



Seminar, 2011, Jamaica

Resources of the Area & Deep Seabed: Types, Distribution and the Role of Marine Scientific Research in Their Discovery

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Resources of Area & Deep Seabed

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- Mineral Resources of the Area
 - Polymetallic nodules
 - Cobalt-rich crust
 - Polymetallic sulphide
- Biodiversity and Genetic Resources of the Deep Seabed
- The Role of Marine Scientific Research
- The Role of ISA and National Practice



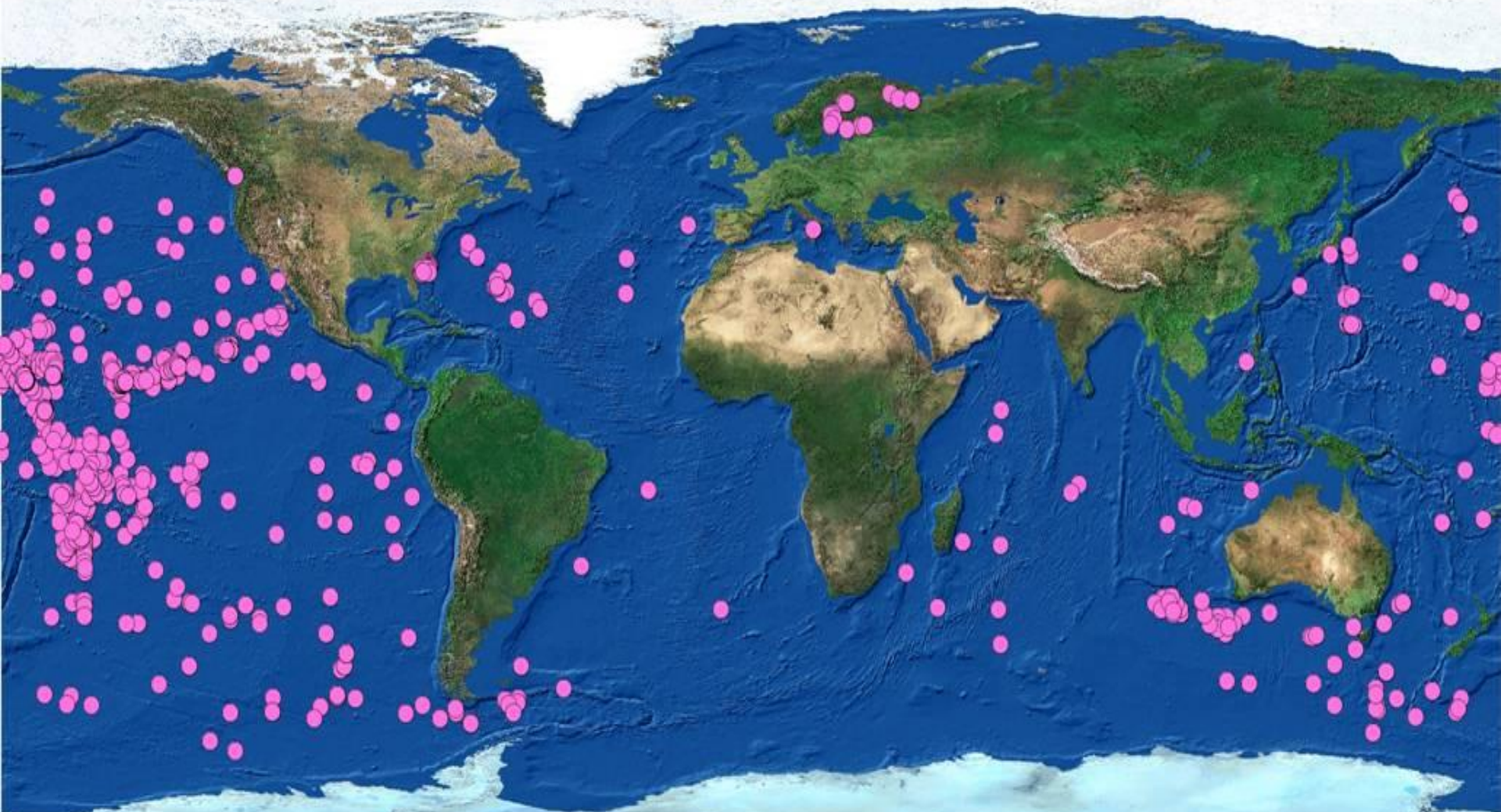
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Mineral Resources of the Area -- Type & Distribution



Polymetallic nodule locations represented in the ISA CDR

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(from ISA data)



Polymetallic nodules

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- “Polymetallic nodules” means one of the resources of the Area consisting of any deposit or accretion of nodules, on or just below the surface of the deep seabed, which contain manganese, nickel, cobalt and copper; (ISA)
- Half buried in soft sediments on ocean floor in about 5000m deep sea;
- Size from 1cm to 10cm;
- Contents: Manganese, Iron, Nickel, Copper, Cobalt, Zinc, Lead, Iridium, Uranium, Palladium, Thorium, Gold etc.



Polymetallic Nodules

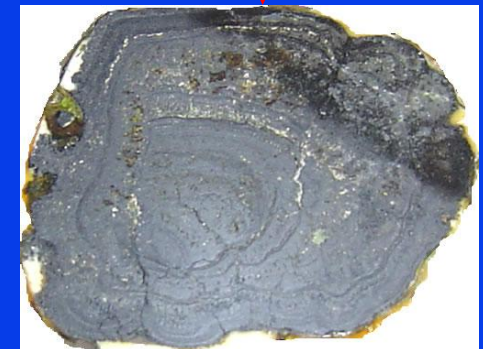
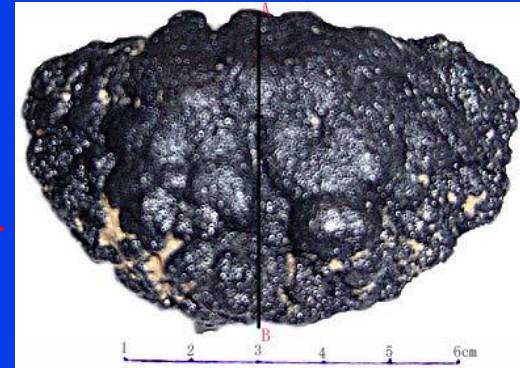
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Deep sea video system



Various shape of nodules



Samples from dragnet

Contents of a nodule: Mn : 27.2%,
Fe : 6.3%, Ni : 1.2%, Cu : 1.0%,
Co : 0.2%, Pt : 0.1 ppm



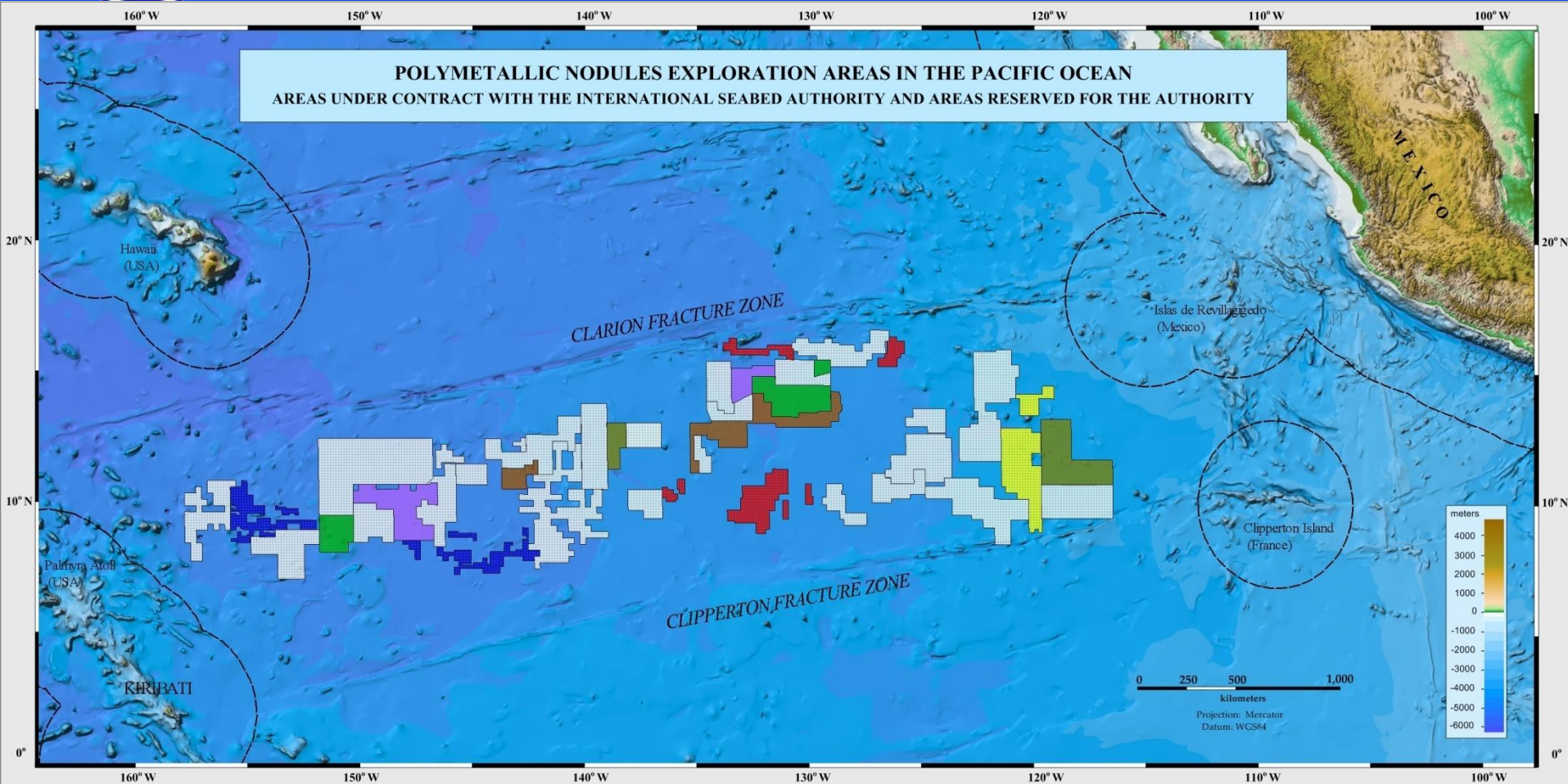
Nodules in C-C zone

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- The regions of polymetallic nodules in the Area with potential economic value based on metal content and abundance lies between the Clarion and the Clipperton fracture zones (C-C zone) in the north Pacific and Central Indian Ocean.
- The estimated quantity of the nodule resource in the C-C zone, is 34 billion metric tons of nodules containing:
 - Mn -- 7500 million metric tons
 - Ni -- 340 million metric tons
 - Cu -- 265 million metric tons
 - Co -- 78 million metric tons (Morgan, 2000).



Nodule Areas in the C-C zone of Pacific Ocean



Legend

Contractor Areas	Reserved Areas
COMRA (China)	Limits of Exclusive Economic Zones
DORD (Japan)	
Government of Korea	
IFREMER (France)	
Interoceanmetal	
Yuzhmorgeologia (Russian Federation)	
FIGNR (Germany)	



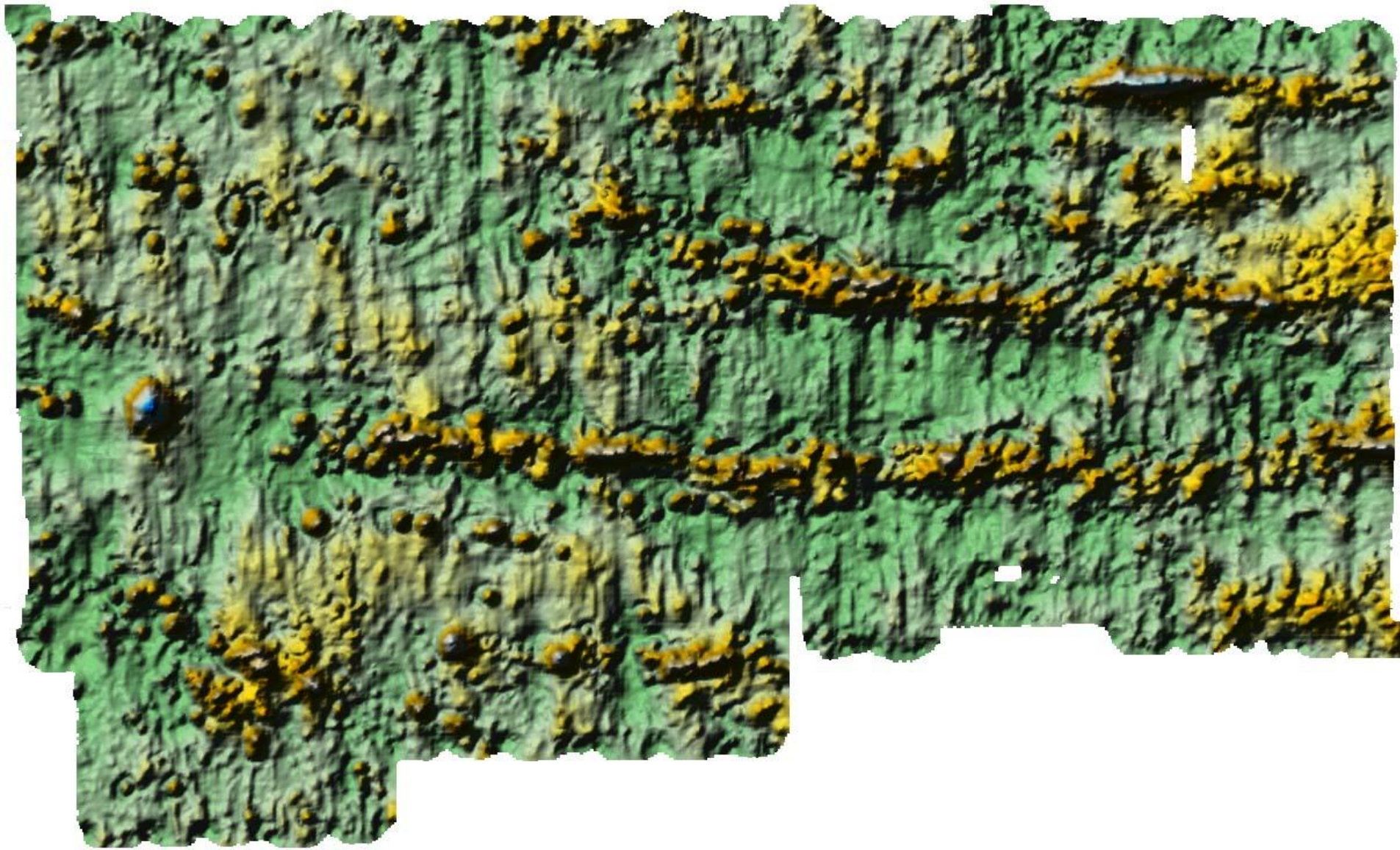
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(from www.isa.org.jm)



Topography of some region of C- C zone

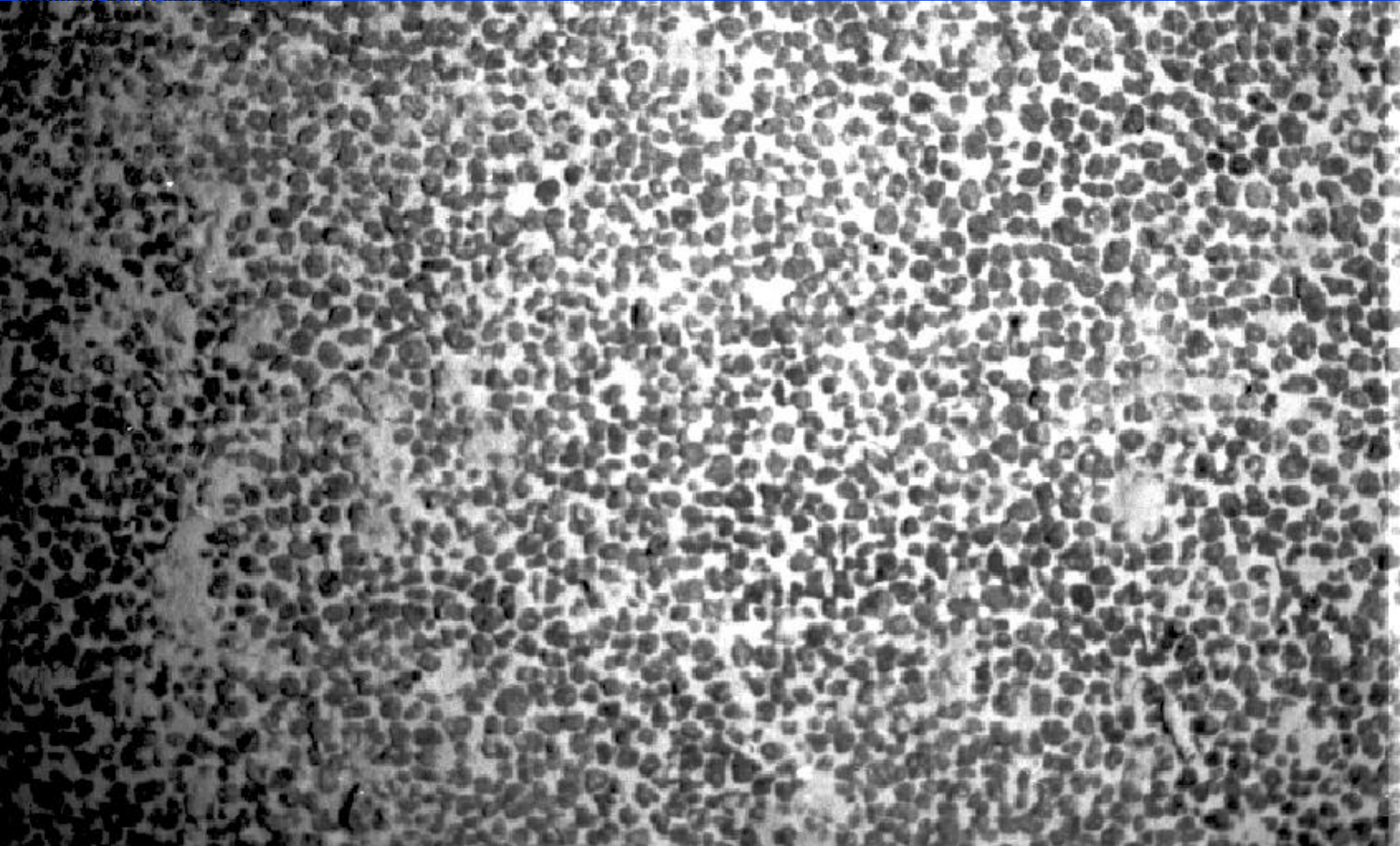
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Nodules distribution in some area

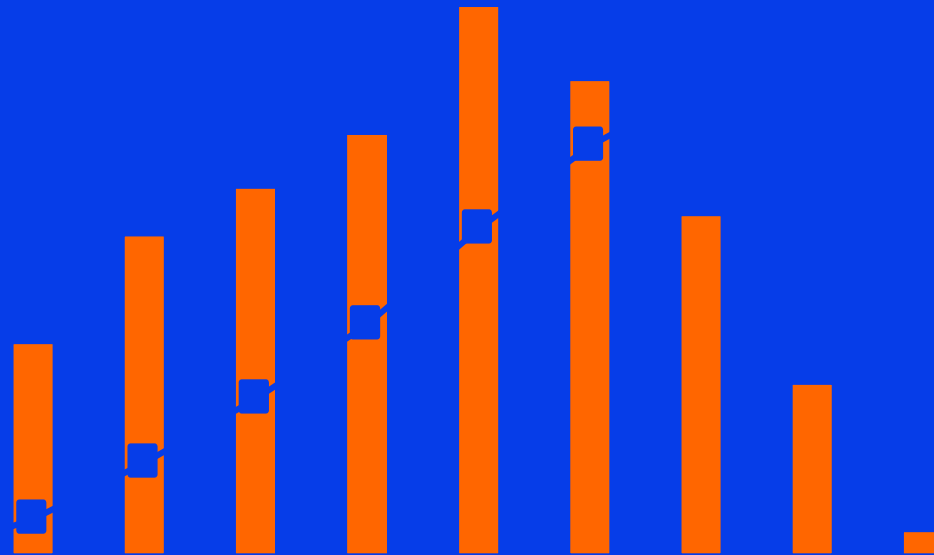
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Distribution frequency of nodule abundance in some region

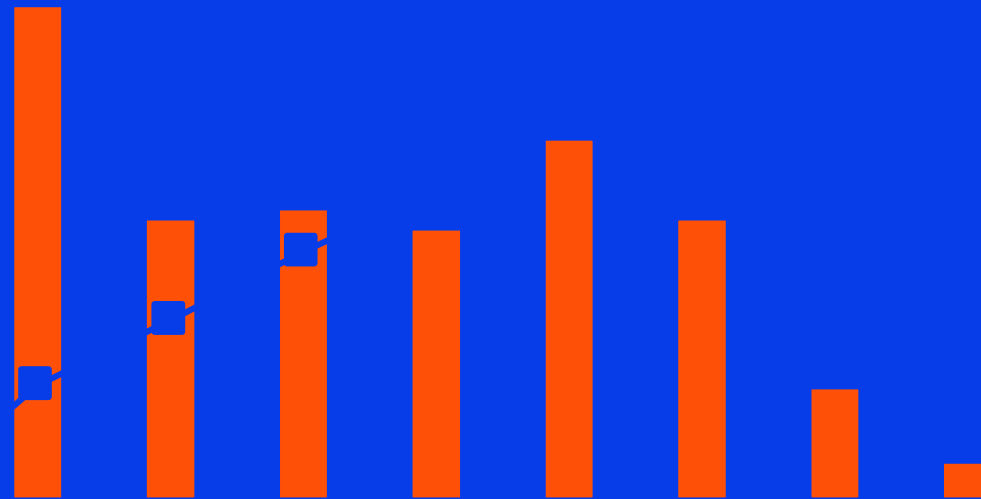
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Distribution frequency of nodule grade in some region

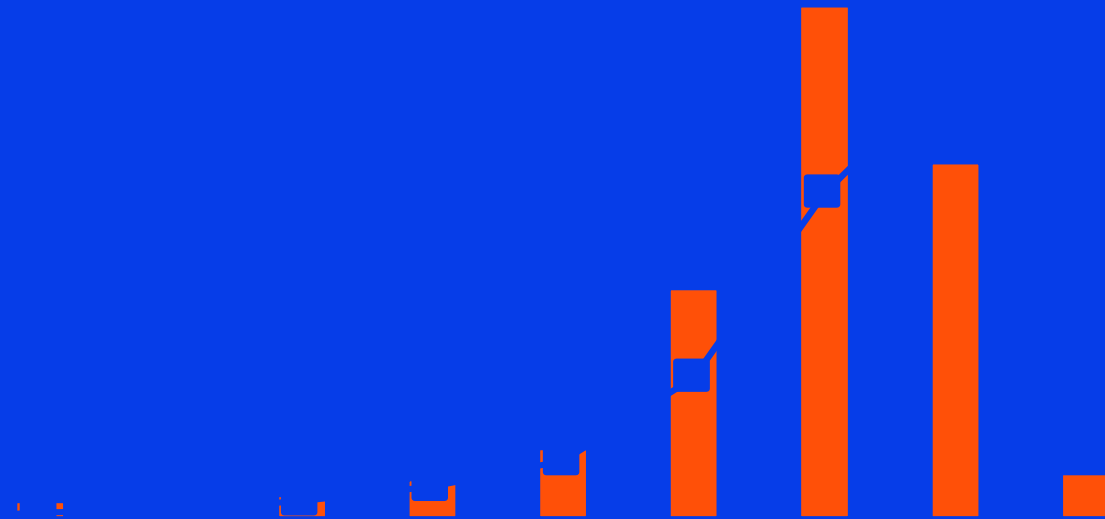
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Distribution frequency of nodule grade in some region

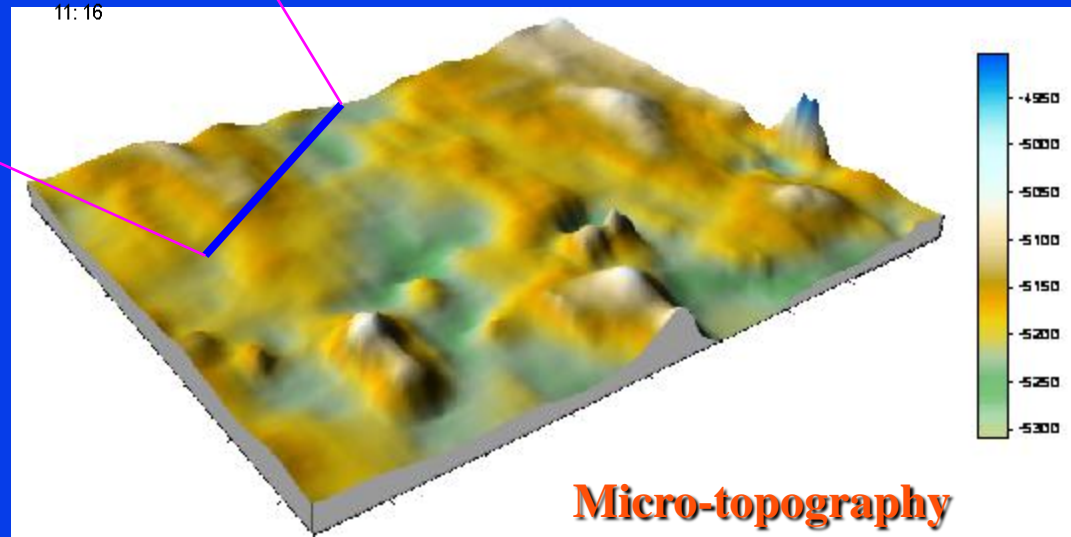
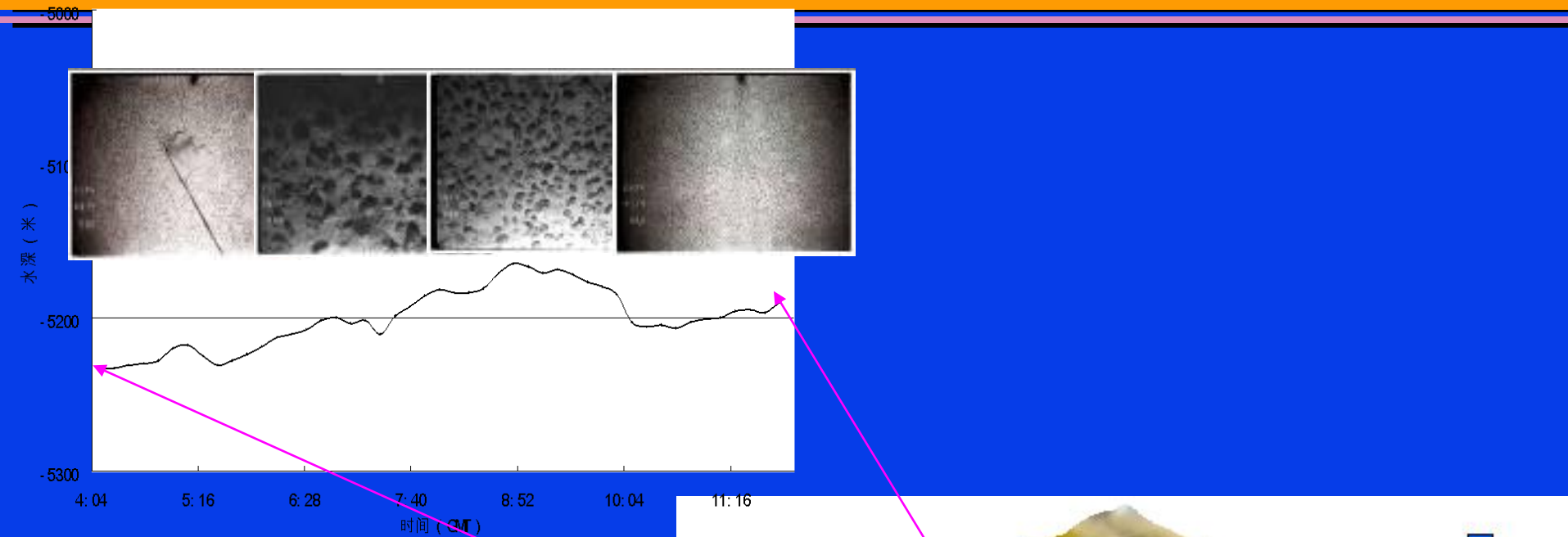
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Distribution of nodules in small distances

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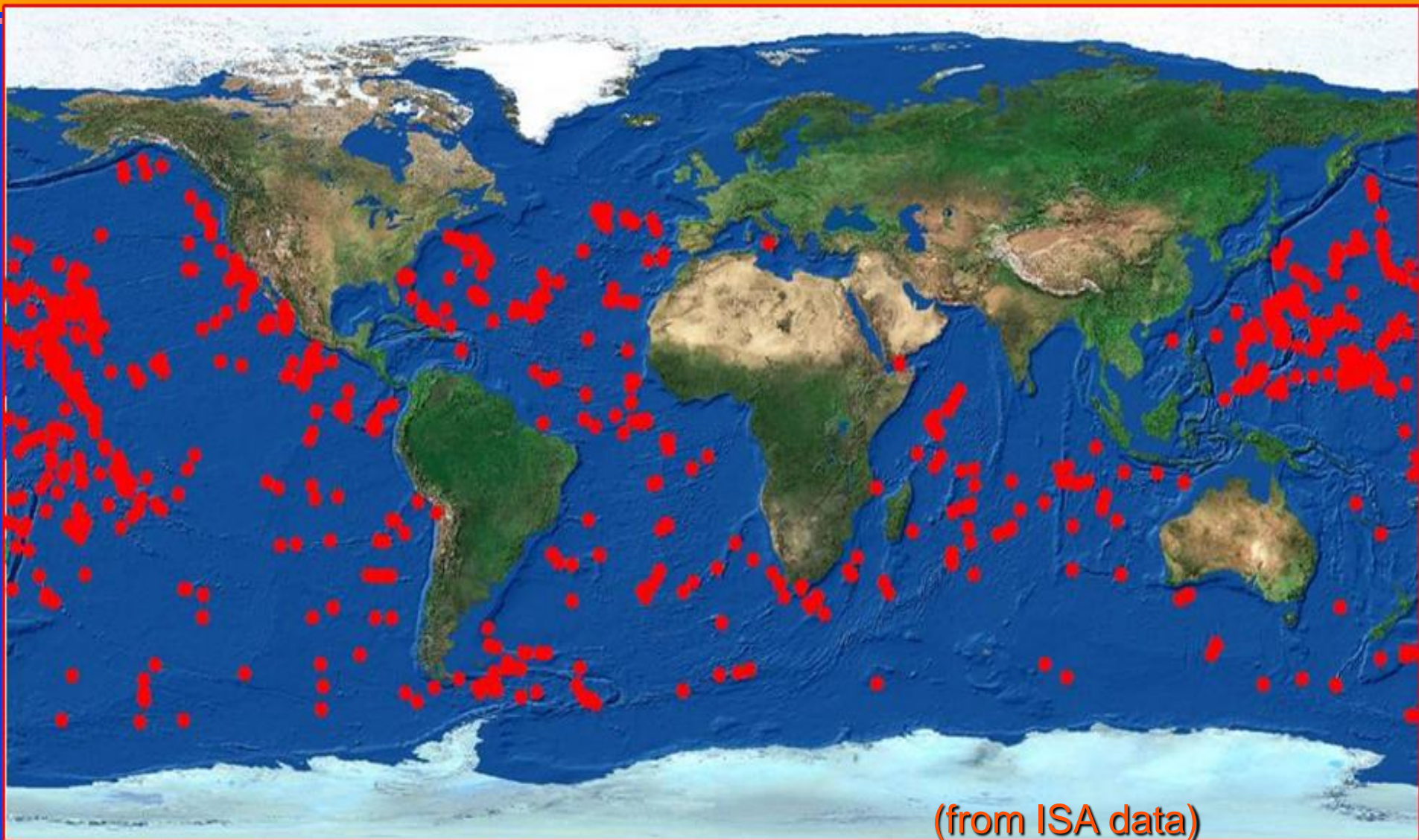


Micro-topography



Cobalt-rich crusts locations represented in the ISA CDR

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Cobalt-rich crusts

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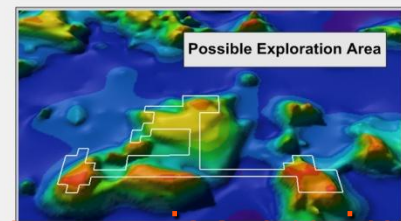
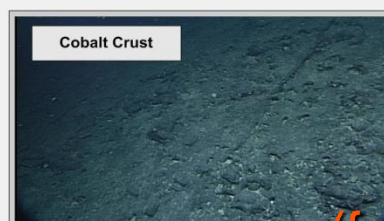
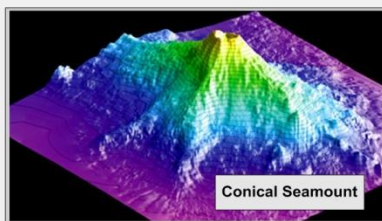
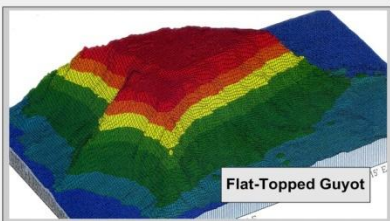
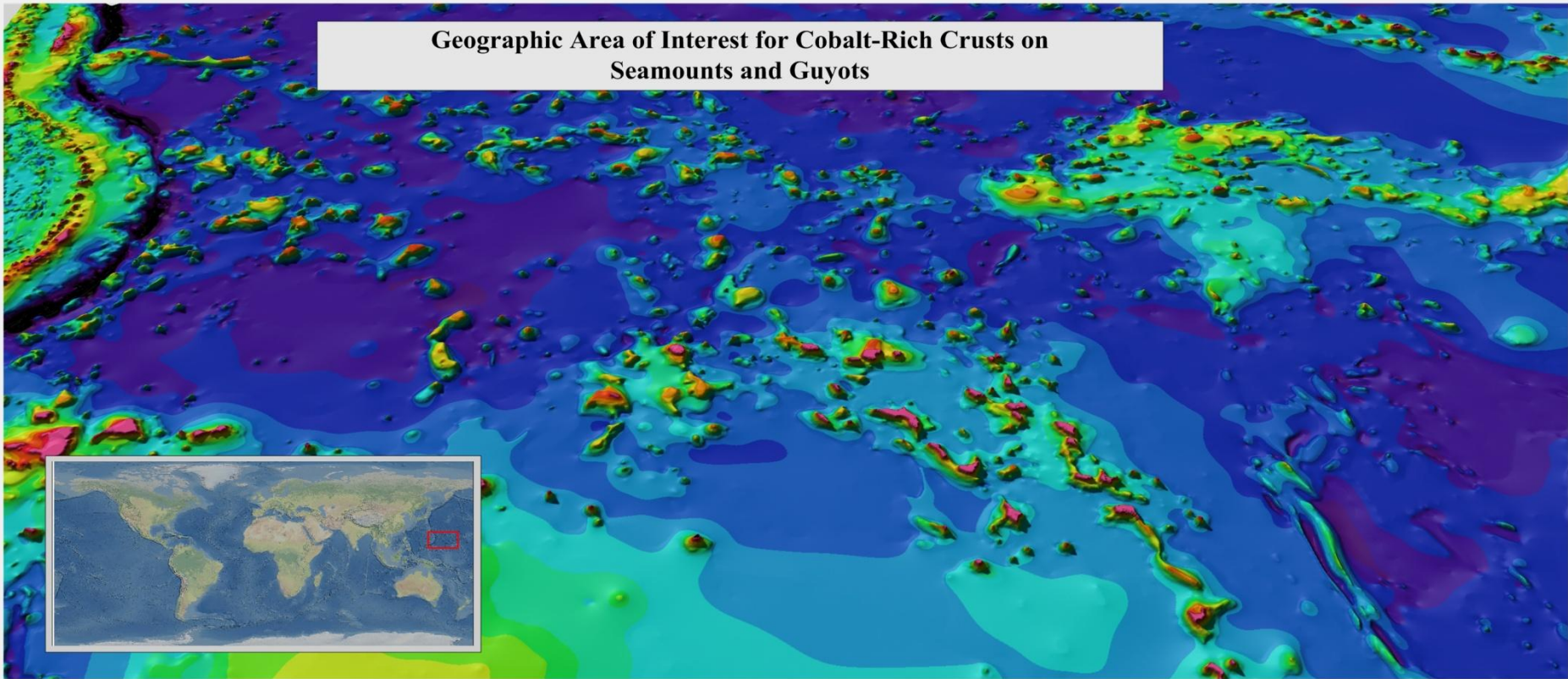
- “Cobalt crusts” means hydroxide/oxide deposits of cobalt-rich iron/manganese (ferromanganese) crust formed from direct precipitation of minerals from seawater onto hard substrates containing minor but significant concentrations of cobalt, titanium, nickel, platinum, molybdenum, tellurium, cerium, other metallic and rare earth elements; (ISA)
- Crusts are mainly distributed on the summit outer rim of seamounts;
- Striking feature of Co-rich crusts is the high Co content (0.55% on average) .



Area of interest for Cobalt-rich crusts in NW Pacific Ocean

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Geographic Area of Interest for Cobalt-Rich Crusts on Seamounts and Guyots



Copyright©ISA 2007
Data Source Bathymetry: GEBCO

(from www.isa.org.jm)



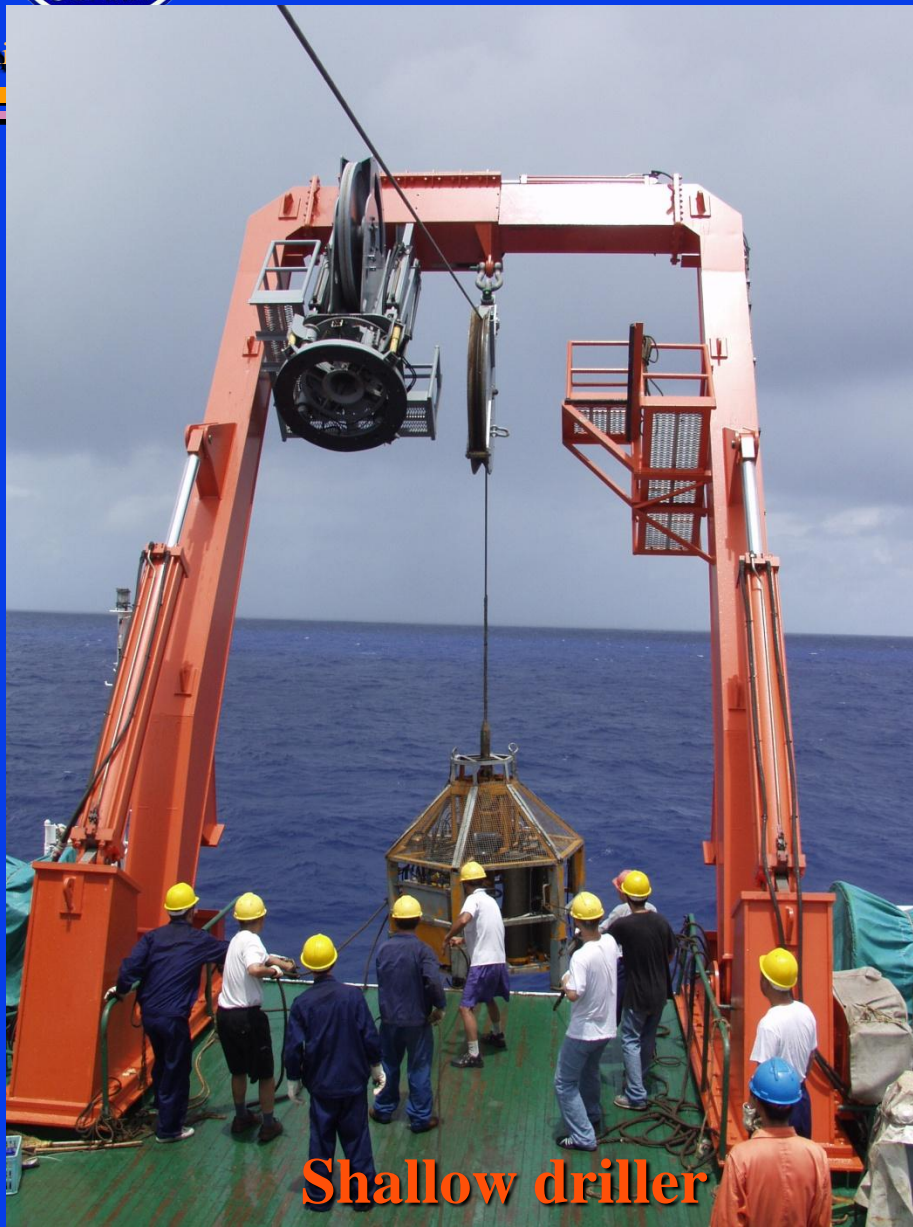
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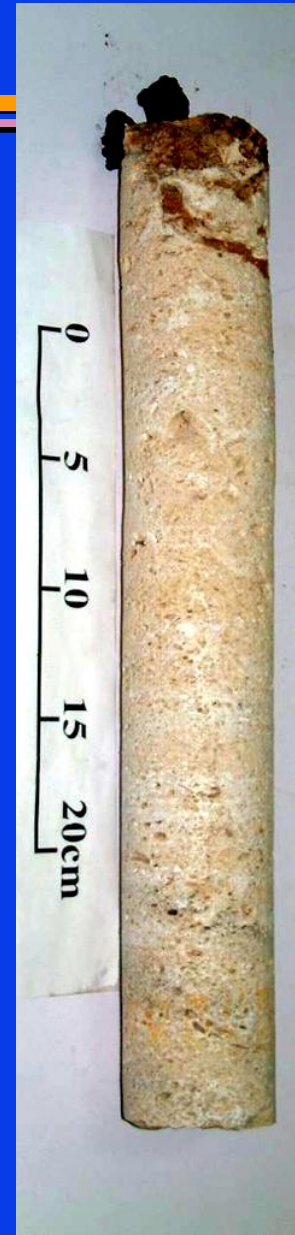
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Shallow driller and cores



Shallow driller

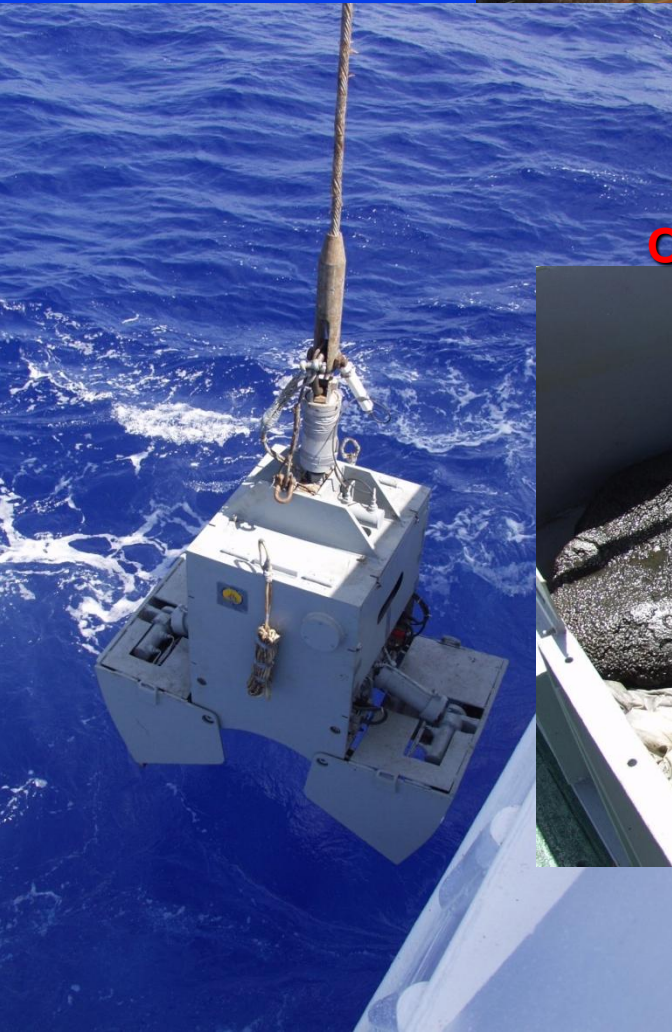




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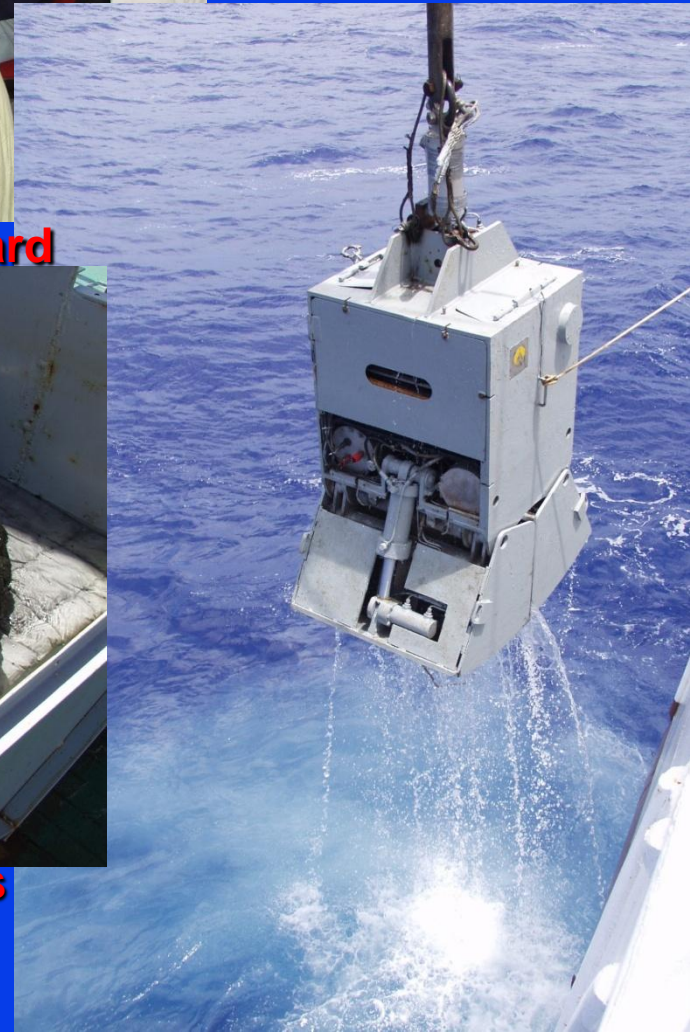
TV grab



Operating TV grab on board



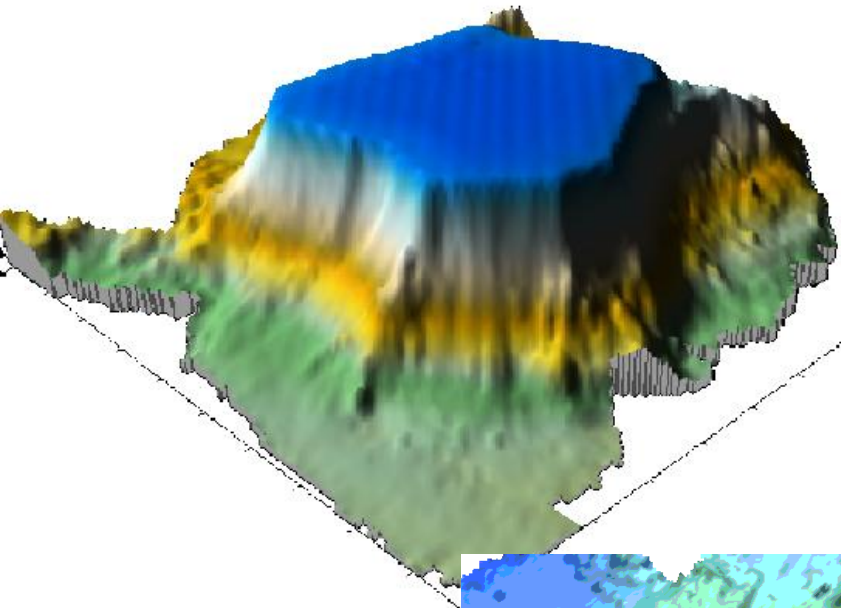
Derived Co-rich crusts



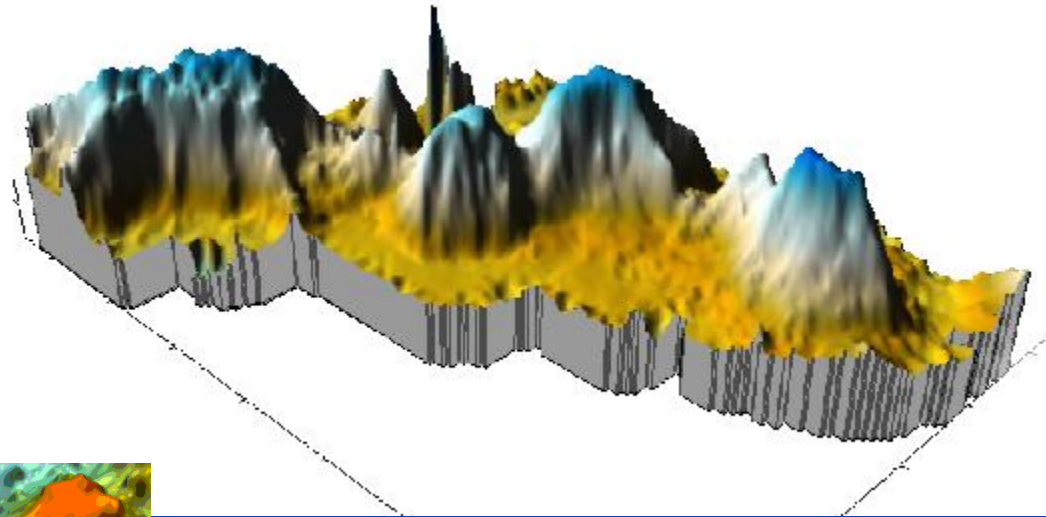


Seamounts where Co-rich crusts occur

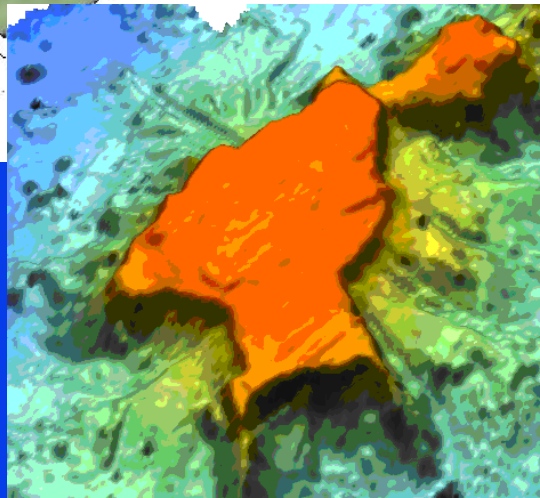
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Guyot



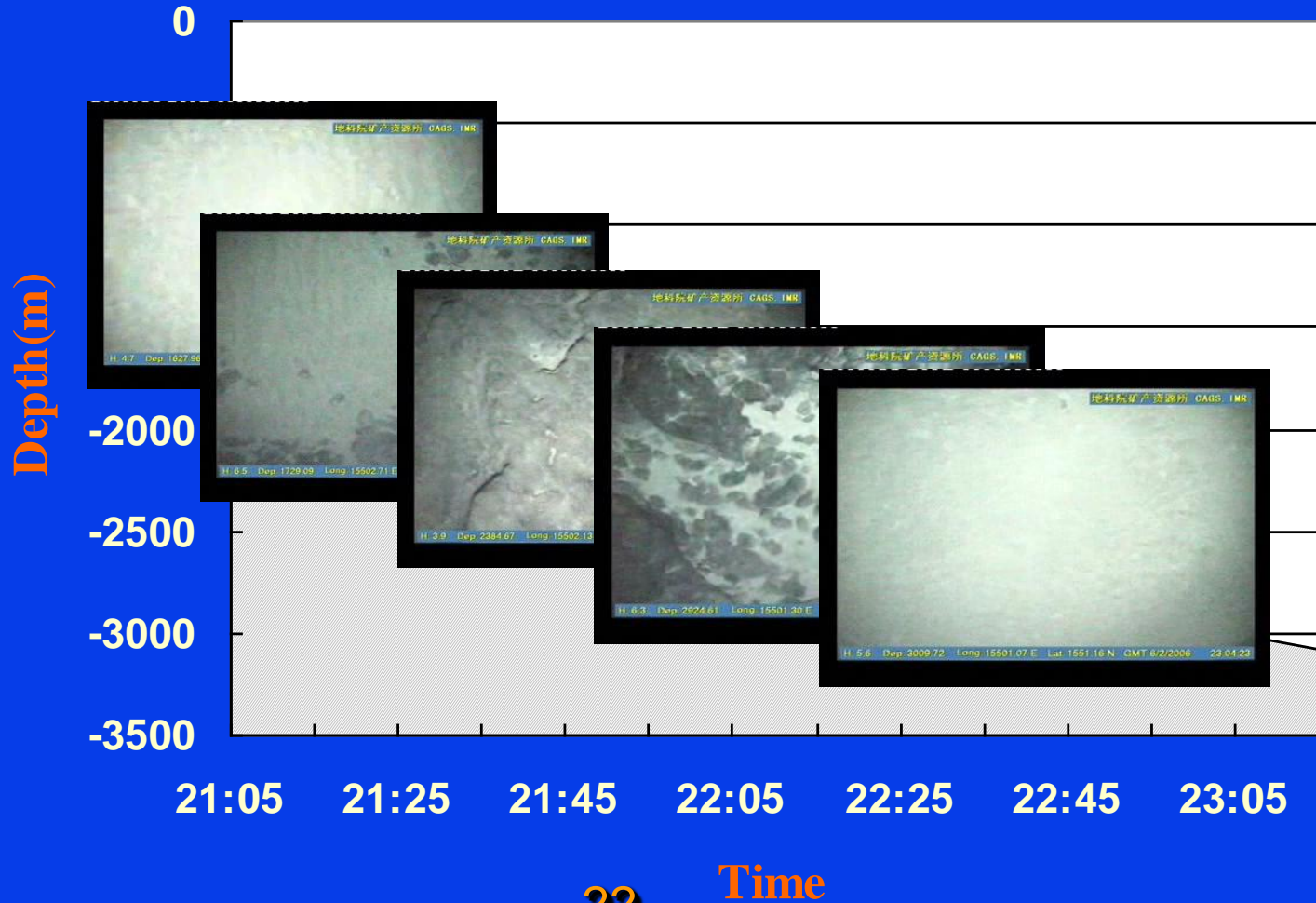
Conical Seamount





Distribution of crust around guyot

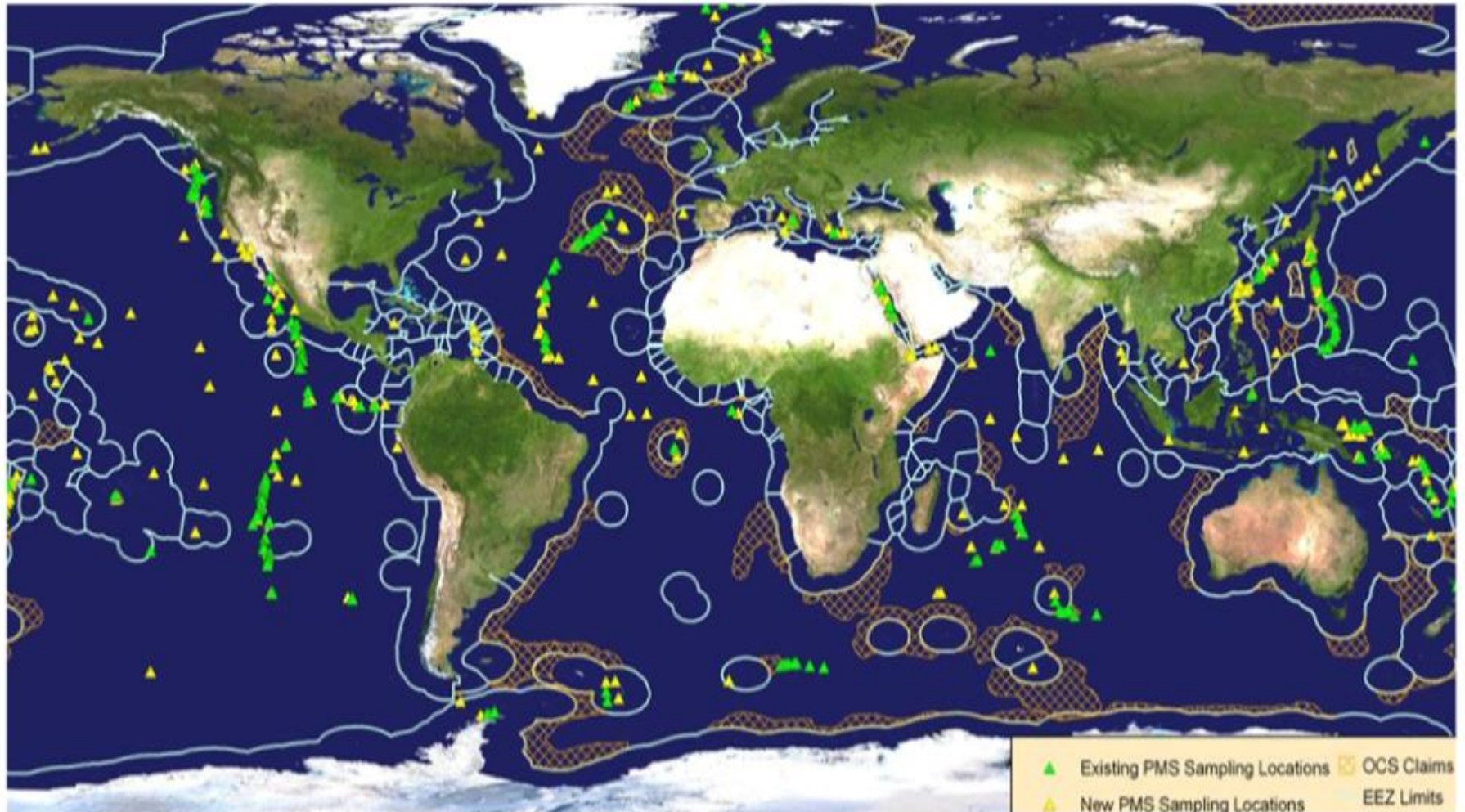
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Locations of polymetallic sulphides occurrence in the ISA CDR

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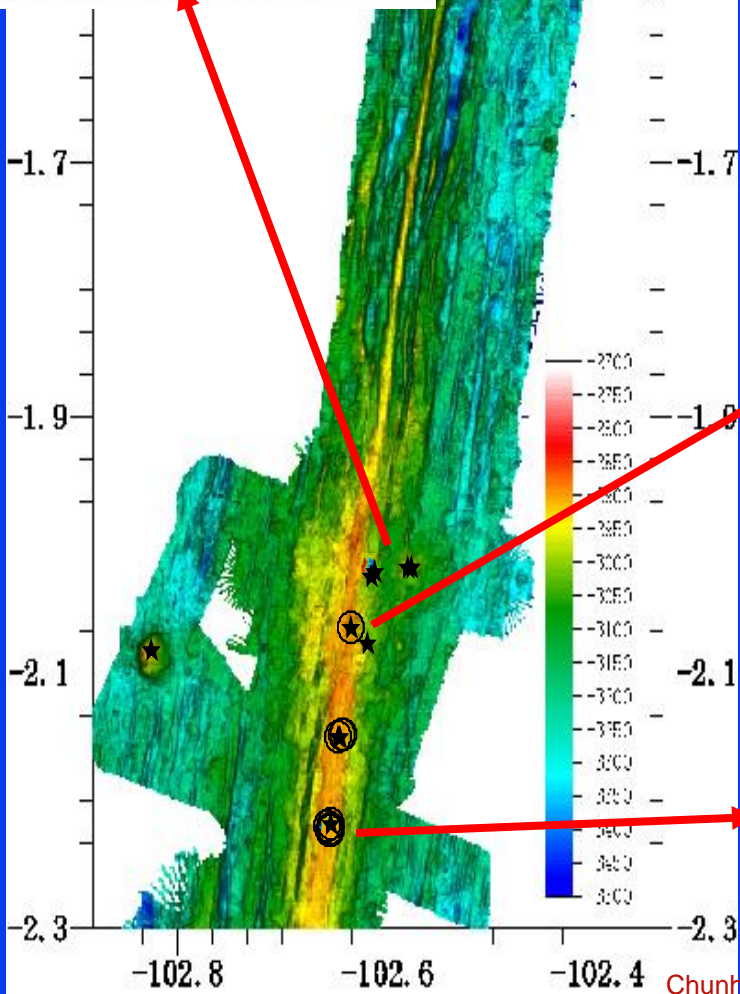
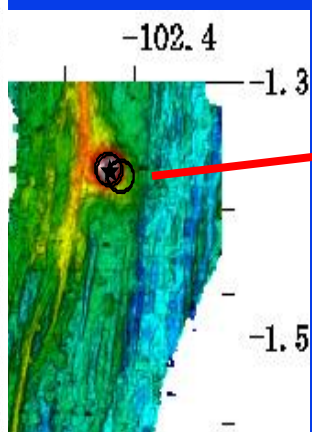
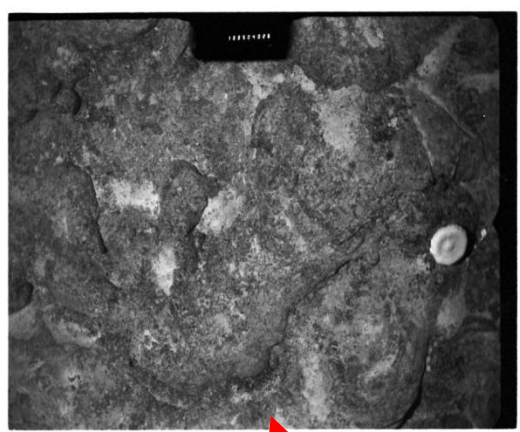




Polymetallic Sulfides

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- “Polymetallic sulphides” Means hydrothermally formed deposits of sulphides and accompanying mineral resources in the Area, which contain concentrations of metals including, inter alia, copper, lead, zinc, gold, and silver; (ISA)
- Many of the sulphide deposits consist of a black smoker complex on top of a sulphide mound which commonly is underlain by a stockwork zone;
- Polymetallic sulfides in the oceanic ridges embrace various groups of deposit: (Zn and Cu), (Cu and Zn) (Zn and Pb), (Au and Ag)....



Chunhu



Some observation for sulfide

(from Hanninton , 2006 and Tao)

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- More than 300 hydrothermal site, about 40% of those are in the Area
- 65% at mid-ocean ridges; 22% back-arc basins; 12% volcanic arcs; 1% mid-plate volcanoes
- About 100 of those host polymetallic sulfides
- 55,000 km of oceanic spreading ridge; 22,000 km of volcanic arc and back-arc spreading
- 2 known to be greater than 1 million tons confirmed by ODP; Several others may also contain >1 million tons
- Individual occurrences extend no more than 1 km
- Resource quantity is strongly controlled by ridge spreading rate



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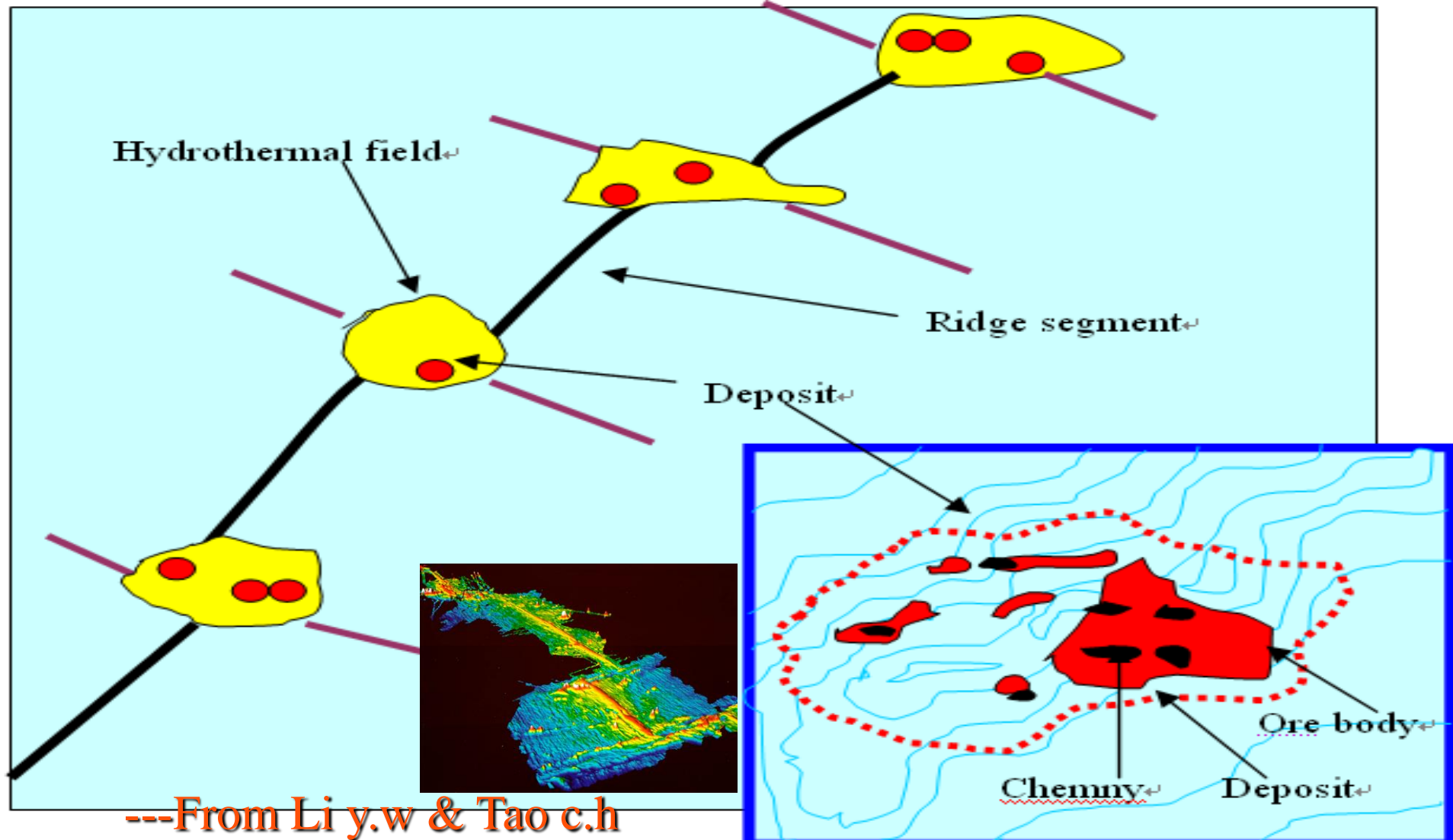
Factors for exploration area

- mid-ocean ridge spreading rates
- density of hydrothermal fields along ridges
- statistical distribution of the number of deposits within a hydrothermal field
- statistical distribution of ore tonnage of deposit
- Min. tonnage of a deposit
- annual ore production
- project mine life



Relationship of sulphide exploration area (mine site) along with the ridge

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Comparison of mineral resources in deep seabed

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	Nodule	Crust	Sulfide
Area	ISB	ISB & LCS	LCS & ISB
Region	Ocean Basin	Sea Mountain	Ridge...
Water Depth	4000-6000 m	800-3000 m	500-3500 m
Estimate resources	.5~14 Bt	?	?
Metal	Cu,Ni,Co,Mn	Co,Ni,Po...	Cu,Pb,Au,Ag
Dimension	2	---	3
Exploration Size	150,000 km ²	? km ²	10,000 km ²
Exploitation Size	75,000 km ²	? km ²	2,500 km ²
ISA participation	Site banking	Join venture/SB	Joint venture/SB



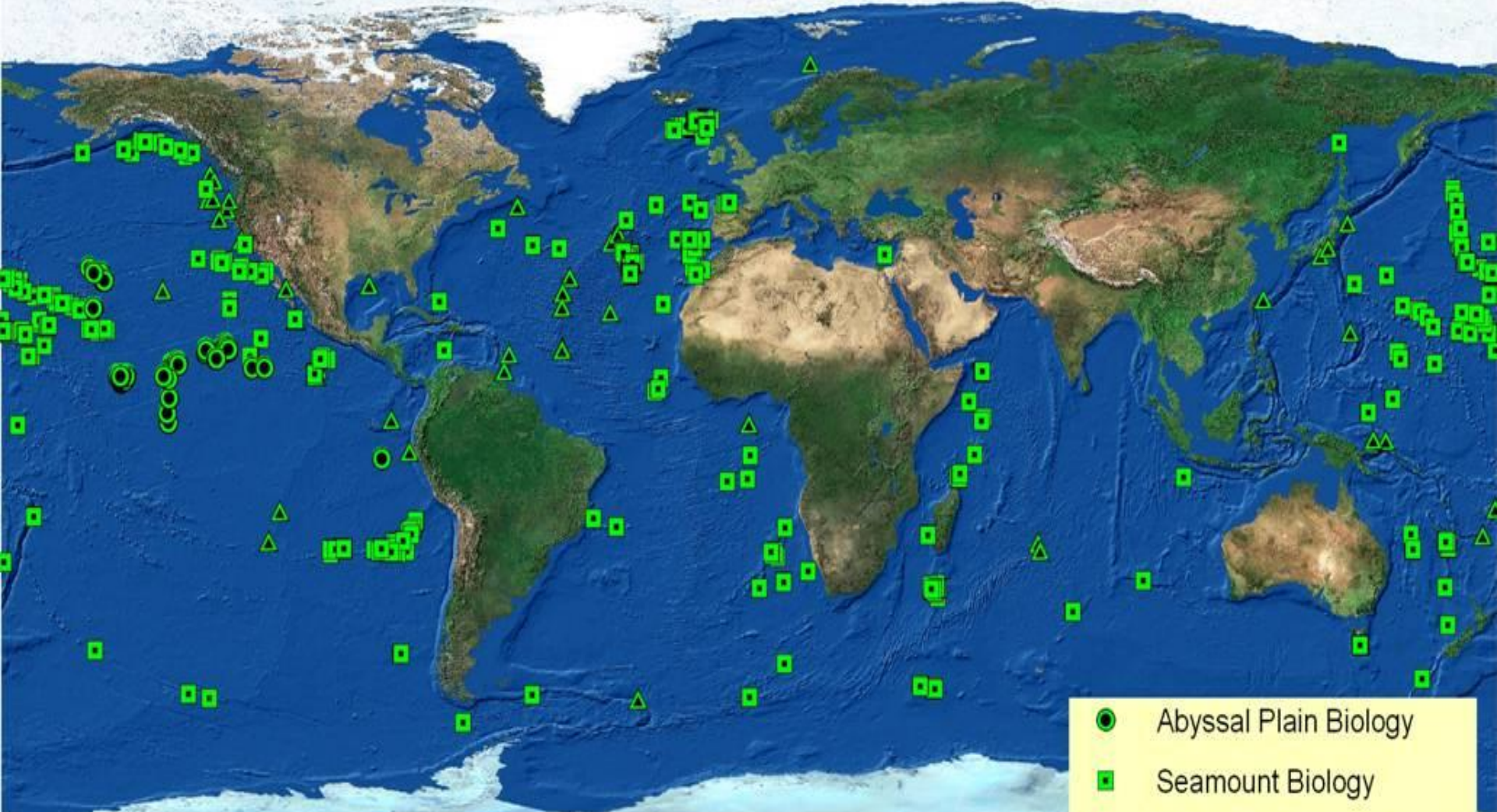
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Biodiversity and Genetic Resources of the Deep Seabed



Biological data locations represented in the ISA CDR

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- Abyssal Plain Biology
- Seamount Biology
- ▲ Hydrothermal Vent Biology

(from ISA data)



Eco-system in deep seabed

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	Continental Margin	Ocean Basin	Sea mountain	Ridge vent (active)
Mineral may exist	various	Nodule	Crust	Sulfide
Water depth	2500-3000 m	4000-6000 m	800-3000 m	500-3500 m
Biodiversity	rich	rich	rich	---
Living area		90% covered by sediments	various	various
Living condition	low t, high p	low t, high p	---	high t & p
Endemic	low	---	high	high
Vulnerability	---	---	---	high



Bio-prospecting

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■ There is no internationally-agreed definition of the term:

- “The exploration of biodiversity for commercially valuable genetic and biochemical resources”; and “the process of gathering information from the biosphere on the molecular composition of genetic resources for the development of new commercial products”. --- (UNEP/CBD/COP/5/INF/7)
- “Systematic search for genes, natural compounds, designs, and whole organisms in wild life with a potential for product development by biological observation and biophysical, biochemical and genetic methods, without disruption to nature”. ---(Academic Press, 2001, p.471)



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Possible elements of a definition of bio-prospecting

- Systematic search, collection, gathering or sampling of biological resources for purposes of commercial or industrial exploitation;
- Screening, isolation, characterization of commercially useful compounds;
- Testing and trials;
- Further application and development of the isolated compounds for commercial purposes, including large-scale collection, development of mass culture techniques, and conduct of trials for approval for commercial sale. ---(UNU-IAS Report, 2005, p.15)



Legal status of genetic resources of deep seabed

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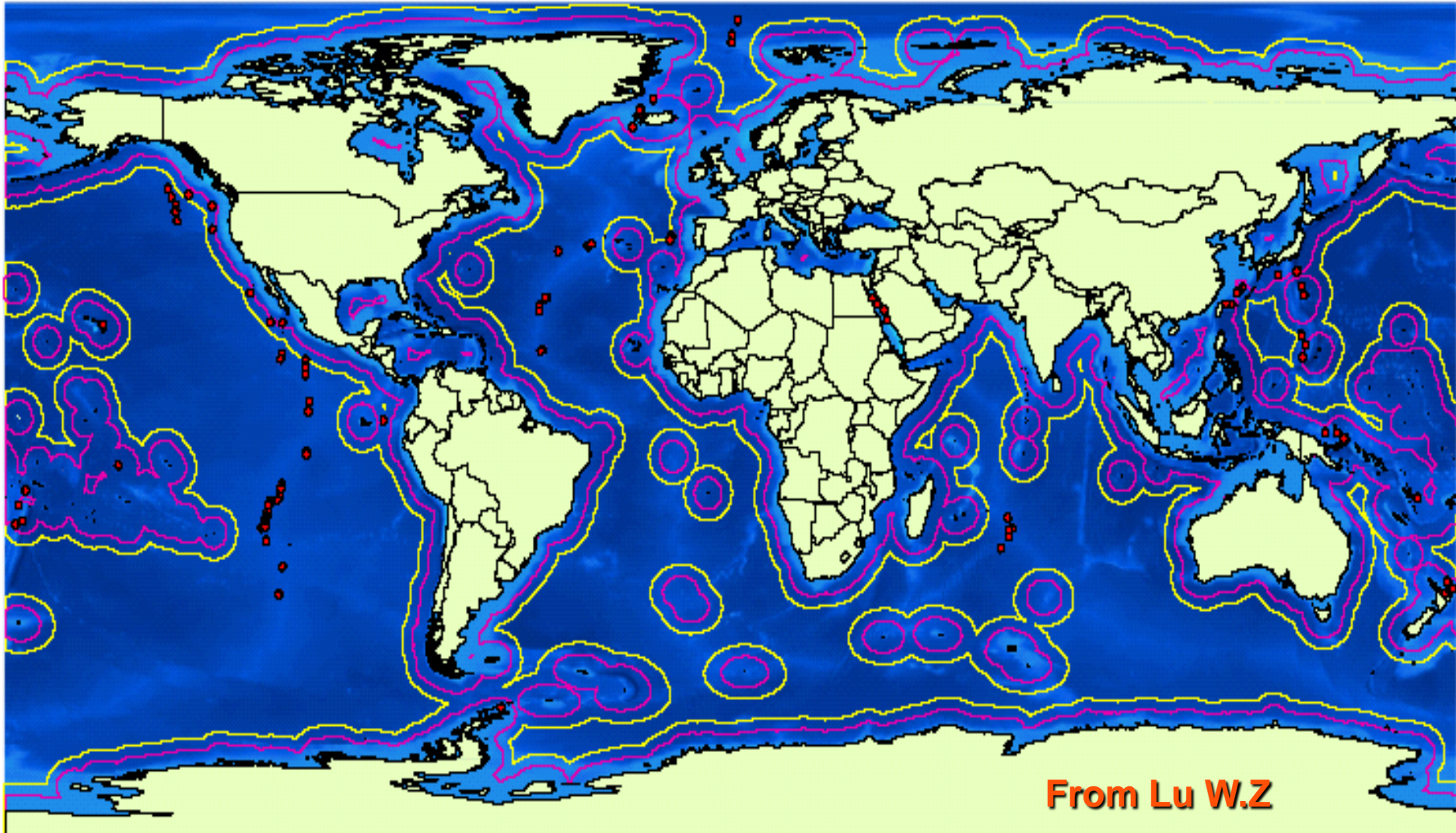
- “Freedom” of the high sea
 - Boundary of EEZ/LCS with 200 nm

- Principle of “common heritage of mankind” of the Area
 - Boundary of continental shelf beyond 200 nm



Boundary between national and international jurisdiction

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From Lu W.Z



- The coincidence of non-living and living resources poses the challenge to develop a regime that allows sustainable development of both resources while protecting the ecosystem.

----ISA



Precautionary approach and management tool

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- Development of modern science and tech generates two main points for management of biodiversity of the seabed:
 - Precautionary approach
 - Management tools
 - Integrated ocean management and ecosystem approaches
 - Environmental impact assessments
 - Area-based management tools, including the establishment of marine protected areas



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Process to Find the Mineral Resources of the Area: – the Role of Marine Scientific Research



Terms for prospecting & exploration

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- “prospecting” means the search for deposits of polymetallic nodules (sulfides, crusts) in the Area, including estimation of the composition, sizes and distributions of polymetallic nodule (sulfide, crust) deposits and their economic values, without any exclusive rights; (ISA)
- “exploration” means searching for deposits of polymetallic nodules (sulfides, crusts) in the Area with exclusive rights, the analysis of such deposits, the testing of collecting systems and equipment, processing facilities and transportation systems, and the carrying out of studies of the environmental, technical, economic, commercial and other appropriate factors that must be taken into account in exploitation; (ISA)



Term for marine scientific research (MSR)

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- There is no internationally-agreed definition of the term “MSR”.
 - Pure scientific research— for non-commercially-oriented purpose;
 - MSR intended to increase scientific knowledge of the ocean for benefit of all humankind;
 - Applied scientific research— for commercially-oriented research.
 - MSR “ of direct significance for the exploration and exploitation of natural resources, whether living or non-living”.
---Art.246(5a), UNCLOS)



Term for MSR

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- The distinction in former is not made with regard to MSR undertaken in the Area
- The Authority may carry out marine scientific research concerning the Area and its resources, and may enter into contracts for that purpose. The Authority shall promote and encourage the conduct of marine scientific research in the Area, and shall co-ordinate and disseminate the results of such research and analysis when available. (Article 143(2) UNCLOS)



The role of MSR

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- MSR is a pioneer activity leading to discovery and interests in resources with economic potential;
- Basic methods and backgrounds for exploring seabed stem directly from the well-developed disciplines of geological, physical and biological oceanography;
- Results from scientific research used for various purposes, including for deepening and broadening the scientific achievement and for discovering and identifying the resources.



Process is comparable between MSR and prospecting (exploration) at sea;

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Step	Prospecting (exploration)	Scientific research
1	Target area based on resources strategy & policy	Objective based on science frontier & interest
2	Desk study	
3-4	Cruise design, survey at sea	
5	Beginning from large area	for general objective
6	Analysis, density stations, smaller area	Analysis, identify specific objective
7	Repeat 3-4...	
8	Delineate area for exploration (exploitation)	Identify area for further study



Resource assessment (1)

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■ Geological factors

- **Target area** -- tectonic features, topography, regional strata, types and features of the surface sediment, regional rift structure;
- **Deposit** -- distribution and coverage features in the case of nodules;
- **Ore** -- types

■ Economic factors

- Grade & Ni-equivalent grade (NEG) in case of nodules
- Abundance & Ni-equivalent abundance (NEA) in the case of nodules
- Amount of resources



Resource assessment (2)

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■ Environmental factors

- Hydrological and meteorological
- Shape and integrity of ore-fields and size of ore-field blocks
- Topography of seafloor, variation of slope and the obstacle.
- Feature of the deposit and ore, including the hardness, size and porosity
- Geotechnics of sediments, including the solidness, shear strength and grain size
- Ecosystem and its sensitive to the operation system

■ Commercial factors

- Investment and the operation cost related to the collecting, recovery, transportation and processing of the minerals
- Variation of price for the metals possibly recovered from the minerals,
- Rate of return.



Hydrothermal ore-forming process and prediction of sulfide resources in ocean ridge

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Scientific Question I :

Geological background, characteristic & forming mechanism of hydrothermal sulfide

Scientific Question II:

Interaction between seafloor hydrothermal activities & environment

Surveying at Sea & Analysis in Lab.

Item 1

Structure of oceanic crust/upper mantel & heat source

Item 2

Characteristics & mechanism of ore-forming

Item 3

Characteristics & environmental effect of hydrothermal plume

Item 4

Hydrothermal microbes & biological metallgenesis

Surveying at Sea & Analysis in Lab.

Item 5

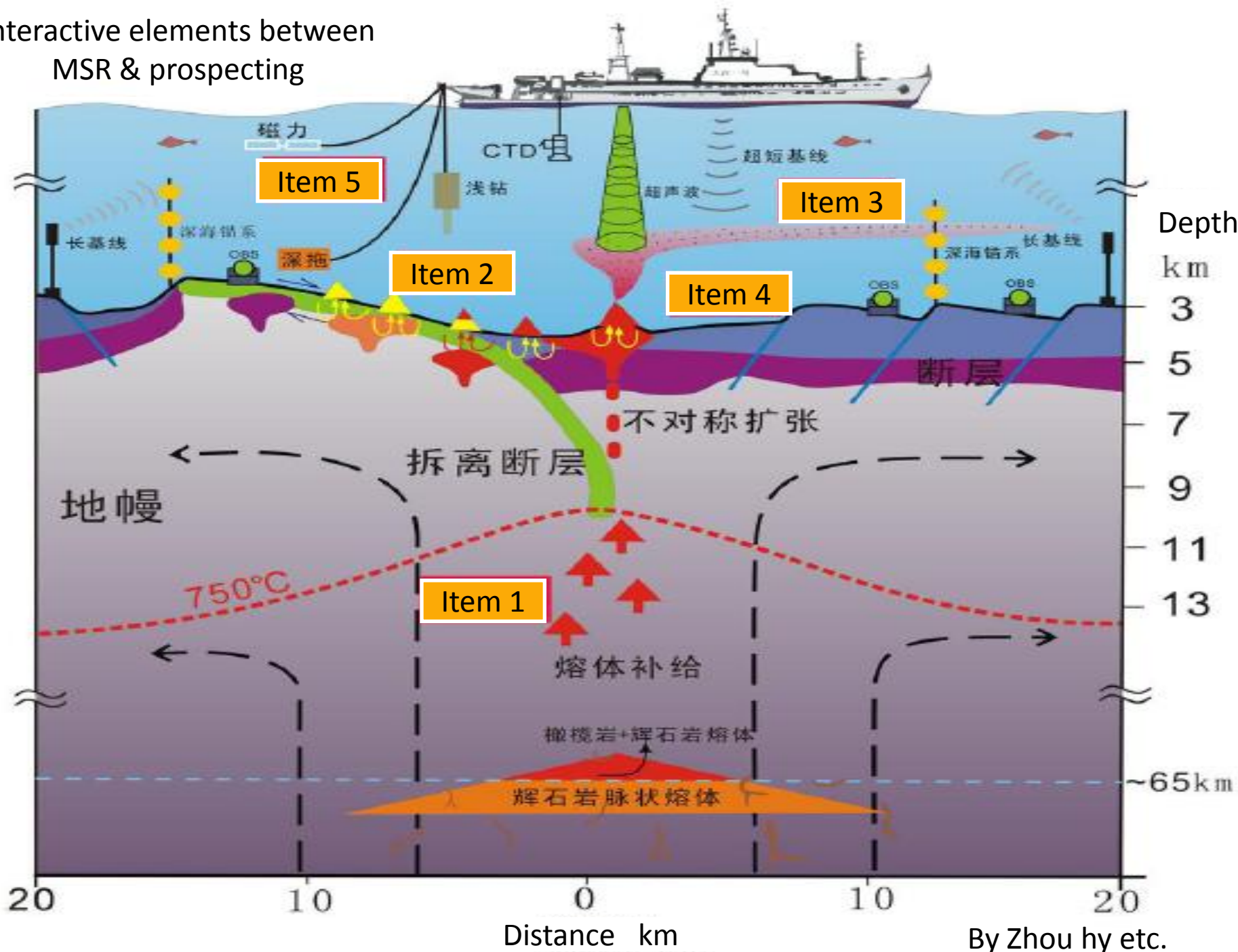
Characteristics of hydrothermal deposit & exploration indicators

Scientific achievements

By Zhou hy etc.

Prediction of sulfide resources

Interactive elements between MSR & prospecting



By Zhou hy etc.



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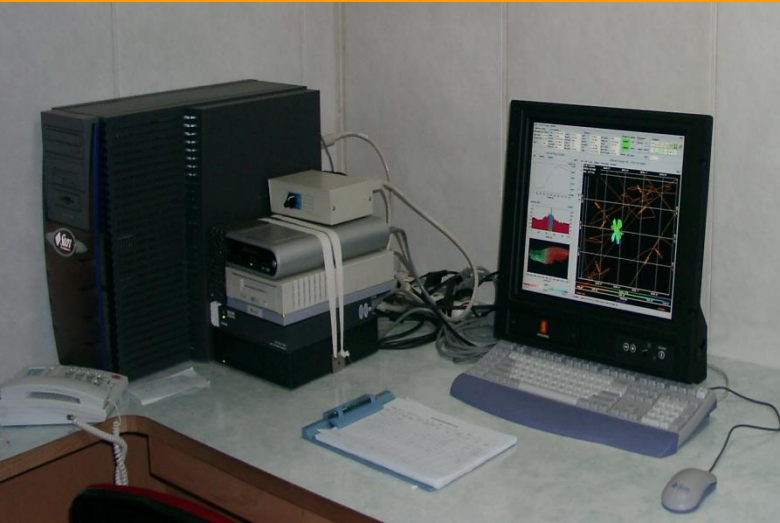
Interactive elements between MSR & prospecting in ocean ridge

- Geosciences subjects such as environment and biology at mid-ocean ridge are science frontiers, which have attracted scientists.
 - **Stage I:** Marine scientific research finds hydrothermal abnormality (turbidity and temperature of water body) which could be generated by hydrothermal vent activities;
 - **Stage II:** Identifying active vents, collecting data and sample for environment and biodiversity study;
 - **Stage III :** Identifying inactive vents, further collecting data and samples for various purposes.



Measurement of topography

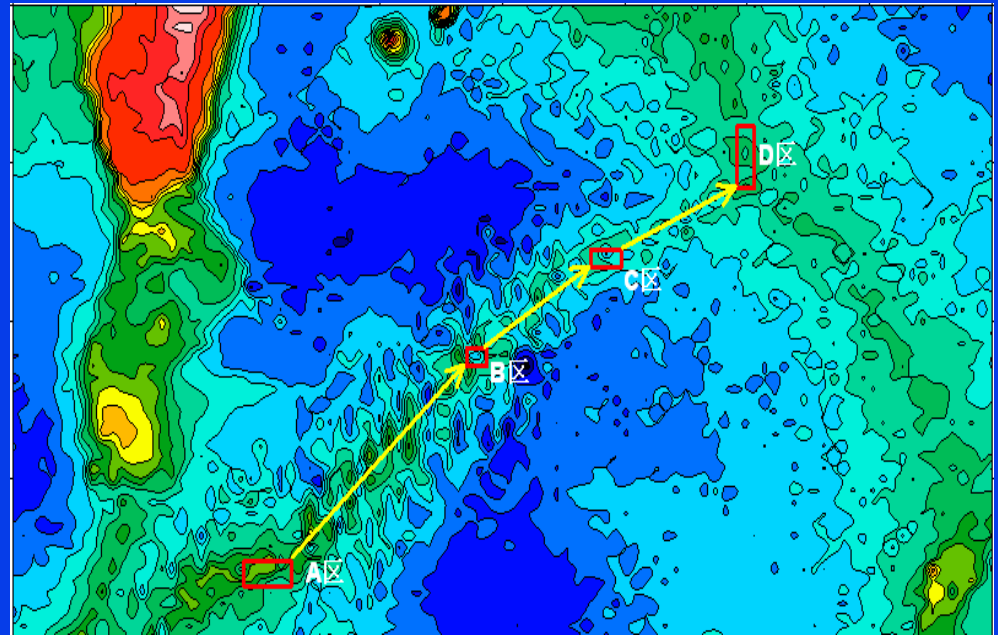
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Monitor of multi-beam system



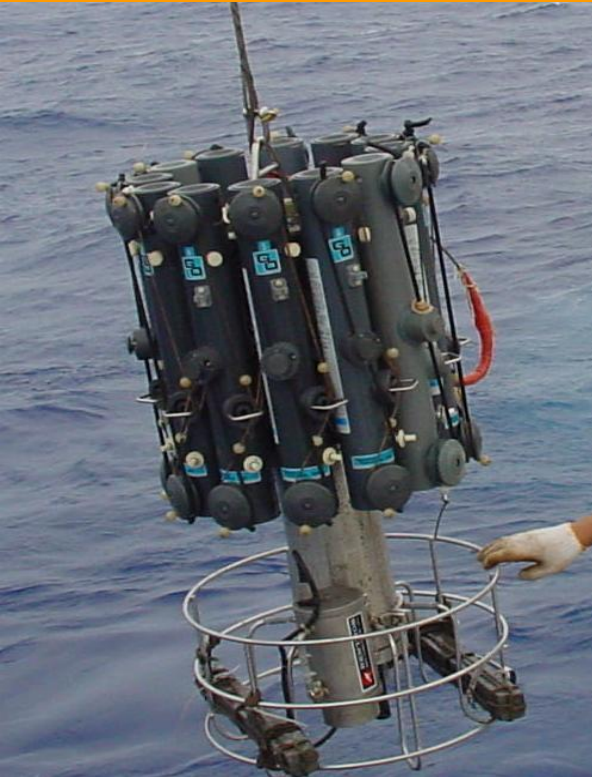
SWIR map



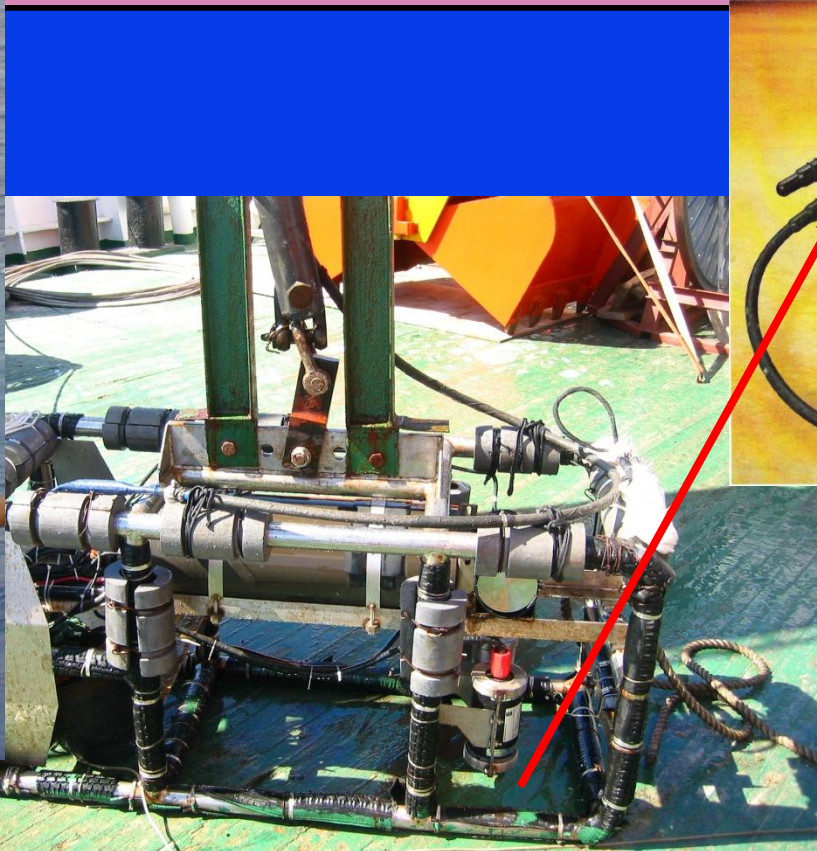


Hydrothermal detecting system gets the abnormal data of magnet, H₂s, Eh data...

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CTD



Near-seafloor magnetometer

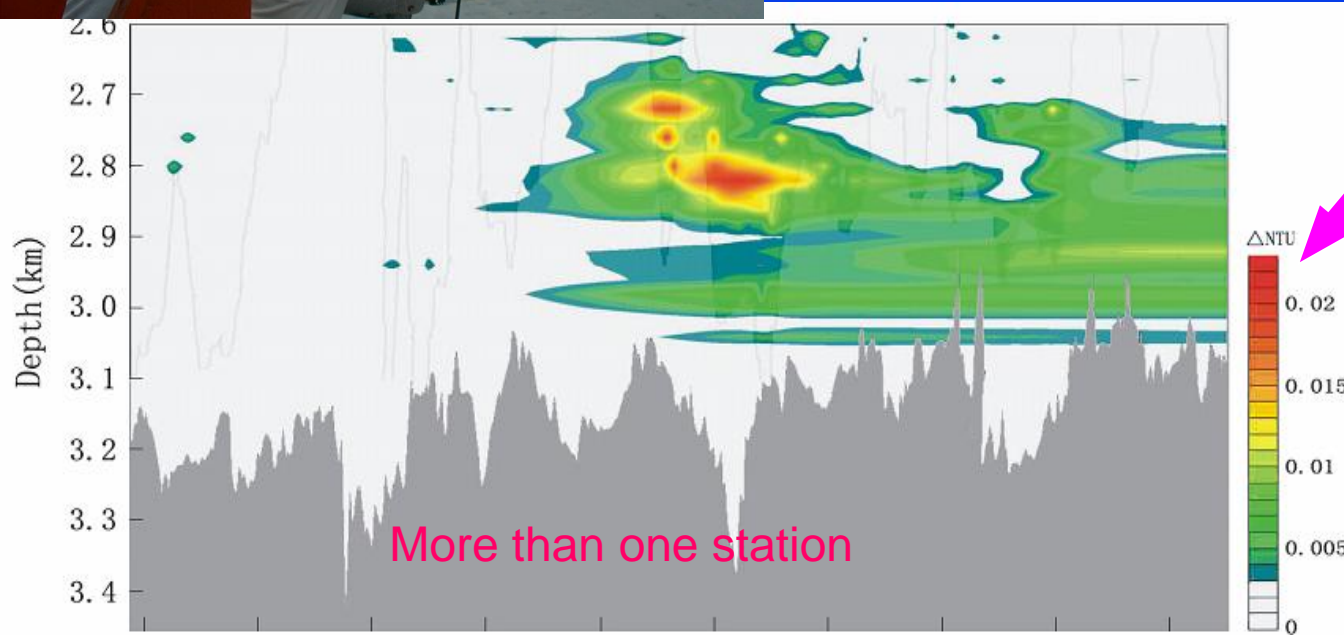
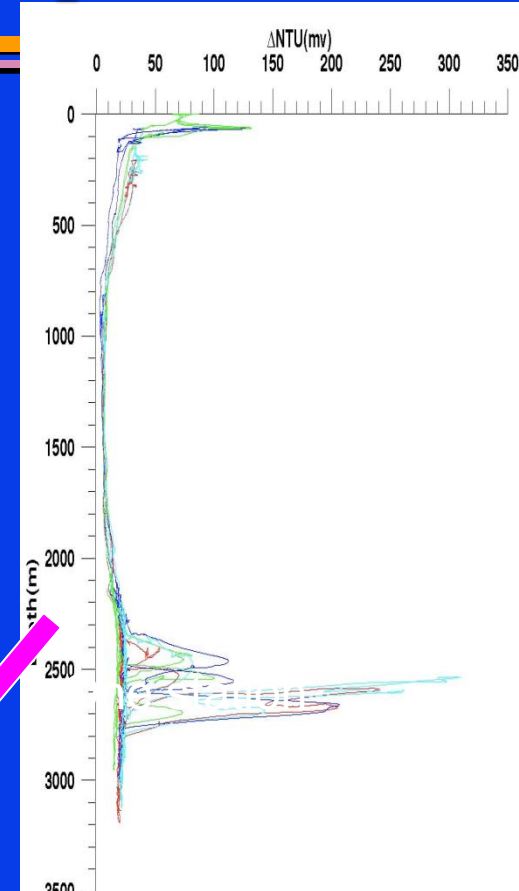
Deep tour- hydrothermal detecting system



Turbidity and temperature abnormality indicates new hydrothermal plume



Miniature Autonomous Plume Recorder (MAPR)



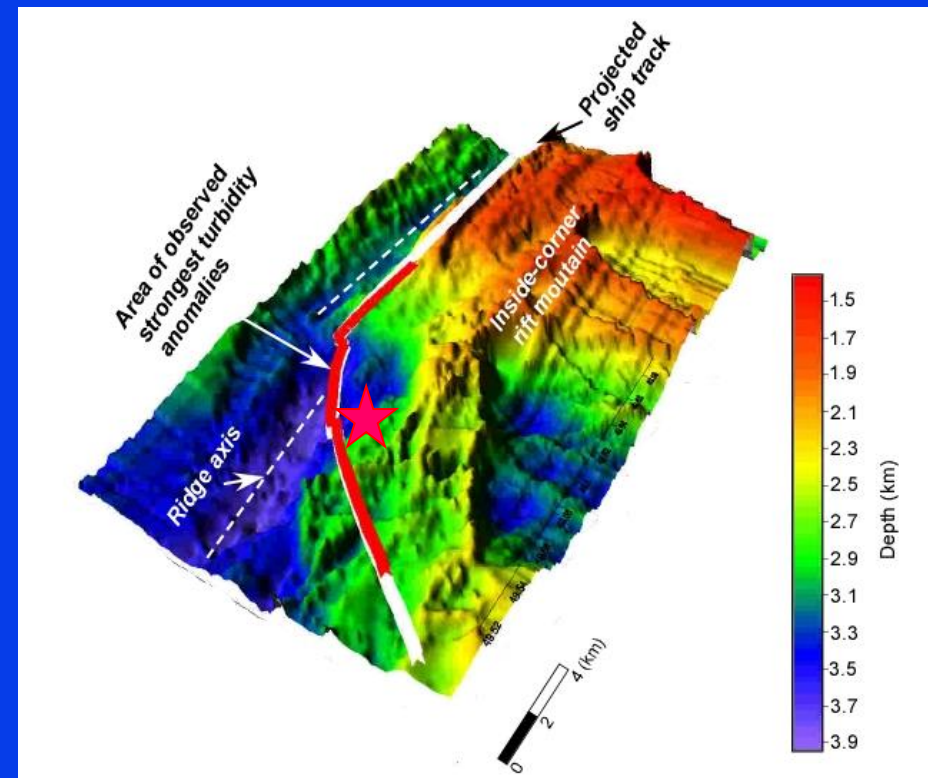


ABE, ROV and other equipment identify the location of vent

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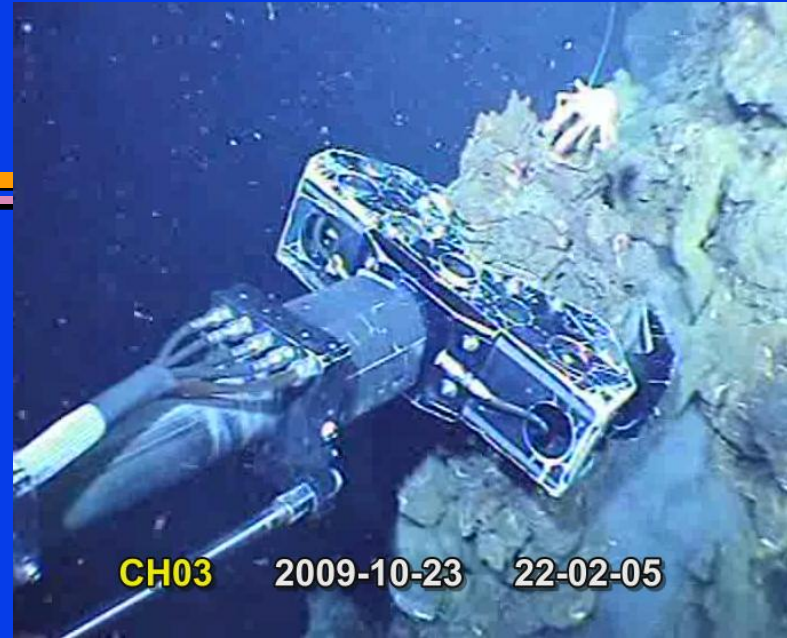
Autonomous Benthic Explorer (ABE)



Sampling and observation



Actinia biological grab net



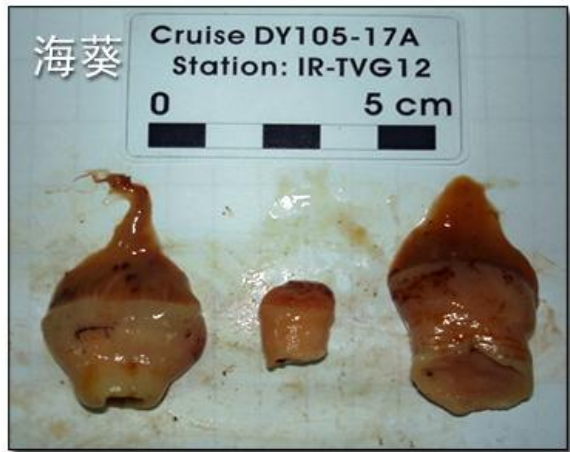
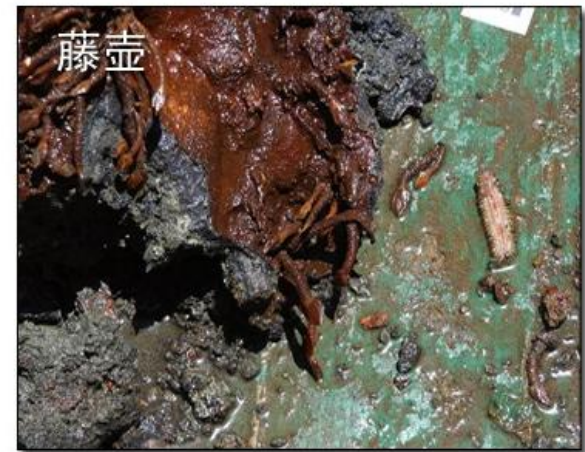
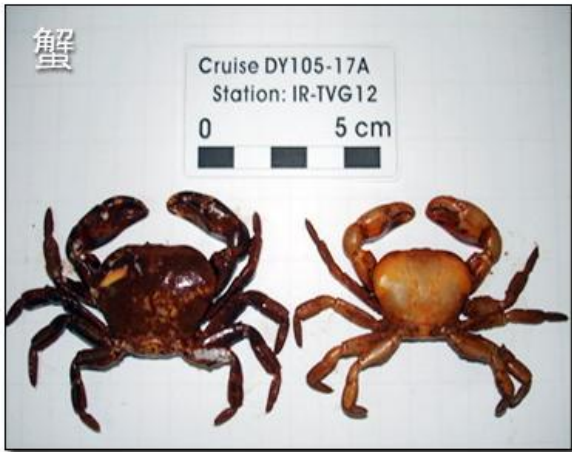
Observing seabed





Biological samples

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The role of MSR

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- Results from scientific research used for various purposes
 - **Further scientific research:** earth science, origin of life, transfer of energy...;
 - **Policy making:** regulation, standards, guideline, criteria, code of conduct...;
 - **Environment protection:** biodiversity, variability and parameter of MPAs...;
 - **Capacity upgrading** of detecting seabed;
 - **Resource:** characteristics of deposit & exploration indicators, assessment for its potential value....



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The Role of ISA and National Practice



The Role of ISA

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- Regulation for exploration and exploitation of mineral resources;
- Regulating the protection of environment of the Area;
- Effective participation in the activities of the Area for developing nations;
- Encouraging the MSR and cooperation.



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Opportunity for scientists from developing countries to participate in MSR in the Area

- Principal: common heritage of mankind
- Reality:
 - Endowment fund (ISA),
 - Willingness
 - Capacity (contractors)
 - --if we agree that prospecting (exploration) are also process of marine scientific research



Article 143 (3), LOS Convention

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- States Parties may carry out marine scientific research in the Area. States Parties shall promote international co-operation in marine scientific research in the Area by:
 - (a) participating in international programs and encouraging co-operation in marine scientific research by personnel of different countries and of the Authority;
 - (b) ensuring that programmes are developed through the Authority or other international organizations as appropriate for the benefit of developing States and technologically less developed States with a view to:
 - (i) strengthening their research capabilities;
 - (ii) training their personnel and the personnel of the Authority in the techniques and applications of research;
 - (iii) fostering the employment of their qualified personnel in research in the Area;



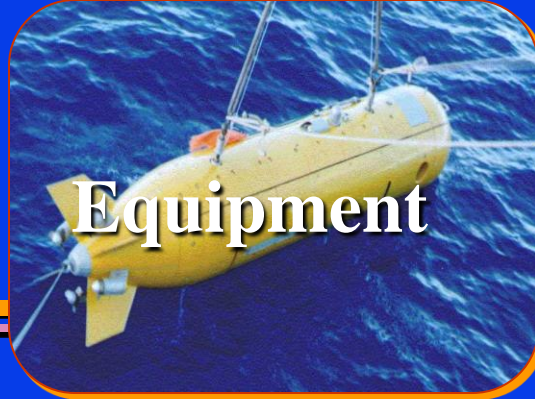
National Practice

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- National Economic Requirement
- Legal and Political Considerations
 - Activities in the Area and deep seabed will follow the regime under the LOS Convention;
- New Areas for Technology Development and Industries
 - Technology can be obtained as time is going and by different means.



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Progress and capacity

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- Survey at sea-nearly 100 legs
 - Resources assessment
 - Collection of data on environment baseline
- R & D activities
 - Equipment and technology for exploration
 - Design for a pilot mining system
 - Ore-dressing & smelting
 - Basic geologic research
- Strategy & Obligations
 - Studies on the law & regulation
 - Development of norms & technical criteria
 - Establishment of databank & sample repository
 - Monitoring of metal market, trends & prospects
 - Obligations as RPI and Contractor
 - Cooperation with ISA and others



The research vessel

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Main index:

Length 104.5 m
Tonnage 5500T
Voyage 20000NM
Width 16.0 m
Crew 75(50)

Main labs: 524m²

LAN and Information Center
Multibeam & Subbottom Lab
Marine Gravity & ADCP Lab
Marine Magnetometer Lab
Marine Seismic Lab
ROV and AUV Lab
DeepTow and USBL Lab

Geological Lab
Chemical and Biological Lab
Oceanography Lab
Biological Gene Lab
X fluorometry Lab
Sample room



A-frame hydraulic lift

Back Deck of R/V

ADCP Laboratory



Network information
integration system



Multi-beam system



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Some Survey Equipment



Trapper of sediment

AUV (6000m)



Camera and video



Shallow driller



ROV (3500m)



Multi-core sampler

TV grab



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Deep Seabed Sample Repository

一层大堂效果图1



Prospect

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- Priority to Prospecting and Exploration
- Attention to Environmental Impact
 - Collection of Data on Baseline
 - Assessment on the Impact from Mining System
 - Research of biodiversity in different areas
- Continuation of R & D
 - MSR and development of equipment
 - Test Mining System and processing Technologies
- Emphasis on Capacity building
- Promotion of Cooperation
 - ISA and Obligations
 - Other contractors
 - Regional & bilateral cooperation



Importance of the national practice

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- Opening the new source for mineral resources which is increasingly important as national economy grows;
- Increasing the know-how of the deep sea and development of the equipment;
- Learning and recognition of the Area for the peaceful utilization of the Area.



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Thank you!