say ultimate control is an indispensable factor for commercial mining. Manual operation of the mining machine is extremely restrained in the sediment plumes. As a contingency action, the operator should be ready and on standby for emergency cases. However, the regular mining operation should be automatically controlled.

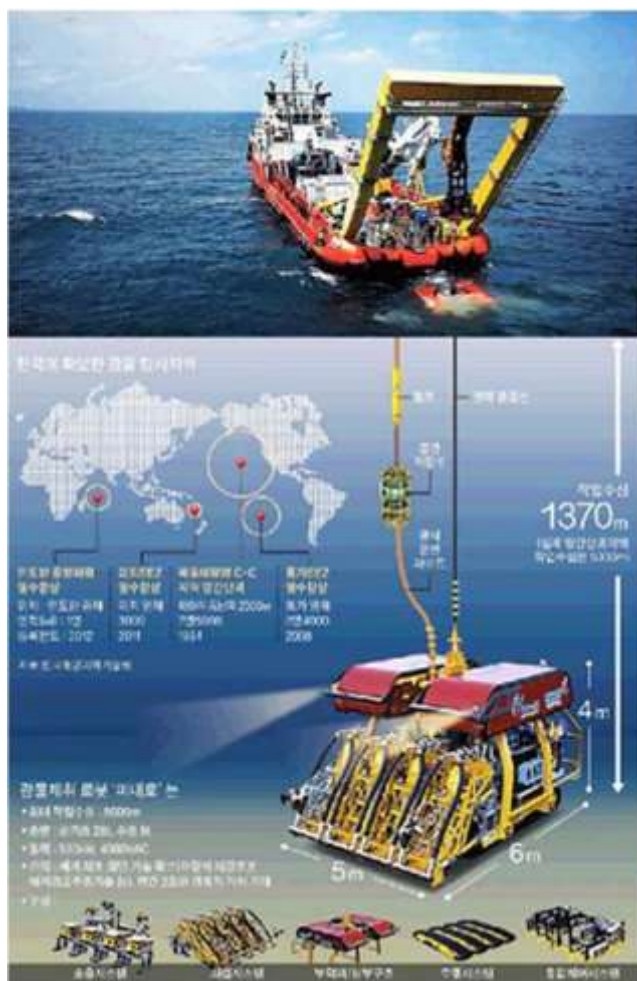
Further on, the seafloor miner should be limited by high-tech robotics, because the driving performance can be achieved in a certain level only through robotics. I will talk in more detail about automatic path tracking. In the mining sector the collector or mining robots should turn to come back to the mine site



after a certain time. We therefore have to design the very optimum mining path before we start as to manually operate is impossible. Automatic tracking of the pre-determined path is very important – that is the main function of the miner robot.

Based on this robotic technology, the performance of the nodule pick-up, crushing, and discharging performances can be much more enhanced.

This slide shows the concept of the continuous mining system from the mining platform. The subsea system will be deployed and recovered on the floor. The miner robot is working and the collected nodules are transported into the buffer. The buffer plays the role of intermediate storage tank and regulates the constant rate of lifting so that the lifting performance is at optimum.



Development points of pilot miner robot

For the development of pilot miner robot, we have several points. The final goal is to reach a technological readiness level (TRL) of 6, by completion of pilot mining test. TRL is a widely-used concept in ocean engineering, from 1-9. 1-3 is a basic fundamental study; 4-6 is a scale test and 7-9 is commercialization phase. The technology level 6 is defined as the developed technology that has been validated through pilot scale tests – that is the definition of TRL-6. Seven is technology transferred to the private sector. Eight is standardization of the rules and nine is commercialization.

In the phases of research and development projects the final goal was definitely defined to reach TRL-6. For robot development, the HSE principle is the baseline for all ocean engineers; health, safety and environment.

Extrapolation to commercial scale should be confirmed through pilot mining tests. After, pilot mining tests, the concept should be continued to commercial mining. We wanted to confirm the high efficiency and high productivity by achieving the collecting efficiency and area coverage performance.

Last but not least the environmental issue should be considered very seriously. In the framework of miner development, we concentrated on minimizing the environmental impact on the benthic system and water column. There was low penetration into the seafloor sediment transportation and separation of the sediment in the operation as much as possible. Minimize the sediment up to the sediment transportation of the surface. Those three factors were our major tests.

The mining robot, MineRo, is the name of my toy. It consists of several parts: the driving system - four tracks; pick-up devices and crushing; pumping system; structural activity parts together with flotation - buoyancy and electrohydraulic system and control. The mine test was chosen to be 30 ton/hr; it is 1/5 of commercial scale. We have compared two kinds of pick-up devices; one is hybrid type and the other one is hydraulic. Finally, we chose hydraulic devices. I have to thank Ted Brockett because he taught me about KISS. The hydraulic system is much simpler and more robust and reliable. In the integrated figure it looks like one part. However, it can be divided into two parts. The total weight is less than 30ton in the air and in water 20 tons; in size, 6.5 m long and 5m wide. The contact pressure mean is about 9kPa. The total power is 550 kW and the working depth is designed and confirmed to be 6000m. Originally MineRo was designed to be used in environmental impact in the CCFZ therefore the depth rating was selected to be 6000m.

Pilot mining robot – MineRo



MineRo can be divided into two parts; two robot units identical in function and 99% equal in shape. Each robot unit has two pick-up devices, two tracks and one discharging pump so that it can be operated individually as it is 4m in width. A large robot cannot be easily transported. If we attach one unit model sideways the mining capacity can be easily extended to commercial scale.

Collecting efficiency [lab test]

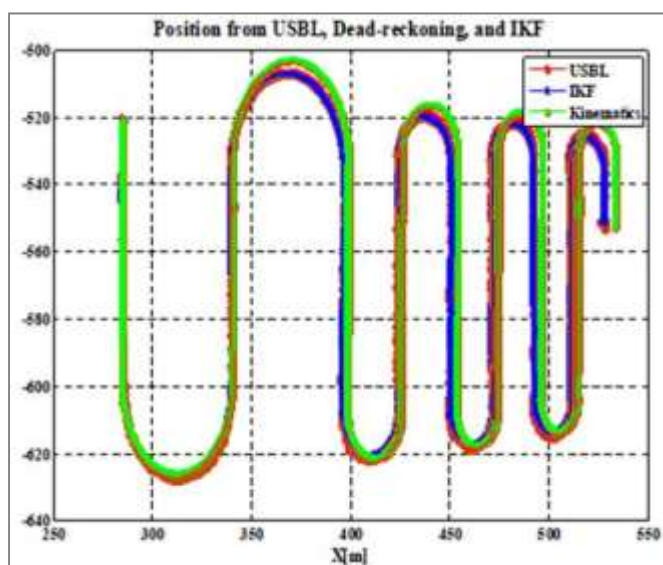
We have tested the collecting or pick-up efficiency in the laboratory. We have varied the design parameters – gap,) the clearance between pick-up and the seafloor. The gap can be

controlled by using the hydraulic cylinder), nozzle shape, flow rates of water pump and so on.

In the laboratory maximum 95% of collecting efficiency has been verified. Because of this gap of the two pick-up devices 100% pick-up was not possible.

Collecting efficiency [sea test]

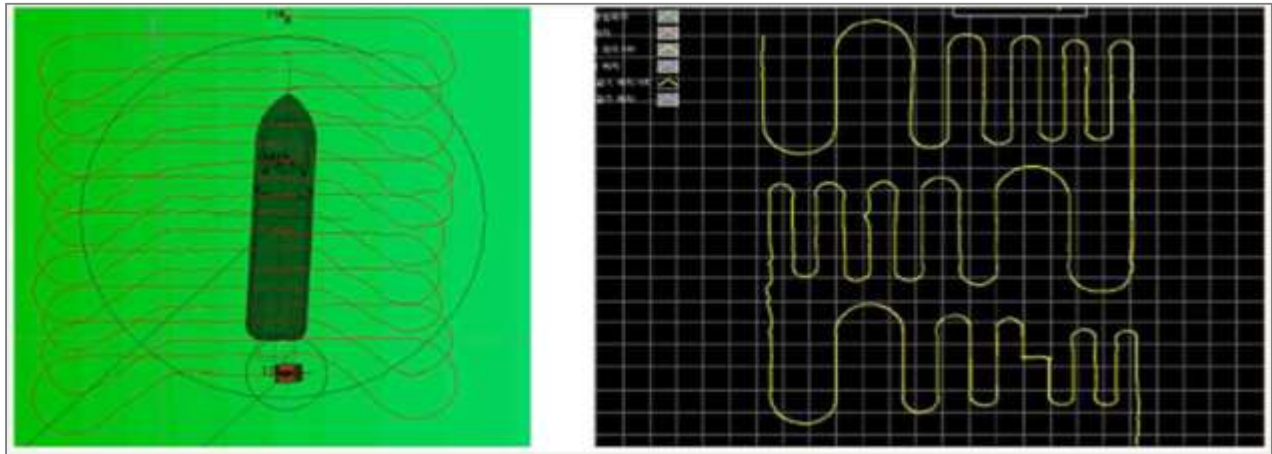
During at-sea tests we tried twice at water depth of 130m - in 2012 and 2013. Before the sea tests we prepared the seafloor with artificial nodules which are very simulated in strength, size and specific weight.



Underwater localization

We had to have the precise underwater localization system. As you see here, we are all using navigation systems in our cars, depend on the devices the accuracy is different. Before we did the MineRo path-tracking test system is a pre-requisite step, not only using the underwater sonar system but also the dead-reckoning and sensor data are merged together to enhance the accuracy of the localization. As we all know the underwater acoustic wave is elastic wave, so that the random noise is inevitable. We always have to work together with this random noise. To get accurate position is very important.

Driving performance

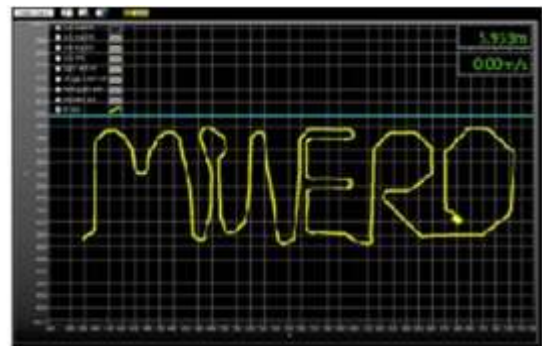
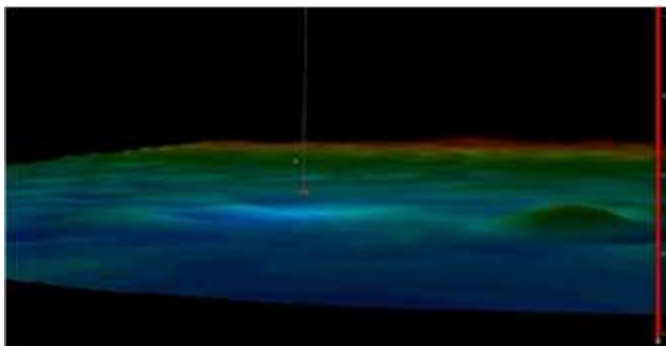


Based on the underwater localization system we have performed steering characteristics investigation of the developed MineRo on the soft seafloor very thoroughly. This slide shows the trajectory path of MineRo. The performance parameters are forward speed, angular velocity, track slip, slip angle, etc.



The next topic is aerial coverage performance. As mentioned by Ted Brockett, you can compare the vacuum cleaner with the vacuum cleaner robot. With the vacuum cleaner you have to move the cleaner to the position where the dust and waste are. The vacuum cleaner robot moves itself and sweeps the whole area automatically. The automatic path tracking of the miner robot is ultimately important for profitable mining of the polymetallic nodules.

Path tracking tests [2013]



We wanted to do all kinds of path tracking tests in the depths of 1370m but as you see the undulation of the seafloor was very irregular and large in magnitude and because of the size of the ship was only 70m long and there was only 1m high wave – this was very serious. So we could not stay there a long time.

We came back to the shallow water region to this precise test in 130m condition.



In this slide in the word “Corea”, the white line is about 5m in scale and the red colour is the real trajectory of the MineRo. If you can see the video the whole path can be followed very successfully. At the same time not only the path tracking but also the constant speed was controlled and kept at 0.29m/s – 0.3m/s.

Safety and eco-friendliness

Safety and eco-friendliness is very important and profitable. By handling the technology development we kept in mind eco-friendliness and safety to be profitable, not only as mandatory and as a duty. We minimized inevitable disturbance of the benthic system; suppressed and controlled mass transfer from the bottom to the surface and reduced emission of CO₂.

Safety measures included prevention of pipe clogging and prevention of structural and machinery damages. Based on this eco-friendliness and safety profitability is assured by saving the cost for sediment and water treatments on board. Pumping efficiency is higher and down time is reduced so that the performance of the miner robot will be maximized.

Counter measures to this environmental issue

We have put in efforts to achieve the goal by design of the optimum contact pressure. MineRo was specifically developed with assurance of floatation – not to sink/penetrate into the deep part of the seafloor; trafficability - enough driving force .

We tried to put the design idea to separate the sediments as much as possible at the MineRo and buffer stage, to that of the sediment transportation up to the surface.

Flow assurance is quite important in the offshore industry for chemical mass transfer and also for water and solid transportation - it is a slurry transportation. If the nodules are too much introduced into a lifting pipe in a 5km long journey it might cause unexpected problem of pipe clogging. At the same time, if we can control the transportation rate in optimum condition for the pump, then the energy consumption with the pumping system can be optimized. That means the CO₂ emission is reduced. The feeder control function was added to the buffer.

Pumpi and Buffee



The long journey of technological development for over 20 years will be ended next year. Pumpi and Buffee are nicknames of the buffer and lifting pumps, they are to be tested in 2015. They would be installed at 500 m to check the performance. The buffer is large compared to the pump which is about 10m high with a total weight of 30 tons.

As mentioned by Tomasz Abramowski this test can be categorized as pre-pilot mining test. The pilot mining test should be conducted in a total integrated way, together with the miner robot with a flexible link to the buffer, from the buffer to the lifting surface.

The original plan of the Korean government was to finish the pilot mining test in 2015 but the goal has been changed. We have to finish the pre-pilot mining test of the robot, buffer and pump by 2015. For a total integrated mining test. Maybe ISA can initiate this kind of large scale mining test. It will be beneficial for all contractors.

Summary of discussion

A participant noted the development of future exploitation and said that this document should consist of several parts, e.g. legal regime, production rate, the needs for some precise regulations of a technical nature which could be included in characteristics of mining corporations. He said Korea already had something along those lines in its presentation, therefore if it was possible for Korea to comment on how to determine those values, it could be a good basis for formulating future exploitation regulations by the LTC.

Dr. Hong said that to quantify the percentage of sediments included in the slurry, transportation up to the surface could be tried only through a total mining test. In a stage of the pre-pilot mining test, a component of the subsystem test, could then be qualitatively judged to decide the function and performance of the subsystems. Quantification of sediments proportion up to the surface could only be conducted by large scale integrated mining test.

Replying to a question on whether it was possible to transport the nodules without crushing, Dr. Hong replied that it was. He said the MineRo pump system was designed to be matched with the 8" inner diameter of the riser. In case of crushing, the crushed size of the nodule would be 20-30 mm.

On the question of whether upscaling to commercial size would be through multiplication of the test size or enlargement of the size itself, Dr. Hong said that there were several alternatives but his preference was to expand the unit robot laterally.

A participant commented that there was close linkage with regard to the classification of resources as well as EIA. Dr. Hong replied that one purpose of developing MineRo was to use it in the EIA in the CCFZ and in the resource assessment to delineate the mineable area of Korea's contract zone. Depending on the maneuvering performance of the vehicle, it could be delineated differently. In this sense the mining technology could be linked together with resource classification or estimation, mineable areas definition, mineable size and amounts of the nodules.

CHAPTER 15: COMRA's Activities in Resource Assessment

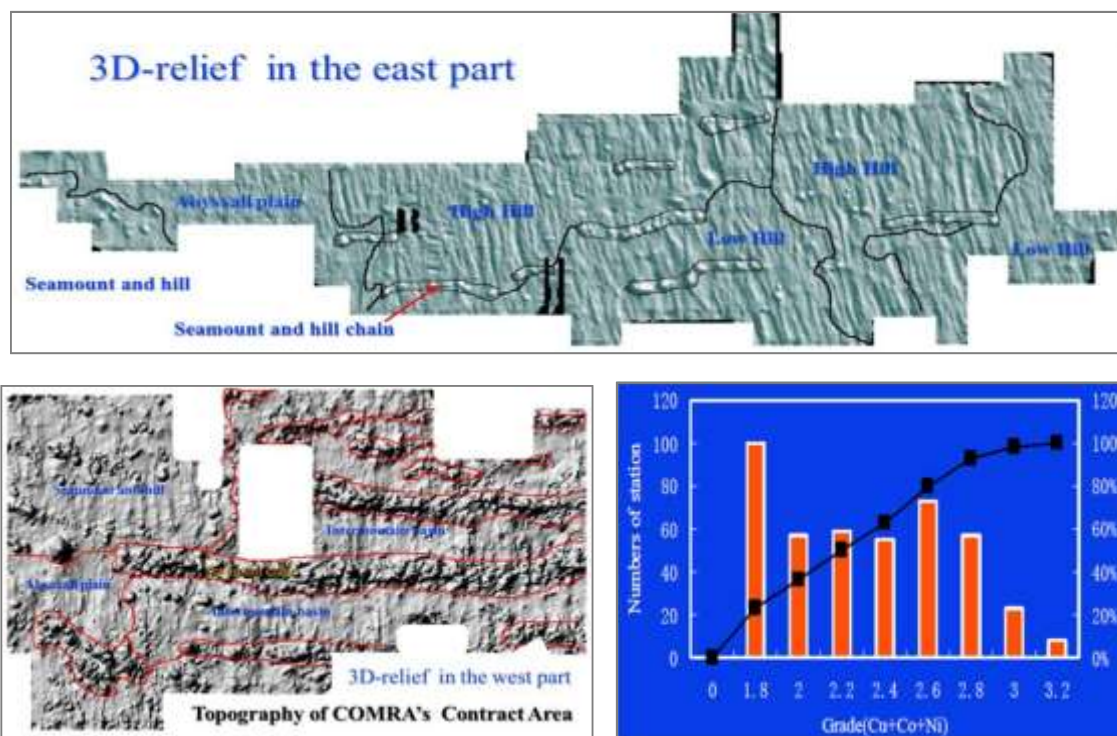
JIN Jiancai, Secretary-General, China Ocean Mineral Resources R & D Association (COMRA)

Dr. Jin informed that COMRA's western license area has lower grade, and the eastern area lower abundance. He said that the block with potential deposits were divided into six parts. The eastern part had 5 kg/m² abundance, about 1.8% grade and about 50 slope, at 9.8km x 9.8 km sampling grid.

An area of 217 km² with flat terrain was chosen for future environmental impact assessment together with equipment testing. Dense sampling and AUV measurements were carried out in this area in 2013 and will continue into 2015. He said that resources in the western part of COMRA's contract area were categorized as inferred, indicated and measured resources using the China (GT 1776-1999) that was based on UNFC 1997 with different categories of resources: 331, 332 and 333.

Dr. Jin said that the resource classification between COMRA and CRIRSCO were comparable; and that COMRA was in the stage of pre-feasibility studies. He mentioned the LTC chairman report in 2006, where the need to establish mineral resources/reserve classification system for the Area was expressed and discussions around system with global applicability, e.g. the UNFC. Mr. Jin presented COMRA's proposed mineral classification system.

I will focus on COMRA's activities in resource assessment. First I will share some features on COMRA's contract areas. It is located in the western margin of the CC zone and consists of two main parts being 200 km apart and spreading 1500 km from east to west – that's a long distance. It has variable grade and abundance of nodules and uneven topography. It has deeper water depths, lower grade in the west and lower abundance in the east when compared with other areas in the CC zone.



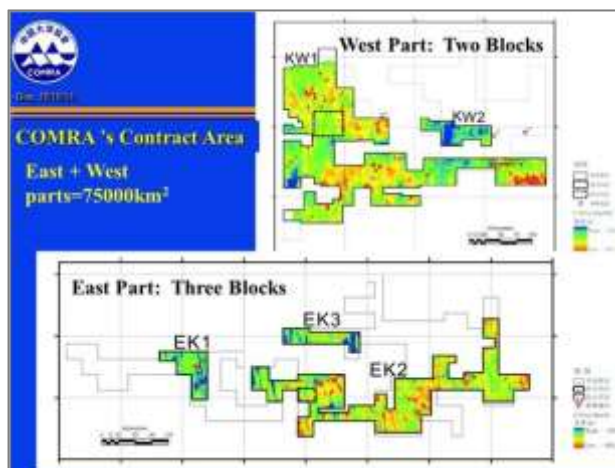
This is the distribution frequency of nodule grade in the west and this is the distribution frequency of nodule abundance in the same part.



My presentation will focus on three aspects. One is the exploration strategy and results. The second is the resource assessment or classification in COMRA's contract area and lastly we have some suggestions for resource or reserve classification.

Exploration strategy and results

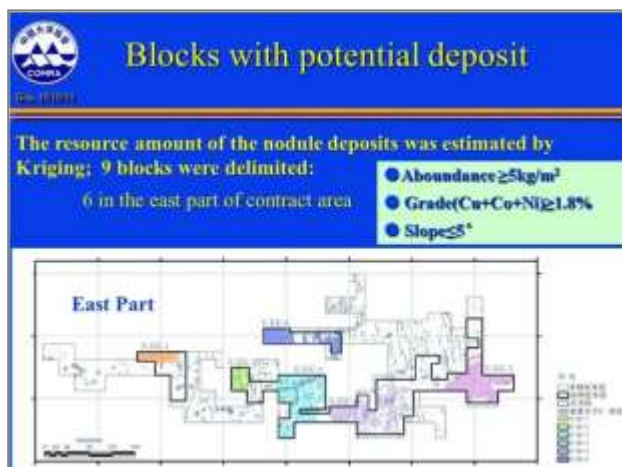
We will collect data for the purpose of assessment of resources and environment impact on the site and then we will design the test mining and processing systems. Today I will not talk much about environmental impact.



For resource assessment and exploration we know that resource assessment combined with exploration at sea is a process of upgrading the nodule resources and a process of delineating a mine site, then evaluating the quality, quantities, distribution and economic value of nodules in the contract area.

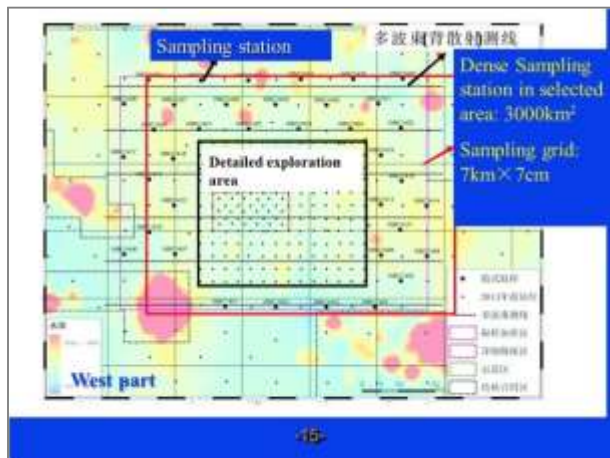
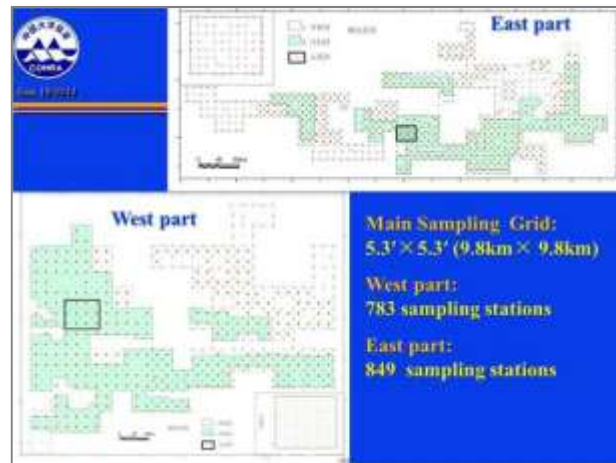
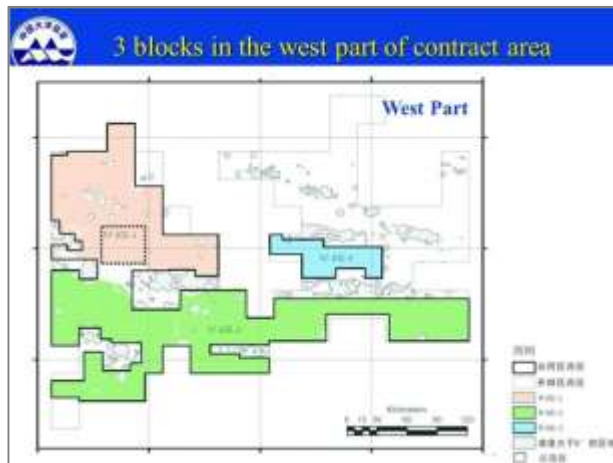
These are some equipment we use in the contract area. I will not go into much detail.

These are the two parts of the contract area; the western and eastern parts. This is a total of 75000 km².



The block with potential deposits are divided into six parts; the eastern part of the contract area. It is indexed for abundance of 5kg/m² and grade with copper, cobalt and nickel at about 1.8% and the slope is about 5 degrees.

Three blocks in the western part of the contract area

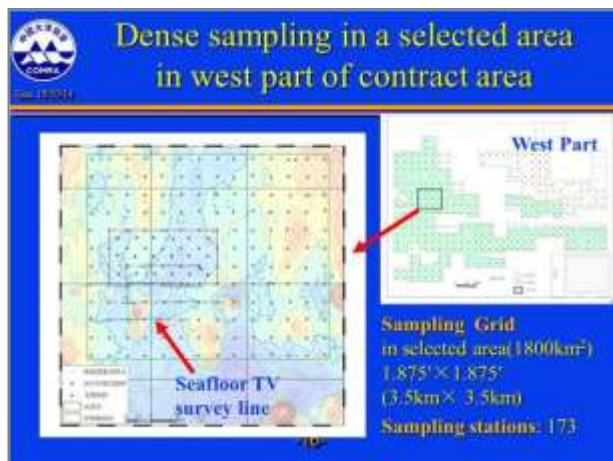


There are three blocks in the western part of the area.

The main sampling grid is 9.8km x 9.8km. In the western part we have 783 sampling stations and in the eastern part we have 849 sampling stations.

Dense sampling in a selected area in west part of contract area

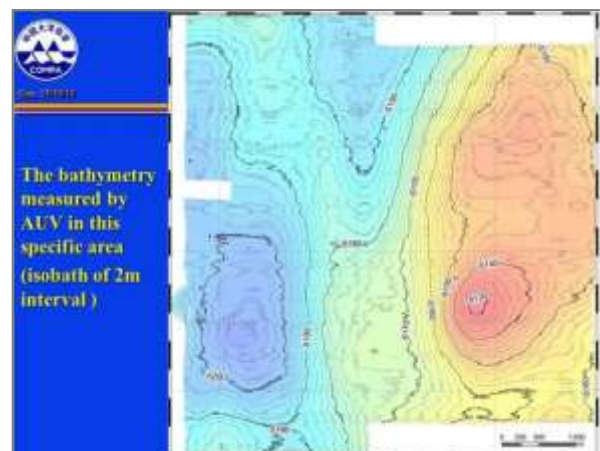
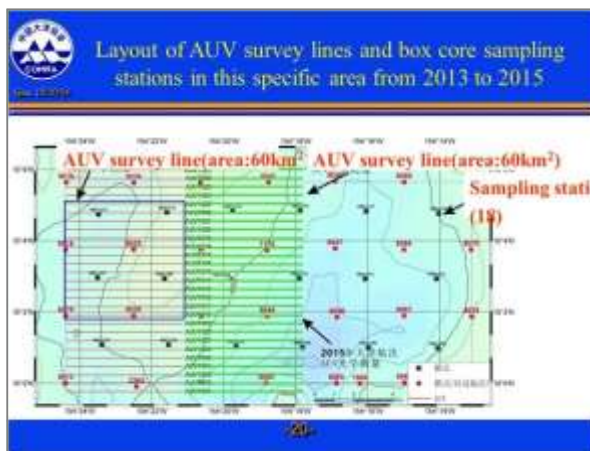
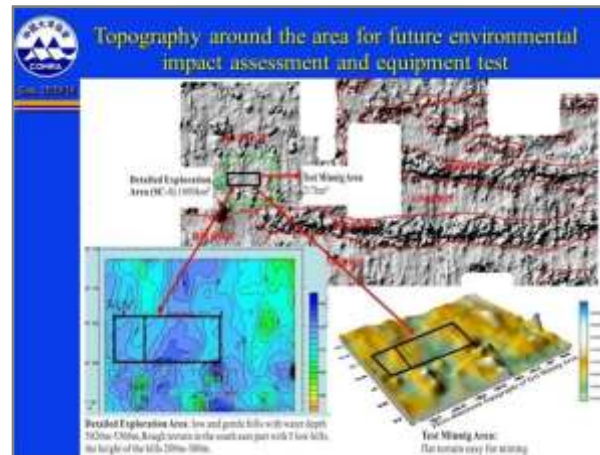
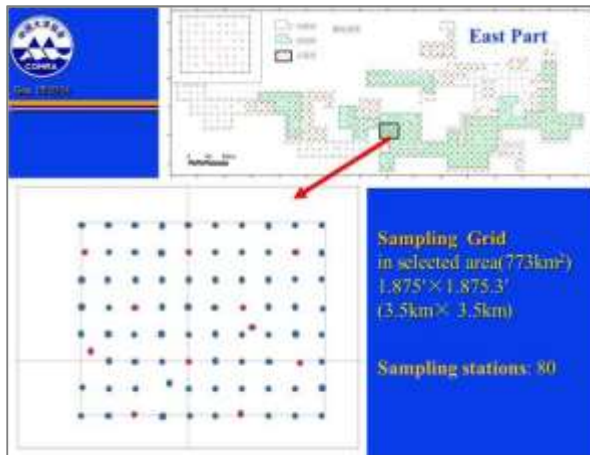
This is some work on dense sampling station in the selected area of 3000km². The sample grid is 7km x 7 cm.



This is the dense sampling area in the western part of the area. From the grid 9.8km we selected the area of 7km. Now from the 7 km in dense samples in the 3500km.

From the area of 1800 km² we chose 217 km² with flat terrain for the future environmental impact assessment together with equipment testing.

Dense geological sampling were carried out at 18 stations, and AUV survey in 120 km² in this area.



This shows the topography around the area for future environmental impact assessment and equipment tests. We carried out and will continue to carry out tests of AUV from 2013 to 2015.

Resource assessment/classification in COMRA's contract area

First there are some geological factors which we considered. The area with:

- Potential deposit – with tectonic features, topography, regional strata, types and features of the surface sediment and regional rift structure
- Deposit – distribution and coverage features of the nodules, and
- The ore – types and mineral features of the nodule.

Environmental factors

Environmental factors were also considered:

- Hydrological and meteorological
- Shape and integrity of ore-fields and size of ore-field blocks
- Topography of seafloor, variation of slop and the obstacle
- Feature of the deposit and ore, including the hardness, size and porosity of nodules
- Geotechnics of sediments, including the solidness, shear strength and grain size

- Ecosystem and its sensitive to the operation system

Commercial factors

The commercial or marketing factors considered were:

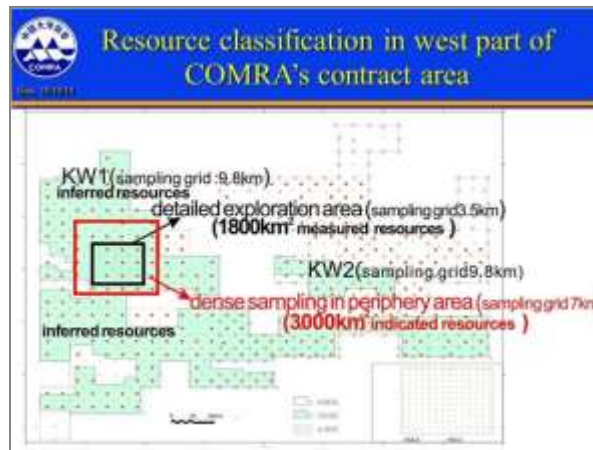
- Investment and the operation cost related to the collecting, recovery, transportation and processing of the nodules
- The variation of price for the metals possibly recovered from the nodules, and
- The rate of return

Main economic indexes to delimit area with potential deposit

- Average boundary abundance: 0.0kg/m^2
- Average boundary grade: $(\text{Cu}+\text{Co}+\text{Ni}) 0.80\%$
- Sea-floor topographic slope $<5^\circ$
- Solid bottom sediments

Resource classification in the western part of COMRA's contract area

Area	Sampling Grid	Resource Categories
Area with potential deposit: 56000 km^2	$9.8\text{ km} \times 9.8\text{ km}$	Inferred Resources
Area in dense sampling: 3000 km^2	$7\text{ km} \times 7\text{ km}$	Indicated Resources
Area with further exploration: 1800 km^2	$3.5\text{ km} \times 3.5\text{ km}$	Measured Resources
Area for specific use: 217 km^2	$2.5\text{ km} \times 2.5\text{ km}$	Measured Resources

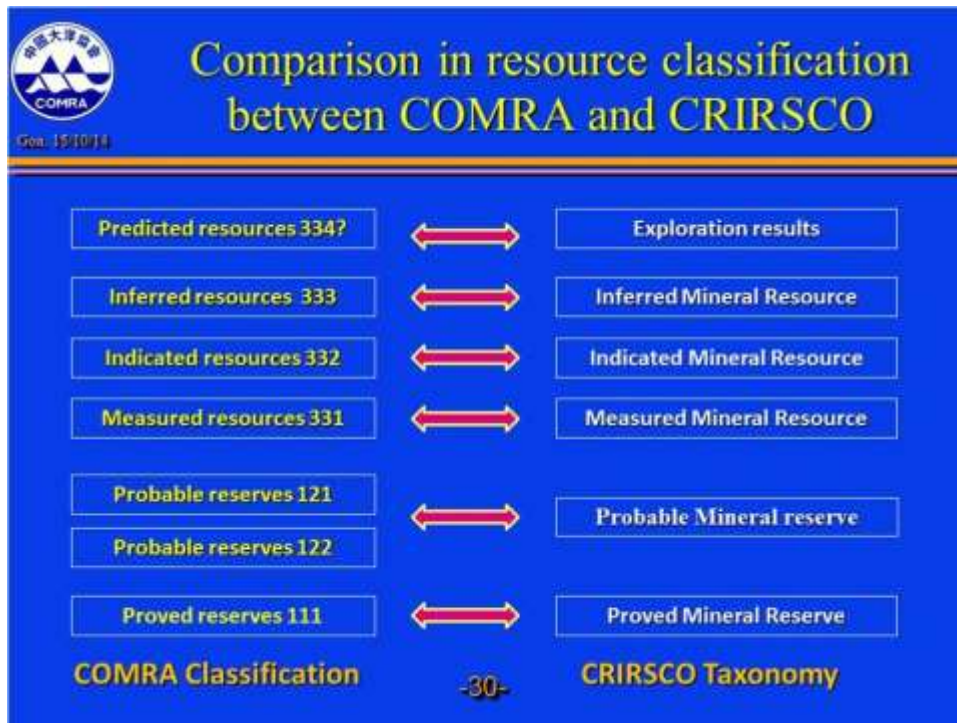


Resource/reserve	Measured	Indicated	Inferred	Predicted
Economic viability	Measured resources (111)			
Economic	Predicted resources (123)	Predicted resources (122)		
Intrinsically economic	Measured resources (331)	Indicated resources (332)	Inferred resources (333)	Predicted resources (334)

Resource classification in the western part of COMRA's contract area was divided into area, sampling grid and resource categories:

Resource classification used by COMRA from China (GT 1776-1999) based on UNFC 1997. We divided the resources into: measured, indicated, inferred. We had different categories of resources: 331, 332 and 333.

Comparison in resource classification between COMRA and CRIRSCO.



I think we can compare the resource classification between COMRA and CRIRSCO.

I now want to make some suggestions for resource and reserve classification and talk about the financial circumstances and link it with feasibility studies. We were optimistic about prices but the situation has changed for nickel cobalt and copper.

China's economic structural improvement and upgrading

The following message is from the Chinese Premier Li Keqiang in 2014:

"In industries with severe overcapacity, we will strengthen environmental protection, energy consumption and technology standards, abolish preferential policies, absorb some excess production capacity and strictly control increases in production capacity. This year, we will reduce outdated production capacity of 27 million metric tons of steel..."

Relationship between Structure of a seabed mining project and resource classification



I also want to remind you of the structure of a seabed mining project form a report of the UN Expert Group in 1989. We can see that all the first group of contractors is still in the stage of R&D (7-10 years). We are not in the feasibility study stage. I tried to make a link between the strategy of seabed mining project and resource classification. In the category of resources/reserves I think that management has to make a decision to proceed. We are in the stage of pre-feasibility studies. There are some points from resources to reserves, after that then we have the reserves. This is where I tried to make some linkage between the two.

As early as 2006 in the report of the LTC chairman there was a proposal for the establishment of a mineral resource/reserve classification system for the Area. The LTC noted the need for classification for the Area. A debate ensued as to the suitability for the resource/reserve of the Area of those existing systems which have been specifically designed to have global applicability, for example the UNFC. It was agreed to retain the proposal for further discussion in order to make it available for use by the Commission as and when required for the resource/reserve of the Area.

So the LTC years ago noted the necessity of this work.

Proposal of mineral resource/reserves classification with the exploration results			
Resource/reserves Categories	Exploration Grid	Exploration Methods and Requirements	Exploration Results reflecting to Map
Inferred resources (333)	10~25km	geological sampling, multi-beam survey, shallow profiling, single channel reflection seismic survey	1:1,000,000~1:500,000 Original data, Topographic...
Indicated resources (332)	5~10km	geological sampling, multi-beam survey, shallow profiling, single channel reflection seismic survey, geotechnical property measuring on shipboard, and other geophysical survey methods	1:500,000~1:250,000 Original data, Topographic, Geological, Abundance and grade, Resource distribution...
Measured resources (331)	2.5~3.5km	geological sampling, deep-tow survey, AUV survey, geotechnical property measuring in situ, other geophysical survey methods that to obtain the accurate topography and landform and distribution on seafloor	1:250,000~1:100,000 Original data, Topographic, Landform, Geological, Abundance and grade, Resource distribution...
Reserves			

Proposal of mineral resource/reserves classification with the exploration results

Lastly, I tried to make some proposal for the mineral resources/reserves classification with the exploration results. Firstly we can see what category we should have, then the grid for exploration and what kind of method and equipment we should use, and then what are the exploration results reflected by the map. It is easy to understand even for members of the Authority.

Summary of Discussions

A participant wanted to know COMRA's anticipated schedule of proposed EIA, the feasibility studies and the mining test. In reply, Dr. Jincai said COMRA was still trying to encourage their government to put the money in the proposed mining system test. Without pilot testing it was very difficult to do the resource assessment, classification and EIA.

Another participant wanted to know if COMRA would be interested (as was previously suggested by IOM) in collaborating with other contractors to conduct some type of joint pilot mining test. Dr. Jincai said that he believed that international cooperation was important, in addition to the cooperation between the different groups in China as well as support from the government.

CHAPTER 16: Polymetallic Nodule Resources Evaluation: How we are doing?

Masatsugu Okazaki

Deep Ocean Resources Development Co., Ltd. (DORD)

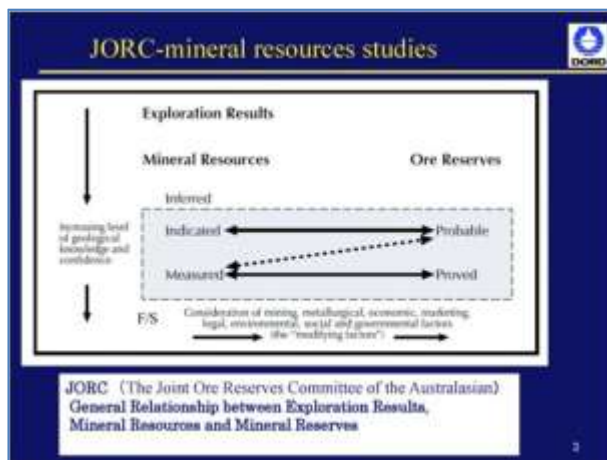
Dr. Okazaki informed participants that DORD's first generation mining area was approximately 6,000 km² with high abundance. A prefeasibility study had been conducted in the area for a 20-year mining operation. He said that with an average abundance of 10 kg/m² and an annual production of 3 million tonnes, DORD would have to produce 10,000 tons/day for 300 working days/year, with about 300 km²/year coverage, totaling 6,000 km² in 20 years.

Additionally, he said that DORD had also conducted a detailed survey in its proposed mining area using an AUV for nodule distribution, detailed topography and continuous photography.

He told participants that DORD constructed its abundance map by applying Kriging to free fall grab (FFG) samples and had used a continuous deep sea camera (CDC) for the photographs to estimate coverage, number of nodules, and abundance. The areas of mineable resources had less than 5° slope gradient, 12.31 kg/m² average abundance, with 92.5% of the total mineral resources being mineable. He said the mineral resources drawn from the FFG were

inferred, and from the FFG and CDC were indicated resources.

Dr. Okazaki concluded that DORD's mineral resources were now more than inferred but not accurate enough for the indicated category. He said statistical treatment of this data was necessary to decide the criteria of the indicated category.



It is good to be here to see many people working together and with the Indian people here in Goa, it is really appreciated.

Resources classification and evaluation

At first we must have mineral resources with a certain level of accuracy to start a feasibility study. Then, based on the mineral resources, economic viability is examined by mining, processing, marketing, environmental, social factors. We must also convince investors that the mining operation will be profitable.



JORC mineral resources

We increased the level of geological knowledge and confidence. First we have the inferred mineral resources then the indicated then the measured. After getting the indicated resources or measured we considered modifying factors.

Definition of mineral resources

Inferred Mineral Resources : Characteristics of ore are estimated with a low level of confidence. Inferred from geological evidence and assumed (but not verified) geological and/or grade continuity. Data are insufficient to allow the geological and/or grade continuity to be confidently interpreted

Indicated Mineral Resources : Characteristic of ore are estimated with a reasonable level of confidence. The locations of sampling and testing are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.

Measured Mineral Resources : Characteristics of ore are estimated with a high level of confidence. It is based on detailed and reliable information. The locations of information are spaced closely enough to confirm geological and grade continuity.

Mostly based on interval of drilling location.

Definition of mineral resources based on the JORC

Inferred mineral resources have a low level of confidence; indicated mineral resources have a reasonable level of confidence and the measured mineral resources have a high level of confidence.

We must decide whether we use the UNFC classification of the JORC code. I made comparisons and essentially this classification introduced to the eastern European countries.

Comparison of UNFC and JORC

UNFC classification	JORC code	Albania
Proved Mineral Reserves 111	Proved Ore Reserves	
Probable Mineral Reserves 121	Probable Ore Reserves	
Feasibility Mineral Resources 211		
Prefeasibility Mineral Resources 221	Modifying Factors	
Measured Mineral Resources 331	Measured Mineral Resources	A+B
Indicated Mineral Resources 332	Indicated Mineral Resources	C ₁
Inferred Mineral Resources 333	Inferred Mineral Resources	C ₂ +P ₁
Reconnaissance Mineral Resource 334		P ₂ , P ₃ , P ₄

UNFC (United Nations Framework Classification for Fossil Energy and Mineral Resources) (E, F, G): (Economic viability, Feasibility, Geological knowledge)

They have just the classification of inferred, indicated and measured resources but they do not have a modification factor feasibility study. So these never become reserves and stay at resource.

JORC has a resource here then after modification factor we have reserves. It is basically the same with the UNFC the difference is the mineral resources are there. Only after the modification factor, we can examine it. Some sort of economic variability and feasibility study. Much more accustomed to it and much more clear

Mining of Polymetallic Nodule

Polymetallic nodule
Not necessary to stay in the same area



On-land situation

Open pit mine



Underground mine



Polymetallic factor situation

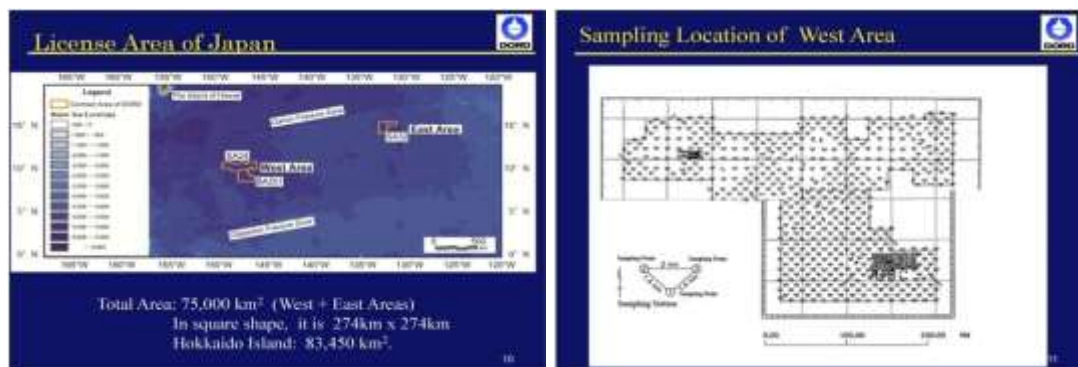
On-land situation cannot be applied to the polymetallic nodules. The situation of polymetallic nodules is different from on-land situation. The differences in the on-land situation are the polymetallic nodules have two-dimensional distribution and vast distribution scale; some are buried but mostly are surficial. Small variation ore grade – we use abundance for drawing a counter line or the grades. The polymetallic nodules are covered by water but mostly exposed on the surface of the seabed. In that case, we should make full use of the photograph and videos.

Another thing that is different between the polymetallic nodules and on-land situation is that on-land mines make a huge structure like open pit mines and underground mines so they need a lot of money to do that. With polymetallic nodules you need a mining vessel and a collector and riser pipe, and after finishing in one place you can move to anywhere you want. On-land you have to stay in the same place for the whole operating period. That is a big difference.

The areas that we are looking for

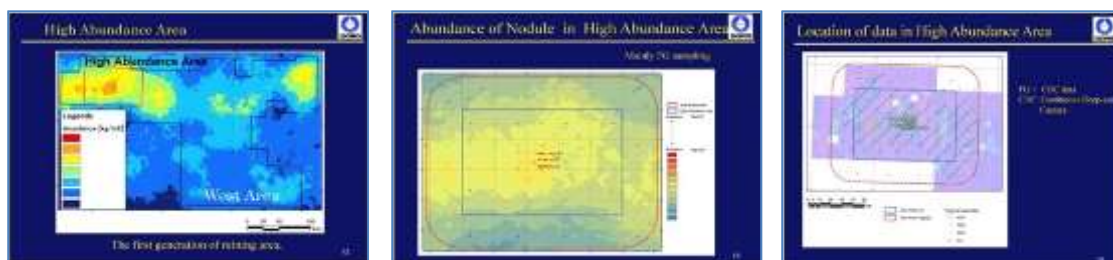
We have a 75,000 km² exploration area. In that we have a first-generation mining area which we call high abundance area. It is approximately 6,000 km². Prefeasibility study is conducted for the area of about 20 years mining operation. If the average abundance is 10 kg/m² and an annual production of 3 million that means we have 10,000 tons/day for 300 working days/year so coverage will be about 300 km²/year. 300km² x 20 years makes 6,000 km². In addition to this we did a model area for detailed survey which is 80 km² (at present). The idea is that we use an AUV survey for detailed surveys conducted for understanding the nature of nodule distribution and detail topography. The results are fed back to the high abundance area using extrapolation method.

Licence areas of Japan

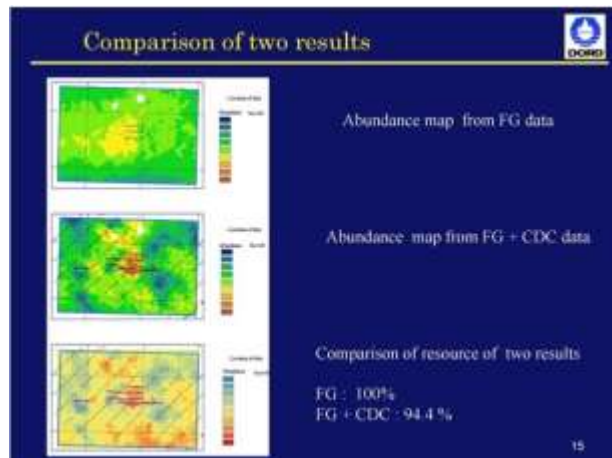


Here is one in the eastern area and another in the western area. It is a very huge area, compared to on-land situation. It is square shaped and is 274 km x 274 km. The slide on the right is our sampling location of the west area. It was done during the pioneer investor's years mostly based on FFG sampling. We took samples from three locations and we used the average; and we used the photograph data for the abundance.

High Abundance Areas



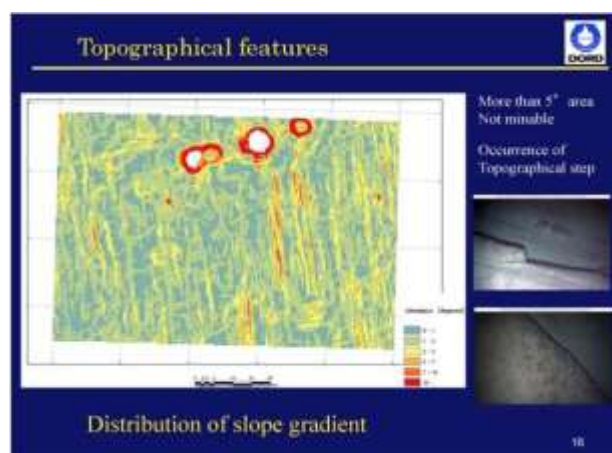
Using the samples from the FFG and using kriging we constructed the abundance map. We also used a continuous deep sea camera which is different from the deep-towed camera. It goes up and down and we just keep towing. One survey can continue up to 50km. Each camera location is about a few km apart. We have free grab sampling in addition and then we add the CDC data, photographs to draw abundance.



Comparing the two results

FG + CDC, up here (middle map) a much higher zone appears but in this area (top map) a lower zone appears. The yellow parts of the map are the same but the red parts get higher and higher and the blue getting lower.

Resource calculation was done using kriging. If we say FG was 100% then FG plus CDC was 94.4%. It can be indicated resource or still stay at the inferred status.



Topographical features

The yellow parts show the distribution of the slope. It is more than 5°. Using the videos and cameras we found a sort of topographic step. It is very tough for the mining machine to move around. At this moment, I am thinking that the slope should be less than 5°.

Physically mineable resources

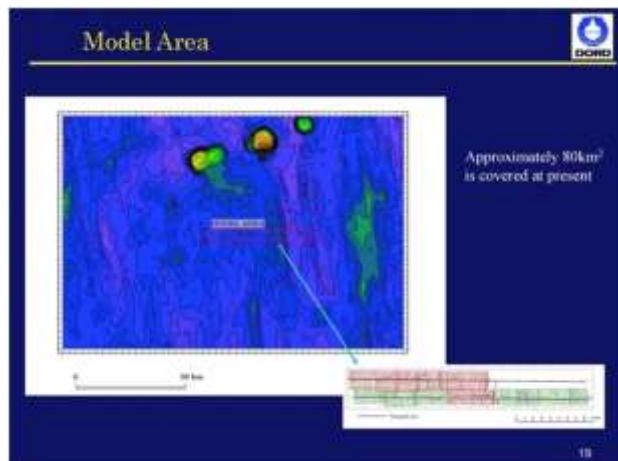
The areas of mineable resources have a slope gradient of less than 5 degrees and a cut-off

abundance of 7.5kg/m². All the areas averaged is 12.31 kg/m². 92.5% of the total mineral resources is mineable.

Evaluation of resources

Resources drawn from the FG are inferred mineral resources and data and resources from the FG and CDC (CP will know more about this), but my understanding is that it is less than indicated. We must improve the results. One of the ways to improve these results are by detail surveys in the model area to feedback results to the high abundance area. We should have an understanding of continuity of nodule distribution and possible relation of nodule distribution to the topography. We must also do a statistical treatment of the data and understanding accuracy, particularly of photographs. Also we need to determine the proper sampling interval for indicated resources by statistical treatment, considering values such as expected value and degree of confidence.

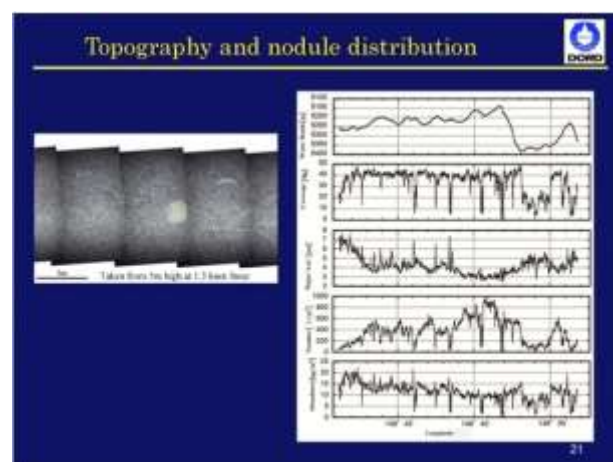
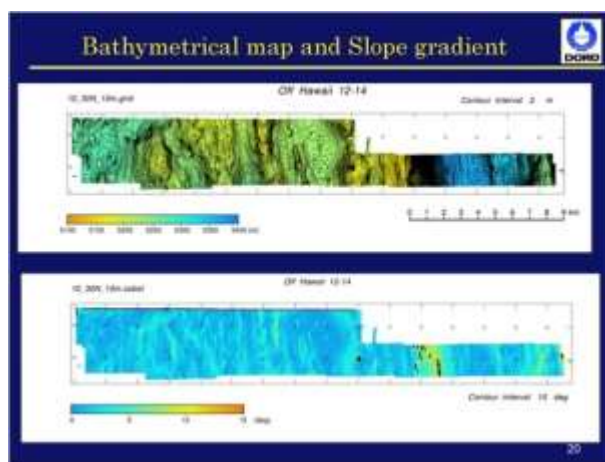
After all those considerations, we can get some numbers from the supplemental data correction in the high abundance area by box corers and seafloor photographs.



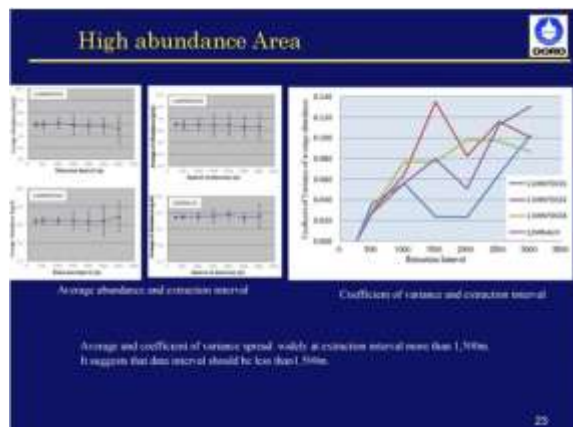
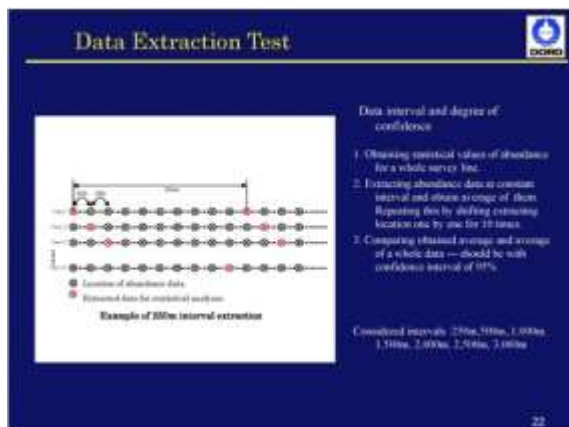
Our model area is about 80km². We used the AUV survey, for topographical surveys. We took continuous photographs of the seabed.

Bathymetry map and slope gradient

You can see the seafloor map and the slope gradient from maps (below left). The area is generally flat just a few contour lines. From the photographs we also get information of coverage, number of nodules. From this we also got information on abundance.

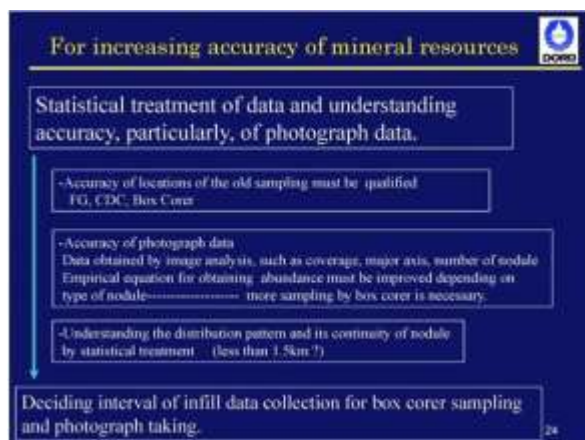


The photos (above right) are of course exaggerated. Abundance is less than 10 which is lower than in other areas. The slide below left is the data extraction test.



In High abundance area

This is one of the statistical treatments (above right). They are considered at intervals of 250m, 500m, 1000m, 1500m, 2000m, and 3000m. After the interval becomes more than 1500m it is all spread out so the data grid interval is better to be less than 1500m.



For increasing the accuracy of mineral resources

Statistical treatment of data and understanding accuracy, particularly of photographs is necessary. Accuracy of the locations of the old sampling must be qualified particularly the FG, CDC and box corer. Also there should be accuracy of the photograph data obtained by image analysis such as coverage, major axis.

The number of nodule empirical equation for obtaining abundance must be improved depending on type of nodule so we need more sampling. Understanding the distribution pattern and its continuity of nodule by statistical treatment is necessary. Using these factors we are going to decide on the interval of infill data collection for box corer sampling and photograph taking.

Conclusions

In concluding I must say that the mineral resources we have now is more than inferred but seems to be not accurate enough for the indicated category. Statistical treatment of this data is necessary to decide criteria of the indicated resources. We infill the data collected by box corers and photographs taken.

Summary of Discussions

Discussions following the presentation focused on different aspects of nodule mining. One participant wanted to know if DORD was able to benefit from the technology and experience of the high-speed exploration system that was developed during the 70's. To this Dr. Okazaki replied that they tried but did not find the system useful.

Asked if they have any strategies to do any additional set of grab sampling, box core sampling, additional geostatistical studies or anything of that sort that to bring the resources in the area of Japan from inferred to indicated, Dr. Okazaki replied that they were analyzing the situation statistically to give them some idea of how long the intervals were for the indicated resources, then with that data input the sampling will be carried out again.

Another participant commented that under the CRIRSCO system minerals can only be called mineral resources if they have reasonable economic prospects.

Moreover, the characteristics of seabed nodules were not like most land-based mineral deposits, but there were land-based mineral deposits that have that similarity. One was alluvial mining which is often just a very thin layer on the surface and the mining has to follow the nuggets. The other was that when mining underground, there were very narrow lines; you actually do it almost in a two-dimensional way. There were also some other analogues to land-based deposits.

The last point, he said was more of a general one for discussion, that the different resource categories under CRIRSCO don't have numbers associated with it. It did not say whether measured is + or - 5% or 10% or whether indicated is + or - 10% or 20%. The reason for that was because the CRIRSCO template has to cover a wide range of deposit types and to try to fix on some numbers. It had been done in the

past and was a very difficult exercise to get agreement. Firstly the numbers given the wide range of deposit types, secondly how to measure those numbers because there were different ways of measuring them and thirdly, the scale, because scale came into classification when you classify the scale of a very large area or volume or a small scale/volume.

However, Dr. Okazaki said that he thinks that the seabed nodule situation is always unique as essentially it is one deposit with many owners or parties with the rights to explore and ultimately to exploit. In that situation there may be an opportunity here for the contractors, through the ISA, to debate what ought to be the criteria for the different classifications of measured, indicated and inferred. Should it be in the order of 1 ½ km spacing samples or should it be 5km. I don't know that you will end up with a definite answer but because we are dealing with essentially one deposit I think there could be some degree of common acceptance of what would be sensible. That I think would be a useful exercise because it would improve the comparability of the reporting of each of the contractors. Without imposing any additional constraints or difficulties in the way of contractors it is just that it improves the comparability. I am just throwing that out as a subject for discussion in the future.

CHAPTER 17: Polymetallic Nodules Resources Classification. French Effort: 1970-2014

Y. Fouquet, G. Depauw, GEMONOD consortium, Institut français de recherche pour l'exploitation de la mer (Ifremer)

Dr. Fouquet informed the workshop that IFREMER moved to large scale exploration in the CCZ during 1975-76, it had its first diving operation in 1989 using a manned submersible, and from 2001-2004 did environmental, economic and geochemical studies and near-seafloor geological mapping and photography. In 2012 the eastern section of the Area was surveyed by a multi-beam system. Ordinary Kriging and conditional simulation was done on the slope and then the density of nodules on the seafloor and mineable areas were defined.

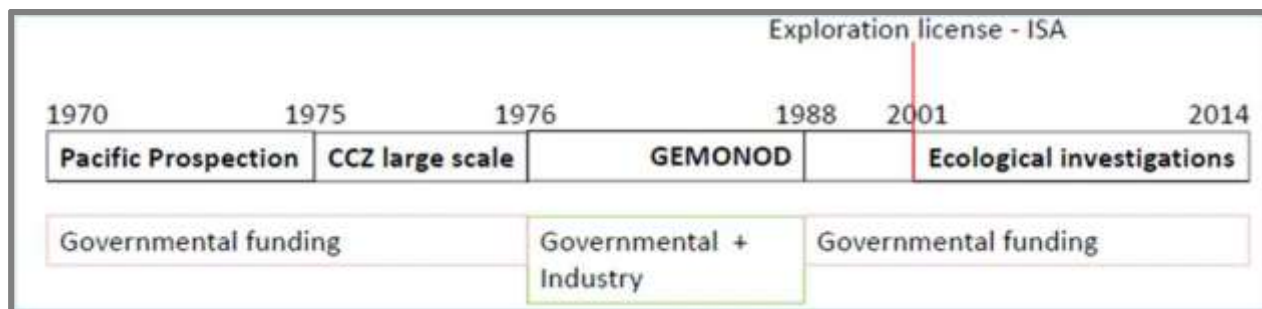
Dr. Fouquet told participants that IFREMER also worked on mining and processing technologies and techno-economic studies. Its next step, he said, should be pilot mining and prefeasibility studies. He said that IFREMER envisioned mining about 1.5 Mt of dry nodules every year in areas with an abundance of about 14 kg/m², for about 50 years, requiring about 30,000 km². With inferred resource shown to be capable of supporting decades of mining, Dr. Fouquet said upgrading this level of knowledge for the whole area was not necessary at this stage.

I was asked to try to summarize the 30 years of experience we have in France on nodules. I will try to show you, not in a detailed point of view, the France side of classification. I will try to show some historical point of view and try to place this in a different scale.

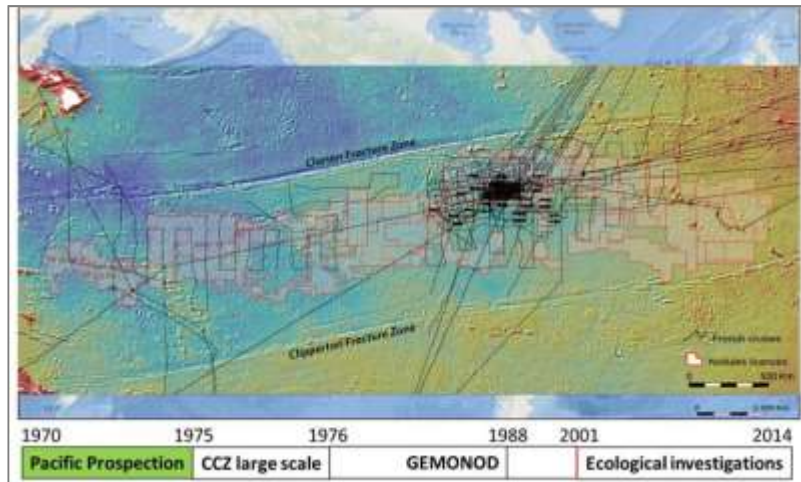
Historical Background

Starting with the historical background, back in the 70s we started with regional prospection in the EEZ and the Pacific. During 1975-1976 we moved to what we call the large scale exploration in the CCZ. Starting in 1976 through to 1988 we looked at local scale particularly in the central CCZ.

With starting of the exploration license in 2001 to 2014 the main focus was on the environmental and ecological studies together with geochemical investigations. For this period we did a total of 50 cruises which is quite a lot.

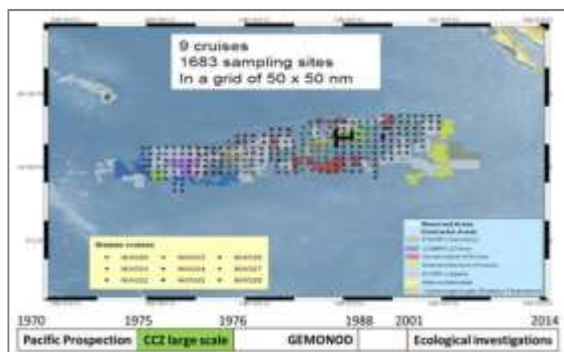


In the first stage we got governmental funding. We had quite a good governmental and industry cooperation through the GEMONOD consortium in the late 1980s then we moved back and we are still at the governmental funding.



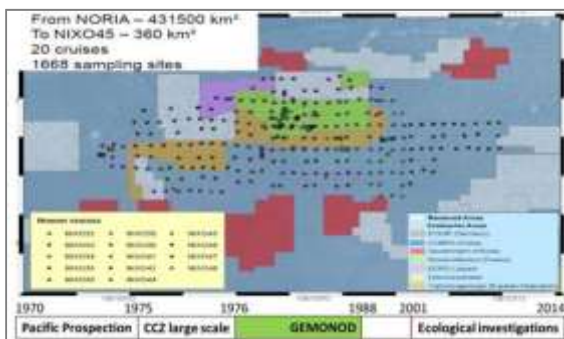
Regional Prospection

We started at the scale of the Pacific with a starting point of exploration in the French Polynesian and then we moved to the CC area where we did a series of cruises (most of the black lines show that we contributed to the definition of this interesting place at the regional scale).



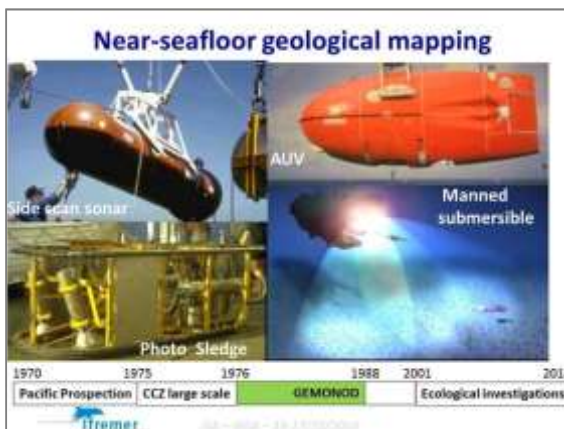
Large scale geological exploration

We then moved to large scale geological exploration and sampling. We had nine cruises; 1683 samples in a grid of 50 nautical miles. Again keep in mind the scales.



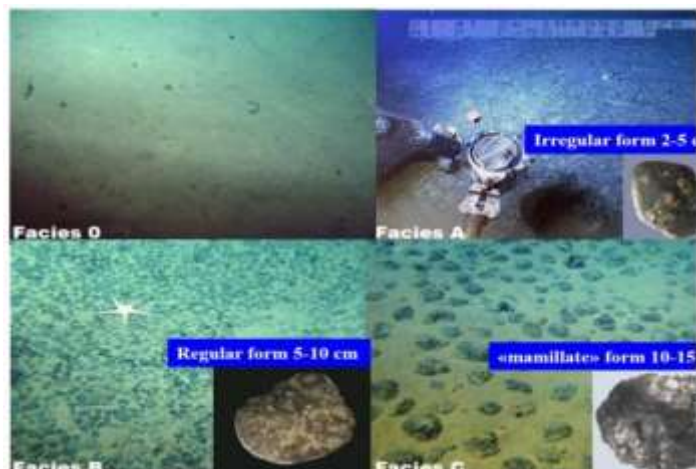
Local scale geological exploration

Then we moved to the more local scale with what we call the NORIA with 22 cruises and more than 1668 samples. In this area (defined in green) is now one of the main part of French license.



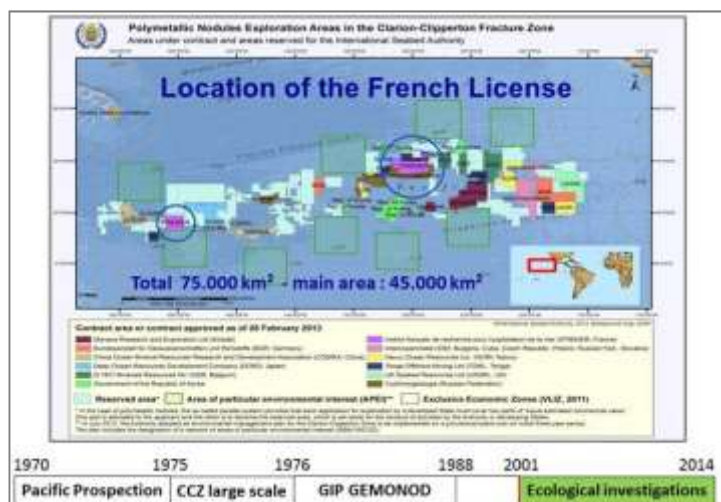
Near-seafloor geological mapping

When we had enough data from the surface we moved to what they call near-seafloor geological mapping using side scan sonar, photo sledge, AUV or the old generation of AUV used for taking pictures of the seafloor. In 1989 we had the very first diving operation using the manned submersible in the nodule area. This was a lot of detailed work and sampling, to work at very detailed stage.



Nodule facies

Using different techniques we defined several types of nodule facies A: irregular – with 2-5 cm in size; Facies B is irregular form – with diameter of 5-10 cm; and facies C are larger nodules up to 15 cm in diameter. We will use this in maps which I will show you later.

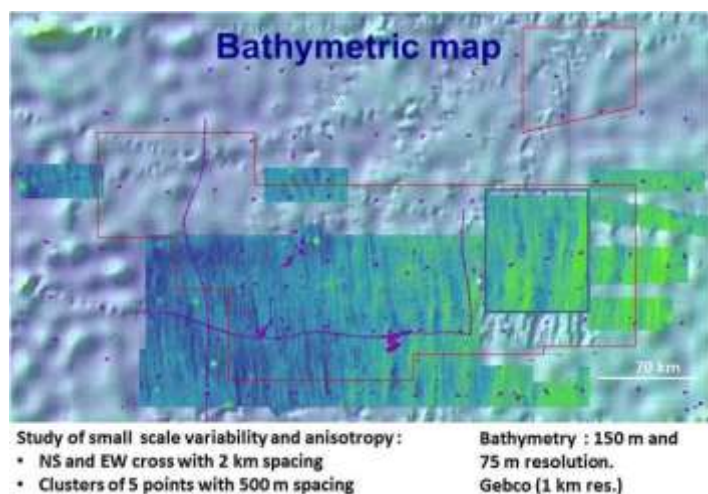


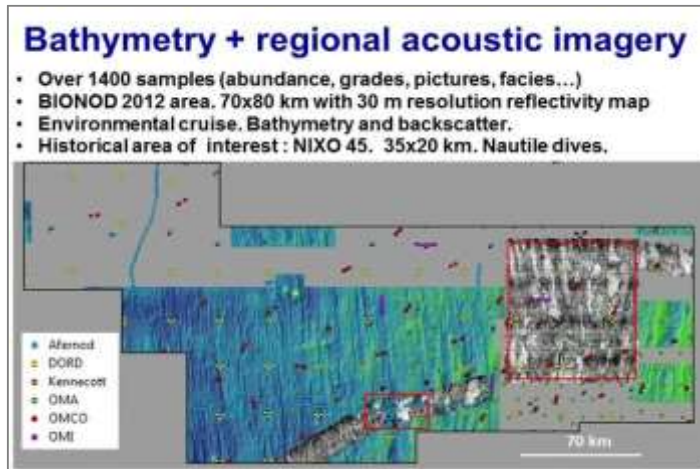
Location of the French License

In 2001 we started the license work mainly through ecological investigations. We had presented these data to ISA in meetings and I would not cover in detail. The main focus in terms of detailed work was in the eastern area.

Bathymetric map

In the western area (in red) we have reposted digital numerical maps of the seabed bathymetry. In the eastern section in 2012 we did with a new generation of multi-beam system, new maps with better resolution; the first map a resolution at 150m and we moved to 75 m resolution with this, again, a question of scale.





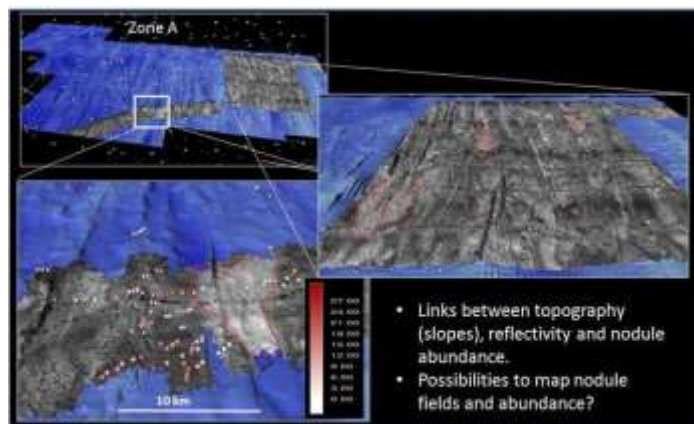
Bathymetry + regional acoustic imagery

Using these new maps we have from the surface ship we were able to have these back scatter maps where you see some white and black in two main working areas. The scale was 70 km for the box. The main work area is here (pointing) and the detailed sampling line crossing this main area.

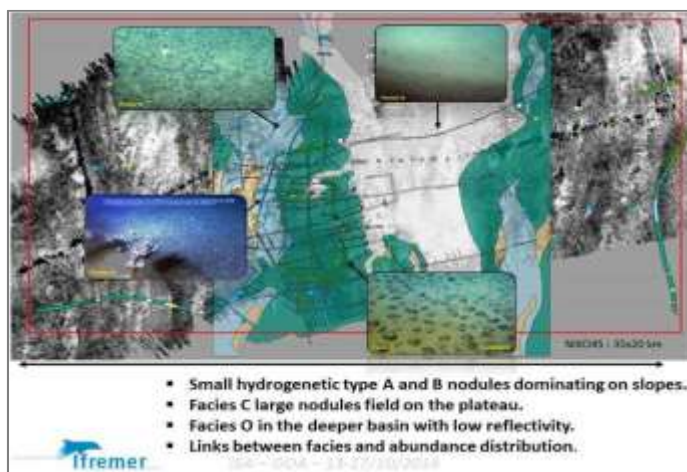
Nodule abundance

All the data was used to discuss the nodule abundance using the backscatter maps of the eastern side.

Reflectivity and density of Nodules

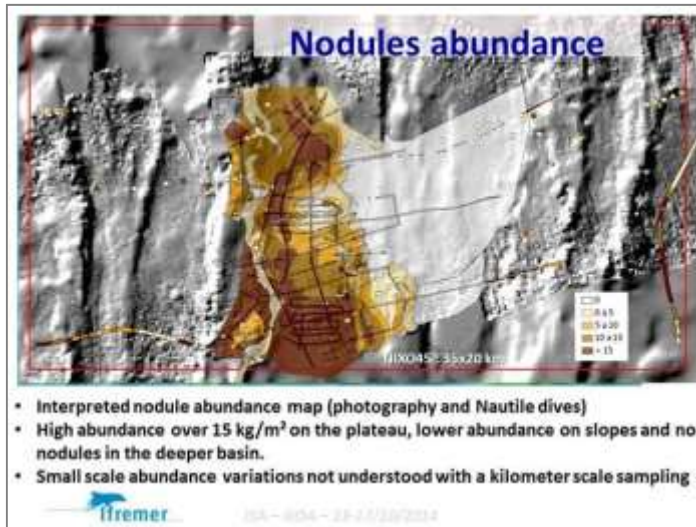


The dots represent the sampling areas. On the main working area you see on the image (white spots) that means there is low density or nearly no nodules. Scale here was zero, 3 to 6 for the white colour, and the red up to 27 and 15-18 the grey area. We focused a lot of work in this area and we have tried to find the link between the topography, the slope and the reflectivity and nodule abundance. We used back scatter images directly from the ship and not from the seafloor, in the case of nodules mapping. We wanted to know if there is a possibility to map nodules just using images obtained directly from the ship.



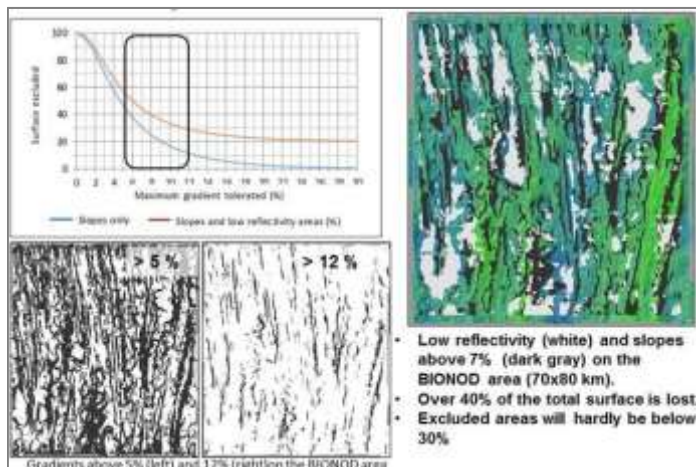
Detailed nodules facies map (photo + dives)

If we take the main area from the backscatter maps we have this deep basin with white etches, then we have the plateau, then slope on higher ground and a steeper slope on this side. Through a combination of photo on the seafloor, diving with Nautilé, and the scattered image we derived the maps of detailed facies; Facies E in the white area with no nodules; Facies B & C were on the slope or on the plateau.



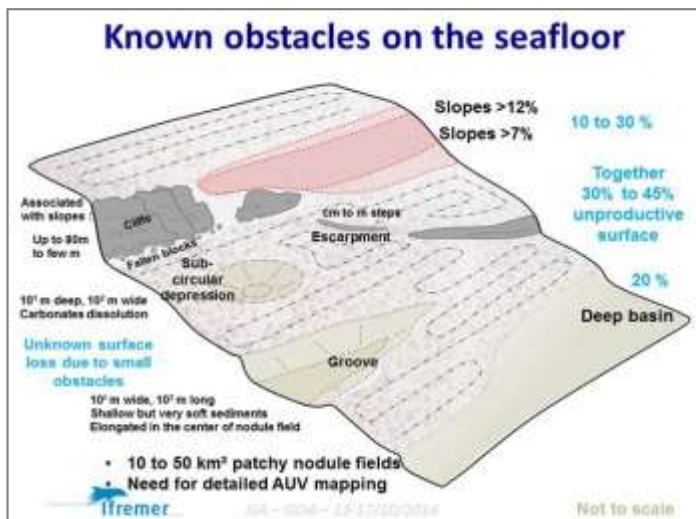
Interpreted nodule abundance map (photography and Nautilie dives)

The nodule abundance map was also done in this area with different types of colour; white 0; orange 5-10; in the southern area 15. Most of the interesting places are located on the plateau. Higher abundance of over 15 kg/m² are on the plateau, lower abundance on slopes and no nodules in the deeper basin. Small scale abundance variations are not understood with a kilometer scale sampling.



Slope and Nodule free areas

Now we consider what was discussed this morning about the slope. We have different processing. If we consider the slope in a group lower than 12% so you have this type of map. Then if you move to 5% you have this map. Then if you combine both this slope and the backscatter images which is a different colour, you can try to decide what percentage of surface you can eliminate using both backscatter and the slope. The low reflectivity (white) and the slope above, we can choose for example 7% for this area which is 70x80 km long, this eliminates therefore over 40% of the total surface, is lost for mining. We think that it will be difficult to go lower than 30%.



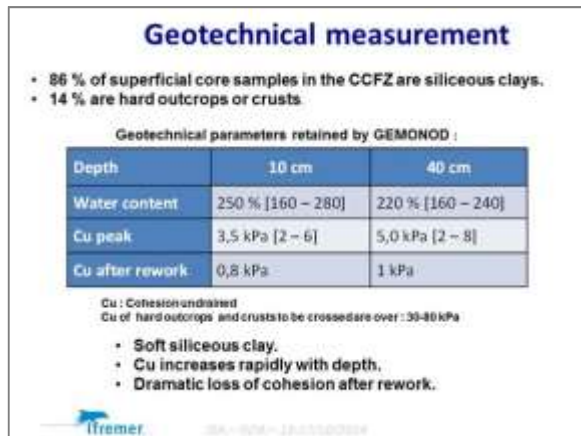
Known obstacles on the seafloor

Here is our drawing to try to summarize what are the questions we have at the local scale if you want to mine. Slope – 12% and relatively steep. If we consider 7% this eliminates 10-30% of the surface. Then if you consider the deep basin with nodules this again is about 20%. Altogether you can

eliminate between 30-45% of what we call unproductive surfaces. Associated with slope, of course we have the cliff up to 80m high and structures such as sub-circular depression which probably is related to dissolution of carbonates. That can be about 100 to several hundred metres in diameter and that can be

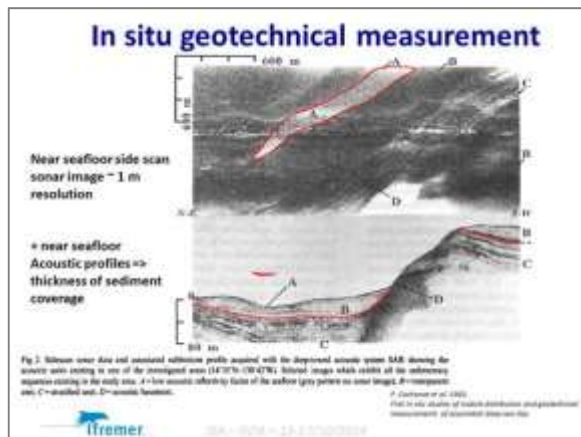
a problem for mining systems. We also have elongated depression with small nodules, where we can have this problem.

If we want to mine we have to consider the structure from the bathymetric map as well as this smaller structure and try to combine your mining technology with different lines, maybe try to cross these smaller features. This opens the question about the need for detailed AUV mapping.



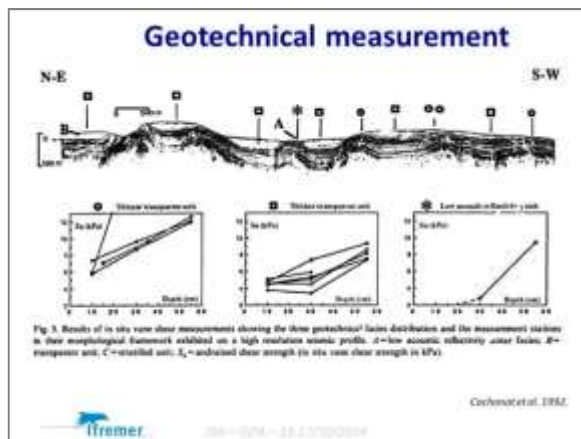
Geotechnical measurement

About 86% of the area is siliceous clay so we can get sediments from most of the area (14 % are hard outcrops or crusts). It has a Cu peak of 3.5 to 5 at 40 cm of depth. It is extremely high when you have hard outcrops and cliffs and so on. Cu of hard outcrops and crusts to be crossed over: 30-80 kPa. The point is that this kPa can stay relatively low after re-working of the area. Cu increases rapidly with depth. You therefore have to be careful with this geotechnical parameter. We have soft siliceous clay and geotechnical parameters increases rapidly with depth and there can be a dramatic loss of cohesion after re-work.



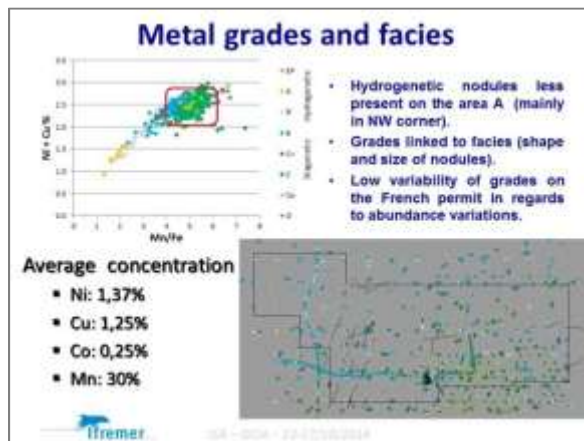
In situ geotechnical measurement

Near seafloor side scan sonar images – you can see here this image is about 1m resolution. This 'A' area which is white patch with no nodules. If you look at the acoustic profiles, the cross section through the sediment there is a transparent level and this 'A' area is located exactly here (pointing). We can see there is a difference in terms of nodules depending of the thickness of the sediment. All these types of detail have to be considered before mining or even assessing the quantity of nodules that you can mine.



In addition in the grey area the geotechnical question is close to zero; it is not a place you can easily work on, even if there are nodules. If you move to the thicker transparent unit it is relatively soft sediment compared to the thinner transparent unit where the co-efficient are higher, importance of geo-technical measurements. Following is the summary of what I have said:

- Cu is linked to sedimentation rates (thickness of unit B):
 - High sedimentation rates have lower Cu
 - Cohesion due to clay bounding and not to compaction.
- Nodule free grooves with low Cu (A) are easily visible with low reflectivity on the side scan sonar but not on the sediments profiles (very thin unit).
- Expected small scale Cu variability (similar to nodule abundance) also linked to sedimentation rates

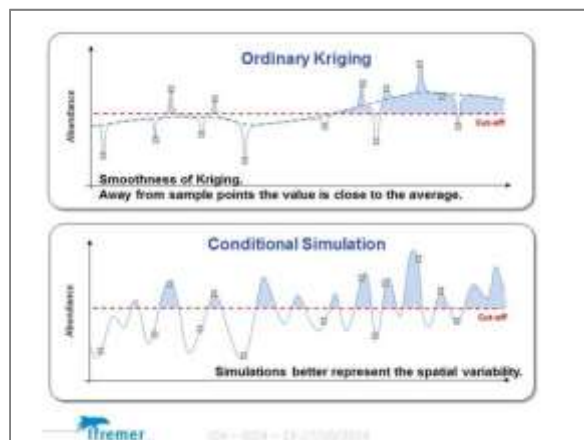
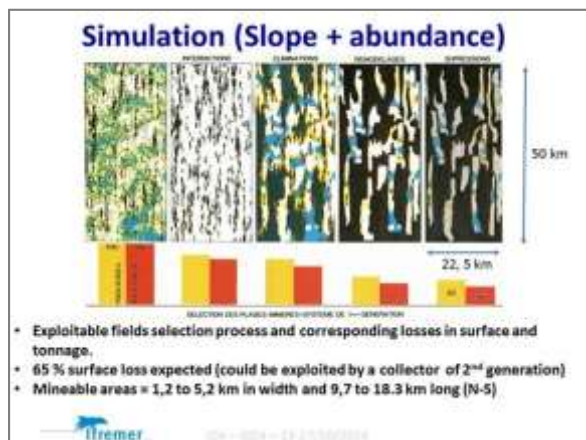


Metal grades and facies / Resource Estimation

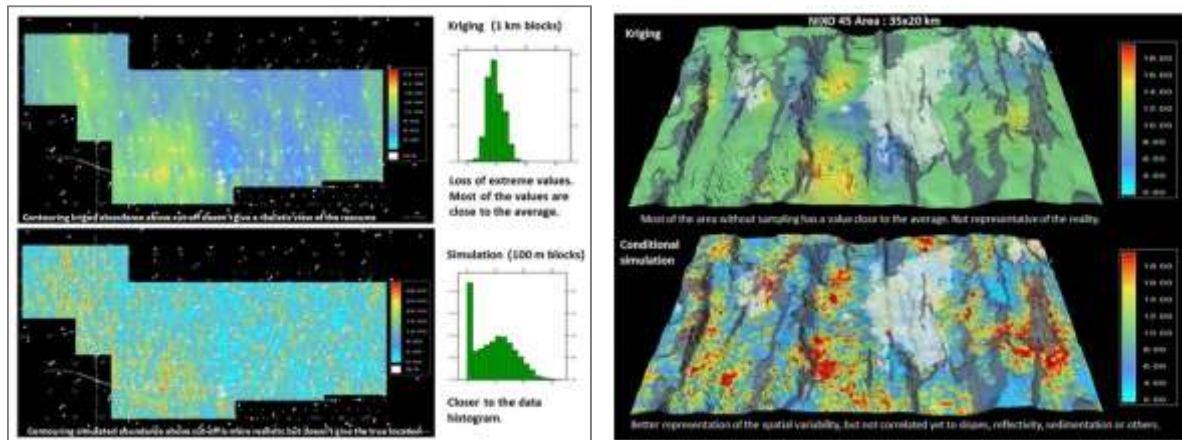
We did some simulation taking into account the slope and the density of nodules on the seafloor trying to see what surfaces we may eliminate through this process. We considered that in exploitable fields we are losing large surfaces; 60% of the surface could be expected to be lost. The model we produced 20 years ago – here in an area of 50 km-22 km long. Mineable areas we defined through this approach is 1.2-5.2 km in width and up

to 10-18 km in length. The question then is, do you collect samples in all these areas or do you try to do some statistical studies.

Simulation (Slope + abundance)



We have re-processed recently these data. Just a few words about statistic - The classical way is by ordinary kriging. If you have long spacing between the sampling what you have is average composition – the mean values. If you consider the conditional simulation with this same set of data – here we have no data but you simulate what you have – you have a better gridding and sampling and the result is much better to represent spatial variability.



If you try these two different models to our area with kriging of 1 km blocks with this type of map (above left) there are some interesting places in this area (pointing) you have loss of values when you are close to the average. On the opposite for the same place, where you use the simulation, you are closer to the data but the granularity of your model is much better and closer to the reality.

This is what you have here in 3-dimension (above right) - the kriging system – the slope and the density of nodules. On the same map with better granularity, closer to reality. We see that there are no nodules in the deep depression (white areas). Most of the interesting places are in the plateau away from the steeper slopes. This gives you a more realistic view of what we are supposed to find.

Annual Production and Duration of Mining

Gemonod technical studies

We did quite a lot of work about the geological and meteorological environment. We collected strategy and technical specification. We did pipe study – rigid and flexible parts (corrosion/abrasion studies); hydraulic lift (comparison of air lift and pumps); surface operation and ship for transportation; processing technologies (hydrometallurgy and pyrometallurgy); technical and economic studies. We did a preliminary study of a pilot (France and Japan). The next step should be pilot mining and prefeasibility studies.

Technical and economy study

For this study we ended with some scenarios – (a). annual production, mining about 1.5 Mt of dry nodules every year at about 14 kg/m² (GEMONOD). This was a compromise between three factors at this time: metal market with the French and European countries; the collector strategy (350 tons/hour for 250 days operating in the year; and of course the productions costs.

(b). the duration of mining - GEMONOD estimated from the simulation that 30,000 km² would provide enough nodules for about 50 years at 1.5Mt of mining per year. We are still trying to model at a regional scale what could be inferred resource of this specific area. Current work on inferred resource, expected to reach about 200 Mt of wet nodules (150 Mt dry) on the 45.000 km² (Zone A) for 50 to 100 years of mining.

Collecting system



In 1989 the conceptual model on the technical study was done for the collecting system using the dredging equipment; flexible cable; rigid pipe to bring the material to the surface with four pumping systems; semi-submersible platform; and the transportation equipment.

This technical operation stopped in 1990 before the pilot test because of low metal prices; technical risks and of course funding.

During the study we did a detailed economical study and estimation of mining operation costs, where mining cost was about 27%; transport to Europe was 15% ; and processing was 58%. The processing was a very important step and has to be considered.

Some conclusions and perspectives

I mentioned the importance of slopes on the resource estimation and the need to discuss the choice on the maximum slope. We need detailed mapping of unknown surface loss due to small obstacles; there is need for detailed mapping. There is local abundance variability so there is a need for correlation with parameters like bathymetry, reflectivity, pictures, slopes, sedimentation rate and so on. There is a need for AUV detailed mapping and box-corers for calibration plus geotechnical parameters and of course detailed sampling at the right scale. Resource upgrade – Inferred resource supports decades of mining, so upgrade to Indicated resources for the whole license area is costly and not necessary at this stage, if you have a good modelling at hand.

Detailed evaluation of resources and mining and environmental strategy during the mining needs to be validated by high resolution bathymetry of about 1m or less, mapping using acoustic imagery with new technology coming out (deep AUV), of course all this need a pilot and pre-pilot mining test.

It is not a long story about classification but my message is about scales. Classification needs scales.

Summary of Discussions:

A participant wanted to know if there was any correlation between the grade and nodule facies, and the strategy in order to improve knowledge about the resource. Dr. Fouquet replied that the grade was changing a little bit but not as much as nodule density, so to make an assessment of the quantity of copper, detailed maps were needed. The old maps even up to 50m in resolution were not good anymore and maps with 1m or even sometimes 50 cm of resolution were needed. To define the mining technology, the strategy needed was to have a 1m or less than 1m scale. The sampling strategy could then be correlated to this and AUV surveys of smaller areas could be moved the statistical way.

Another participant wanted to know if there appeared to be a significantly larger loss and a smaller fraction of mineable area in the French area and it was because (i) the area was un-mineable due to the slope; (ii) low metal content or (iii) low or virtually no nodules and if the same area was significantly

different in topography and distribution. Dr Fouquet replied that there was some difference in terms of tectonics and number of fault spacing although sometimes it was difficult to compare with different scales and that the resolution also was very important.

A participant mentioned that the previous speaker indicated that he did not have the confidence in acoustic backscatter as a means of measuring abundance specifically from a system that was developed in the 70s, whereas a significant majority of Ifremer assessment of the resource was in fact based on acoustic backscatter and wanted to know how accurate acoustic backscatter were.

Dr. Fouquet said Ifremer had tested it in the place of high density of data and that it worked relatively well but that the back scatter data had to be correlated to similar back scattered maps. He said high resolution mapping was needed and expressed confidence in the back scatter over the mapping near seafloor though AUV.

CHAPTER 18: Polymetallic Nodules Programme - Resource Evaluation

M. Shyamprasad, Ministry of Earth Sciences, Government of India,
CSIR-National Institute of Oceanography

Dr. Prasad informed participants that India had identified its first generation mine site (FGM) in 2009-2010 and subsequently a test mine site – a single block of 1/8 degree in 2013. He said over 2,500 stations were sampled mostly by free fall grab (5-7 at each site). Starting from a grid of one degree, it sampled at 14 km and 7 km grids in 18,400 km² area. He told participants that India undertook 76 expeditions for resource estimation and mineable area identification.

Dr. Prasad said that Single beam and multi-beam echo-sounding mapping was done for seabed topography to relinquish areas. Sampling at 0.125 degree grid, baseline environmental data at 64 stations in five candidate tests and reference sites was done and a simulated mining experiment was conducted in 1997. For a first generation mine site to sustain production for 20 years, 20% of the area was sampled at 7 km grid, with sufficient topographic information to eliminate adverse topography and areas of steep slopes. Dr. Prasad informed participants that in 2010 India developed an underwater collector and crushing system and underwater mining machine, for mining nodules in 500 meters depth, and an unmanned ROV and in-situ soil tester for 6000m water depth. The integrated mining system for mining of nodules up to 6000m depth was still in progress.

Dr. Singh advised that 15% of the grade qualifies for a measured category and that 10% of the Area (75 000km²) will have sufficient resources for 20 years mine life.

Introduction

Most of the contractors have been exploring for polymetallic nodules for about three or four decades now so they come with a valuable amount of history, so do we. January 26 happens to be the republic day of our country. In 1981 on the 26th of January we made history of sorts with the team led by Dr. S.Z. Qasim. We discovered the first nodules in the Indian Ocean. The team also comprised Dr. H.N. Siddiquie who later launched the project for polymetallic nodules. He recruited 100 youngsters, including me and it has done wonders for the Indian Oceanography as well as to the polymetallic nodules exploration, which is continuing.

The first recovery of nodules created a splash because it heralded the era of deep seabed exploration capabilities of the country.

Sedimentary basins in the Indian Ocean

These are the basins in the Indian Ocean where there is potential for nodule formation. We chose the Central Indian Ocean Basin. I produced this scanned document of the map that we made in the 1980s to find out which could be the most appropriate basin for exploring nodules in the Indian Ocean. So if you look closer we chose the CIOB three and a half decades ago.

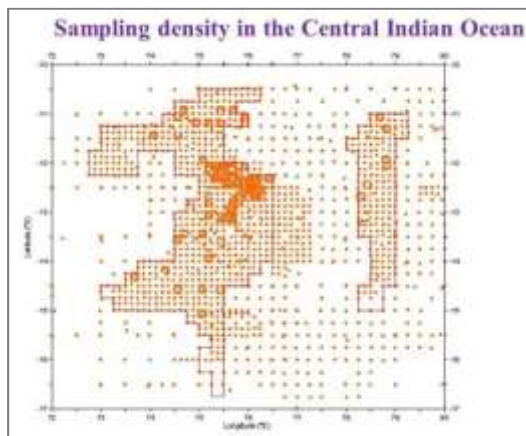
These are some of the milestones in the exploration saga of the Indian subcontinent: the first nodule was collected in January 1981; in 1982 we had the honour of being recognized as a pioneer investor; in December 1982 we signed UNCLOS III; and in August 1983 was a good milestone for us because there

were so many agencies involved in the nodule exploration and processing as well – so the first metal from nodules was extracted and 2 million km² are explored in the Indian Ocean; in 1987 the pioneer area was allocated – 150,000 km²; in 1994 we relinquished 20% of the area (block size of 25 km); in 1996 10% more of the area was relinquished; in 2002 there was 20% of the final relinquishment area; 2009-2010 we identified the first generation mine site; and in 2013 there was identification of what we call the test mine site – a single block of 1/8 of a degree with further activities to be carried out.

Quantum data obtained from the Central Indian Ocean

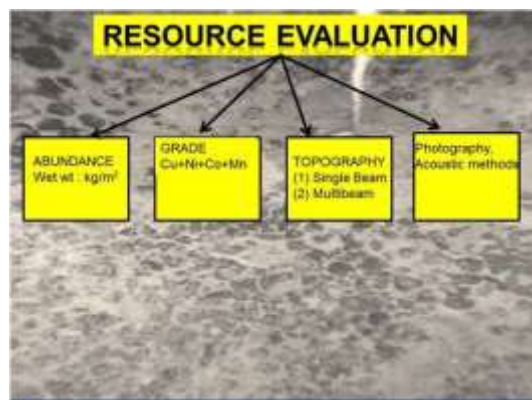
The total area surveyed is 3 million km². We had to narrow it down from an entire basin to a small area. We had sampled from over 2,500 and in each location 5-7 operations were carried out mostly by FFG because there was a robust average in a particular spot. The total number of operations to date is close to 11,000. Starting from a grid of one degree and finally we were sampling at 14 km and 7 km grid in a part of the area totaling approximately 18,400 km².

This enabled us to identify First generation mine –site (FGM) and then there was metallurgical labs involved in metal processing, and therefore we collected about 300 tons of nodules. We took 50,000 photographs of the seafloor using deep-towed systems as well as spot sampling systems. Echosounding



at 12 and 3.5 KHz of penetration and sub-bottom profiling as well at 500,000 lkm and multibeam swath bathymetry in the 90s when we changed the exploration systems. So, around 300,000 sq km was done by multi-beam swath bathymetry. Then we saw the need for high resolution swath bathymetry and 12,000 lkm was done; 50 stations were cored and 76 expeditions were done in eight vessels. Scientific publications in national and international journals were done and many more ongoing.

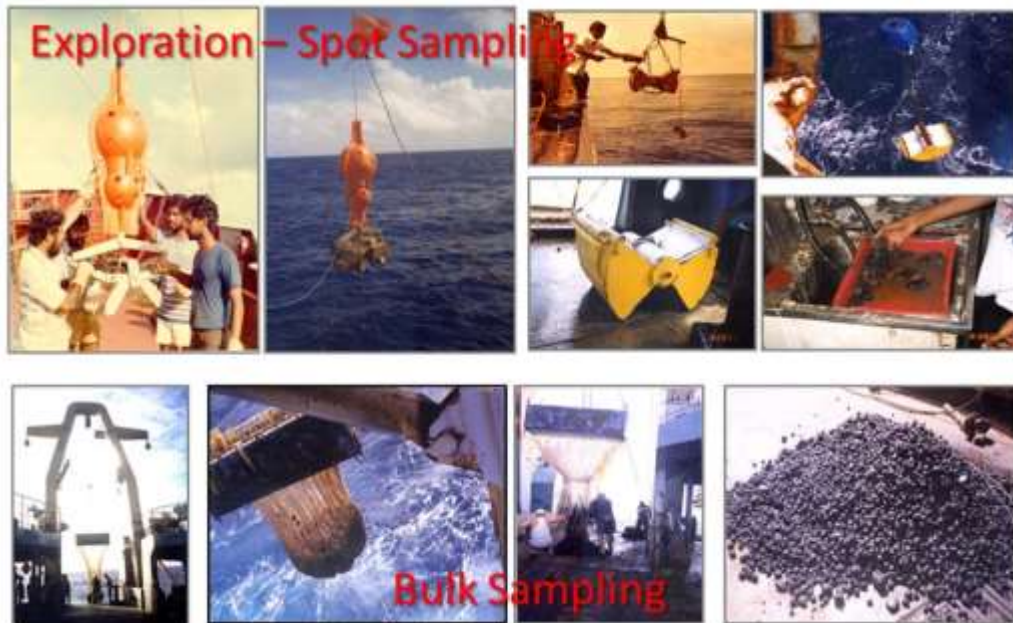
Density of sampling in the Indian Ocean



The slide (left) shows sort of convergence from a large grid to an area, which is most interesting perhaps the richest, in the Indian Ocean.

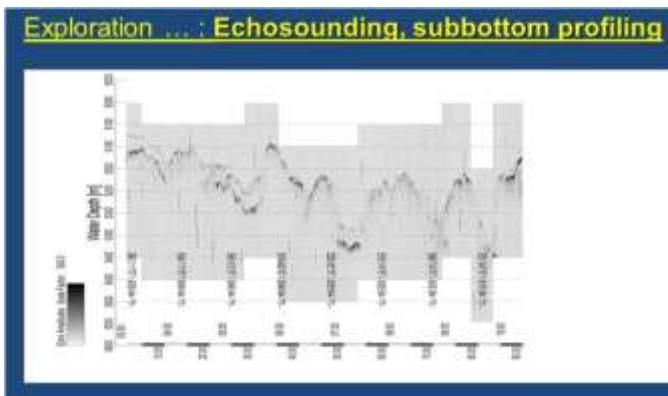
Resource evaluation

These are four aspects of resource evaluation - abundance, grade, topography and photography. Abundance and grade will tell us our estimation and the topography will tell us how much is mineable. Photography and Acoustic methods are indirect methods.



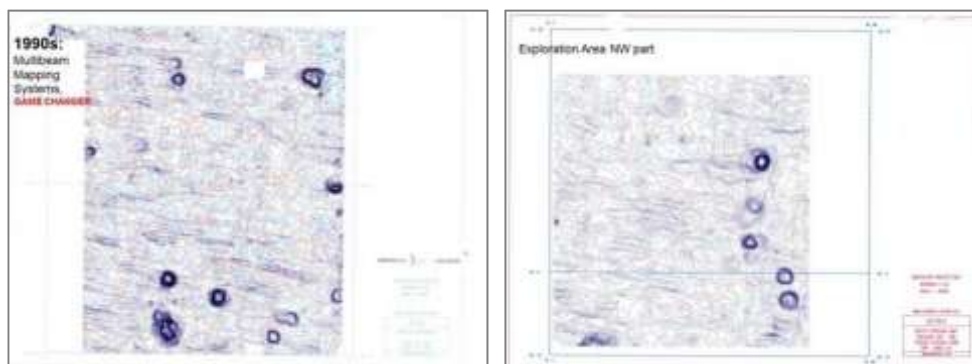
We use spot sampling in most of the areas using this particular sampler. This gives you an economy of operation in a particular spot if you want to deploy five grab samplers it would hardly take 4-5 hours whereas one which is tethered and

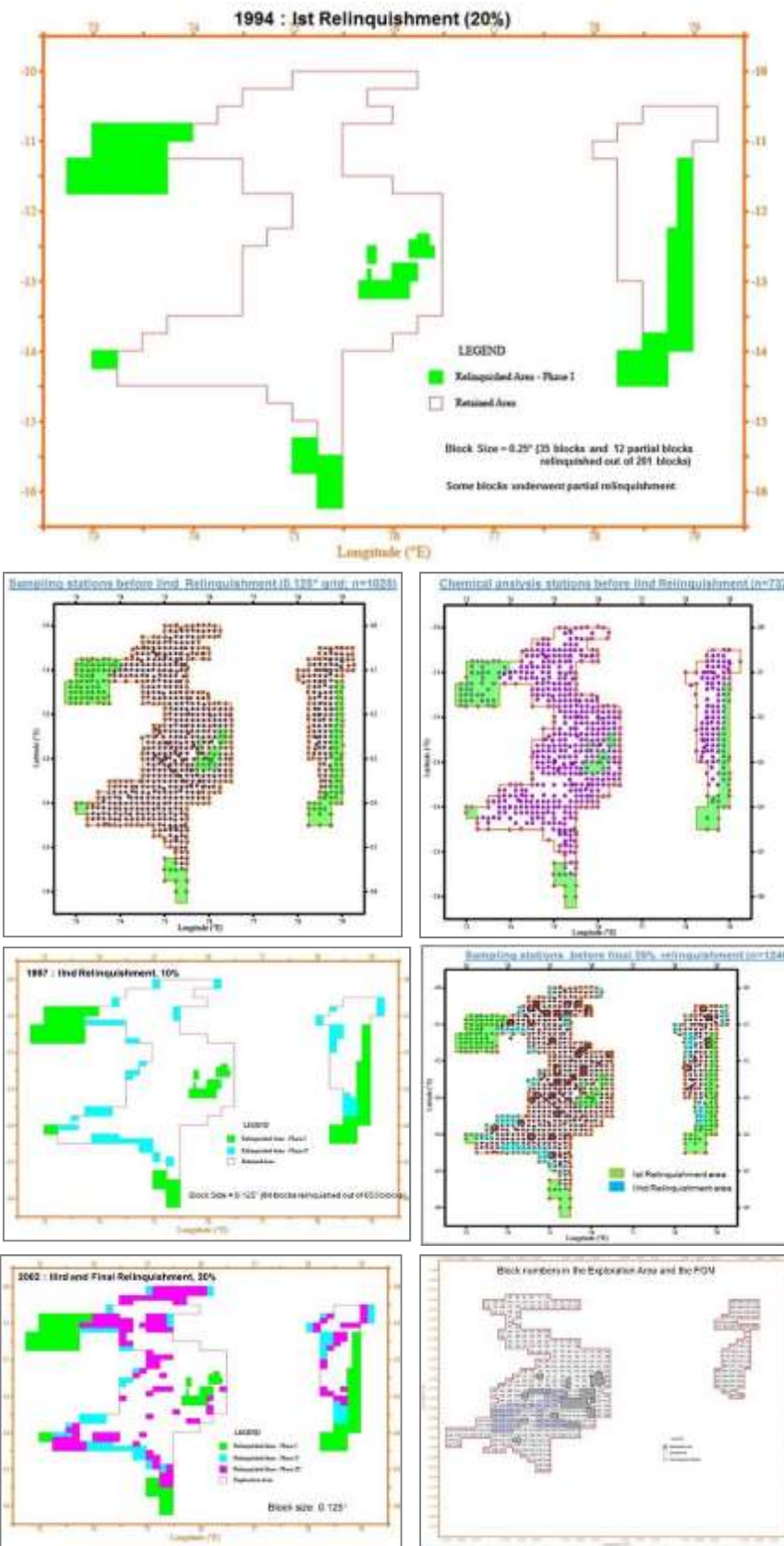
lowered by wire will take an equal amount of time. Spot sampling was done using the Pettersson Grab and Russian designed Okean grab as well. This would give us an assurance that the seafloor had been sampled, as FFG when comes back, we are not sure if it was closed properly. For bulk sampling we used dredges, collected 300 tonnes of nodules.



Echo-sounding and sub-bottom profiling are integral part of surveying. Before 1990 we used the single beam echo-sounding. Sometimes we use 3.5 kHz for penetration and sediment thickness. In 1987 all this data up to that time help us to identify the pioneer area and the reserved area which were allocated to us. In the 1990s we did multi-beam mapping.

This was a game changer. After mapping in 1994, we did multi-beam mapping to help us identify the relinquishable areas in terms of the bad topography. Subsequently before the second relinquishment we did sampling at 0.125 degree grid.

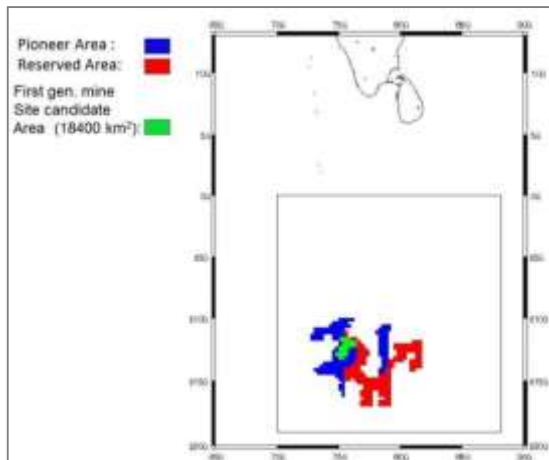




The shaded areas are relinquished portions. The other shaded areas are first generation mine sites.

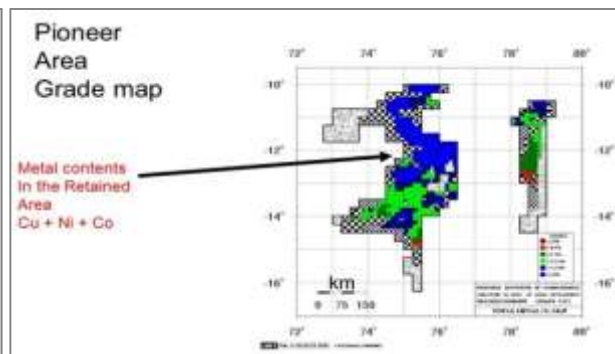
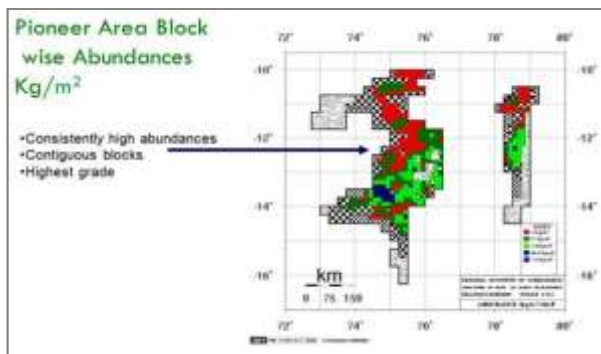
For a first generation mine site you have to first identify a candidate area and then do close-grid sampling and high-resolution sampling because the earlier maps don't have that kind of resolution to see small topography features and then we do resource evaluation, in terms of total metal.

Establishment of criteria for mine site

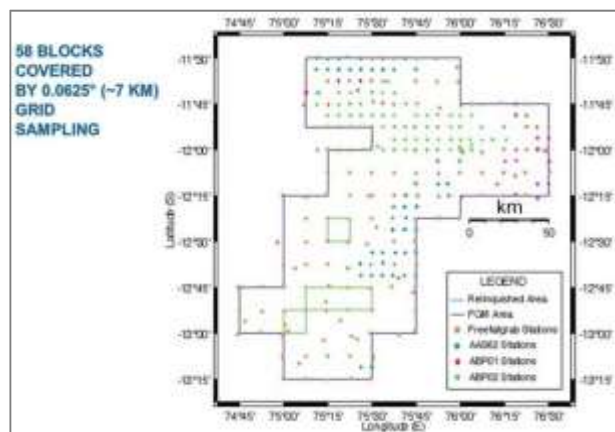


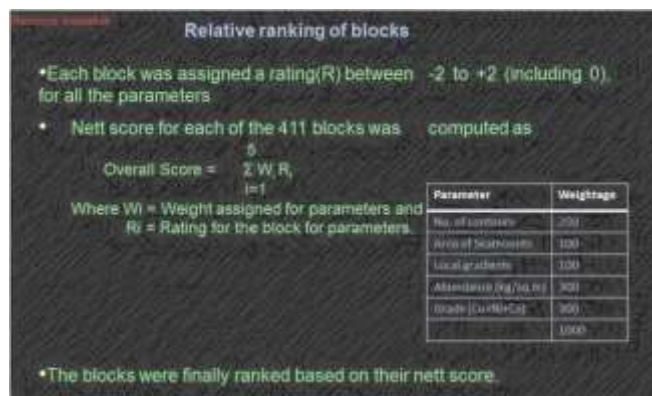
The criteria was that (a) the mine site should be able to sustain a process plant for about 20 years and the explorations (b) should have at least 20% of the area samples at close grid, i.e. at 0.0625° or 7 km grid interval and (c) available topographic information should indicate the seamounts and adverse topography areas of steep slopes.

The first task we identified the portion which was the green and the blue which are the retained area which is candidate site - about 18400 km^2 .



This is the block wise abundance in the area. We chose that area because we were interested in looking at blocks which were contiguous as we thought of the concept of a continuous mining system rather than patches of areas. So the area had consistently high abundances, contiguous blocks and the highest grades. This was 18400 km^2 . In this area we narrowed down the grid of sampling of 58 blocks.





Relative ranking of blocks

Then we did a relative ranking of blocks. We had 411 blocks at 10125 gradient of it. Each of the blocks were assigned a rating between -2 to +2 for all the parameters. The net score of 411 blocks was computed using formula (indicated in above slide) with this kind of weightage (indicated in above slide). Finally, each block had a score and based on the net score they were ranked.

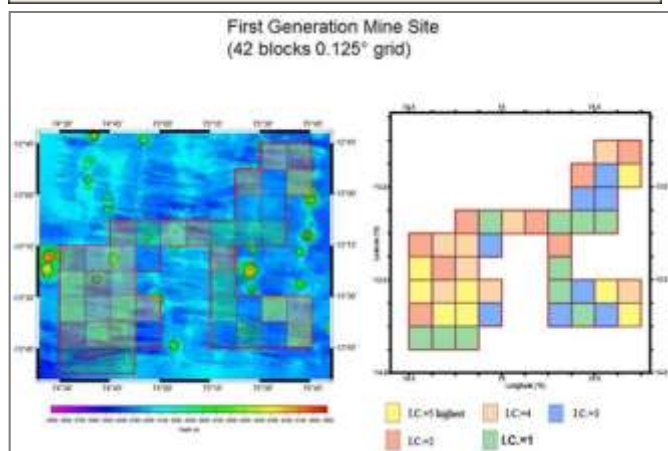
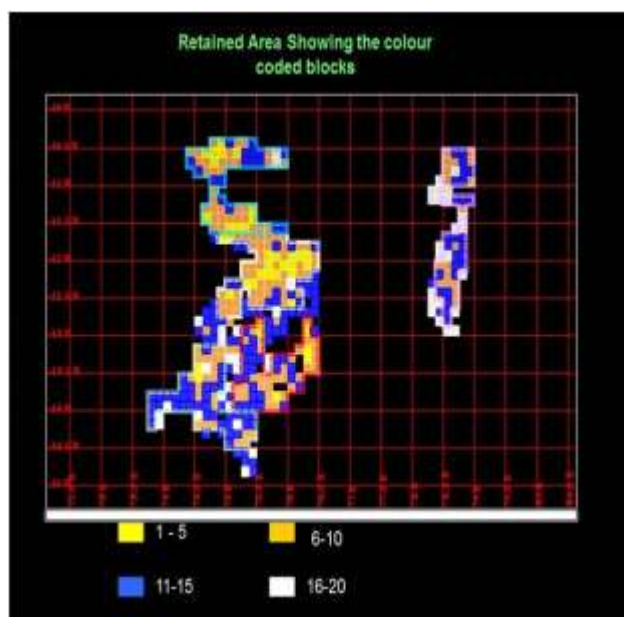
For the FGM identification what we did was that we had 411 blocks, each having a net score, so divide them into these kinds of four groups: 1-5 – 1-53 blocks; 6-10 – 54-234 blocks etc. After colour coding the blocks so that we had a visual estimate when we looked at the area we saw where the clusters were. We had a bunch of yellow clusters which were the best bunch in the area.

Ranking of blocks for FGM identification

The blocks further categorised (1-20) and finally into four groups of blocks which were colour coded **yellow** (best), **orange**, deep **blue** (poorest) to help identify clusters.

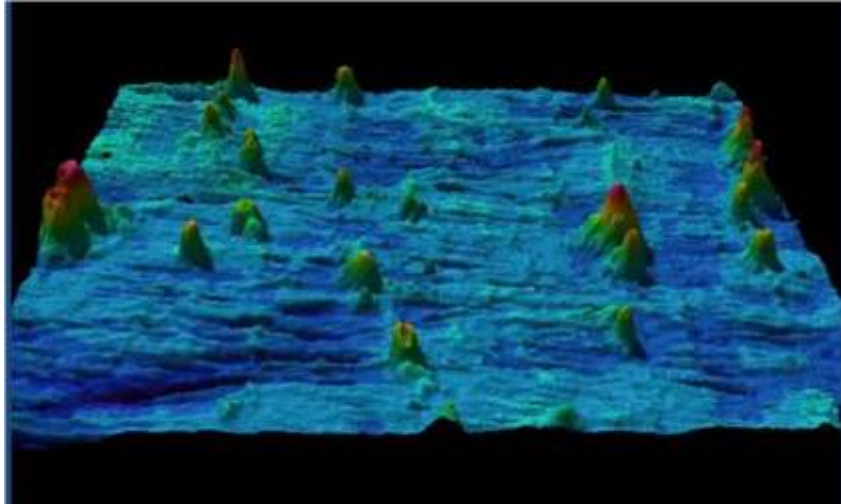
Categories	Group	No of Blocks
I	1 to 5	1 to 53
II	6 to 10	54 to 234
III	11 to 15	235 to 395
IV	16 to 20	395 to 411

After colour coding the blocks, the entire retained area was visually scanned to identify clusters of rich (yellow) blocks. Such clusters were identified to zero in on the First Generation Mine Site.



First Generation Mine Site : (42 blocks 0.125° grid)

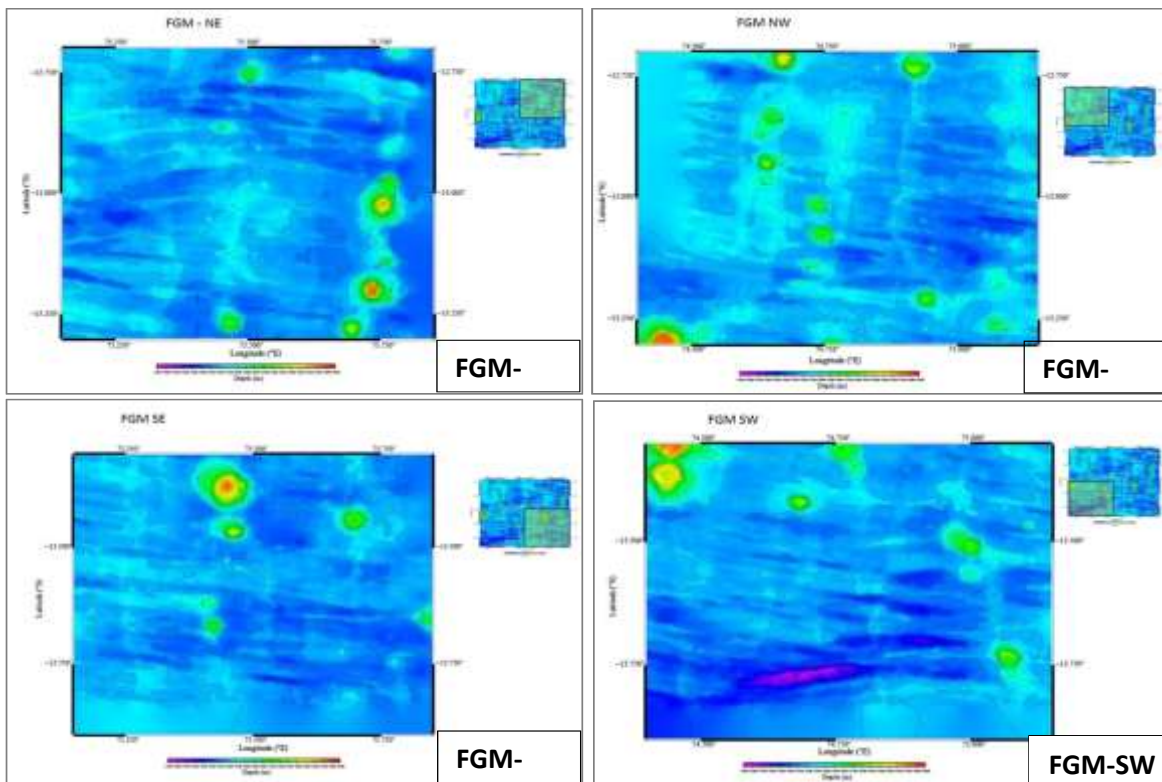
This was FGM identified and bathymetry map overlain.



Present FGM- exaggerated 12x times

This is high resolution map of FGM. Below are four such maps, from N-E to S-W.

We did videography and photography using more modern techniques than in the 1990s. We have seen over these three decades of exploration, several changes in technology which has helped us to define the areas as we continue to work in the CIOB. This is the area where also did tests for shear strength etc.





We thought we would then zero in on a single block of 0.125 degree x 0.125 degree so that further work will be carried out to improve our EIA, etc. for further narrowed down sampling.

The criteria for ranking were once again bathymetry, abundance and grade. We did digital terrain modelling [DTM] of most of the blocks. The geologists here would appreciate the granulations of the seafloor which are interpolated compression against the Indian Plate. The exaggeration is so high and there are a lot of flat areas. When you finally get around to mapping out your mine tracks I think the DTM will be much help with much higher resolution, than what we have.

Identification of Test Mine-site

[TMS]

- **Ranking of blocks of the FGM, and identify one block of 0.125° X 0.125° (i.e. ~14 km x 14 km)**
Criteria for ranking -
1. Bathymetry (weightage high 500)
2. Abundance (weightage 250)
3. Grade (weightage 250)

Test Mine-site

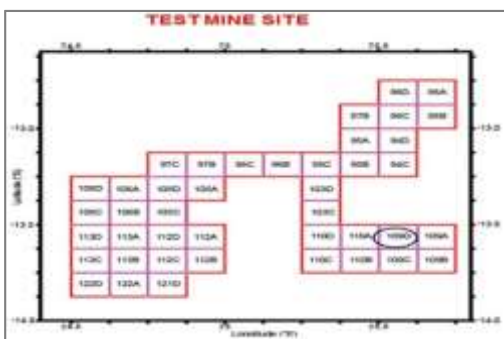
This [below left] is identified as Test Mine-site where further activities will be concentrated.

Mining technology development

We have different institutes in the country which are specialist in different areas. We have National Institute of Ocean Technology [NIOT] in Chennai.

Technologies developed

Underwater mining machine for 500 metres has been developed. We also developed an underwater collector and crushing system for manganese nodules mining in shallow water. We then developed an unmanned ROV for 6000m



water depth. In-situ soil tester for 6000m depth was developed. The integrated mining system for mining of polymetallic nodules up to 6000m depth is a work in progress.

Highlights of work done

- Objective was to realize a pilot scale mining system along with the collector and crusher system and demonstrate the shallow bed mining capability in water depths up to 500metres in the Indian waters.
- The performance of the systems developed during this period and the analysis of results formed the basis for scaling up for the technology for the deep sea application.
- As a demonstration platform, a technology demonstration vessel was acquired.

In order to realize pilot scale mining the first test was done at 500m in the Indian waters. The performance of the systems was satisfactory enough and we had the confidence that we can shift our efforts or scale it up to the deep sea. In the process an excellent vessel has been obtained which will facilitate all the work.

Development of Underwater Collection and Crushing Systems

Development of Underwater Collection and Crushing Systems

- Design and Development of Collector, Crushing Systems, Undercarriage, Enhanced Hydraulics, Buoyancy packs Electronics and Control Systems
- A Remotely operable artificial nodule laying system was tested off Chennai coast in 2007 at 500 m depth.
- Mining machine with collection and crusher system was realized and tested in the test pond in March 2010.
- The remotely operable artificial nodule laying system was used for nodule laying tested off Malvan coast at 512 m depth in September 2010.
- A 500 metre test mining system was launched at the Angria bank, off Malvan coast at 512 m depth



Infrastructure Development :

- Installation and commissioning of Hyperbaric chamber.
- Hydrotransport test facility commissioned.

Development of in-situ Soil Tester

- In order to validate the compact fully electrical in situ soil tester, test was conducted off Ennore port at around 14m depth in July 2010.
- Subsequently, the modified in-situ soil tester was tested successfully at 5462m depth at CIOB during October 2011.



These are components of going in to that, I think most people involved know that it is highly complex. We have the development of underwater collection and crushing systems: design and develop collector crushing systems, undercarriage, enhances hydraulics, buoyancy packs electronics and control systems. When you are testing in the continental shelf with all that nodules you have to design a nodule layer – it is good enough to do it in a pond in the backyard of the institute. There was a nodule-laying apparatus which was also designed. The remotely-operated artificial nodule laying system was used for nodule laying tested off the Malvan coast at 512M depth in September 2010. A 500m test mining system was also launched that the Angria bank, off the Malvan coast at 512m depth.

The infrastructure that was developed [slide above right] - installation and commissioning of Hyperbarion chamber and a hydrotransport test facility was commissioned. This was done is-situ.

Soil Tester Testing at CIOB, 2011

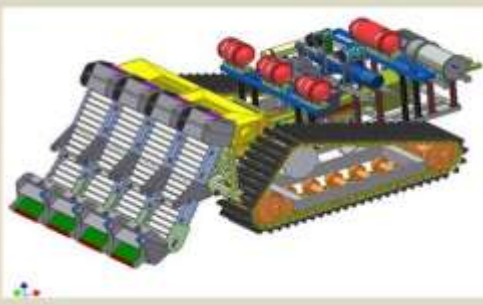
The soil tester was done in the CIOB in 2011 at a depth of 5462m depth. The indigenously developed sub-sea motor was also successfully developed and then there was a demonstration. The new sub-sea termination assembly for the in-situ tester cable was used for the first time at 5462m depth and qualified the same.

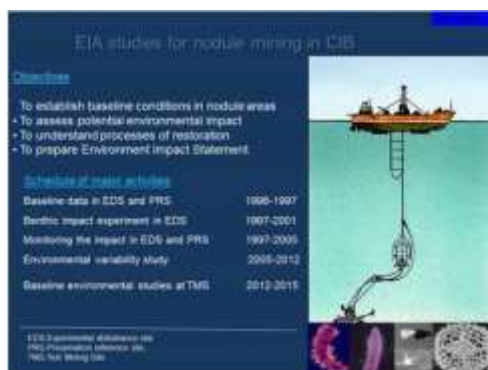
Development and Testing of Deep Ocean ROV (Remotely Operable Submersible - ROSUB- 6000)

A deep ocean ROV was developed and tested at the PMN site in the CIOB at 5289m. We had a design phase initiated with preliminary design calculation/drawing for various sub-systems. Studies on acoustic positioning system for positioning the mining system at 6000 metres depth were done and hydraulic closed circuit pumps for 600 bar pressure in hyperbaric chamber were tested. Scientific data such as Sound Velocity, Dissolved Oxygen, Conductivity were collected. Water samples, bottom video and still pictures and short core samples were also collected at the PMN site.

Concept development for Integrated Deep-sea Mining system for 6000m depth

- Design phase initiated with preliminary design calculation/drawing for various sub-systems.
- Studies on Acoustic Positioning System (APOS) for positioning the mining system at 6000 metres depth.
- Initial testing of hydraulic closed circuit pumps for 600 bar pressure in hyperbaric chamber





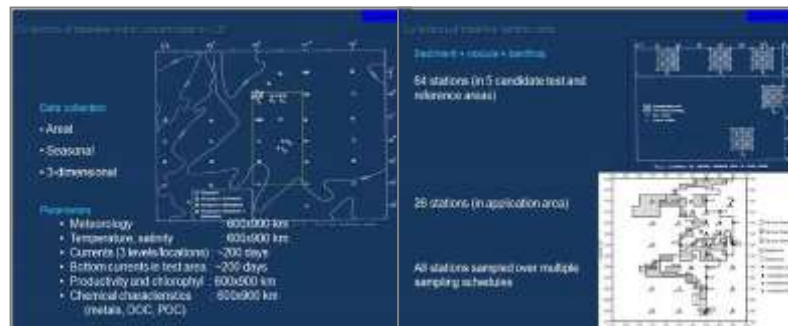
Environment Impact Assessment

The basic concept we had for EIA studies was to establish baseline conditions in the nodule areas; assess potential environmental impact and understand the processes of restoration and to prepare EI statement.

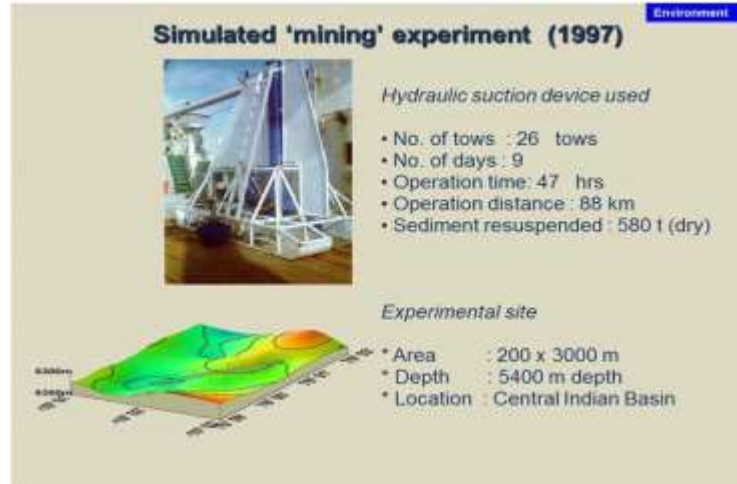
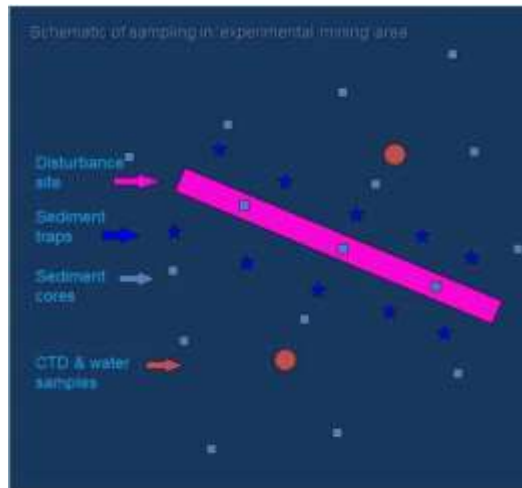
These were the studies conducted over the past two decades: Baseline data 1996-1997; benthic impact experiment and EDS 1997-2001; monitoring the impact in EDS and PRS 1997-2005; environmental variability study 2005-2012; baseline environmental studies at test mine site which is currently being done and will be completed next year.



These (left) are the parameters done: sediment size; water content; shear strength, sediment geochemistry; macrofauna diversity and abundance; meiofaunal diversity and abundance; bacterial diversity and abundance and currents and sediment flux.

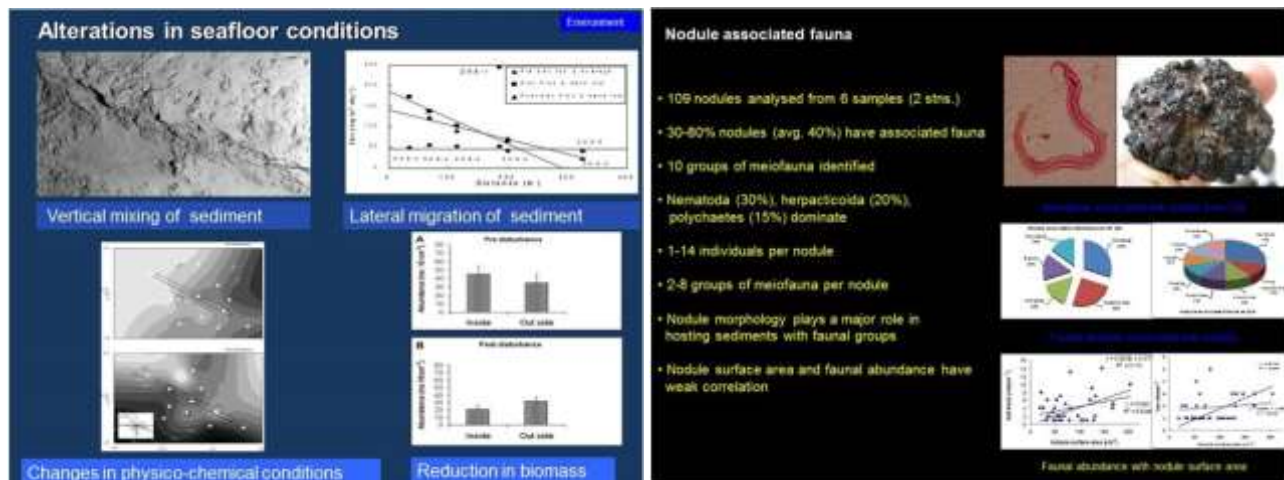


We took a larger area with these parameters: meteorology; temperature and salinity; currents; bottom currents; productivity and chlorophyll and chemical characteristics such as metals, POC and DCC.

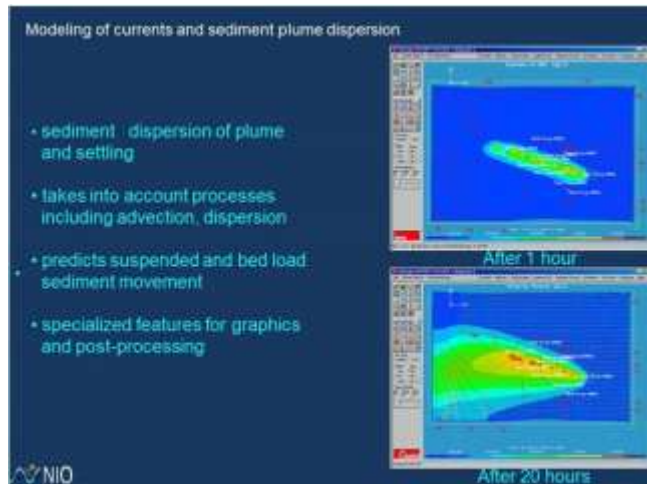


The collection of baseline data (left) was done at 64 stations in five candidate test and reference sites. The simulated mining experiment was done in 1997 in the Indian Ocean, where about 600 t of sediment was suspended.

Alteration in Sea-floor conditions



Environmental conditions (above) seem to vary over different time scales (seasonal and annual) on a wide range but always follow a particular trend near seafloor currents and are very slow and in gyres. This slide (above right) shows all kinds of small worms associated with sediments and fauna – mega, meo and epi.



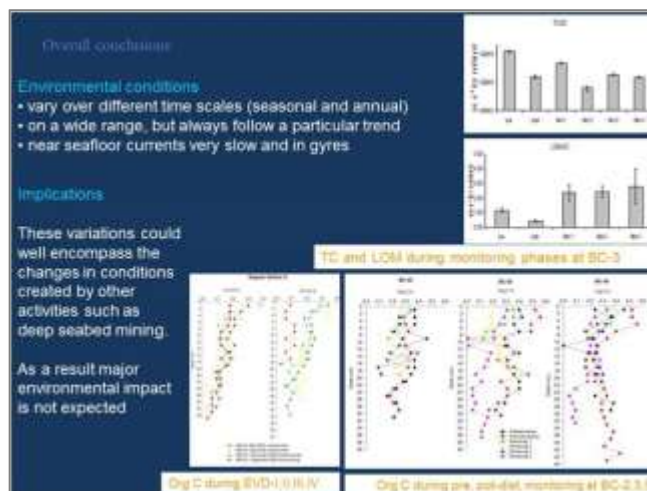
Modeling of currents and sediment plume dispersion

The implications are that the variations could well encompass the changes in conditions created by other activities such as deep seabed mining. As a result major environmental impact is not expected.

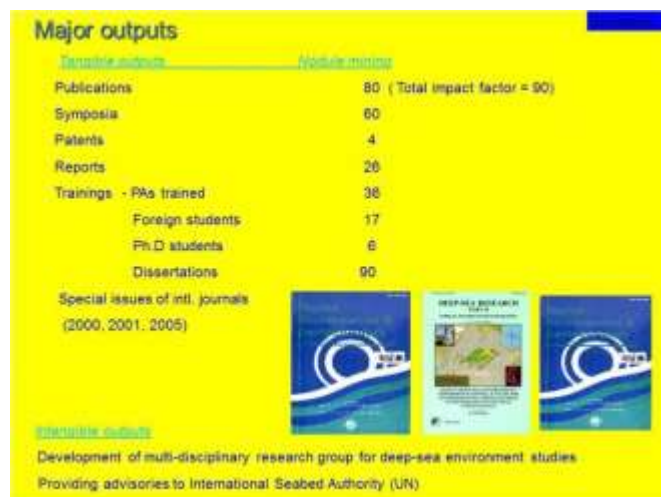
Overall conclusions

Major Outcomes

1. Assessing the potential impact of nodule mining on environment in test and reference areas
 - Benthic conditions getting restored
 - Degree of restoration is different
 - Natural conditions taking over
 2. Natural variability
 - Water column : 34 stations (Physical, Chemical, Biological observations)
 - Benthic : 40 stations (Geological, Biological)
 3. Environmental data for nodule mining
- Findings - Significant seasonal and annual variability observed



Major outputs are as summarized in the slide below



Databases generated

Database	Phases included	Parameters included	Contents (format)
PMN-EIA database - I	Baseline, Pre-disturbance, Post-disturbance	All parameters of water column and benthic environment	EIA metadata (MS Word) EIA analysed data tables (MS Access) EIA reports (Multipage compressed Tiff)
PMN-EIA database-II	Monitoring-I, Monitoring-II, Monitoring-III, Monitoring-IV	All parameters of benthic environment (no data on water column parameters collected during these phases)	EIA metadata (MS Word) EIA analysed data tables (MS Access) EIA reports (MS Word)
PMN-EIA database-III	EVD-I, EVD-II, EVD-III, EVD-IV	All parameters of benthic environment (no data on water column parameters was collected during these phases)	EVD metadata tables (MS Word) EVD analysed data tables (MS Access) EVD reports (Adobe Acrobat)

All our databases have been submitted to the ISA.

Supplementary information from Dr. Singh

Just to sum up some of the points Dr. Prasad mentioned just to ensure that the focus on the major points are not lost:

1. NIO was identified as the nodule agency by the government of India for exploration of nodules but within a year of starting the work on exploration, an independent engineering consulting company was associated with the programme right from the first year. The point I was making yesterday was that in India for the government managed projects we associate an independent, competent organization that works as a competent person. NIO did all the work, but the reporting, estimating and formulation of QC protocol and the reporting, but it was not signed by NIO. It was always signed by the engineering consulting company. Just to make sure it is an independent agency that actually submits the report to the government. It is the same thing for the land-based mining as well. The company does the physical work but the reporting and estimating are always done by the independent consultant company.
2. To sum up, for the 75,000 km² area the work completed stands at 12.5 km sampling grid; part of the area sampled at 6.5 km. We measured the shear strength of the sediments collected from the seafloor – a number of them – but we have in addition, also were carried out in-situ tests. This is important because that is a prerequisite for designing the mining system.
3. Continuous bathymetric survey for the entire 75,000 km² area has been completed, dredging for more than 40 tons has been completed to allow the process tests at pilot scale. As far as the EIA is concerned the very large area was covered to capture the temporal and spatial variations. Disturbance was created and pre-disturbance baseline data was established and subsequent monitoring over the years was done to look at the impact of these disturbances. This gives us a basis for evaluating future impacts of the kind of mining operations that will be carried out. As far as mining is concerned, we have tested at 500m, the collector mechanism, the crushing and

the transport of the nodules from 500m based on artificial nodules. With this step, the next step is for the selected test mining block, the mining system will be tested particularly for ensuring the efficient collection mechanism. We are targeting eventually the integrated part but our immediate task is to ensure that the collection mechanism is a reasonably efficient one.

4. Processing – more than 13 processes have been tested in different national laboratories. Eventually one process route was tested at 500 kg per day scale – a fairly large demonstration plan. As a result we have designed it based on which we could upscale but the engineering consulting company says that the data generated is fine but it is not scalable to the commercial scale and therefore the more work you do more questions are raised, therefore we need more work to refine data as eventually we have to go to the engineering phase. How do we go there unless we generate design data to suit that requirement.
5. When we did the pilot testing we recovered only three metals: copper, nickel and cobalt. However, it was understood subsequently that perhaps for many reasons three-metal project will not be viable and there will be serious problems in the execution of the project. I must say that the integrated nodule project goes through overlapping regulatory regime. As long as they are in the ocean we are controlled by the regulations of the Authority and the moment we are on land then national legislation prevails. Looking at a 3-metal recovery plan, 3M tons of waste will be stored and the land acquisition legislation that is available today, it is very unlikely that the government will permit just 2% recovery of the 3M tons and store the rest of it as a waste, therefore we decided that we have to go for the 4th metal and carry forward the production of alloys being upgraded to the pilot scale as well.
6. I come now to the classification process. One of the points that were made was that none of these systems are specifying the confidence limits required for classifying the resources into different categories. My suggestion is in case of nodule deposits it is doable, and therefore it is time that we all agree that specification of relative errors be specified. My suggestion is we specify to less than 10% for the measured category; 15% for the indicated and more than 15% for the inferred. This is just a thought. This is just in case this is accepted, we see the extensive work that was done in the CCZ and also the CIOB in the Indian Ocean. My assessment is that at the level of 75,000 km² (size) if you have done sampling at the grade of approximately 15 km, you get an accuracy of +/- 10% even if you take just the arithmetic mean of the abundance values the grade will be still better, probably much higher. Fortunately, irrespective of whether you are in the CCZ or CIOB as long as you are doing 15% in both the cases you will be less than 10%. If that is the case, perhaps in quite a few cases where the sampling has been done at 14km, will qualify for reserve, provided we don't introduce the bathymetric part into the system, because we had some difficulties in mapping the bathymetric part and slope angles. I will put that aside for the time being, considering the quantum and the grade. I think that 15 km spacing qualified for a measured category.
7. There is need to look at some other points. 75 km² is one size, the next level in my reckoning is 10% of that area. Why 10%? Because 10% of the area will have sufficient resources for 20 years mine life so it could be one area; or an aggregate of 2-3 areas.

Summary of Discussions

A participant remarked that it was very important to reduce waste and hence India's four metal metallurgy idea was significant from this point. To this, Dr. Singh said that the problem was residue as it was a very low grade residue material and tough to convert to manganese alloys.

Seeing the sled device on the deck in a photograph, a participant (Dr. Ted Brockett) told participants that the device was made by a company in Seattle, Washington. He said the sled was used by this group (NIO, India) and was also used by IOM, MMAJ and NOAA to conduct benthic impact experiments and was sitting in a warehouse in Seattle. He said NOAA has indicated many times that any organization interested in ocean mining and who wanted to do a benthic impact experiment could use that device at no cost so for organizations who haven't done their experiments yet could avail themselves of the device which had not been used since NIO used it in 1997.

Another participant commented that as they were now (as was also presented by the DORD), beginning to get some numbers on what might be inferred to indicated etc., they were going to follow the CRIRSCO method at least as an interim to take them forward into the next phase.

A participant commented that he had listened very carefully to how a large area could support an economic professional mining programme; and recalled the discussions during the PREPCOM and during the deliberations for the nodules. Dr. Singh replied that the selection of 10% of the area would be one of the best parts of the entire 75000 km² and therefore the average abundance would be higher in this area and his assessment was that it will by and large provide 20 years mine life without any problems.

CHAPTER 19: CCZ Nodule Projects: 2013 Mineral Resource Estimate per N143-101

John Parianos

Tonga Offshore Mining Limited (TOML)

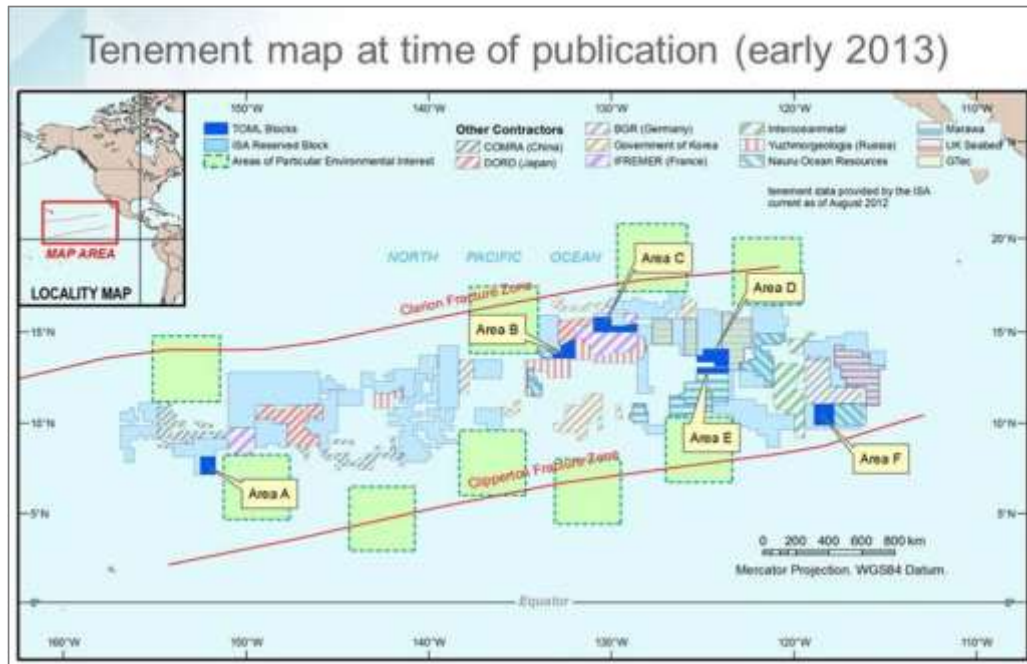
Mr. John Parianos said that the TOML license has six blocks (A-F), returned (to ISA) by the Pioneer Investors. Area E and F have few samples, so were not included for classifying resources. Mr. Parianos informed that for going through the code NI 43-101, TOML had done data verification by obtaining public data and preparing a completely independent data set. Similar results were obtained by interrogating the model picture with the International Seabed Authority's 2010 map; using colour codes and comparing it to TOML's estimates model.

TOML took a block model approach in 10km x 10km, did Kriging and simulation for the purposes of an inferred resource. Mr Parianos said the TOML reported a range of results and used abundance as a cut-off, along with a grade/tonnage curve. He said the grade barely changed although the abundance, which is the key economic variable, did; and that the appropriate cut-off at this inferred stage was not known.

Good afternoon everybody – I am really happy to be here today. I really enjoyed the lunch. It is also a privilege for me to represent Tonga – and the only other thing I really want to say for a start is that we are the only developing nation represented here. That means a couple of things. The first is - we would really like to thank the countries – the developed nations if you like, the countries that contributed to the reserved areas that Tonga was able to collect – specially Japan, Russia, France, Korea and Germany. Thank you very much because without your pioneering efforts we would really not be here today - we would not have had a chance to present.

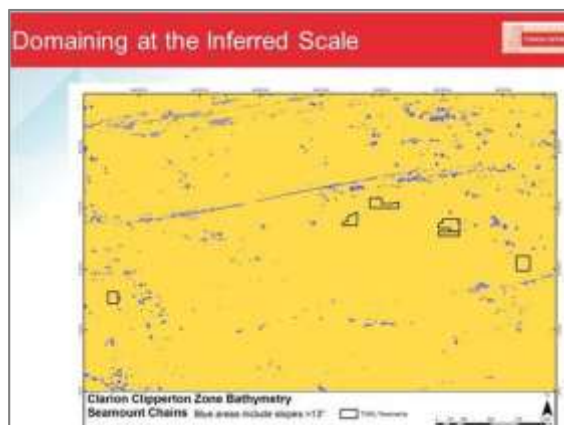
And that leads me to the next point I like to make. And this talk is a little bit different to the ones before because we have not done decades of exploration. We have done one cruise; we think we have to do one more cruise to get to the next stage in our adventure. And the reason we could do that is because of three main reasons. The first reason is the quality of the work that went before; done by the pioneers – the second reason is the quality of the deposits itself. The CCZ is a phenomenal mineral reserve. The third reason is the quality of the code we used to report the resources and reserves. We certainly pushed the limits when we reported these resources. We had a very good team of guys helping us to get this through, but in the end we met the criteria to define the resource. We honestly believe we did it honestly and we have material. So it is really great that it all came together. This talk really about what little work you need to do to get the resource. I think that is a different way of looking at things. Certainly when you are a commercial company like we are you don't want to waste effort, you don't want to waste time. We wanted to get to our stated objectives.

So the key work that we have done is captured in this report. It is a public report and it has been posted on this website called SEDAR [(System for Electronic Document Analysis and Retrieval; the electronic filing system for the disclosure documents of public companies and investment funds across Canada).



Basically it is a website in Canada used to disclose public documents [also available at [http://www.nautilusminerals.com/i/pdf/CCZTechnical Report-Updated.pdf](http://www.nautilusminerals.com/i/pdf/CCZTechnical%20Report-Updated.pdf)]. High level transparency is what is critical for public companies and I think a lot of the obstacles we face in getting this mineral resource published was around transparency, trying to make sure that we were clear in everything to do with mineral resource. It is quite a long report and there is no way we can get through all of that this in this presentation. What I want to do is touch on some of the key aspects from our company's point of view; on what we have been able to do to get to our goals.

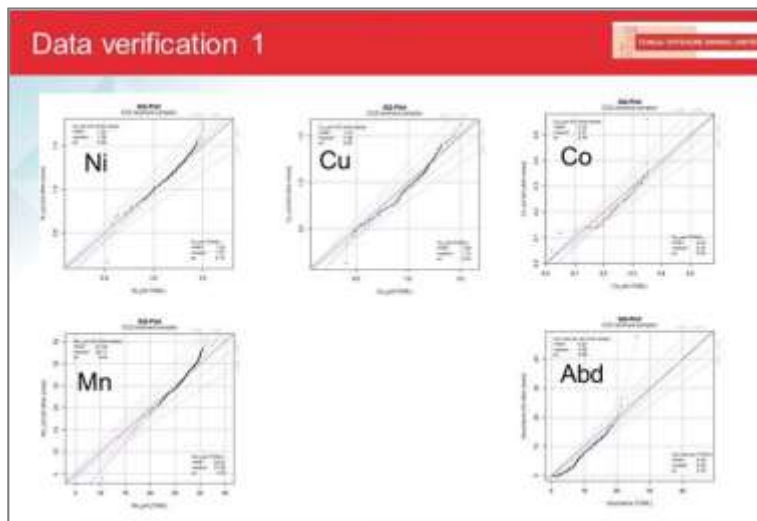
So in case you don't know this is a map of the CCZ that dated back in early 2013. The Tonga Offshore mining licences are quite different. We don't have one or two big blocks; we have six little blocks scattered through the CCZ. Area A is in the far west; it is part of the mineral resources and it is a piece of



ground returned by Japan. Area B and C are more in the centre and these were returned by Russia and France respectively. Area D was again returned by Japan and Area E by Korea and here in the east with somewhat different characteristics. Area E and F were not included in the mineral resource estimation because we did not have enough samples to be confident about classifying as a resource.

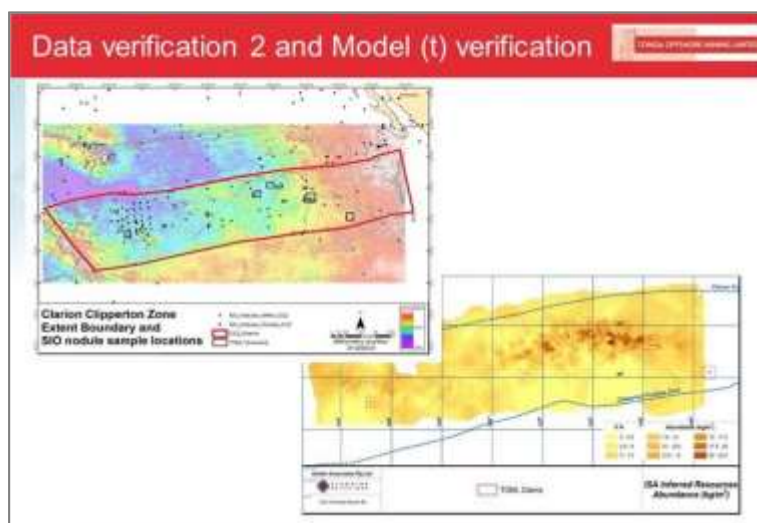
In various details discussed by Matthew, a couple of days ago, he talked about domain. One of the points he made is the CCZ is one single deposit. I don't know if many people saw it that way. It was only by going

through the code that we realized that we had to grapple with these particular aspects and we had to grapple with the idea of domain. Often an ore body is broken down into discreet domains and different character, so the question was do we have parts of the CCZ that are significantly different at the inferred level of confidence. The answer is no – not really. This is a very coarse grained map of slope, we used publically available GEBCO data, at the inferred level of confidence and we are very happy in that domain.



We had another problem – data quality. Whilst it is good to get all this information on the licenses from the pioneers the data was lacking in certain characteristics. There was no information on how the samples had been collected. There was no information on what test samples had been done – a lot of the stuff that is really taken for granted in marine sampling programmes. We thought at first that were not going to get our mineral resource. For the quality controls you just did not know what you were doing and it if it were

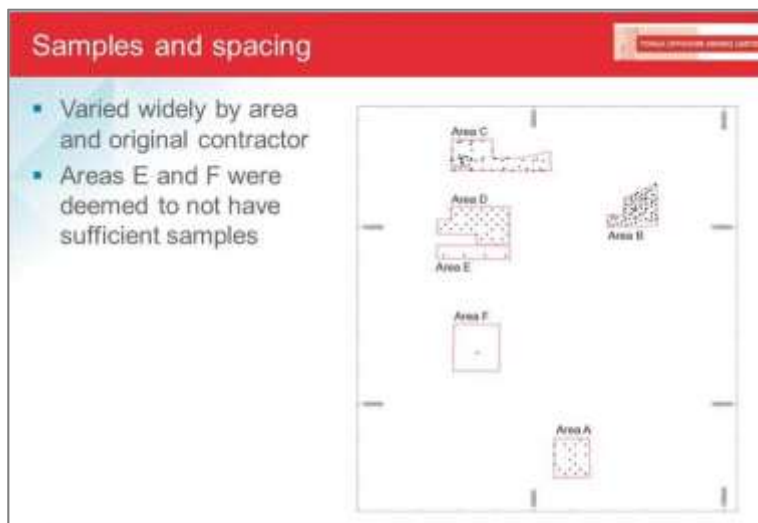
possible. However, something came to our help – that was the fact that the data came from different contractors. We know it was done differently, we don't know how it was done differently. They had different sampling devices and sampling protocols and different regimes. What Matthew realized basically is that it made no difference; chemistry was really no the problem here. Statistically the CCZ is certain immense benefits compared to other types of resource. These charts basically try and show how consistent the grade is – not so much between the contractors. The indication of this goes all the way to processing by the way. I know a lot of people worry about the metallurgical processing. If you ask any metallurgist would you like a hundred years supply of all that never-changes chemistry you would get a pretty happy response.



So this is some of the other data verification we had to do. For example the map at the top here shows the CCZ which has our licenses on the bathymetric map, and the dots are not data from the International Seabed Authority. This is publicly available data from Scripps Oceanographic Institute in San Diego. We could not just trust what the ISA gave us, I am very sorry about this Secretary-General, We got a completely independent data set and prepared them statistically, and we got exactly the same results.

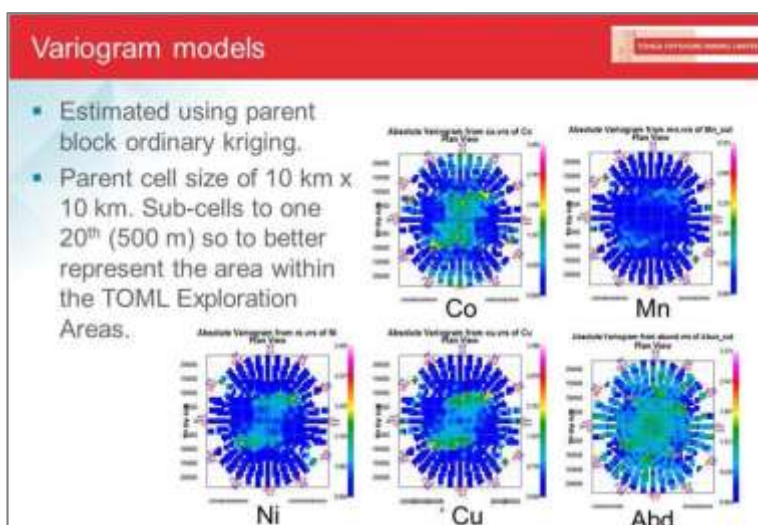
The map (bottom) is actually a check on the model. This is a map by the model group done by the International Seabed Authority. It was done back in 2010 under the guidance of a lot of people in this

room including Charles Morgan who was one of our key people. Charles could not give us the model because it is confidential – the data but the map is public knowledge. So, again, we simply interrogated the model picture by using the colour codes; these are the colour codes of abundance and you can simply go and add up the different colour blocks inside each cell and you get a reporting on this model on abundance and then we compared that back to our own model of estimates of the same sub areas and we got a very similar result. So that was fantastic. We were able to compare completely different data sets, completely different models and get a lot of confidence.



I did touch on sample spacing before so this is the sample locations for each of those blocks now they are not in their right space anymore because when it comes to modeling the area is too big for any computer so it made much more sense that we project everything back into one space. You see straight away why Area F does not qualify. In fact there are two samples there but they are on top of each other and Area E has only four samples which was right on the limit of what we thought was acceptable. In the other areas we thought we had

enough samples and it was interesting to see how different the samples spacing are between the work left to us by the previous contractors. Again you can see that Area A and Area D are roughly similar and that is because they are both from Japan. The Russian did the most detailed work of anyone from the grounds, we have returned and that is Area B.



Matthew took those sample points and he took a block model and then he interpolated the results with the block model. We did ordinary kriging as it was justifiably unbiased technique to use and we were quite conscious we have done a bit of simulation since but for the purposes of an inferred resource this is what we thought we had done was necessary. You do not need to do more.

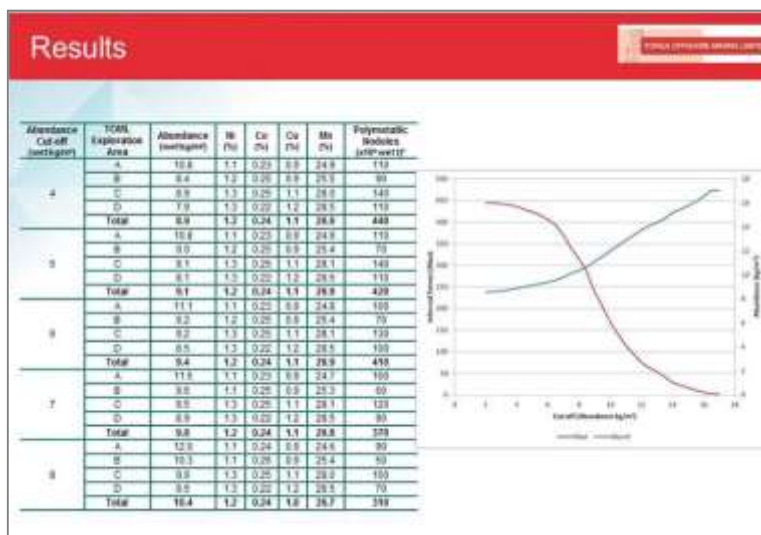
You can see the three variograms have quite good structures. That is nickel, copper, cobalt and the

structure you can be seen in the patterns of the different colours. So this is looking in all angles for the chemistry basically. It is just a way of searching around a particular point - the average of all points - to see how things change. When you start to see a pattern you get some ideas of the grades are behaving in a particular way and the orientation. For manganese it doesn't really matter because. For abundance it is much easier to see the structure.



In presenting the information we found that it helped to build these element maps. So what they are basically is the outcomes of the block model that is why you get that granularity. The one that works best in the theory on variograms; the one that really matters on the variograms and the ones that work the worst on the variograms are the copper, nickel and the cobalt. To me the interesting thing is (and we have had some discussion) - we start to wonder if we can start to see some structure in these diagrams and it is encouraging

because we want to go from inferred to indicated ; if we start to see some kind of structure the patterns in these diagrams give us hope . As we begin to do more work it will become more apparent and a lot of the work shown today has been very encouraging as well because we can see the other contractors have done more and are indeed getting the sorts of structure that you would like to see in your data to get to indicated.



If you read the report you will see a couple of things with regard to the declared mineral resource. In a lot of Nautilus' presentations we get, tonnage and grade but the technical report itself reports range of results. You can see we use abundance as a cut-off like everyone else, we have broken it down a little bit and we present an abundance/grade curve for the resource. This is to emphasize the uncertainty. Again, it is inferred resource. We do not really know what is the appropriate cut-off at this stage. We are pretty sure it is

somewhere in this range, thus we get some change in these figures and we are using the abundance cut off so the grade barely changes and the abundance does change.

That is my presentation and the only thing that I can add to that is that when we started the job we did not know what we were aiming for. If I can use an Indian sport analogy – it is good to know if you are playing cricket or hockey before you go on the field because one has a small goal area and the other one you just hit it where you no one stands to catch it. I think that helps contractors to focus on the work you need to do.

Summary of Discussions

A participant asked what changes were expected in the next version, as the presented version was an updated version. Mr. Parianos said that the reports of the two versions (2012 and 2013 version) were 95% identical. The differences were the feedback incorporated in the newer version by the regulator, after convincing them that it was one of the biggest resources on the planet, and it had more metal than all the nickel deposits put together in the whole world. The code helped in that they had a checklist to go through and each stage was defended. The next step was to get to the indicated resource.

Another question was put forward as to which site was for mining. Mr. Parianos said that TOML was not ready to present an area for mining because they were not at an indicated mineral resource yet. He said TOML had about three or four areas and was at a concept level and entering pre-feasibility studies. In the case of the resource it was selecting the best area considered for mining.

When asked whether TOML had a time line for the next phases of the programme, Mr. Parianos replied it was the soonest possible time. On the matter of spacing between sampling in blocks A and C, he said the distance was about 20 kilometers; to get it to indicated it was about 7 km and inferred about 10 km. It did vary by area and it was critical to see the different amounts of structure between the different blocks.

Another participant said that the presentation was based on extremely limited data sets and asked if there was any kind of data that TOML did not want reflected at the workshop. Mr. Parianos said it would have been easy to take an estimate for the whole area by taking the map of ISA and picking the data spots. TOML used other information such as the geology of the region; tectonic - stratigraphic reconstruction of the area; the formation of nodules; the adjacent areas, and took a little bit of risk in application.

CHAPTER 20: Lead up of the Polymetallic Nodules Project and Context

Jacques Paynjon

Global Sea Mineral Resources NV (GSR)

Mr. Jacques Paynjon informed that the company signed the contract in January 2013. It has done a cruise in the Area for 55 days and while at the site, the group noticed that there was some sort of mechanism to define the presence/absence of nodules on the seabed and were able to confirm it with the box corers and dredges with cameras on board. He showed some graphs on publically available data in GSR Area, previous attempts and tests of deep sea mining technology and touched on the baseline study done during its 2014 cruise.

Thank you for organizing this workshop because I think the subject we are discussing is essential for the continuation of the ISA, I think it is very important for the ISA to reach a final conclusion on what has been discussed the last two days and I also feel it has been very productive. Now I am the last speaker or the last company presenting. As many of you know, we are also one of the last to sign the contract with the ISA and we are certainly one of the last to have started these activities, yet, we have just finalized, by the way, I think a month ago, our first proofs. So, to put things in perspective, that makes things very difficult for me to talk about resource classification. But what I can do is very briefly present to you who we are, what drives us and just a short insight in what we have done during this first year. I think we will go into it lightly during the July session of the ISA. We will have a presentation then and we will go from there.

So, GSR, the first thing I have to say is that we have just changed our name into Global Sea Mineral Resources that is why you will always and everywhere see the abbreviation GSR. We applied for the contract in 2012 (for the former OMA zone – about 150,000 km²), and we signed the contract in early 2013 because of Belgian legislation and a promise that we had made to the Belgian government that we would not start before Belgian legislation was implemented, it had everything to do with responsibilities. That legislation was implemented in October 2013, we started preparing the cruise and the result of that first year is that we just finalized it. Now let us see if I can go through some slides.



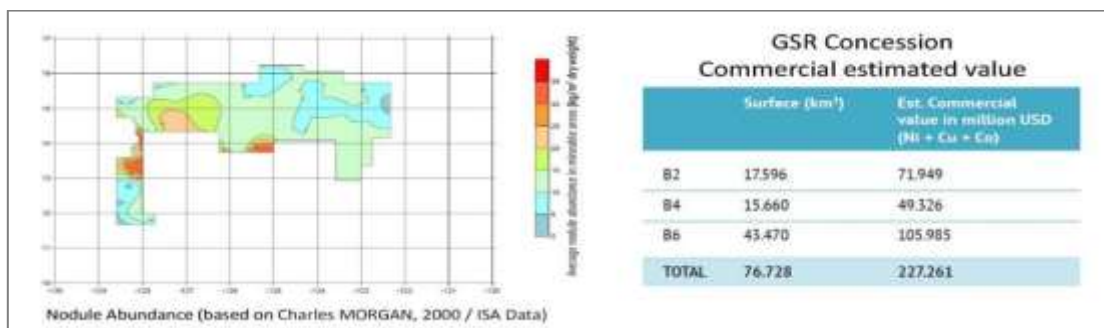
GSR Concession - Location

The area I think you know approximately where the GSR area is – for those who don't know the GSR area is the former ocean mining associates area and we divided it up in three parallel entities what I perhaps also have to say, because the previous speaker, John, alluded that he is the only one representing a developing state – I am certainly not representing one but the remainder of the former OMA

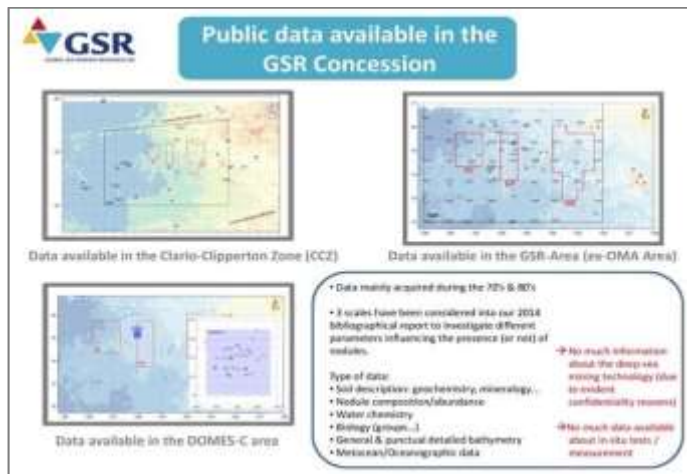
area has been granted to the Cook Islands and we are technical partner of the Cook Islands, but they hold the contract. So, we will develop the former OMA area in its totality.

What can I give you as information on resource classification? really not much. The only thing I can do is fall back on the application filed recently, so I have included a very short slide on what is in the area to give you an indication, and it is good to point out that you will see in the last text line that we took into account the 60% of minable during our application (A “mineable” areas has a favourable morphology and sufficient abundance of nodules > 8kg/m² (dry weight); I can agree with some of the previous speakers that the 60 percent that is already shown is preliminary data from the first cruise, the 60 percent is very high, very high so the final minable areas will be much lower than that, definitely. It has to do with the topography, has everything to do with the inclination in the area, with other limiting factors with regards to exploitation rules, so a very small area will be minable.

Estimation of the Economical Value of the GSR Concession



Again, I give you this because I have to show something – so let me just walk through it.



What we did as you can see in the text box, I mean we are looking at types of data like historical data – but a lot is not available. If you come in as an industry partner as we do, because – perhaps I need to elaborate on that. Now who is GSR - GSR has been set up

– as a, let's say a forward reconnaissance action by an industrial party in Belgium – a party operating on the world scale – a leader in its field of work which is marine contracting, one of the major world players, annual turn-over around 3 billion Euros, and we have a lot of expertise with everything that has to do with water we are very diversified in the contracting business and

we have been doing that - let's say for more than 150 years I think, 170/180 years, so there is a lot of in-house experience. And it is because of the fact that , you know, the industrial world is very small – and sometimes you don't need that much indicators to have an industry that will reflect one issue and to say that there is opportunity, let's go for it. And that is what happened here when there were some

indications, let's say in the industrial market, that it might be an opportunity to return to polymetallic nodules mining. So, what we as an industrial party have done is previous to applying for a contract, we had a look at that – we went into some detail and tried to garner some information on the available techniques worldwide – some of you know, I look at John... some people know what we did. So we had a look around and we saw what was possible so the moment we internally came up with our engineers and design departments and the constructors, came up with the answer that mining – and mining is the wrong word because everyone talks about mining – we don't talk about minable areas, but we talk about harvesting, so when we go about polymetallic nodules we're not talking about mining, we're talking about harvesting. We are not going to take that as a definition, we're not going to take anything that is in the soil, what is above the soil we will take. What is in the soil stays there. So for us it is harvesting, not mining. So once it became clear that it is technically feasible we said let's go for it.

That's the way we usually operate; when we decide to go for it, then we decide to go for it – but nevertheless it also means because we are an industrial party we also need to answer to our shareholders and some of the entities controlling us are the stock-listers which means that we do not have to report to them once a year, we have to report to them several times a year to these people. The numbers have to be good and we need to be convincing or it doesn't work so that fits a little bit already in the context of what we are discussing here. You need to have a standardized system

internally anyhow to convince the shareholders because it is a prelude of what you will do afterwards once you've got the markets, so a little bit already in the same direction.

Previous conceptual attempts and tests of deep-sea mining technology



I just said we looked into what has happened in the past and the slide on the left, I think somebody knows it very well. It comes from Greece 1978, it is from Lockheed Martin – unfortunately UK Seabed Resources is not here to perhaps elaborate on that but what they essentially did with regard to technology is look into whether the factors that prevented operations in those days are still factors that exist today; and there for us – perhaps preliminary- but for us the conclusion is no. So, that is why we move on. What do we do?



Baseline Study - 2014 GSR Cruise, Multidisciplinary Approach

We set out on a cruise like I said – we started somewhere in half July and we were at sea, we were in the area for some 55 – 56 days. The general idea, and that is also what we presented in our plan of work to the ISA was first of all nothing of the area, so that is very simple coming from construction, the first thing you need is to know is what you are talking about. So we said that we have an area of 75,000 sq. kilometres so the first thing we

need to do is define which areas we look into and which areas we don't look into. So we had to make that chart, chart out the area that's what we did. So the 75,000 km were all mapped yes we did it by echo-sounder, we have a resolution vertically of some 50 metres, the accuracy is not what it is when you do it with navy, but for a large scale it is a good operation. So we had a look and it works perfectly. Like you see it on the screen. We also looked on the back scatter information and there I have to agree with earlier speakers that if you look at the back scatter information you could define things. I am not saying this certainly – I am not a scientist but what my people tell me and what they demonstrated to me is that when they were on site and when they were gathering all the bathymetry data and the back scatter data and were analyzing it they immediately saw that there was some sort of a mechanism to define whether there are nodules fields or no. And luckily we had box core on board – two box cores and two dredges, so we tested it out and it worked. So the box core confirms what we saw on the back scatter. So where the back scatter said no nodules, there were no nodules, where the back scatter said it was nodule filled, it was nodule filled. One of the things we also did on the cruise - first of all I must mention to you QYQC chrome system before and the importance of it. I definitely think they are – because of our core business, QYQC is something we grew up with. I mean our clients are worldwide and we work also for the oil and gas which means we have fulfilled all the requirements concerning QYQC systems. So we took all those things also in what we do now. But one of the things– but let me go back a little bit- The first criteria, or the main priority of this cruise was to map the area. But someone of my people told me “Jacques are you going to convince our shareholders that the bathymetrical chart that you are putting out is worth the money you are spending. I say perhaps but it might be difficult. Why don't you take some box cores like you did, why don't you dredge like you did, so we said ok – let's try. So we did. And we also said, if we have to have something that goes down why can't we see what goes down there, what happens down there? So we mounted some cameras on it, both on the Box cores as on the dredge and both worked perfectly well, very nice to see. Certainly for somebody who is new to the business like me to see your dredge go down for the first time to see what it does, to see what the impact it has is nice. So that is what we did.



Equipment & Operations

This is a smaller view of the equipment. We have on the left hand side below you see a box core on the right hand side below you see the dredge, in between you see the vessel we used. We chartered the Mount Mitchell from Global Seas in Seattle. In general we were happy with it. A good vessel to do that bathymetric survey, but not really to take along next year but for this year. You see the winch and plasma cable, like I said everything worked well. Box core units - the manufacturer had made a

mistake so we lost or practically lost the first one. It went down with some air in it, the air couldn't escape so the result was inevitable. My guys adapted the next one and we saw the old one coming up and since then we had a one hundred per cent success rate. We did not do much with the alternate, the sledge needed a little bit sanding, luckily because we had installed cameras, we saw what was happening when the dredge hit the surface. So we saw how we had to change the system and where we

need to amend. Let's say we tried it a couple of times and every time we got a little bit more result, we learn from it every time. So we say let's try it now, now we must handle it, and we had little bit down to 1,000kg.



Summary of discussions

So also that worked, but like I said we just finalized so everything is at our partners universities and in our own labs so, there's not much to report on that as yet, but will do in July.

Dredge & box-core Sampling

These are some of the photographs that I can share with you, so when we talk about nodule fields yes, we have it. You can see the results of the box core. You can see the last dredge operation. So, we are very much looking forward to the next step – and I will try to answer any questions that you may have.

A participant asked about the GSR programme and how quickly it would want to get to a pilot mining test. Mr Paynjon advised that GSR needed to report to its shareholders, on a regular basis, who will decide whether to provide the funds needed to continue. To convince them, GSR needed to come up with results, and it was not going to take that long. He said if one started doing a test [feasibility], one would not go for everything at the same time. It would be phased and when looking at the full scale, a full pile of mining scale would not work but certainly with intervals.

On the question of whether GSR had a letter of sponsorship from his state; and if he had any applications from the state side for support, Mr. Paynjon answered that there was no support. In the western world, within a country a government represents its people and represents its industries. So after the shareholders, GSR convinced the federal government. And that is how they attained liberal sponsorship. He said there were some conditions like legislation which was the norm; but there were no other commitments toward my sponsoring state because of the shareholders structure.

An expert made a general comment that some of the contractors have been doing this work for close to fifteen years, with two who have been at it for a year or two. The two new kids on the block were probably going to be out there mining long before the old-timers got out there and he hoped that the other contractors would take notice and use that as incentive to get out there, finish their exploration, get their collector tests done and do a pile of mining tests.

Mr. Paynjon encouraged operators to collaborate as after a while everyone will have to talk to somebody and join one or another operator because there will be the need for operators and GSR considered themselves operators. One participant wanted to know if GSR would engage in the resource classification exercise. Mr. Paynjon said 'they would but would probably ask for the Canadian national instrument because it was the most strict which was to their advantage.

PART IV: RECOMMENDATIONS OF THE THREE WORKING GROUPS

Status of Contractor Activities in Resource Assessment

The third day of the workshop addressed the status of each contractor's efforts towards the classification of deep seabed polymetallic nodule resources in their exploration areas. Contractors were requested to indicate, in their presentation, the criteria that they have selected for the estimation of mineable areas, including, inter alia, production requirements (annual production rates and duration of mining), grade of nodules, abundance of nodules, and seafloor characteristics. Utilizing the average grade and abundance of nodules, contractors were requested to divide their exploration areas into areas where nodules have an average grade and abundance higher than a cut-off level, determined by the contractor and below this cut-off level. Based on seafloor characteristics, the contractor were requested to divide its exploration area into areas where seafloor characteristics (slope, number and size of obstacles and sediment shear strength) are (a) within an acceptable range and (b) are unacceptable.

In this context, mineable areas will be defined as having a combination of grade and abundance above respective cut-off levels and acceptable seafloor characteristics. A mine-site has to contain a sufficient number of mineable areas capable of supporting an economic mining venture.

Working Group Deliberations

Three Working Groups were constituted, that comprised of eminent experts, contractors and international resource classification experts, to examine the objectives of the workshop on nodule resource classification in the Area. These groups were constituted to address the following:

Working Group 1, chaired by Mr. Ted Brockett to address the state-of-the-art collector device, possible collaboration among Contractors to test their collectors, and analyze the exploration data & estimates of mineable areas presented with a view to identifying where standardization is required in the relevant areas of the CCZ and CIOB.

Working Group 2, chaired by Dr. Pat Stephenson to address the guidelines for estimation of mineral resources and reserves as per the international reporting standards and the steps required to implement them for the deep seabed mineral resources, and to help the contractors to standardize the classification of polymetallic nodule resources into proven, probable and possible reserves of metals. This working group will also address any issues arising from differences in national reporting standards and how they can be resolved.

Working Group 3, chaired by Dr. Georgy Cherkashov, to determine the amount of work required by each contractor to complete the resource classification exercise for their respective areas and how long it would take.

Working Group 1 : State-of-the-Art Collector Devices

Members:

Ted Brockett (ted@soundocean.com); Sup Hong (suphong@kriso.re.kr); Tae Kyeong Yeu (yeutk@kriso.re.kr); Sang Bum Chhi (sbchi@kiost.ac); Kong Ming (kongming@brgimm.com); Tomasz Abramowski (t.abramowski@iom.gov.pl); Russell Howorth (matadrevula@gmail.com); Jin Jincai (jin@comra.org); Jacques Paynjon (Paynjon.Jacques@milan-int.be); Masatsugu Okazaki (okazaki@dord.co.jp)

Recommendations:

- 1) Working Group I welcomed the presentations from contractors on the State-of-the-Art of their collector development programs, and recommended that the Authority accept and make public this information.
- 2) There was general consensus among the State Owned Contractors of Working Group I to continue discussion of potential collaborative efforts associated with pilot mining tests and environment impact studies (benthic impact experiments) associated with collectors, and therefore the group recommended that such discussions be continued.
- 3) Working Group I recommended that the Authority continue to support collaboration amongst interested contractors with regards to pilot mining tests and environmental assessment efforts as a means of helping contractors, reduce risk, reduce cost, share/develop technology, and reduce collector related environmental impact. Such support might include such things as: Future workshops and Working Group I meetings, coordination of collaborative pilot mining and environmental impact assessment, etc.
- 4) Working Group I recommended that the Authority provide to the contractors in a timely manner copies of the draft rules and regulations, for the transition from exploration to exploitation, and for exploitation.
- 5) Working Group I recommended that the Authority support the recommendation of counsel and facilitate the review and release of the CCZ environment management plan taking into consideration the relevant proposal from the Netherlands.
- 6) The contractors within Working Group I were provided with a contractor PMT collector survey document. Each contractor was requested to fill out the survey on a voluntary basis and to provide the completed survey to the Authority prior to the end of November 2014.
- 7) The contractors within Working Group I were in general agreement that it was too early to identity where standardization is required in respect to collector systems, and recommended that work continue on this issue.

PMT Collector Survey Form (sample).

Name:

Email:

PMT Collector Description

Organization Name:

Collector Name:

Proprietary (Can this Information Be Shared?):

Collector Type (Hydraulic, Mechanical, Hybrid, Other):

Describe:

Current Status:

Estimated Date of Completion:

Annual Throughput:

Horsepower:

Propulsion Type:

Number of Propulsion (Track, Screw, etc.) Elements:

Active Width:

Modular Design:

Length Overall:

Width Overall:

Height Overall:

Estimated Weight in Air: Estimated

Weight in Water: Estimated

Seafloor Bearing Load: Maximum

Hourly Throughput: Maximum

Nodule Size:

Crusher Type:

Maximum Nodule Size after Crusher:

Name:

Email:

Sediment Rejection (If yes, how?): Oversize

Nodule Rejection (If yes, how?): Maximum

Speed:

Maximum Cross Slope Angle:

Maximum Up-Slope Angle:

Maximum Down-Slope Angle:

Minimum Turning Radius:

Obstacle Detection & Avoidance (Describe):

Maximum Manageable Obstacle Size:

Redundant Systems (Describe):

Describe Any Auxiliary Equipment Required:

Umbilical Requirements (Power, fiber, breaking strength, etc.):

Sensor Suite (List sensors & other components):

Are you willing to collaborate with other contractors (If yes, how?)?

Land Based Tests

Deep Sea Collector Tests (Ship, winch, umbilical?)

Pilot Mining Test

Name:

Email:

Describe any impediments to completion of collector development:

What specific data is required from exploration surveys?

Have you or do you plan to conduct a Benthic Impact Experiment?

Please include illustrations (or similar) showing function collector concept.

What can ISA do to help your collector development program?

Working Group 2

1. Working group 2 was charged to address the guidelines for estimation of mineral resources and reserves as per international reporting standards and the steps required to implement them for the deep seabed mineral resources, and to help the contractors to standardize the classification of polymetallic nodule resources into proven, probable and possible reserves of metals. The working group was also asked about any issues arising from differences in national reporting standards and how they can be resolved.
2. The group began its work with the draft revision of the CRIRSCO International Reporting Template (Annex 1), prepared on Wednesday. The discussion began by adding clarity to the concept of “mineable areas”, applying the definition used by the UN Ocean Economics and Technology Branch of that area “where four conditions are met:
 - (a) nodules are known to be present;
 - (b) the grade is above a pre-determined cut-off;
 - (c) the abundance is above a predetermined cut-off; (d) the topography is of an acceptable nature.
3. The group found that resources of the mineable area correspond to the ‘mineral resources’ category of the CRIRSCO template, including inferred, indicated and measured categories.
4. The group also found that the term “proven, probable and possible reserves” refers to the CRIRSCO categories of measured, indicated and inferred mineral resources and, if the pre-feasibility or feasibility studies supporting conversion of resources to reserves have been applied by the contractor, to proven and probable reserves.
5. The group recognized that materials that do not qualify as CRIRSCO mineral reserves or resources may be classified within appropriate categories of the UN Framework Classification.
6. The group found that in the application of the modifying factors listed in the template, the categories of weather, transportation, underwater topography and international benefit sharing should be considered.
7. The group found that in the case of non-Public reports to the International Seabed Authority, the “Competent Person” requirement to belong to a professional association with disciplinary power was not applicable. The group also reinforced the CRIRSCO provision that resource classification may be undertaken in a team approach utilizing several competent persons with expertise in different areas.

Working Group 3

1. Most contractors already follow the existing classification systems, either UNFC or CRIRSCO;
2. The ISA should prepare the guidelines for resources classification as soon as possible;
3. Such guidelines should not refer to any cut-off values since it will depend on geological, but also technological and economic factors. Those should be defined by contractors;
4. Contractors agreed to use the resources classification scheme issued by the ISA in their practice and in the reports to the ISA (annual, after five-year periods and upon expiry of the contract).

PART V: CLOSING REMARKS

Dr. S. Rajan, Director, National Centre for Antarctic and Ocean Research
(NCAOR), Goa

His Excellency, my friends from different parts of the world, I think I'll have the last word. Before I came in here one of my colleagues told me to make it short and sweet and not talk a lot. I'll copy that and make it short and sweet. It has been a pleasure hosting all of you. You have been wonderful and I have learned a lot from you. As His Excellency pointed out there has been some hiccups. I'm sorry about those because that's beyond our control. Thankfully you have been very good about it. I don't know why it happened so often here, but normally it doesn't happen. It has been a learning curve for me also as Dr. Wakdikar pointed out. I get to meet all of you. I get to learn a lot from you and the messages you take across is one of friendship and together we can achieve a lot. I think that should be the thing that is uppermost in our minds and if we have achieved that I'd say this workshop has been successful. If we all learn to live together to move forward because unless we all learn to move forward together I think we'd be back to where we started. We'd be going around in circles which I'm sure nobody would like, whether it's the people from the LTC, the people from the Seabed Authority or the contractors. I'm sure nobody would like to feel that we're going back and forth and going around in circles without achieving anything. I'm sure by the next time the LTC meets, you'll not be disappointed. Definitely, I'm sure that we are going to come back to you saying look here we have achieved the results that we were hoping for.

Before I sign off I would like to say thanks to all of you and to the organising people, the people who were with me. I think that I'd just like to ask all of them to just please stand and give them a big hand ladies and gentlemen. If the workshop has been successful, it is thanks go to them. If there were any problems, blame that on me. Thank you so much. No more discussions on polymetallic nodules from now on. Please discuss something about Goa as Goa has much more to offer than what you can ever think of. Enjoy your time here and I wish all of you a safe journey back home. Thank you.

H.E. Mr. Nii A. Odunton, Secretary-General International Seabed Authority

Classification experts, competent person, representatives of contractors, members of the Legal and Technical Commission and representatives of the host government, on behalf of the Authority I wish to express profound thanks to you for making this workshop possible. In my inaugural address, I stated what the Authority's objectives for these workshops were. Namely, these were:

- to ascertain the work being undertaken by contractors for polymetallic nodule exploration in the Area with a view to the standardization of the exploration and resource data required in Section 11 of the standard clauses of Exploration contracts;
- to review current practice in land-based mineral development on national reporting standards for exploration results and resource classification;
- to identify special aspects of polymetallic nodule deposits that should be addressed in resource reporting standards;
- to identify any issues arising from differences in national reporting standards to which the Authority should respond;
- to assist contractors to identify and implement best practices in polymetallic nodule resource evaluation;
- to identify the work to be completed by contractors to fulfil item;
- to determine the time required to fulfil the identification and implementation of best practices in polymetallic nodule resource evaluation; and
- to provide guidance to the ISA regarding relations with mineral information standards organizations, including potential cooperation with CRIRSCO's work and the UNFC.

We met for these past few days, today we convened working groups to look at among other things, areas of possible collaboration, the standards by both groups and see how they could be both implemented by contractors and to also see what work was required to be fulfilled by contractors in this regard. We have heard the results of the working groups. There is no hierarchy in the three working groups. In relation to the resource classification, the idea is that it is to be applied to all contractors and all contractors will be required to do this in their 15-year exploration contracts.

The report of Working Group three was interesting to me because I hear that the standards we are talking about for the resource classification are already being implemented by all contractors. I also hear that these contractors will be able to complete their work, be they of the first group, the pioneer investors or the new entrants into polymetallic nodule exploration, by their contract deadlines. Under the circumstances, I have some difficulty because one of the reasons I convened this workshop was to agree on the standards to use for the resource classification and to find out whether or not there was indeed scope to be able to go forward to the Council and tell them that we have this resource

classification scheme that we are going to use and that the contractors may need more time to implement the scheme.

Having been informed that the work is already being done in accordance with classification scheme of both UNFC and CRIRSCO already and that the work will be completed by the time the contracts expire and I'm talking about those that expire in the immediate future, the urgency that I associated with this work is nonexistent. The urgency I had associated with this was the fact we could, if there was more time required, implement either or both schemes and that this could be made known to the Council in consideration of any requests that come to it for the extension of exploration contracts. If indeed the work will be completed on time by those contractors whose contracts expire shortly, I don't have a basis for asking for anything to do with any extension. The work will be done; the scheme is already being followed and that's it.

The matter of the classification scheme is something that I think should be applied by all contractors present and in the future and we will do the work associated with it in time for consideration by the Legal and Technical Commission and subsequently, they make their recommendations to Council.

Council may or may not decide to adopt them, and one would hope, and I suspect, Council will indeed adopt them. If everybody else who came before whose contracts expire in the near future is already applying it, and have no problem providing us with the information that I'd indicated before which was considered by working group two, mineable areas, proven, possible resources and reserves, I've done my work at least from my vantage point.

I thank everybody for participating in the workshop. What we will do is, we will go back to Kingston, get the information, the presentations, and the guidelines that we've drawn up and need to adjust. I will make sure everybody gets a copy of it to be able to comment on it and I will make this information available to the Legal and Technical Commission. However, I'm not in a position, based on the information I've got from the third working group in relation to any time requirements by those contractors whose contracts will expire soon. I must admit that on the basis of the presentation I heard, it's not immediately obvious to me that either UNFC or CRIRSCO is being utilized by everybody at the present time. However, working group three reports that this is indeed the case and working group three was with the representatives of contractors.

I have to report what the conclusions and recommendations of the workshop were. We will try to put all the material together. In that regard I'll be very grateful, if all participants give the Authority, their email addresses because that's how I'd like to send them to you.

I would be eager to receive your comments since there is no urgency to provide all of this information to the Legal and Technical Commission in February because that was to be done to ensure that their recommendations were made available to the Council at its meeting in 2015. We will proceed however and try and get some information to Council. But in relation to the resources classification scheme, I don't see that I'm requested by any contractor to help facilitate any extension in this regard.

I wish to thank the host government, very very much. It was a very very good location. Yes we did have some problems with light outages however since I do come from a country where this is quite regular, I'm not in a position to complain. We are in a fabulous location, the Vivanta is very nice. I'm also grateful for whatever results we have received. Thank you very much.

Dr. M.P. Wakdikar, Advisor, MOES-Government of India

Thank you so much. Respected Secretary-General and delegates, it is my pleasure to be here at the closing session of the workshop. Personally, this is the first time for me to attend the Authority's workshop. I've gained significantly in terms of understanding resource classification and specifically in the context of UNFC and CRIRSCO classification system which affords the potential of providing a template for polymetallic nodules. All are aware of the substantial progress which has been made in this direction in this workshop. This is quite significant, specifically for the purpose of reporting following the criteria of transparency, materiality and competence.

Another important aspect pertains to the presentations by various contracting parties which deal with the exploration aspects and further nodule exploration aspects into the field of harvesting; specifically in terms of technology developments pertaining to the mining system, as well as the extractor regulations. There have been a lot of promising results which we could see from the presentations made by various contracting groups.

The entry of the private sector into the field of exploration has added a new impetus and optimism which the Secretary-General is vigorously pursuing. One can see the workshop which is specifically at the insistence of the Secretary-General which he told us the lastly himself. He himself has decided the venue for workshop. It is my entire appreciation on behalf of all delegates, and Mr. Nii Odunton who is very much here.

I take this opportunity to thank each one of us who have been here which have made this workshop possible. My sincere appreciation goes to Dr. Pratima Jauhari who has single-handedly worked on this organization of the workshop. It was very efficient and I hand over this mike to Dr. Rajan who has been contributing immensely along with his team. I think I would give this opportunity to Dr. Rajan to formally give the vote of thanks. Thank you.

ANNEX 1 (Final version of working group 2 deliberations):

International Seabed Authority Reporting Standard for Polymetallic Nodules in the Area

Reporting standard of the International Seabed Authority for mineral exploration results assessments, mineral resources and mineral reserves

I. Introduction

1. The present document sets out the standard to be observed in all documents submitted to the International Seabed Authority that include the reporting of estimates of resources in the Area, which that are not intended for public release or for the prime purpose of informing investors or potential investors and their advisers. These estimates should be reported according to the Authority's resource classification system that is based on the three main resource categories: (a) mineral exploration results assessments; (b) mineral resources; and (c) mineral reserves (see figure below). It is based on the November 2013 edition of the international reporting template of the Committee for Mineral Reserves International Reporting Standards (CRIRSCO).¹

2. In the present document, important terms are defined in paragraphs highlighted in bold. When appearing in the definition of other such terms, those terms are underlined. The template clauses are shown in plain font. Paragraphs in italics that are placed after the respective clauses are intended to provide assistance and guidance to readers for interpreting the application of the clauses in the reporting standard of the Authority. Enclosure 1 contains a list of generic terms, equivalents and definitions provided to avoid duplication or ambiguity.

II. Scope

3. The main principles governing the operation and application of the reporting standard are transparency and materiality:

¹ The present annex has been prepared at the request of the International Seabed Authority by a group comprising: C. Antrim, Executive Director at the Rule of Law Committee for Oceans, United States of America; H. Parker, Deputy Chair of the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) and Consulting Mining Geologist and Geostatistician at Amec Foster Wheeler, United States; and P. R. Stephenson, former Co-Chair of CRIRSCO and Director and Principal Geologist at AMC Consultants, Canada; with input from CRIRSCO members. It follows guidelines drawn up by a working group at a workshop convened by the Authority, in collaboration with the Ministry of Earth Sciences of India, on the classification of polymetallic nodule resources, held in Goa, India from 13 to 17 October 2014. The working group members were: Mr. Stephenson; Ms. Antrim; M. Nimmo, Principal Geologist at Golder Associates, Australia; D. MacDonald, Chair of the Expert Group on Resource Classification of the Economic Commission for Europe; P. Kay, Manager at Offshore Minerals, Geoscience Australia; P. Madureira, Deputy Chief of the Task Group for the Extension of the Continental Shelf, Portugal; G. Cherkashov, Deputy Director at All-Russia Research Institute for Geology and Mineral Resources of the World Ocean, Russian Federation; T. Ishiyama, Deep Ocean Resources Development, Japan; T. Abramowski, Director General at the Interoceanmetal Joint Organization, Poland; J. Parionos, Chief Geologist at Tonga Offshore Mining Limited, Tonga; and J. Paynjon, G-TEC Sea Mineral Resources NV.

(a) Transparency requires that the Authority and, particularly, its Legal and Technical Commission be provided with sufficient information, presented in a clear and unambiguous way, so as to understand the report and not to be misled;

(b) Materiality requires that the report contain all the relevant information that the Authority and, particularly, its Legal and Technical Commission may reasonably require and expect to find in the report, for the purpose of making a reasoned and balanced judgement regarding the mineral resources or mineral reserves reported on.

4. **The reporting standard specifies the required minimum standard for all documents submitted to the Authority that include the reporting of mineral exploration results assessments, mineral resources and mineral reserves. It is not intended for release to the general public or for the prime purpose of informing investors or potential investors and their advisers.**² Reporting entities are encouraged to provide information that is as comprehensive as possible in their reports.³

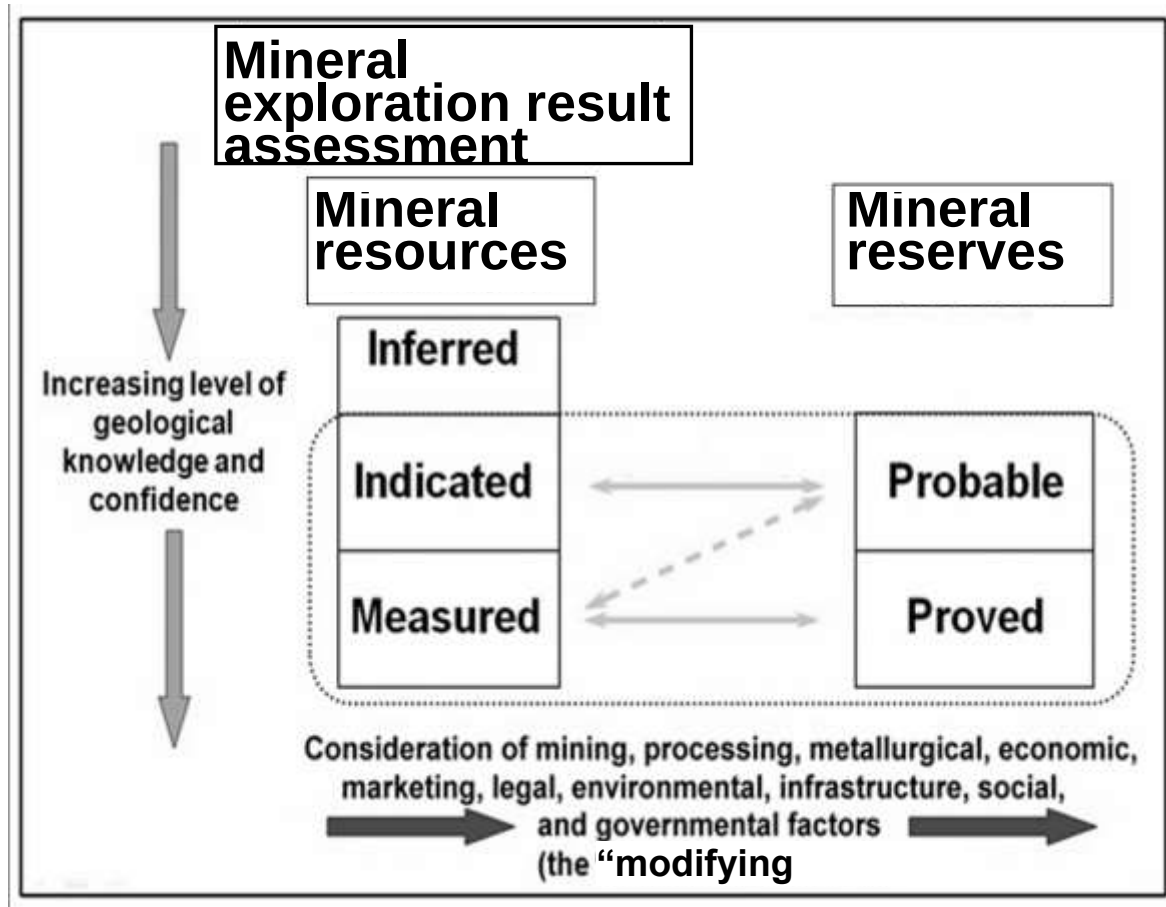
5. The estimation of mineral resources and mineral reserves is inherently subject to some level of uncertainty and inaccuracy. Considerable skill and experience may be needed to interpret pieces of information, such as geological maps and analytical results based on samples that commonly represent only a small part of a mineral deposit. The uncertainty in the estimates should be discussed in the report and reflected in the appropriate choice of mineral resource and mineral reserve categories.

6. The reporting standard is applicable to all **mineral resources** for which the reporting of **mineral exploration results assessments, mineral resources and mineral reserves** is required by the Authority under its rules, regulations and procedures.

7. It is recognized that a further review of the reporting standard will be required from time to time.

² Where reports are prepared for the prime purpose of release to the general public or for informing investors or potential investors and their advisers, the Authority recommends that they comply with one of the reporting standards that are recognized by CRIRSCO has being consistent with its international reporting template.

³ While every effort has been made in the reporting standard of the Authority to cover most cases likely to be encountered when reporting on mineral exploration results assessments, mineral resources and mineral reserves, there may be occasions when doubt exists as to the appropriate form of disclosure. On such occasions, users of the reporting standard and those who compile reports to comply with the standard should be guided by its intent, namely, to provide a minimum standard for such reporting and to ensure that such reporting contains all the information that readers may reasonably require and expect for the purpose of making a reasoned and balanced judgement on the mineral exploration results assessments, mineral resources or mineral reserves reported on.



General relationship between mineral exploration results assessments, minerals resources and mineral reserves

III. Reporting terminology

8. **Modifying factors** are considerations used to convert mineral resources into mineral reserves. These include, but are not restricted to, mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors.

Guidance

The figure in paragraph 7 illustrates the framework for classifying tonnage and grade estimates to reflect different levels of geological confidence and different degrees of technical and economic evaluation. Mineral resources can be estimated mainly on the basis of geological information with some input from other disciplines. Mineral reserves, which are a modified subset of the indicated and measured mineral resources (shown within the dashed outline in the figure), require

consideration of the modifying factors affecting extraction and should in most instances be estimated with input from a range of disciplines.

10. Measured mineral resources may be converted into either proved mineral reserves or probable mineral reserves. Measured mineral resources may be converted into probable mineral reserves because of uncertainties associated with some or all of the modifying factors that are taken into account in the conversion from mineral resources into mineral reserves. This relationship is shown by the broken arrow in the figure. Although the trend of the broken arrow includes a vertical component, it does not, in this instance, imply a reduction in the level of geological knowledge or confidence. In such a case, the modifying factors should be fully explained (see also para. 21 for a subdivision of mineral resources).

IV. General reporting

11. Reports to the Authority concerning a contractor's mineral exploration results assessments, mineral resources or mineral reserves must include a description of the style and nature of mineralization.

12. A contractor must disclose any relevant information concerning a mineral deposit that could materially influence the economic value of that deposit to the contractor. A contractor must promptly report any material changes in its mineral resources or mineral reserves to the Authority.

13. Throughout the reporting standard, certain words are used in a generic sense when a more specific meaning might be attached to them by particular groups within the industry. In order to avoid duplication or ambiguity, those terms are listed in enclosure 1 together with other terms that may be regarded as synonymous for the purpose of the present document.⁴

V. Reporting of mineral exploration results assessments

14. An exploration target is a statement or estimate of the exploration potential of a mineral deposit in a defined geological setting, where the statement or estimate, quoted as a range of tons and of grade or quality, relates to mineralization for which there has been insufficient exploration to estimate mineral resources.

15. Mineral exploration results assessments include data and information generated by mineral exploration programmes which might be of use to readers of the report but do not form part of a declaration of mineral resources or mineral reserves.⁵

16. This sort of data is common in the early stages of exploration when the quantity of data available is generally not sufficient to allow for any estimates other than in the form of an exploration target to be reached.

17. If a contractor reports mineral exploration results assessments in relation to mineralization not classified as a mineral resource or mineral reserve, then estimates of

⁴ The use of a particular term throughout the present document does not signify that it is preferred or necessarily the ideal term in all circumstances. The contractors would be expected to select and use the most appropriate terminology for the commodity or activity reported on.

⁵ It should be made clear in reports that contain mineral exploration results assessments that it is inappropriate to use such information to derive estimates of tonnage and grade. It is recommended that such reports carry a continuing statement along the following lines: "The information provided in the present report/statement/release constitutes mineral exploration results assessments as defined in the reporting standard of the International Seabed Authority, in relation to clause 24. It is inappropriate to use such information for deriving estimates of tonnage and grade".

tonnage and associated average grade must not be reported other than in the form of an exploration target.⁶

18. Reports on mineral exploration results assessments relating to mineralization not classified as a mineral resource or mineral reserve must contain sufficient information to allow a considered and balanced judgement of the significance of the results. Reports on mineral exploration results assessments must not be presented so as to unreasonably imply that mineralization of potential economic interest has been discovered.

VI. Reporting of mineral resources

19. A mineral resource is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction.⁷

20. The location, quantity, grade or quality, continuity and other geological characteristics of a mineral resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling.

21. Mineral resources are subdivided, in order of increasing geological confidence into "inferred", "indicated" and "measured" categories.

22. Portions of a mineral deposit that do not offer reasonable prospects for eventual economic extraction must not be included into a mineral resource.⁸

23. An inferred mineral resource is that part of a mineral resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply, but not verify, geological and grade or quality continuity.

24. An inferred mineral resource has a lower level of confidence than that applying to an indicated mineral resource and must not be converted into a mineral reserve. It is reasonably expected that, with continued exploration, the majority of inferred mineral resources could be upgraded to indicated mineral resources.⁹

⁶ Descriptions of exploration targets or exploration potential given in reports should be expressed so as not to misrepresent them as an estimate of mineral resources or mineral reserves.

⁷ The term "mineral resource" covers mineralization which has been identified and estimated through exploration and sampling and within which mineral reserves may be defined by the consideration and application of Modifying Factors.

⁸ The term "reasonable prospects for eventual economic extraction" implies a judgement (albeit preliminary) by the contractor with respect to the technical and economic factors likely to influence the prospect of economic extraction, including the approximate mining parameters. In other words, a mineral resource is not an inventory of all mineralization drilled or sampled, regardless of cut-off parameters, likely mining dimensions, location or continuity. It is a realistic inventory of mineralization which, under assumed and justifiable technical and economic conditions, might, in whole or in part, become economically extractable. Any material assumptions made in determining the reasonable prospects for eventual economic extraction should be clearly stated in the report. Any adjustment made to the data for the purpose of making the mineral resource estimate, for example by cut-off or factoring grades, or the factoring of seabed nodule abundance measurements, should be clearly stated and described in the report.

⁹ Confidence in the estimate is usually not sufficient to allow for the results of the application of technical and economic parameters to be used for detailed planning. For this reason, there is no direct link from an inferred resource to any category of mineral reserves (see the figure in para. 7). Caution should be exercised if that category is considered in technical and economic studies.

25. The inferred category is intended to cover cases in which a mineral concentration or occurrence has been identified and limited measurements and sampling have been completed, but in which data are insufficient to allow the geological or grade continuity to be confidently interpreted. Commonly, it would be reasonable to expect that the majority of inferred mineral resources could be upgraded to indicated mineral resources with continued exploration. However, owing to the uncertainty of inferred mineral resources, it should not be assumed that such upgrading will always occur.

26. **An indicated mineral resource is that part of a mineral resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated at a level of confidence high enough to allow for the application of modifying factors in sufficient detail to support mine planning and the evaluation of the economic viability of the deposit.**

27. **Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation.**

28. **An indicated mineral resource has a lower level of confidence than that applying to a measured mineral resource and may only be converted into a probable mineral reserve.**¹⁰

29. **A measured mineral resource is that part of a mineral resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated at a level of confidence high enough to allow for the application of modifying factors to support detailed mine planning and a final evaluation of the economic viability of the deposit.**

30. **Geological evidence is derived from detailed and reliable exploration, sampling and testing and is sufficient to confirm geological and grade or quality continuity between points of observation.**

31. **A measured mineral resource has a higher level of confidence than that applying to either an indicated mineral resource or an inferred mineral resource. It may be converted into a proved mineral reserve or to a probable mineral reserve.**

Guidance

32. *Mineralization may be classified as a measured mineral resource when the nature, quality, amount and distribution of data are such as to leave no reasonable doubt, in the opinion of the contractor determining the mineral resource, that the tonnage and grade of the mineralization can be estimated to within close limits, and that any variation from the estimate would be unlikely to affect significantly potential economic viability.*

33. *This category requires a high level of confidence in, and understanding of, the geology and the controls of the mineral deposit.*

34. *Confidence in the estimate is sufficient to allow for the application of technical and economic parameters and to enable an evaluation of economic viability with a high level of confidence.*

35. The choice of the appropriate category of mineral resource depends upon the quantity, distribution and quality of data available and the level of confidence attached to those data.

¹⁰ Mineralization may be classified as an indicated mineral resource when the nature, quality, amount and distribution of data are sufficient to allow for a confident interpretation of the geological framework and to assume continuity of mineralization. Confidence in the estimate is sufficient to allow for the application of technical and economic parameters and to enable an evaluation of economic viability.

Guidance

36. *Mineral resource classification is a matter for skilled judgement and the contractor should take into account those items in enclosure 1 that relate to confidence in mineral resource estimations.*

37. *In deciding between indicated mineral resources and measured mineral resources, it may be useful to consider, in addition to the explanations relating to geological and grade continuity in paragraphs 26 and 29, the language in the guideline attached to the definition of measured mineral resources, namely that “any variation from the estimate would be unlikely to affect significantly potential economic viability”.*

38. *In deciding between inferred mineral resources and indicated mineral resources, it may be useful to consider, in addition to the explanations in paragraphs 23 and 26 relating to geological and grade continuity, the guideline attached to the definition of indicated mineral resources, namely that “confidence in the estimate is sufficient to allow for the application of technical and economic parameters and to enable an evaluation of economic viability”, which contrasts with the guideline relating to the definition of inferred mineral resources, namely that “confidence in the estimate of inferred mineral resources is usually not sufficient to allow for the results of the application of technical and economic parameters to be used for detailed planning” and that “caution should be exercised if that category is considered in technical and economic studies”.*

39. *The contractor should take into consideration the style of mineralization, scale and cut-off parameters when assessing geological and grade continuity.*

40. Mineral resource estimates are not precise calculations, being dependent on the interpretation of limited information on the location, shape and continuity of the occurrence and on the available sampling results. The reporting of tonnage and grade figures should reflect the relative uncertainty of the estimate by rounding off to significant figures and, in the case of inferred mineral resources, by using terms such as “approximately”.¹¹

Guidance

41. *The contractor is encouraged, where appropriate, to discuss the relative accuracy or confidence level of the mineral resource estimates. The statement should specify whether it relates to estimates that are global (whole resource) or local (a subset of the resource for which the accuracy /or confidence level might differ from that of the whole resource), and, if local, state the relevant tonnage or volume. Where a statement of the relative accuracy or confidence level is not possible, a qualitative discussion of the uncertainties should be provided (see enclosure 1).*

42. Reports of mineral resources must specify one or more of the “inferred”, “indicated” and “measured” categories. Categories must not be reported in a combined form unless details of the individual categories are also provided. Mineral resources must not be reported in terms of contained metal or mineral content unless

¹¹ In most cases, rounding off to the second significant figure should be sufficient. For example, 10,863,000 tons at 8.23 per cent should be stated as 11 million tons at 8.2 per cent. There will be occasions, however, where rounding off to the first significant figure may be necessary in order to convey properly the uncertainties in estimation. This would usually be the case with inferred mineral resources. To emphasize the imprecise nature of a mineral resource estimate, the final result should always be referred to as an estimate and not a calculation.

corresponding tonnages and grades are also presented. Mineral resources must not be aggregated with mineral reserves.¹²

43. Enclosure 1 provides, in a summary form, a list of the main criteria that should be considered when preparing reports on mineral exploration results assessments, mineral resources and mineral reserves. These criteria need not be discussed in a report unless they materially affect the estimation or the classification of the mineral resources.¹³

44. The words “ore” and “reserves” must not be used in providing mineral resource estimates, as those terms imply technical feasibility and economic viability and are only appropriate when all relevant modifying factors have been considered. Reports and statements should continue to refer to the appropriate category or categories of mineral resources until technical feasibility and economic viability have been established. If a re-evaluation indicates that any part of the mineral reserves is no longer viable, such mineral reserves must be reclassified as mineral resources or removed from the mineral resource and mineral reserve statements.¹⁴

VII. Reporting of mineral reserves

45. A mineral reserve is the economically mineable part of a measured or indicated mineral resource.

46. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted, and is defined by studies at pre-feasibility or feasibility level, as appropriate, that include the application of modifying factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.

47. The reference point at which reserves are defined, usually the point where the ore is delivered to the processing plant, must be stated. It is important that, wherever the reference point is different, a clarifying statement be included to ensure that the reader is fully informed of what is being reported.

Guidance

48. *Mineral reserves are those portions of mineral resources that, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the contractor making the estimates, can be the basis of a viable project, after taking account of all relevant modifying factors.*

49. *When reporting mineral reserves, information on estimated mineral processing recovery factors is very important, and should always be included in reports.*

¹² Reporting tonnage and grade outside the categories covered by the reporting standard is not permitted.

¹³ It is not necessary, when reporting, to comment on each item in enclosure 1, but it is essential to discuss any matters that might materially affect the reader’s understanding or interpretation of the results assessments or estimates reported on. This is particularly important where inadequate or uncertain data affect the reliability of, or confidence in, a statement of exploration results assessments or an estimate of mineral resources or mineral reserves, for example, poor sample recovery, reliance on video or acoustic seabed reconnaissance results, etc. If there is doubt as to what should be reported, it is better to provide too much information rather than too little. Uncertainties in any of the criteria listed in enclosure 1 that could lead to under- or over-statement of resources should be disclosed.

¹⁴ It is not intended that the reclassification from mineral reserves to mineral resources, or vice versa, should be applied as a result of changes expected to be of a short-term or temporary nature, or where a contractor’s management has made a deliberate decision to operate on a non-economic basis. Examples of such cases include commodity price fluctuations expected to be of short duration, mine emergency of a non-permanent nature and transport strike.

50. The term “economically mineable” implies that the extraction of the mineral reserve has been demonstrated to be viable under reasonable financial assumptions. What may be “realistically assumed” will vary with the type of deposit, the level of study that has been carried out and the financial criteria of the individual contractor. For this reason, there can be no fixed definition for the term “economically mineable”. However, it is expected that companies will attempt to achieve an acceptable return on the capital invested, and that returns to investors in the project will be competitive with alternative investments of comparable risk.

51. In order to achieve the required level of confidence in the mineral resources and all the modifying factors, studies of pre-feasibility or feasibility, as appropriate, will have been carried out before determining the mineral reserves. The study will need to determine a mine plan that is technically achievable and economically viable and from which the mineral reserves can be derived.

52. The term “mineral reserves” need not necessarily signify that extraction facilities are in place or operative, or that all necessary approvals or sales contracts have been received. It signifies that there are reasonable expectations of such approvals or contracts. The contractor should consider the materiality of any unresolved matter that is dependent on a third party on which extraction is contingent.

53. Any adjustment made to the data for the purpose of making the mineral reserve estimate, for example by cut-off or factoring grades, or the factoring of seabed nodule abundance measurements, should be clearly stated and described in the report.

54. It should be noted that the reporting standard does not imply that an economic operation should have proved mineral reserves. Cases may arise where probable mineral reserves alone may be sufficient to justify extraction. This is a matter of judgement by the contractor.

55. **A probable mineral reserve is the economically mineable part of an indicated and, in some circumstances, measured mineral resource. The level of confidence in the modifying factors applying to a probable mineral reserve is lower than that applying to a proved mineral reserve.**

56. A probable mineral reserve has a lower level of confidence than a proved mineral reserve but is sufficiently reliable to serve as the basis for a decision on the development of the deposit.

57. **A proved mineral reserve is the economically mineable part of a measured mineral resource and implies a high degree of confidence in the modifying factors.**

58. A proved mineral reserve represents the highest level of confidence for reserve estimates.¹⁵

59. The choice of the appropriate category of the mineral reserve is determined primarily by the relevant level of confidence in the mineral resource and after considering any uncertainties in the modifying factors. The allocation of the appropriate category must be made by the contractor.

60. The reporting standard provides for a direct relationship between indicated mineral resources and probable mineral reserves, and between measured mineral resources and proved mineral reserves. In other words, the level of geological confidence for probable mineral reserves is similar to that required for the determination of indicated mineral resources. The level of geological confidence for

¹⁵ The style of mineralization or other factors could mean that the status of proved mineral reserves is not achievable in some deposits. The contractor should be aware of the consequences of declaring material of the highest confidence category before satisfying themselves that all of the relevant resource parameters and modifying factors have been established at a similarly high level of confidence.

proved mineral reserves is similar to that required for the determination of measured mineral resources. Inferred mineral resources are always in addition to mineral reserves.

Guidance

61. *The reporting standard also provides for a two-way relationship between measured mineral resources and probable mineral reserves. This provision is to cover cases in which uncertainties associated with any of the modifying factors considered when converting mineral resources into mineral reserves may result in there being a lower degree of confidence in the mineral reserves than in the corresponding mineral resources. Such a conversion would not imply a reduction in the level of geological knowledge or confidence.*

62. *A probable mineral reserve derived from a measured mineral resource may be converted into a proved mineral reserve if the uncertainties in the modifying factors are removed. No amount of confidence in the modifying factors for the conversion of a mineral resource into a mineral reserve can override the upper level of confidence that exists in the mineral resource. Under no circumstances can an indicated mineral resource be converted directly into a proved mineral reserve (see the figure in para. 7).*

63. *The application of the category of proved mineral reserves implies the highest degree of confidence in the estimate, with consequent expectations in the minds of the readers of the report. Such expectations should be borne in mind when categorizing a mineral resource as measured.*¹⁶

64. Mineral reserve estimates are not precise calculations. The reporting of tonnage and grade figures should reflect the relative uncertainty of the estimate by rounding off to significant figures (see also para. 40).¹⁷

Guidance

65. *The contractors are encouraged, where appropriate, to discuss the relative accuracy or confidence level of the mineral reserve estimates. The statement should specify whether it relates to estimates that are global (whole reserve) or local (a subset of the reserve for which the accuracy or confidence level might differ from that of the whole reserve), and, if local, state the relevant tonnage or volume. Where a statement of the relative accuracy or confidence level is not possible, a qualitative discussion of the uncertainties should be provided (see enclosure 1 and the guidelines in para. 40).*

66. Reports of mineral reserves must specify one or both of the categories of “proved” and “probable”. Categories must not be reported in a combined proved and probable mineral reserve unless the relevant figures are provided for each category. Reports must not present metal or mineral content figures unless corresponding tonnage and grade figures are also given. Mineral reserves must not be aggregated with mineral resources.¹³

Guidance

67. *Mineral reserves may incorporate material (dilution) that is not part of the original mineral resource. It is essential that this fundamental difference between mineral resources and mineral reserves be borne in mind and caution exercised if attempting to draw conclusions from a comparison of the two.*

¹⁶ See also the guidelines in paras. 32-34 regarding the classification of mineral resources.

¹⁷ To emphasize the imprecise nature of a mineral reserve, the final result should always be referred to as an estimate and not a calculation.

68. *When revised mineral reserve and mineral resource statements are reported, they should be accompanied by a reconciliation with previous statements. A detailed account of differences between figures is not essential, but sufficient comments should be provided to enable significant changes to be understood by the reader.*

69. When figures for both the mineral resources and the mineral reserves are reported, a statement must be included in the report that clearly indicates whether the mineral resources include the mineral reserves or are reported in addition to them.

70. Mineral reserve estimates must not be included in mineral resource estimates under a single combined figure.¹⁸

Guidance

71. *The measured and indicated mineral resources are additional to the mineral reserves. In the former case, if any measured and indicated mineral resources have not been modified to produce mineral reserves for economic or other reasons, the relevant details of these unmodified mineral resources should be included in the report. This is to assist the reader of the report in making a judgement on the likelihood of the unmodified measured and indicated mineral resources eventually of being converted into mineral reserves.*

72. *Inferred mineral resources are by definition always in addition to mineral reserves. For reasons stated in paragraph 24 and in the present paragraph, the reported mineral reserve figures must not be included in the reported mineral resource figures. The resulting total is misleading and may be misunderstood or misused to give a false impression of a contractor's prospects.*

VIII. Technical studies

73. **A scoping study is an economic study of the potential viability of mineral resources that includes appropriate assessments of realistically assumed modifying factors, together with any other relevant operational factors that are necessary to demonstrate at the time of reporting that progress to a pre-feasibility study can be reasonably justified.**

74. **A pre-feasibility study is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumptions with regard to the modifying factors and the evaluation of any other relevant factors that are sufficient for an contractor, acting reasonably, to determine whether all or part of the mineral resource may be converted into a mineral reserve at the time of reporting. A pre-feasibility study is at a lower confidence level than a feasibility study.**

75. **A feasibility study is a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable modifying factors, together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or**

¹⁸ In some cases, there are reasons for reporting mineral resources inclusive of mineral reserves and, in other cases, for reporting mineral resources in addition to mineral reserves. It must be made clear which form of reporting has been adopted. Appropriate forms of clarifying statements may be reported.

finance, the development of the project. The confidence level of the study will be higher than that of a pre-feasibility study.

Guidance

76. Enclosure 1 provides, in a summary form, a list of the criteria that should be considered when preparing reports on mineral exploration results assessments, mineral resources and mineral reserves. Those criteria need not be discussed in a report unless they materially affect the estimation or the classification of the mineral reserves. Changes in economic or political factors alone may be the basis for significant changes in mineral reserves and should be reported accordingly.

Enclosure 1

Checklist of assessment and reporting criteria

1. The present table is a checklist that those preparing reports on mineral exploration results assessments, mineral resources and mineral reserves should use as a reference. The checklist is not prescriptive and, as always, relevance and materiality are overriding principles that determine what information should be reported. It is, however, important to report any matters that might materially affect a reader's understanding or interpretation of the results assessments or estimates that are reported. This is particularly important where inadequate or uncertain data affect the reliability of, or confidence in, a statement of mineral exploration results assessments or an estimate of mineral resources or mineral reserves.

2. The order and grouping of the criteria in the table reflect the normal systematic approach to exploration and evaluation. Criteria in the first group (sampling techniques and data) apply to all succeeding groups. In the remainder of the checklist, criteria listed in one group would often apply to succeeding groups and should be considered when estimating and reporting.

Criteria	Explanation
Sampling techniques and data (criteria in this group apply to all succeeding groups)	
Sampling techniques	Nature and quality of the sampling (e.g. free-fall grab samplers, box corers, box grab samplers, etc.) and measures taken to ensure sample representativity.
Sample recovery	• Indication of whether the recovery of samples has been properly recorded and the results assessed • Measures taken to maximize sample recovery and ensure the representative nature of the samples • Indication of whether a relationship exists between sample recovery and grade and whether sample bias may have occurred owing to the preferential loss or gain of fine and coarse material
Logging and sample description	• Indication of whether the samples have been logged or described to a level of detail sufficient to support appropriate mineral resource estimations, mining studies and metallurgical studies • Indication of whether logging is qualitative or quantitative in nature and provision of sample photographs
Subsampling techniques and sample preparation	• Nature, quality and appropriateness of the sample preparation technique • Quality control procedures adopted for all subsampling stages to maximize the representativity of samples • Measures taken to ensure that the sampling is representative of the material collected in situ • Indication of whether sample sizes are appropriate for the grain size of the material being sampled • Statement as to the security measures taken to ensure sample integrity is recommended

<i>Criteria</i>	<i>Explanation</i>
Quality of assay data and laboratory tests	• Nature, quality and appropriateness of the assaying and laboratory procedures used and whether the technique is considered partial or total • Nature of the quality control procedures adopted (e.g. standards, blanks, duplicates or external laboratory checks) and whether acceptable levels of accuracy (i.e. lack of bias) and precision have been established
Location of data points	• Accuracy and quality of surveys used to locate other sample sites used in the mineral resource estimation • Quality and adequacy of the topographic control (providing locality plans)
Data spacing and distribution	• Data spacing for reporting mineral exploration results assessments • Indication of whether the data spacing and distribution are sufficient to establish the degree of geological and grade continuity appropriate for the mineral resource and mineral reserve estimation procedures and the classifications applied • Indication of whether sample compositing has been applied
Reporting archives	Documentation of primary data, data entry procedures, data verification, data storage (physical and electronic) for preparing the report
Audits or reviews	Results of any audits or reviews of the sampling techniques and data

**Reporting of mineral exploration results assessments
(criteria listed in the preceding group also apply to this group)**

Mineral rights and land ownership	• Type, reference name or number, location and ownership, including agreements or material issues with third parties, such as joint ventures, partnerships, overriding royalties, environmental setting, etc. • Security of the tenure held at the time of reporting, along with any known impediments to obtaining a contract to operate in the area • Location plans of the mineral rights and titles. It is not expected that the description of a mineral title in a technical report should represent a legal opinion but it should be a brief and clear description of such title as understood by the author
Exploration done by other parties	Acknowledgment and appraisal of exploration by other parties
Geology	• Type of deposit, geological setting and style of mineralization • Reliable geological maps should exist to support interpretations
Data reporting methods	• When reporting mineral exploration results assessments, maximum and minimum grade truncations (e.g. the cut-off of high grades) and cut-off grades are usually material and should be stated • The assumptions used for any reporting of metal equivalent values should be clearly stated
Diagrams	Where possible, maps and scaled tabulations of sample results should be included for any material discovery being reported, if such diagrams significantly clarify the report
Balanced reporting	Where the comprehensive reporting of all mineral exploration results assessments is not practicable, the representative reporting of both low and high grades and widths should

<i>Criteria</i>	<i>Explanation</i>
	be applied to avoid the misleading reporting of such assessments
Other substantive exploration data	Other exploration data, if meaningful and material, should be reported, including (but not limited to): geological observations; geophysical survey results; geochemical survey results; seabed photography or sonar results; bulk samples and the size and method of treatment; metallurgical test results; bulk density and the geotechnical and rock characteristics; potential deleterious or contaminating substances
Further work	Nature and scale of planned further work (e.g. tests for lateral extensions)

Estimation and reporting of mineral resources
(criteria listed in the first group and, where relevant, in the second group, also apply to this group)

Database integrity	• Measures taken to ensure that the data have not been corrupted by, for example, transcription or keying errors, between its initial collection and its use for mineral resource estimation purposes • Data verification or validation procedures used
Geological interpretation	• Confidence in (or, conversely, the uncertainty of) the geological interpretation of the mineral deposit • Nature of the data used and of any assumptions made • Effect, if any, of alternative interpretations on the mineral resource estimation • Use of geology in guiding and controlling the mineral resource estimation • Factors affecting the continuity of both grade and geology
Dimensions	Extent and variability of the mineral resource expressed as length (along strike or otherwise) and width
Estimation and modelling techniques	• Nature and appropriateness of the estimation techniques applied and key assumptions, including the treatment of extreme grade values, domaining, interpolation parameters and the maximum distance of extrapolation from data points • Availability of check estimates, previous estimates and mine production records, and indication of whether the mineral resource estimate takes appropriate account of such data • Assumptions made regarding the recovery of by-products • Estimation of deleterious elements or other non-grade variables of economic significance • In the case of a block model interpolation, block size in relation to the average sample spacing and the search employed • Any assumptions behind modelling of selective mining units (e.g. non-linear kriging) • Indicate any assumptions about correlation among variables • Process of validation, checking process used, comparison of model data to sampling data and use of reconciliation data, if available • Detailed description of the method used and the assumptions made to estimate the tonnage (or abundance) and grades (section, polygon, inverse distance, geostatistical

Criteria	Explanation
	or other method) • Description of how the geological interpretation was used to control the resource estimates • Discussion of the basis for using or not using grade cutting or capping. If a computer method was chosen, description of the programmes and parameters used • Geostatistical methods are extremely varied and should be described in detail. The method chosen should be justified. The geostatistical parameters, including the variogram, and their compatibility with the geological interpretation should be discussed • Experience gained in applying geo-statistics to similar deposits should be taken into account
Moisture	Indication of whether the tonnage or abundance is estimated on a dry basis or with natural moisture, and the method of determination of the moisture content
Cut-off parameter	Basis of the adopted cut-off grade or grades, or quality or quantity parameters applied, including the basis, if appropriate, of equivalent metal formulae
Mining factors or assumptions	• Assumptions made regarding possible mining methods, minimum mining dimensions and internal (or, if applicable, external) mining dilution. It may not always be possible to make assumptions regarding mining methods and parameters when estimating mineral resources. Where no assumptions have been made, this should be reported • In order to demonstrate realistic prospects for eventual economic extraction, basic assumptions are necessary. Examples include geotechnical parameters, seabed topography, size of seabed mining area, infrastructure requirements and estimated mining costs. All assumptions should be clearly stated
Metallurgical factors or assumptions	• Metallurgical process proposed and appropriateness of that process to the type of mineralization. It may not always be possible to make assumptions regarding metallurgical treatment processes and parameters when reporting mineral resources. Where no assumptions have been made, this should be reported • In order to demonstrate realistic prospects for eventual economic extraction, basic assumptions are necessary. Examples include the extent of metallurgical test work, recovery factors, allowances for by-product credits or deleterious elements, infrastructure requirements and estimated processing costs. All assumptions should be clearly stated
Bulk density	• Indication of whether the bulk density is assumed or determined. If assumed, basis for the assumptions. If determined, method used, whether wet or dry, frequency of the measurements and nature, size and representativeness of the samples
Classification	• Basis for the classification of the mineral resources into varying confidence categories • Indication of whether appropriate account has been taken of all relevant factors (i.e. the relative confidence in tonnage or grade computations, the confidence in the continuity of geology and metal values, quality, quantity and the distribution of the data) • Indication of whether the result appropriately reflects the view that the contractor has of the deposit

<i>Criteria</i>	<i>Explanation</i>
Audits or reviews	Results of any audits or reviews of the mineral resource estimates
Discussion of relative accuracy and confidence	• Where appropriate, statement of the relative accuracy or confidence level of the mineral resource estimate using an approach or procedure deemed appropriate by the contractor. For example, application of statistical or geostatistical procedures to quantify the relative accuracy of the resource within stated confidence limits or, if such an approach is not deemed appropriate, qualitative discussion of the factors that could affect the relative accuracy and confidence level of the estimate • The statement should specify whether it relates to global or local estimates, and, if local, state the relevant tonnage or abundance, which should be relevant to the technical and economic evaluation • The documentation should include the assumptions made and the procedures used • The statements of relative accuracy and confidence level of the estimate should be compared with production data, where available

Estimation and reporting of mineral reserves
(criteria listed in the first group and, where relevant, in other preceding groups, also apply to this group)

Mineral resource estimate for conversion into mineral reserves	• Description of the mineral resource estimate used as a basis for the conversion into a mineral reserve • Clear statement as to whether the mineral resources are reported in addition to the mineral reserves or include them
Study status	• Type and level of the study undertaken to enable the conversion of the mineral resources into mineral reserves • The reporting standard does not require for a final feasibility study to have been undertaken to convert mineral resources into mineral reserves; however, it requires that studies to at least pre-feasibility level have determined a mine plan that is technically achievable and economically viable, and that all modifying factors have been considered
Cut-off parameter	Basis of the cut-off grade or grades or quality parameters applied, including the basis, if appropriate, of equivalent metal formulae. The cut-off parameter may be an economic value per block rather than a grade
Mining factors or assumptions	• Method and assumptions used to convert the mineral resource into a mineral reserve (i.e. either by the application of appropriate factors by optimization or by a preliminary or detailed design) • Choice, nature and appropriateness of the selected mining method or methods, size of the selected mining unit and other mining parameters, including associated design issues • Assumptions made regarding geotechnical parameters (e.g. the seabed floor slope and the topographic conditions) • Mining dilution factors, mining recovery factors and minimum mining widths used • Infrastructure requirements of the selected mining methods and, where available, historical reliability of the performance parameters

<i>Criteria</i>	<i>Explanation</i>
Metallurgical factors or assumptions	• Metallurgical process proposed and appropriateness of that process to the style of mineralization • Indication of whether the metallurgical process is a well-tested technology or novel in nature • Nature, amount and representativeness of the metallurgical test work undertaken and the metallurgical recovery factors applied • Any assumptions or allowances made for deleterious elements • Existence of any bulk sample or pilot-scale test work and degree to which such samples are representative of the orebody as a whole • The tonnage and grades reported for mineral reserves should state clearly whether they are in respect of material sent to the plant or after recovery • Comment on the existing plant and equipment, including an indication of their replacement and salvage value
Cost and revenue factors	• Derivation of, or assumptions made, regarding the projected capital and the operating costs • Assumptions made regarding revenue, including head grade, metal or commodity prices, exchange rates, transportation and treatment charges, penalties, etc. • Allowances made for royalties payable, international benefit sharing, etc. • Basic cash flow inputs for a stated period
Market assessment	• Demand, supply and stock situation for the particular commodity, as well as consumption trends and factors likely to affect supply and demand in future • Customer and competitor analysis, along with the identification of likely market windows for the product • Price and volume forecasts and the basis for such forecasts
Other	• Effect, if any, of natural risk, infrastructure, environmental, legal, marketing, social or governmental factors on the likely viability of a project and on the estimation and the classification of the mineral reserves • Status of titles and approvals critical to the viability of the project, such as mining leases, discharge permits and governmental and statutory approvals • Environmental descriptions of anticipated liabilities • Location plans of mineral rights and titles
Classification	• Basis for the classification of the mineral reserves into varying confidence categories • Indication of whether the result appropriately reflects the view that the contractor has of the deposit • Proportion of probable mineral reserves that have been derived from measured mineral resources, if any
Audits or reviews	Results of any audits or reviews of the mineral reserve estimates

<i>Criteria</i>	<i>Explanation</i>
Discussion of relative accuracy and confidence	• Where appropriate, statement of the relative accuracy or confidence level of the mineral reserve estimate using an approach or procedure deemed appropriate by the contractor. For example, application of statistical or geostatistical procedures to quantify the relative accuracy of the reserve within stated confidence limits or, if such an approach is not deemed appropriate, qualitative discussion of the factors that could affect the relative accuracy and confidence level of the estimate • The statement should specify whether it relates to global or local estimates and, if local, state the relevant tonnage or abundance, which should be relevant to the technical and economic evaluation. The documentation should include the assumptions made and the procedures used • Statements of the relative accuracy or confidence level of the estimate should be compared with production data, where available

Enclosure 2

Generic terms and equivalents, and definitions

The reporting standard of the International Seabed Authority uses in a generic sense certain words that might have a more specific meaning attached to them by particular groups in the industry. In order to avoid duplication or ambiguity, those terms are defined below, together with other terms that may be regarded as synonymous for the purposes of the present guidance.

<i>Generic term</i>	<i>Synonym or similar term</i>	<i>Definition</i>
Cut-off grade	Product specification	The lowest grade, or quality, of mineralized material that qualifies as economically mineable and available in a given deposit. It may be defined on the basis of economic evaluation or on the physical or chemical attributes that define an acceptable product specification
Feasibility study	–	A comprehensive study of a mineral deposit in which all geological, engineering, legal, operating, economic, social, environmental and other relevant factors are considered in such detail that it may reasonably serve as the basis for a final decision by a financial institution to finance the development of the deposit for mineral production
Grade	Quality; assay; analysis; value	Any physical or chemical measurement of the characteristics of the material of interest in samples or product
Metallurgy	Processing; beneficiation; preparation concentration	Physical or chemical separation of constituents of interest from a larger mass of material; methods employed to prepare a final marketable product from material as mined. Examples include screening, flotation, magnetic separation, leaching, washing and roasting
Mineral reserve	Ore reserve	A deposit that has been classified as a reserve. “Mineral” is the preferred term in the reporting standard of the Authority, but “ore” is in common use and generally acceptable. Other terms can be used to clarify the meaning, for instance “seabed reserves”
Mineralization	Type of deposit; style of mineralization	Any single mineral or combination of minerals occurring in a mass, or deposit of economic interest. The term is intended to cover all forms in which mineralization might occur, whether by type of deposit, mode of occurrence, genesis or composition
Mining	Seabed harvesting	All activities related to the extraction of metals and minerals from the earth, whether on the surface, underground or on the seabed

<i>Generic term</i>	<i>Synonym or similar term</i>	<i>Definition</i>
Pre-feasibility study	Preliminary feasibility study	A comprehensive study of the viability of a mineral project that: (a) has advanced to a stage where the mining method has been established and where an effective method of mineral processing has been determined; and (b) includes a financial analysis based on reasonable assumptions of technical, engineering, legal, operating and economic factors and the evaluation of other relevant factors sufficient for a suitably qualified and experienced qualified person to determine, within reason, whether all or part of the mineral resource may be classified as a mineral reserve
Recovery	Yield	The percentage of material of initial interest that is extracted during mining or processing; a measure of mining or processing efficiency
Tonnage	Quantity; volume; abundance	An expression of the amount of material of interest irrespective of the units of measurement (which should be stated when figures are reported)

ANNEX 2: Background Document

Workshop on Polymetallic Nodule Resource Classification

Introduction:

1. In January 1994, the Preparatory Commission for the ISA and the International Tribunal for the Law of the Sea convened a meeting of its technical experts to review the state of deep seabed mining and make an assessment of the time when commercial production might be expected to commence¹. In the 20 years since, along with the establishment of the International Seabed Authority, a number of developments of a legal, structural, economic and technical nature have taken place.
2. Following the adoption of the Regulations on Prospecting and Exploration for polymetallic nodules in the Area, by the International Seabed Authority, it entered into exploration contracts, in 2001 with six entities for these resources; the Interoceanmetal Joint Organization (IOM), Yuzhmorgeologiya, the Government of the Republic of Korea (KORDI), China Ocean Mineral Resources research and Development Association (COMRA), Deep Ocean Mineral Resources Development Co. Ltd (DORD) and Institut français de recherche pour l'exploitation de la mer (IFREMER). The Government of India signed an exploration contract with the Authority in 2002 and the Institute for Geosciences and Natural Resources of Germany signed an exploration contract in 2006 under the same regulations. Nauru Ocean Resources Inc. entered into an exploration contract in 2011, Tonga Offshore Mining Limited (TOML) in 2012, UK Seabed Resources Ltd in 2013 and G-Tec Sea Mineral Resources NV in 2013. Pending the decision on the applications by the Cook Islands, UK Seabed Resources Ltd and Ocean Mineral Singapore Pty Ltd, the Authority has approved 13 exploration contracts for polymetallic nodules exploration.
3. Under the Regulations, an exploration contract is for fifteen years duration, and is to be executed in three phases of five years each². Six contracts will expire in 2016 and another in 2017. These are the contracts entered into by the IOM and Yuzhmorgeologiya on 28th March 2001; the Republic of Korea on 26 April 2001, the People's Republic of China on 21st May 2001, France and Japan on 19th June 2001. India's contract will expire on 24th March 2017.
4. Each contractor is required to submit an annual report to the Secretary-General covering its programme of activities in the exploration area and containing, as applicable, *inter alia*, information in sufficient detail on: the exploration work carried out during the calendar year, including maps, charts and graphs illustrating the work that has been done and the results obtained; the equipment used to carry out the work, including the results of tests conducted of

¹ Report of the Group of Technical Experts to the General Committee of the Preparatory Commission for the International Seabed Authority and for the International Tribunal for the Law of the Sea LOS/PCN/BUR/R.32 1 February 1994.

² Regulations on Prospecting and Exploration for polymetallic nodules in the Area ISBA/6/A/18 proposed mining technologies, but not equipment design data, and the results obtained from environmental monitoring programmes, including observations, measurements, evaluations and analyses of environmental parameters.

5. In addition, Annex IV, Section 11 of the regulations requires that:

11.1 The Contractor shall transfer to the Authority all data and information that are both necessary for and relevant to the effective exercise of the powers and functions of the Authority in respect of the exploration area in accordance with the provisions of this section.

11.2 Upon expiration or termination of this contract the Contractor, if it has not already done so, shall submit the following data and information to the Secretary-General:

- (a) Copies of the geological, environmental, geochemical and geophysical data acquired by the Contractor in the course of carrying out the programme of activities that are necessary for and relevant to the effective exercise of the powers and functions of the Authority in respect of the exploration area;
- (b) The estimation of mineable areas, when such areas have been identified, which shall include details of the grade and quantity of the proven, probable and possible polymetallic nodule reserves and the anticipated mining conditions;³
- (c) Copies of geological, technical, financial and economic reports made by or for the Contractor that are necessary for and relevant to the effective exercise of the powers and functions of the Authority in respect of the exploration area;
- (d) Information in sufficient detail on the equipment used to carry out the exploration work, including the results of tests conducted of proposed mining technologies, but not equipment design data;
- (e) A statement of the quantity of polymetallic nodules recovered as samples or for the purpose of testing; and
- (f) A statement on how and where samples are archived and their availability to the Authority.

11.3 The data and information referred to in section 11.2 hereof shall also be submitted to the Secretary-General if, prior to the expiration of this contract, the Contractor applies for approval of a plan of work for exploitation or if the Contractor renounces its rights in the exploration area to the extent that such data and information relates to the renounced area.

³ The terminology in the regulations reflects the categorization of mineral reserves at the time the regulations were developed, but it does not reflect current international accounting and mineral assessment reporting standards that have developed and been widely accepted since that time. Over the two decades since the Authority came into being, the terminology related to "reserves" has evolved and coalesced around industry-standard definitions that have been incorporated into international accounting standards for the extractive industries and in national mineral assessment and reporting standards maintained by professional societies that are being adopted into international accounting standards.

6. Annex IV, Section 9 of the Regulations on “Book Records”, states that :

“The Contractor shall keep a complete and proper set of books, accounts and financial records, consistent with internationally accepted accounting principles. Such books, accounts and financial records shall include information which will fully disclose the actual and direct expenditures for exploration and such other information as will facilitate an effective audit of such expenditures.”

7. Together therefore, sections 9 and 11, mandate the application of internationally accepted standards and practices applicable to the assessment and reporting of mineral resources of the seabed beyond national jurisdiction. No standards or guidelines were provided to contractors to perform resource assessments and to report on the relevant work that were doing in this regard during exploration. No standards or guidelines exist for undertaking such work for deep seabed minerals. The results of the work undertaken so far by contractors reflect this reality. If this situation is not addressed, upon the expiration of exploration contracts for polymetallic nodules, the data and information made available to the Authority with regard to, *inter alia*, mineable areas will not show whether or not they are financial assets. Applicable standards have been developed for land-based mining. Utilizing these standards, company reports of mineral resources and reserves are not simply a repackaging of the findings of a mineral exploration program. They examine the exploration results through lenses of technology selection and design, commodity markets, estimates of construction, infrastructure and operating costs, legal, regulatory, environmental and social factors. The assessment of mineral resources and reserves provides a comprehensive assessment of the economic viability of a mining operation. It also marks the start of the transition of a mining operation from exploration to exploitation. These standards need to be developed for deep seabed polymetallic nodules of the Area so that the transition from exploration to exploitation within the framework of the international minerals industry can occur.

8. This paper reviews the evolution and current status of the standards that have been established for land-based mineral development. It also provides a summary of the work that has been completed and reported to the Authority with regard to resource assessment of the polymetallic nodules in contract areas for exploration. Since the effective dates of exploration contracts varies among contractors, progress in resource assessment show considerable variation. The paper provides a background for the necessary standardization that has to take place for polymetallic nodules to be commercialized, utilizing the considerable work that has been undertaken by professional organizations within the minerals industry.

Standards applicable to land-based mining

9. For land-based mining, the formalization of international standards for mineral assessment and reporting has been driven by investors and stockholders and implemented by national resource management and financial securities agencies, but the details of the standards for determining reserves and resources and the professional standards for assessment and categorizing mineral deposits have been driven by international standards established by professional organizations in the fields of accounting and mineral economics.

International Mineral Assessment Standards Organizations

10. Professional societies have made significant contributions in clarifying reporting standards, identifying and sharing best practices, and recognizing experts competent to oversee exploration and assessment activities. Both the Authority and the seabed mining industry can benefit from applying practices developed for land-based mineral deposits, and they will also benefit from the development of standards and approval of their use by the same organizations that establish standards for land-based extractive industries.

11. There are four bodies that will be closely involved in establishing international mineral assessment and reporting standards that will apply to activities in the Area:

- International Accounting Standards Board (IASB)
- International Marine Minerals Society (IMMSOC)
- Society of Petroleum Engineers Oil and Gas Resources Committee (SPE OGRC)
- UN ECE Framework Classification

The International Accounting Standards Board

12. The specific reference to “internationally accepted financial principles” in the regulations for exploration and in contracts with the Authority is directly related to the work of the International Accounting Standards Board. In the years following the Authority’s adoption of exploration regulations in 2000, there have been significant advances in the adoption of international financial standards. Significant work has been undertaken on standards for the extractive industries that will be applicable to financial information, including the estimation of mineral resources and reserves in the contract areas.

International Standards for Mineral Assessment and Reporting

13. The IFRS Foundation is an independent non-profit organization whose goals are to develop a single, globally-accepted and enforceable set of standards governing financial reporting standards, promote the use of those standards, give attention to emerging economies and small to medium-sized entities, and promote and facilitate adoption through convergence with national standards. IFRS promotes the development and adoption of financial reporting standards through the work of its International Accounting Standards Board (IASB). The IFRS and the ISAB were founded in 2001; a year after the Authority adopted its rules and regulations for prospecting and exploration for polymetallic nodules.

14. Since the establishment of the IFRS Foundation and its International Accounting Standards Board, application of the standards developed by the IASB have either been required or permitted by 124 countries including 103 members of the Authority and 15 of the 20 current and prospective states sponsoring exploration contracts (the five outstanding state sponsors are small island states of which only Cuba has a significant land based minerals industry). As such, the work of the IASB will be the primary source for internationally accepted accounting standards for contractors with the Authority.

15. In August of 2009 the IASB released a working draft of a discussion paper titled "Extractive Industries." In early 2010 the Discussion Paper was published and distributed for public comment. In addressing the accounting issues related to mineral reserves and resources, the Discussion Paper reached beyond ISAB's expertise to identify two professional mineral assessment and reporting organizations to establish the basis for definitions of reserves and resources. For international standards applicable for mineral assessment and reporting, the Discussion Paper turned to the "International Reporting Template for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves" prepared by the **Committee for Mineral Reserves International Reporting Standards (CRIRSCO)**.

16. The discussion paper went beyond the definition of mineral reserves and resources to discuss financial and legal issues in determining the conditions under which a mineralization may be claimed as a financial asset. This includes the existence of legal rights, including exploration and exploitation rights that are necessary to the exploitation of the mineral deposit. Committee for Mineral Reserves International Reporting Standards (CRIRSCO) was established in 1994, the same year in which the Authority was established. The current membership of CRIRSCO comprises seven national professional organizations from North and South America, Europe, Australia, Africa and Asia (see Table 1).

Table 1 — CRIRSCO Membership

Nation/Region Represented	CRIRSCO Member Organization
Australia Canada Chile Europe Russia South Africa United States	Australasian Joint Ore Reserves Committee (JORC) Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Chilean Institute of Mining Engineers (IMEC) Pan-European Reserves & Resources Reporting Committee (PERC) National Association for Subsoil Examination (NAEN) South African Mineral Codes (SAMCODES)

17. CRIRSCO's mission statement is:

The mining industry is a vital contributor to national and global economies; never more so than at present with soaring demand for the commodities that it produces. It is a truly international business that depends on the trust and confidence of investors and other stakeholders for its financial and operational well-being. Unlike many other industries, it is based on depleting mineral assets, the knowledge of which is imperfect prior to the commencement of extraction. It is therefore essential that the industry communicates the risks associated with investment effectively and transparently in order to earn the level of trust necessary to underpin its activities. The aim of CRIRSCO (Committee for Mineral Reserves International Reporting Standards) is to contribute to earnings and maintaining that trust by promoting high standards of reporting of mineral deposit estimates (Mineral Resources and Mineral Reserves) and of exploration progress (Exploration Results).

18. CRIRSCO works by consensus. Its recommendations are implemented and enforced at the national level by government agencies, particularly by securities agencies and stock

market managers that oversee informational materials published by firms seeking funds through sales of stocks.

19. Membership in CRIRSCO is open to National Reporting Organizations (NROs) that meet the following criteria to be accepted for CRIRSCO Membership:

- Produce and be responsible for maintaining a reporting standard that is compatible with the Template and which is recognized as the standard for Public Reporting, or has the wide support of professional bodies, in the country/region;
- Agree to conduct international consultation with NROs represented on CRIRSCO before making amendments to its National or Regional reporting standard;
- Include credible, self-regulating, professional bodies that provide disciplinary systems and codes of ethics that govern the behaviour of Competent Persons or equivalents as defined in the Template; and
- commit to engaging in CRIRSCO activities.

Society of Petroleum Engineers Oil and Gas Resources Committee (SPE OGRC)

20. Beginning from the same basic roots as the CRIRSCO taxonomy, the Society of Petroleum Engineers “Oil and Gas Resources Committee” (SPE OGRC) developed a contemporary taxonomy that reflects differences between how the hard mineral and energy sectors have historically approached the identification and assessment of resources and reserves as potential financial assets of an exploration or development company. The SPE OGRC taxonomy includes a wider range of sub-economic or speculative resources in the taxonomy so it is related to, but not directly comparable with, the mineral taxonomy developed by CRIRSCO.

21. Consultation continues between CRIRSCO and SPE to improve the correlation between categories in the two taxonomies. Until that time, both systems will inform the application of internationally accepted accounting standards with regard to their target resources.

UN ECE Framework Classification (UNFC)

22. The UN Economic Commission for Europe began work on a comprehensive Framework Classification for mineral and energy resources in the 1990s, preparing its “Framework Classification for Reserves and Resources of Solid Fuels and Mineral Commodities” in 1997. Continuation of this work led in 2009 to the release of “United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009.” Consultations between CRIRSCO and the UNECE led to the incorporation of the CRIRSCO definitions of reserves and resources into the UNFC.

23. The UNFC taxonomy is more complex than either the CRIRSCO or SPE-OGRC taxonomies. One source of complexity is the separation of technical feasibility from economic matters, resulting in a three dimensional system that provides resource managers with greater illumination on the potential for development through policy actions affecting economic factors (including legal and regulatory issues) and technology development.

24. The complexity of the UNFC and its lack of wide acceptance in internationally accepted accounting standards let the ISAB to recommend the use of the CRIRSCO and SPE-OGRC systems. However, the UNFC may be more suitable than these two systems in broad resource management applications, including tracking and projecting changes in development potential across different minerals, technologies and legal and economic conditions.

Evolution of Reporting Standards for Exploration Results

25. The importance of publicly reported exploration data has grown radically over the past century. The starting point is illustrated by the recommendation of Herbert Hoover, mining engineer and future president of the United States, that ore in place be divided into three classifications: proved, probable and prospective.

26. Hoover's classifications depended on the division of ore deposits into blocks of uniform characteristics. The classification was intended to replace an older evaluation of "ore in sight" that had been subject to abuse in mineral assessment and reporting. In Hoover's three-part classification, assessment of deposits depended on the uniformity of such blocks and the assurance through sampling and testing of the characteristics of each block. This classification of degree of geological assurance of economically mineable ore provided the foundation upon which modern systems of exploration and assessment of ore deposits are based.

27. Hoover's classification, which reflected the consensus of professionals in mining engineering in the early 20th century, responded to the needs of two categories of stakeholders: mine developers and investors in mining developments⁵. Over the next several decades, and particularly after the lessons learned during and after World War II in critical and strategic materials supply, national resource managers and planners became a third stakeholder in the assessment and measurement of mineral deposits. Improvements in geologic understandings, resource modelling and remote measurement led to a broadening of the inputs affecting the evaluation of the economic viability of potential deposits.

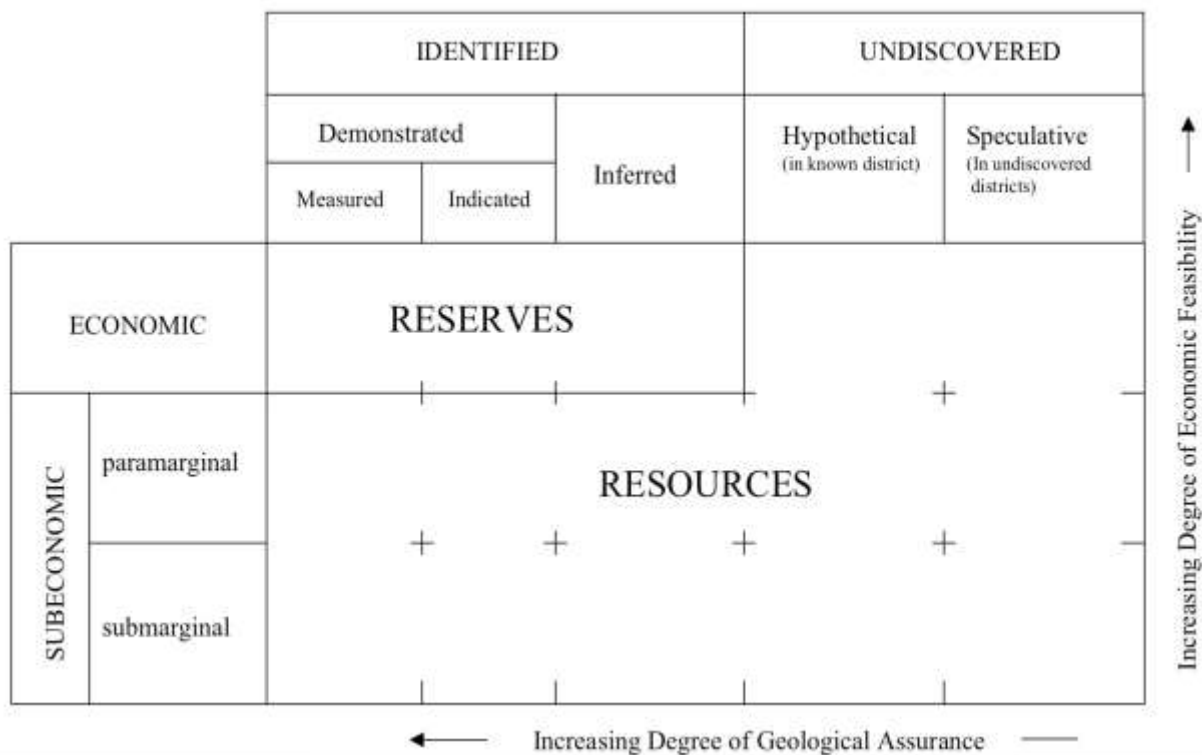
Development of the Taxonomy for Exploration Results

28. As mineral development projects grew in size and expense, as new independent companies focused on discovery and exploration of prospective deposits grew in number, and as the cost of development expanded beyond the scope of individual company resources, it became increasingly more important for developers to assess with increasing assurance the real potential of a deposit for commercial development. Similarly, it became more important for the resource owner, either private or public, to understand the potential value of a deposit in order to set rates for its sale or lease.

⁴ Herbert Hoover, *Principles of Mining*, (New York, NY: McGraw-Hill Book Company, 1909) page 19. Accessed On-line at <http://www.gutenberg.org/files/26697/26697-h/26697-h.htm#page_19> on July 8, 2013.

29. In the 1970's, a new structure for assessing mineral resources was developed. One of the early new taxonomies was prepared by the US Geological Survey.⁶ Known as the "McKelvey Box," for the head of the USGS, Dr. Vincent McKelvey, the taxonomy arrays mineral deposits in two dimensions based on assurance of the geological nature of a deposit on the horizontal axis and potential for commercial development on the vertical axis (see Figure 1). The "McKelvey Box" served as the starting point for the more detailed taxonomies of today.

Figure 1 — USGS Taxonomy of Mineral Resources and Reserved: The “McKelvey Box”



In Figure 1: *Reserves* are the part of a mineral resource which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. *Demonstrated Reserves* are determined by measurement with “*Measured Reserves*” determined by detailed sampling and “*Indicated Reserves*” computed from more widely spaced sampling. *Inferred Reserves* are estimated based on assumed continuity of more widely spaced samples in which estimates between samples may be based on factors other than direct sampling. “Reserves” in the McKelvey Box corresponds roughly to Hoover’s three ore classifications (proven, probable, and possible). What is added are levels of economic viability below current economic conditions and mineral deposits that have yet to be found. Identification of deposits in this broader characterization provides a basis for policy making with regard to future exploration and the development of exploitation technology.

⁵ USGS, “Principles of the mineral resource classification system for the U.S. Geological Survey,” *USGS Bulletin 1450-A*, Washington, DC, 1976.

30. The 1990s saw major advances in mineral resource taxonomy and reporting standards. These were prepared to address the needs of three different audiences: the mining industry, the finance and investment sector, and resource owners, managers and planners.

Reporting standards

31. Mineral information and public reports, including measured data, inferred information and theoretical assessments, is of interest to three distinct clients, with each category of clients having its own needs and interests:

- *Developers*, for determining whether and how to develop a site, the development, selection and improvement of technology, and the development of operational plans for exploitation and exploitation operations;
- *Investors, lenders and insurers*, for evaluating the economic prospects for development and for estimating the value of investments and the value of the site as collateral for loans;
- *Owners and managers* of resources who must consider not only issues of development, but the management of the resource to ensure the greatest value to all stakeholders, not just for the value of exploitation, but for protection of other values of the area under consideration, and the maximization of value over time.(category of the International Seabed Authority)

32. While all three sets of stakeholders have interests in the raw data, information and observations of the minerals and the surrounding environment, they have differing needs for level of detail and type of analysis. In many countries, reporting standards for exploration results and mineral resource assessment and reporting are governed by laws under which the dissemination of mineral information to potential investors and to stockholders is regulated. As the mineral industry is international, mineral exploration experts sought to bring order to differing national standards.

33. In order to minimize confusion and incompatibility among national reporting standards regarding mineral resources, professional organizations in key mineral producing nations joined together to help bring national reporting standards into compatibility. Established in 1994 as the “Mineral Definitions Working Group” under the auspices of the Council of Mining and Metallurgical Institutes (CMMI), the body became the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) in 2002.

34. In 2007, CRIRSCO became a task force of the International Council on Mining and Minerals (ICMM) and in 2009 became a “Strategic Partner” of the Council. The Council provides administrative and financial support for CRIRSCO but is not involved in the substantive work of the body.

Professional Societies in Standard Setting for Mineral Assessment and Reporting

35. CRIRSCO's focus is on the public reporting of mineral resource and reserve information. Public reports include:

- Reports prepared for investors or potential investors
- Annual Reports
- Quarterly Reports
- Information Memoranda
- Websites
- Public Presentations
- Stock Exchange Information Systems

36. Information in some or all of these categories of reports may be regulated by national authorities, particularly those that regulate investment markets and stock exchanges. Publication of data in nations with different standards would undermine efforts to make reliable information available to potential investors.

37. CRIRSCO identifies three principles that guide the work of the organization and its members: transparency, materiality, and competence.

- *Transparency* - to inform with a clear and fair description of the mineral assets.
- *Materiality* - to inform with concrete and concise information.
- *Competence* - to inform with knowledge, expertise, and judgment.

38. Underlying these three principles is the essential requirement that the reporting system earns and maintain the public trust.

The CRIRSCO Taxonomy of Mineral Resources and Reserves

39. The CRIRSCO taxonomy of mineral resources (see Figure 2) has its roots in the "McKelvey Box" but it has both a different orientation and increased specificity. In orientation, geological assurance increases toward the lower edge of the diagram and economic prospects increase as one moves toward the right. In specificity, the taxonomy addresses a specified "exploration target" so it excludes hypothetical and speculative resources and minerals from consideration. The taxonomy focuses on known mineral deposits that show serious indication of potential economic value.

40. Progress of mineral classification from Inferred Resources to Proved Reserves is based on exploration of the site, giving increasingly detailed geologic understanding of the site, and research and development to understand and improve the “modifying factors” that affect the economic outlook for commercial development. Modifying factors include mining, processing, metallurgical, economic, marketing, legal, environmental, social, infrastructure and governmental considerations. Details of the resource and reserve categories are provided below in Table 1.

Figure 2 — CRIRSCO Taxonomy for Mineral Reserves and Resources

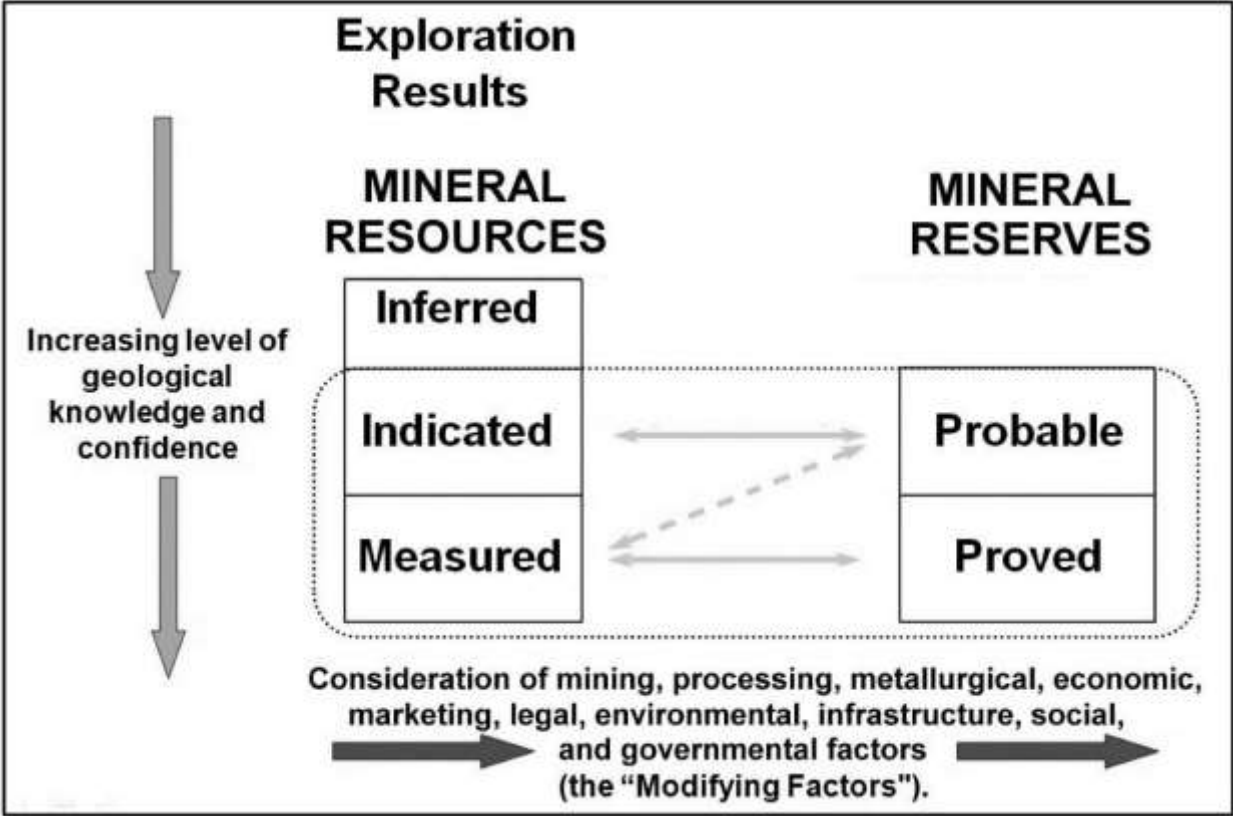


Table 2: Industry Standard Definitions of Resource and Reserve Categories ⁷

Mineral Resource

A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling.

Inferred Mineral Resource

An Inferred Mineral Resource is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity. An Inferred Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

Indicated Mineral Resource

An Indicated Mineral Resource is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation. An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve.

Measured Mineral Resource

A Measured Mineral Resource is that part of a Mineral Resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit. Geological evidence is derived from detailed and reliable exploration, sampling and testing and is sufficient to confirm geological and grade or quality continuity between points of observation. A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proved Mineral Reserve or to a Probable Mineral Reserve.

⁶ Source: CRIRSCO Standard Definitions, October, 2012:
<http://www.criresco.com/news_items/CRIRSCO_standard_definitions_oct2012.pdf>

Mineral Reserve

A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified. The reference point at which Reserves are defined, usually the point where the ore is delivered to the processing plant, must be stated.

Probable Mineral Reserve

A Probable Mineral Reserve is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Mineral Reserve is lower than that applying to a Proved Mineral Reserve.

Proved Mineral Reserve

A Proved Mineral Reserve is the economically mineable part of a Measured Mineral Resource. A Proved Mineral Reserve implies a high degree of confidence in the Modifying Factors.

41. CRIRSCO has developed and refined a template for the assessment and reporting of mineral deposit information. The template addresses not only the classification of mineral deposits; it establishes a methodology for applying the classifications. The most important elements of the template are the concept of the “Competent Person” and the “Modifying Factors” that are applied to exploration results by the Competent Person(s) to properly categorize the mineralization.

Role of the “Competent Person” in Mineral Classification

42. Classification of minerals into the specified taxonomy is a task that requires trusted professional judgement. This judgement is incorporated in the taxonomy by the specification that public reports be prepared under the direction of a “Competent Person” (equivalent terms in different national systems are “Qualified Person” and “Competent Qualified Person”).⁸ While it is up to each country to define the qualifications, experience, and responsibilities of this person, CRIRSCO provides a standard definition for this role:

A “Competent Person” is a minerals industry professional who is a member at an appropriate classification of an organization specified by the national authority with enforceable disciplinary processes including the powers to suspend or expel a member.

Such a person must have a minimum of five years relevant experience in the style of mineralisation or type of deposit under consideration and in the activity which that person is undertaking.

⁷ Alternative terms in national regulation include “Qualified person” and “Competent Qualified Person.”

43. The “Competent Person” is responsible for directing or overseeing the conduct of exploration and research related to the determination of mineral resources and reserves and may be assisted by other “Competent Persons” in areas that contribute to the assessment. The Competent Person is the critical element of the mineral reporting system. The quality and accuracy of public reports depends upon the work of the Competent Person so CRIRSCO has prepared a Code of Conduct for the Competent Person. The Code is contained in the International Reporting Template. A copy of the Code of Conduct is provided as Appendix 1 of this background paper. Breaches of the code are responded to by the national professional organization of which he or she is a member.

Transforming Geological Information into Mineral Resource and Reserve Assessments

44. Where exploration results address the issue of geological assuredness of mineral endowment, it is the “modifying factors” that determine the economic potential of a specific mineralization.

45. Modifying factors include:

- Commodity Prices
- Mineral Excavation Technology
- Metallurgy of Mineral Recovery
- Transportation
- Capital and Operating Expenses of Operation
- Infrastructure
- Fees, Royalties and Taxes
- Assurance of Legal Title and Right to Mine
- Environmental Regulation and Costs of Compliance
- Social Factors
- Training Projects

46. Other than cases of straight-forward expansion of a known exploitation project, the evaluation of modifying factors will draw upon site and industry specific studies and upon the judgement of the “Competent Person.” In such cases, the “Competent Person” is required to layout and justify the bases of the assumptions used in his or her evaluation. The overall evaluation and the information and expertise upon which it is based may be presented in a series of increasingly detailed and rigorous assessments that begin with “**scoping studies**” and extend through “**pre- feasibility**” and “**feasibility studies** (see Table 3 for definitions of these studies).

47. The Canadian Institute of Mining, Metallurgy and Petroleum (CIM, a member organization of CRIRSCO) has prepared an extensive set of best practice guidelines for estimation of mineral resources and mineral reserves. The guidelines include 35 pages of generally applicable recommended best practices, and are supplemented by additional commodity specific recommended practices.

Table 3: Categories of Reports Used in Defining “Modifying Factors” and Evaluating Mineral Resources⁸

Scoping Study A Scoping Study is an order of magnitude technical and economic study of the potential viability of Mineral Resources that includes appropriate assessments of realistically assumed Modifying Factors together with any other relevant operational factors that are necessary to demonstrate at the time of reporting that progress to a Pre-Feasibility Study can be reasonably justified.
Pre-Feasibility Study A Pre-Feasibility Study is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumptions on the Modifying Factors and the evaluation of any other relevant factors which are sufficient for a Competent Person, acting reasonably, to determine if all or part of the Mineral Resource may be converted to a Mineral Reserve at the time of reporting. A Pre-Feasibility Study is at a lower confidence level than a Feasibility Study.
Feasibility Study A Feasibility Study is a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The confidence level of the study will be higher than that of a Pre-Feasibility Study.

Best Practices in Mineral Resource and Reserve Assessment and Reporting

48. The “Competent Person” is also able to draw upon best practices, guidelines and standards established within the profession and within specialized fields related to the “modifying factors.” Evaluation of mineral resources may draw upon professional standards and guidelines and upon best practices developed for specific categories of minerals and mineralization.

⁸ Source: CRIRSCO, *Standard Definitions*, October 2012:
<http://www.criirSCO.com/news_items/CRIRSCO_standard_definitions_oct2012.pdf>

49. The best practice guidelines laid out by CIM provide guidance in nine categories¹⁰:

(a) Qualified (Competent) Person

50. A mineral resource/mineral reserve assessment will be directed by a “Qualified/Competent Person,” but may require that such person be assisted by individuals qualified/competent in subspecialties of the assessment.

(b) Definitions

51. Strict adherence to the formal definitions of resource and reserve categories and levels of studies (“pre-feasibility, “feasibility”) as defined in law and professional best practices must be maintained.

(c) The Resource Database

52. The Resource Database has three components: primary data (observed and measured); interpreted data; and data related to “modifying factors” that include engineering, economic, mining, metallurgical, legal and social data related to the determination of commercial viability.

(d) Geological Interpretation & Modelling

53. Models and interpretations of data must be clearly presented and based on primary data. Models must be selected for their appropriateness to the specific mineralization.

(e) Mineral Resource Estimation

54. Available data must be assessed to determine its adequacy or to identify gaps that must be filled to achieve the appropriate level of confidence. Data must be archived and made available for future reference.

(f) Quantifying Elements to convert a Mineral Resource to a Mineral Reserve

55. Details of references on modifying factors must be met or exceed criteria for preliminary feasibility studies before a mineral resource may be advanced to a mineral reserve.

(g) Mineral Reserve Estimation

⁹ CIM Best Practice Guidelines <<http://web.cim.org/UserFiles/File/Estimation-Mineral-Resources-Mineral-Reserves-11-23-2003.pdf>

56. A Mineral Reserve estimate must be based on a collection of information whose results are based at least on the level of a Preliminary Feasibility Study. The Qualified/Competent Person must understand the significance of each discipline's contribution to the overall reliability of the assessment. Documentation of the evaluation process must be maintained throughout the life of the mine.

(h) Reporting

57. A comprehensive technical report signed by the Qualified/Competent Person(s) should be prepared on completion of a particular phase or stage of work. Public reports of mineral resources and mineral reserves should be based on reports approved by the Competent/Qualified Person(s).

(i) Reconciliation of Mineral Reserves

58. Mineral production during exploitation could be monitored and reconciled with mineral resources and mineral reserve estimates. This provides a cross-check on the estimation process and reconciliation of estimates with actual performance.

International Reporting Template

59. The "International Reporting Template" was developed as a guideline for national implementation of mineral reporting systems. It was initially prepared based on the experiences of experts from Australia, Canada, South Africa, Chile, the UK and Europe and the United States and released in 2005. As a common standard, the International Reporting Template has resulted in revisions of national standards to bring them in compliance with the new international standards.

60. An outline of the contents of the International Reporting Template is provided below. The template includes sections that are specific to five categories of minerals:

- (1) mineralized fill, low grade mineralization, stockpiles, dumps and tailings,
- (2) Coal,
- (3) Diamonds and other gemstones,
- (4) Industrial minerals, and
- (5) Unconventional energy resources.

61. The International Reporting Template is a check list of assessment and reporting criteria for exploration results, mineral resources and mineral reserves. Having been developed from experience in land-based mineral develop, the template includes some specific examples of

techniques for general land based mineral assessment and some techniques specific for one category of minerals (gemstones). It provides general guidance that could be applied to deep seabed minerals, but does not address issues specific to polymetallic nodules.

62. The Template includes in its appendices recommended rules of conduct and guidelines for “Competent Persons” engaged in preparation of reports on exploration results, mineral resources or mineral reserves. A copy of the Code of Conduct is provided as Appendix 2 of this report.

63. CRIRSCO drew upon the national reporting codes to produce a template for developing national codes consistent with the practice of CRIRSCO members. The International Reporting Template (IRT) draws from the codes adopted by the professional organizations representing Australasia, Chile, UK and Western Europe, Canada, South Africa, and the United States.⁷The highly annotated template is intended to serve as a guide that is based on successful national reporting codes and standard that have already been developed and tested. The template includes extensive annotation and guidance. It also includes sections directed at specific categories of mineralization.¹¹

64. The main sections of the International Reporting Template are as follows:

- Introduction
- Scope
- Competence and Responsibility
- Reporting Terminology
- Reporting General
- Reporting of Exploration Results
- Reporting of Mineral Resources
- Reporting of Mineral Reserves
- Technical Studies
- Reporting of Mineralized Fill, Pillars, Low Grade Mineralization, Stockpiles, Dumps and Tailings
- Reporting of Coal Exploration Results, Resources and Reserves
- Reporting of Diamond and Other Gemstone Exploration Results, Mineral Resources and Mineral Reserves
- Reporting of Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves
- Reporting of Unconventional Energy resources

¹⁰ The November 2013 edition of the International Reporting Template may be downloaded from the CRIRSCO site at <http://www.crirSCO.com/templates/crirSCO_international_reporting_template_2013.pdf>

The Template also includes an illustrative checklist of general and mineral-specific practices.

- Sampling Techniques and Data
- Reporting of Exploration Results
- Estimation and Reporting of Mineral Resources
- Estimation and Reporting of Mineral Reserves
- Estimation and Reporting of Diamonds and Other Gemstones

65. While illustrative of the information required to construct /evaluate mineral deposits, the checklist does not address deep seabed minerals. The Template is designed as a starting point for national governments and is open to extension through the specification of mineral and commodity-specific guidelines and best practices.

The Resource Database¹¹

66. A Resource Database is established by the collection, verification, recording, storing and processing of the data and forms the foundation necessary for the estimation of mineral resources and mineral reserves. The establishment of a QA/QC program of all data is essential during this process. Components of the Resource Database typically will include geological data (e.g. lithology, mineralization, alteration, and structure), survey data, geophysical data, geochemical data, assay data, rock quality and bulk density information and activity dates.

67. As stated in the CIM Standards and as noted above, a Mineral Resource must have reasonable prospects of economic extraction. Consequently, preliminary data and information concerning a number of factors (e.g. mining, metallurgy, economics and social and environmental sensitivity) will be collected and assessed during the estimation of a Mineral Resource.

General comments (land-based deposits)

- A database consists of two types of data, primary data and interpreted data. Primary data are parameters amenable to direct physical measurement. Examples include assays, survey data, and geological observations. Interpreted data sets are derivations or interpretations of primary information. Examples are geological projections and block models.
- Bulk density is an important parameter that should be measured and recorded at appropriate intervals, and in an appropriate manner, for the deposit. The choice of methods for determining the bulk density of a particular deposit will depend on the physical characteristics of the mineralization and the available sampling medium.

¹¹ May 30, 2003 - Adopted by CIM Council on November 23, 2003

- The QP should be diligent in ensuring that the final database fairly represents the primary information. Data verification is an essential part of finalising the resource database.
- The Resource Database provides a permanent record of all the data collected from the work carried out, the date of the work, observations and comments from the results obtained. It should be readily available for future reference. The database provides all of the information necessary to enable current and future geological interpretations and modelling.
- Although most databases are generally maintained in an electronically-stored digital format, hand-printed tables with well-organized information may also form a database. It is recommended that data be stored digitally, using a documented, standard format and a reliable medium that allows for easy and complete future retrieval of the data.

Primary Data Visualization

- It is essential that the systematic recording of geological observations from mapping and drill hole logging be entered into an organized database.
- Data collection and display must foster a good geological understanding of a deposit as a prerequisite for the Mineral Resource estimation process
- The important primary data must be identified and accurately presented in three dimensions, typically on a set of plans and sections. Examples are lithology, structural measurements, assays, etc.
- Where local mine coordinates are used on geological maps and sections, a mechanism for conversion to universal coordinates must be provided. Maps and sections must include appropriate coordinates, elevation, scale, date, author(s) and appropriate directional information.
- Data positioning information should be relative to a common property co-ordinate system and should include the methodology and accuracy used to obtain that information. Accurate location of data points is essential. If data points are referred to a particular map or grid, those reference data should be included, the map properly identified and the coordinate system clearly stated.
- If primary data have been intentionally omitted from the presentation, they should be identified with an explanatory note for their exclusion.

Interpreted Data Visualization

- The geological interpretation including mineralization and its controls (e.g. structure, alteration, and lithology) is essential for MRMR estimation. The primary data (i.e. from outcrops, trenches and drill holes) should be clearly identifiable and be distinct from the interpreted data so that it may be utilised in subsequent interpretations and Mineral Resource estimates.
- The relevant geophysical/geochemical/topographic data used to support the interpretation of faults or boundaries must be included or referenced appropriately.
- Since the mineralising episode(s) and related features of the geology are critical aspects in the mineral resource/mineral reserve estimations, they must be clearly represented. Examples are controlling features, style(s) and age(s) of mineralization, boundaries of the mineralization, and zonation of the mineralization.

Polymetallic Nodules of the Area

68. Mineable areas are neither defined in the Regulations nor in the Convention. The term is first used in the United States "Deep Seabed Hard Mineral Resources Act" of 1978. In this regard, the Act states that: "The applicant must submit with the application a resource assessment to provide a basis for assessing the area applied for. This assessment must include a discussion of mineable and unmineable areas, taking into account nodule grade, nodule concentration, and other factors such as seafloor topography. These areas may be delineated graphically. The resources in the area must be described in relation to the applicant's production requirements, operating period, and recovery efficiency in order to justify the area applied for"¹²

69. Mineable areas comprise three crucial factors; the grade of nodules, the abundance (concentration) of nodules and seafloor characteristics.¹³ Thus mineable areas will be defined by each contractor as having a combination of grade and abundance above respective cut-off levels and acceptable seafloor characteristics (slope, number and size of obstacles and sediment shear strength are the factors upon which the collector system would be designed and its recovery efficiency determined). Mine sites within the exploration area will have to contain a sufficient number of mineable areas capable of supporting an economic mining venture, including its operating period. Grade and abundance are geological factors; seafloor characteristics will determine the design of the collector system and the latter's recovery efficiency.

70. Within two to three years from now, seven Contractors for polymetallic nodules exploration in the Area are coming to the end of their contracts. For this reason, to order to ascertain the work done by the contractors in complying with the Regulations and to provide clarification of the terms contained in paragraph 1 (b) of Section 11 (paragraph 2 above), the

¹² H.R.2759 (96TH): Deep Seabed Hard Mineral Resources Act (Public law 96-283).

¹³ Analysis of exploration and mining technology for manganese nodules – (Seabed minerals series; v.2) United Nations. Ocean Economics and Technology Branch, 1984.

present workshop for Contractors, mineral classification experts, scientists, engineers and members of the Authority's Legal and Technical Commission has in part been organized.

71. The information and data that have been submitted to the Authority in relation to the process by which mineable areas have been identified by the contractors, including the criteria that have been utilized to identify such areas or the proposed technologies to collect nodules is presented below. Indeed, no information has been provided to the Authority with regard to the size and duration of possible economic mining ventures. This information would indicate the number of mineable areas in a given exploration area that would support the mining venture. Similarly, no information has been provided to the Authority with regard to proposed collectors for mining nodules, the results of tests of these technologies and their recovery efficiencies. In the absence of the requisite resource classification data, the Authority is challenged in its efforts to establish a suitable fiscal regime for polymetallic nodule mining in the Area.

The Resource Assessment work reported by the Contractors to the Authority

IOM

72. Using the UNFC classification system, IOM has classified the polymetallic nodules deposits in its exploration area as Inferred. Its resource assessment work was accomplished using geo-statistical methods, such as Kriging and the geological blocks methods of interpolation. The contractor had identified 15 ore nodule fields of different sizes with $> 10 \text{ kg/m}^2$ wet nodules, for future development. Allocation of ore nodule fields and assessment of resources was carried out on data from 516 sampling stations distributed within an area of 63,075 km².

Part of the criteria used by IOM to identify mineable areas was by excluding areas containing slopes with more than 7° gradient and outcrops with more than 3 meters amplitude. IOM reported that the relative error of nodule resource assessment varied from 13 to 68 per cent [mean 35%] for estimating grid practice at the present stage, whereas the assessment accuracy of average metal was less than 10 per cent.

73. The monetary value of products of mining and processing the commercial ore within the contoured prognostic nodule resources of the IOM exploration area was calculated for different indices of ore-bearing (1.0, 0.7, 0.6, 0.5), dilution (5, 10 and 15%), and losses during mining and transportation (20, 30 and 40%). IOM calculated that the supply of commercial ore for a future mining enterprise processing 3 million tonnes dry nodules per year, as the worst-case scenario of geological and mining conditions should be sufficient to meet required terms of an exploitation license. The Inferred nodule resources estimate that could be economically viable to be mined at the favourable market condition provided a sound basis for future mining activities.

74. IOM continues the selection and delineation of additional ore nodule sites within ore fields and development of more detailed nodule technology, processing technology and environment.

YUZHMOREGEOLOGIYA – RUSSIAN FEDERATION

75. Yuzhmorgeologiya, in its 2010 annual report, described a total of 32 ore deposits (industrial ore) with development potential in the Area. In its 2011 report, Yuzhmorgeologiya describes 38 ore deposits as being the most prospective, ranging in area from 11 to 310 km², length 6-67 km and width 1.0 to 7.5 km. The Contractor has used a sampling grid of 6 to 3km with the distance between stations ranging from 2 to 4 km.

76. Yuzhmorgeologiya plans to continue the demarcation of the deposits and assessment of the resource content (resource computation) of the nodules which could be developed in the future and for identification of sites favourable for development in the area demarcated as containing nodule deposits.

THE GOVERNMENT OF THE REPUBLIC OF KOREA (KORDI)

77. KOREA, in its 2011-15 programmes of activities has indicated that it will outline priority mining areas and carry out a benthic impact experiment in its exploration area in preparation for commercial production. It proposes to use high precision acoustic surveys for assessment of resource potential in the priority mining area; and pre-pilot mining test at 1000 m depth in the East Sea of Korea. However, KORDI provides limited information on its resource assessment and classification work.

CHINA OCEAN MINERAL RESOURCES RESEARCH AND DEVELOPMENT ASSOCIATION (COMRA)

78. COMRA reports that it has set up a data and information management system for mathematical and geological models for evaluating and predicting the mineral resources for economic prospecting. It has used sampling grids of 5.3'x5.3' or 9.8km x 9.8km in selected areas and carried out a resource assessment.

79. The contractor has made an economic analysis of commercial deep sea mining on varieties of production, consumption and market conditions of metals produced from the categories of minerals to be derived from the Area based on the results of general, technical and economic evaluation. It concludes that due to uncertainty of technology, operating costs and environmental protection costs, as well as competition with land based mineral resources, the commercial development prospects for mining polymetallic nodules is not certain in the short term.

DEEP OCEAN RESOURCES DEVELOPMENT CO. LTD (DORD)

80. DORD has used the land based Code of the Australian Joint Reserve Committee (JORC, 2004) to classify the mineral resources in its exploration area as Inferred. DORD collected a significant amount of data on occurrence, density and know-how of exploration during 1975 to 1996. A review and economic appraisal work was conducted in 2010 with respect to the value of ore deposits using the Discounted Cash Flow (DCF) method. DORD reports that though

the technological developments for low cost mining and smelting are necessary, because of the stable supply of minerals from land, the advancement of Research and Development related to deep-sea mineral resources has been sluggish. Therefore, it has taken old methods and cost estimates into consideration. The contractor has assumed that the project would be economically viable.

INSTITUT FRANÇAIS DE RECHERCHE POUR L'EXPLOITATION DE LA MER (IFREMER)

81. IFREMER has compiled and geo-referenced all the data that it collected during 1975 to 1988. In 2012, it undertook a major integrative overview on environment work carried out in its licence blocks and plans biological work with Germany for the period 2011-16 in the Area. No developments on resources and resource classification have been reported by the contractor.

MINISTRY OF EARTH SCIENCES, GOVERNMENT OF INDIA

82. The contractor has identified a first generation mine-site, an area of 7858 km², in its exploration area and has divided the mine site into 42 blocks of 0.125°x 0.125° for detailed exploration and comprehensive resource evaluation.¹⁴

83. The MOES of India plans to identify a test mining site (a block of 12.5km x 12.5km) within the contractor's First Generation Mine-site to carry out a preliminary techno-economic evaluation of the mining complex including processing and recovery of additional metals and value added products. Based on the existing resource evaluation with further refinement relating to block- wise estimation variances and the available sampling grids, the contractor plans to attempt classification of the resources in the Area into measured, indicated and inferred categories, during 2014-15.

BGR, GERMANY

84. Based on conceptual studies and modelling of limited available data, BGR has identified 'a highly prospective area of approximately 2000 km² with a high density of mineable nodule areas of economic interest, which would be sufficient for 7-12 years of mining'. The Contractor reports the coefficient of variation for the main metal content (Mn, Cu, Ni, Mo, V) is a factor 3 lower than the coefficient of variation for nodule abundance (approximately 10% versus 30%). The nodule abundance being the controlling factor for resource estimation, the contractor projected to improve the quantity and quality of nodule abundance data.

85. BGR reports that it has prepared an internal report with the Aker Wirth Company regarding a study on the "Technical development and economic feasibility of mining polymetallic nodules from the deep-sea". This covered :

- An evaluation of existing deep-sea mining techniques;

¹⁴ The term "first generation mine site" is to be defined.

- an assessment of these techniques regarding environmental issues, safety, capital expenditure, operating costs, and profitability;
- a survey of related technological sectors regarding their transferability and based on the results of these studies, and
- The development of a detailed conceptual design for a nodule mining and lifting system, including computer simulations of important sub-systems and components and basic concepts for a production platform and a nodule ore transport system to a land-based metallurgical processing plant.

86. In its 2013 Annual Report, BGR reported its resource calculations for the entire PA1 as “indicated mineral resource” according to the CIM Definitions Standards for mineral resources and mineral reserves (2010).

TOML-TONGA

87. Tonga Offshore Mining Limited (TOML), TONGA signed its contract with the ISA in 2012. However, in its first annual report, it has classified the deep sea polymetallic nodule resources as Inferred deposits. This classification follows the Canadian Securities Exchange Standards and is in accordance with the JORC standards (NI43-101 or JORC standards). The resources have been classified based on conceptual costing and revenue modelling and relative metal price assumptions, conceptual production cost per tonne at each stage of the production chain, based almost entirely on proven technology. The resource modelling reviewed the historical data available for the CCZ.

NORI

88. Based on the interpretation of geological and geophysical data collected during 2012, NORI has generated a nodule distribution model including correlation with the seafloor topography and sediment characteristics, which was used for its resource estimate and geological model. This model also incorporated historical data. The Inferred mineral resource estimates were prepared in accordance with the CIM ‘Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines’ and the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code, 2012).

89. The remaining polymetallic nodule contractors are yet to report on their resource assessment work, as well as the classification of the resources.

Comments on reported work

90. With the limited amount of information and data on the polymetallic nodule resources in exploration areas, in particular for contracts that expire between 2016 and 2017, there is an urgent need to Inform and educate all stakeholders (including staff of the Authority, members of Authority, commissions and committees, sponsoring states and contractors) in the international standards for mineral assessment and reporting through

discussions with experts in the establishment and application of such standards. There is also an urgent need to work with the Committee on Mineral Reserve Information Reporting Standards (CRIRSCO) in order to apply the CRIRSCO standards to mineral reserve and mineral resource reporting by all contractors and, through the CRIRSCO standards, maximize consistency with national reporting standards.

91. Of the seven contracts that expire by 2017, only one contractor has provided criteria to define mineable areas, the number of such areas that have been identified in its exploration area and a classification of these resources. Another contractor has provided information on “ore deposits” in its exploration area without reference to the criteria used to define “ore deposits”. A third contractor refers to a first generation mine site without and definition of the term. Two others indicate that they have undertaken resource assessment work but provide no data or reports on the work. Only one contractor has indicated the classification system that it has used.

92. As can be gleaned from the above, the comparability of assessments across deposits and development sites is not possible. This will require clear standards, and these standards must reflect the nature of the resource and the technology and economics of their exploitation.

93. In order for such comparability to be possible, there is a need to review the work being undertaken by contractors in this regard, agreement on the utilization of applicable land-based standards and their utilization in the short term for polymetallic nodules, establishment of a continuing relationship with organizations such as CRIRSCO to refine standards, and a determination of the additional work to be performed by contractors and the time required to fulfill. Consideration must also be given to elaborate on the best practices for the “Resource Database” identified in the CIM Best Practices in regard to the ‘end of contract’ regulation applicable to exploration contractors regarding transfer of exploration and resource data from the contractor to the Authority at the end of the exploration contact.

Objectives of the workshop

- (I) Ascertain the work being undertaken by contractors for polymetallic nodule exploration in the Area with a view to the standardization of the exploration and resource data required in Section 11 of the standard clauses of Exploration contracts;
- (II) Review of current practice in land-based mineral development on national reporting standards for exploration results and resource classification;
- (III) Identification of special aspects of polymetallic nodule deposits that should be addressed in resource reporting standards;
- (IV) Identification of any issues arising from differences in national reporting standards to which the Authority should respond;
- (V) Assist contractors to identify and implement best practices in polymetallic nodule

resource evaluation;

- (VI) Identification of the work to be completed by contractors to fulfil item (i);
- (VII) Determine the time required to fulfil item (v), and
- (VIII) Provide guidance to the ISA regarding relations with mineral information standards organizations, including potential cooperation with CRIRSCO's work;

Appendix 2: Recommended Rules of Conduct Applicable to "Competent Persons"¹⁵

The following recommended Rules of Conduct apply to Competent Persons engaged in the practice of preparing or contributing to public reports that include statements of Mineral Exploration Results, Mineral Resources or Mineral Reserves. These Rules are in addition to the Professional Codes of Ethics that may apply due to the Competent Person's membership of a recognized professional body. In the event of a conflict, the rules of the Competent Person's recognized professional body will prevail. The Rules of Conduct are listed under various areas of responsibility, highlighted in bold text.

The Public and Society

Competent Persons must discharge their duties with fidelity to the public, and at all times in their professional or employed capacities carry out their work with integrity and professional responsibility.

In particular:

- Recognize at all times, that the responsibility of Competent Persons towards the Public overrides all other specific responsibilities including responsibility to professional, sectional, or private interests or to other Competent Persons.
- Ensure that public comments on geological, engineering and metallurgical and related matters are made with care and accuracy, without unsubstantiated, exaggerated, or premature statements; they should be made clearly and concisely.
- Base documentation underpinning Public Reports on Mineral Resources and Mineral Reserves on sound and relevant estimation techniques, adequately validated data and unbiased judgement.
- Note that when required to do so, Competent Persons should give evidence, express opinions or make statements in an objective and truthful manner on the basis of adequate knowledge and understanding.
- Recognize that where required to do so, Competent Persons should be prepared to disclose details of qualifications, professional affiliations and relevant experience in all public reports.

¹⁵ CRIRSCO, International Reporting Template, November, 2013. Accessed at <http://www.crirSCO.com/templates/crirSCO_international_reporting_template_2013.pdf> on February 23, 2014

The Profession, Employers and Clients

Competent Persons must uphold the honour, integrity, reputation and dignity of their profession and maintain the highest level of conduct in all professional matters. In particular they should:

- Act with due skill, care and diligence at all times in conducting their activities.
- Perform work only in their area of competence.
- Never knowingly mislead or deceive others, falsify or fabricate data.
- Respect and safeguard confidential information.
- Acknowledge and avoid wherever possible both real and perceived conflicts of interest.

International Standards for Mineral Assessment and Reporting

- Distinguish between fact and opinion so that it is clearly evident what is interpretation of fact and what is professional judgement. Competent Persons may give a considered professional opinion based on facts, experience, interpretation, extrapolation or a combination of these.
- Ensure the scientific and technological contributions are thorough, accurate and unbiased in design, implementation and presentation.
- Ensure that sound and relevant estimation techniques, adequately validated data and unbiased judgement are applied to the documentation upon which public reports on Mineral Resources and Reserves are based.
- Comply with all laws and regulations relating to the mineral industries and rules, regulations and practices as established and promulgated by the relevant regulatory authorities.
- Use their best endeavours to ensure that their employer or client complies with the rules and regulations and practices of the relevant regulatory authorities.

Professional Bodies, Colleagues and Associates

Competent Persons must at all times conform to the rules of the professional bodies to which they belong and respect and acknowledge the contributions of colleagues and other experts in enabling them to conduct their work.

They should:

- Accept responsibility for their own errors.
- Demonstrate a willingness to be judged by their professional peers.
- Agree to be bound by the disciplinary code of the professional body to which they are affiliated.
- Encourage others to accept the same responsibilities, to join a recognized professional body and to be bound by these Recommended Rules of Conduct.

The Environment, Health and Safety

In performing their work, Competent Persons should strive to protect the natural environment and ensure that the consequences of their work do not adversely affect the safety, health and welfare of themselves, colleagues and members of the Public.

- Ensure that consideration of the modifying factors used to determine Mineral Reserves fully recognizes the need to provide a safe working environment.
- Ensure that Mineral Reserve estimates acknowledge the likely environmental impact of development and ensure that appropriate allowances are made for mitigation and remediation.

Acknowledgement

The Secretariat acknowledges the help of Dr. Caitlyn Antrim, Director, Center for Leadership and Global Diplomacy, Virginia, USA, in preparation of this Background document.

