COMRA’s Activities in Resources Assessment

JIN Jiancai
Secretary-General
China Ocean Mineral Resources R & D Association (COMRA)
jin@comra.org
Features of COMRA’s Area

- Western margin of CC zone;
- Consisting of two main parts being 200 km apart and spreading ~1,500 km from east to west;
- Variable grade and abundance of nodules and uneven topography;
- Deeper water depth, lower grade in west and lower abundance in east, comparing with others in CC zone.
Topography of COMRA’s Contract Area

3D-relief in the east part

- Abyssal plain
- High Hill
- Low Hill
- Abyssal plain
- Intermountain basin

3D-relief in the west part

- Seamount and hill
- Seamount chain
- Abyssal plain
- Seamount chain
- Intermountain basin
Distribution frequency of nodule grade in western part of contract area
Distribution frequency of nodule abundance in western part of contract area
Activities in Resources Assessment

- Exploration Strategy and Results
- Resource Assessment/classification in COMRA’s Contract Area
- Suggestion for Resource/reserve Classification
Activities in Resources Assessment

- Exploration Strategy and Results
- Resource Assessment/classification in COMRA’s Contract Area
- Suggestion for Resource/reserve Classification
Exploration in the Contract Area

- To collect data and information for the purpose of
  - assessment of resources and environment impact on the site,
  - design of the test mining and processing systems
Resource assessment combined with exploration at sea is a process of upgrading the nodule resources and a process of delineating a mine site.

Evaluating the quality, quantities, distribution and economic value of nodules in the contract area.
Survey Equipment

- Trapper of sediment
- Camera and video
- TV grab
- Box sampler
- Multi-core sampler
- AUV (6000m)
- HOV (7000m)
Goa, 15/10/14

COMRA’s Contract Area

East + West parts = 75000 km²
The resource amount of the nodule deposits was estimated by Kriging; 9 blocks were delimited:

- 6 in the east part of contract area
- Abundance ≥5kg/m²
- Grade(Cu+Co+Ni)≥1.8%
- Slope≤5°
3 blocks in the west part of contract area
Main Sampling Grid: 5.3’ × 5.3’ (9.8km × 9.8km)

West part:
783 sampling stations

East part:
849 sampling stations
- Sampling station

- Dense Sampling station in selected area: 3000km²

- Sampling grid: 7km × 7cm

- Detailed exploration area

- West part
Dense sampling in a selected area in west part of contract area

Sampling Grid in selected area (1800 km$^2$)
$1.875’ \times 1.875’$
$(3.5 \text{ km} \times 3.5 \text{ km})$

Sampling stations: 173

Seafloor TV survey line
Sampling Grid in selected area (773km$^2$)
$1.875' \times 1.875.3'$
$(3.5km \times 3.5km)$

Sampling stations: 80
An area, sizing 217km$^2$, with flat terrain within the 1800km$^2$ was selected for future environmental impact assessment together with equipment testing;

Dense sampling and AUV measurements were carried out in this area:

- Geological sampling stations: 18
- AUV survey area: 120km$^2$
Topography around the area for future environmental impact assessment and equipment test.

**Detailed Exploration Area:** low and gentle hills with water depth 5020m-5306m, Rough terrain in the south east part with 5 low hills, the height of the hills 200m-300m.

**Test Mining Area:** flat terrain easy for mining.
Layout of AUV survey lines and box core sampling stations in this specific area from 2013 to 2015
The bathymetry measured by AUV in this specific area (isobath of 2m interval)
Activities in Resources Assessment

- Exploration Strategy and Results
- Resource Assessment/classification in COMRA’s Contract Area
- Suggestion for Resource/reserve Classification
Geological factors

Area with potential deposit:
- tectonic features, topography, regional strata, types and features of the surface sediment, regional rift structure;

Deposit:
- distribution and coverage features of the polymetallic nodule;

Ore:
- types and mineral features of the nodule.
Environmental factors

- 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

- Investment and the operation cost related to the collecting, recovery, transportation and processing of the nodules;
- Variation of price for the metals possibly recovered from the nodules;
- Rate of return.
Main economic indexes to delimit area with potential deposit

- Average boundary abundance: \( \geq 5.0 \text{kg/m}^2 \)
- Average boundary grade: \((\text{Cu}+\text{Co}+\text{Ni}) \geq 1.80\%\);
- Sea-floor topographic slope \(< 5^\circ\);
- Solid bottom sediments
<table>
<thead>
<tr>
<th>Area</th>
<th>Sampling Grid</th>
<th>Resource Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area with potential deposit: 56000 km²</td>
<td>9.8km × 9.8km</td>
<td><strong>Inferred</strong> Resources</td>
</tr>
<tr>
<td>Area in dense sampling: 3000 km²</td>
<td>7km × 7km</td>
<td><strong>Indicated</strong> Resources</td>
</tr>
<tr>
<td>Area with further exploration: 1800km²</td>
<td>3.5km × 3.5km</td>
<td><strong>Measured</strong> Resources</td>
</tr>
<tr>
<td>Area for specific use: 217km²</td>
<td>2.5km × 2.5km</td>
<td><strong>Measured</strong> Resources</td>
</tr>
</tbody>
</table>
Resource classification in west part of COMRA’s contract area

KW1 (sampling grid: 9.8km)
- Inferred resources
- Detailed exploration area (sampling grid: 3.5km) (1800km² measured resources)

KW2 (sampling grid: 9.8km)
- Inferred resources
- Dense sampling in periphery area (sampling grid: 7km) (3000km² indicated resources)
<table>
<thead>
<tr>
<th>Economic viability</th>
<th>Resource/reserve</th>
<th>Measured</th>
<th>Indicated</th>
<th>Inferred</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Proved reserves (111)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Probable reserves (121)</td>
<td>Probable reserves (122)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsically economic</td>
<td>Measured resources (331)</td>
<td>Indicated resources (332)</td>
<td>Inferred resources (333)</td>
<td>Predicted resources 334</td>
<td></td>
</tr>
</tbody>
</table>
### Comparison in resource classification between COMRA and CRIRSCO

<table>
<thead>
<tr>
<th>COMRA Classification</th>
<th>Exploration results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted resources 334?</td>
<td></td>
</tr>
<tr>
<td>Inferred resources 333</td>
<td>Inferred Mineral Resource</td>
</tr>
<tr>
<td>Indicated resources 332</td>
<td>Indicated Mineral Resource</td>
</tr>
<tr>
<td>Measured resources 331</td>
<td>Measured Mineral Resource</td>
</tr>
<tr>
<td>Probable reserves 121</td>
<td>Probable Mineral reserve</td>
</tr>
<tr>
<td>Probable reserves 122</td>
<td></td>
</tr>
<tr>
<td>Proved reserves 111</td>
<td>Proved Mineral Reserve</td>
</tr>
</tbody>
</table>

-30-

**CRIRSCO Taxonomy**
Activities in Resources Assessment

- Exploration Strategy and Results
- Resource Assessment/classification in COMRA’s Contract area
- Suggestion for Resource/reserve Classification
Nickel Price

Price in 2013: $15015/t
Average of last 5 years: $18376/t
Average of last 10 years: $20082/t

Source: LME
Copper Price

Price in 2013: 7314$/t
Average of last 5 years: 7353$/t
Average of last 10 years: 6413$/t

Source: LME
Cobalt – Price

Price in 2013: 12.65$/lb
Average in last 5 years: 16.43$/lb
Average in last 10 years: 20.46$/lb

Source: Metal Bulletin
China’s economic structural improvement and upgrading

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, ……

From Report in 2014 by Premier Li Keqiang of China
### Structure of a seabed mining project

--from report of UN expert group in 1989

<table>
<thead>
<tr>
<th>Possible duration</th>
<th>Early period</th>
<th>R &amp; D (7-10y)</th>
<th>Feasibility (2-3y)</th>
<th>Construct (4-6y)</th>
<th>Production (20y)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exploration</strong></td>
<td>Prospecting</td>
<td>Exploration Stage I &amp; II</td>
<td>Reserves</td>
<td>Mining preparation</td>
<td>Start up</td>
</tr>
<tr>
<td><strong>Mining</strong></td>
<td>Concepts</td>
<td>Pilot tests</td>
<td>Further tests?</td>
<td>Mining equipment</td>
<td></td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td>Approaches</td>
<td>Pilot plant</td>
<td>Further tests?</td>
<td>Processing plant</td>
<td></td>
</tr>
<tr>
<td><strong>Marketing</strong></td>
<td>Products</td>
<td>Supply/Demand</td>
<td>Update</td>
<td>Sales contracts</td>
<td></td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td>Analysis</td>
<td>Analysis</td>
<td>Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td></td>
<td><strong>Decision to proceed</strong></td>
<td><strong>Decision to start</strong></td>
<td><strong>Ongoing decision</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Relationship between Structure of a seabed mining project and resource classification

<table>
<thead>
<tr>
<th>Possible duration</th>
<th>Early period</th>
<th>R &amp; D (7-10y)</th>
<th>Feasibility (2-3y)</th>
<th>Construct (4-6y)</th>
<th>Production (20y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>Prospecting</td>
<td>Exploration Stage I &amp; II</td>
<td>Reserves</td>
<td>Mining preparation</td>
<td>Start up</td>
</tr>
<tr>
<td>Mining</td>
<td>Concepts</td>
<td>Pilot tests</td>
<td>Further tests?</td>
<td>Mining equipment</td>
<td></td>
</tr>
<tr>
<td>Processing</td>
<td>Approaches</td>
<td>Pilot plant</td>
<td>Further tests?</td>
<td>Processing plant</td>
<td></td>
</tr>
<tr>
<td>Marketing</td>
<td>Products</td>
<td>Supply/Demand</td>
<td>Update</td>
<td>Sales contracts</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Analysis</td>
<td>Analysis</td>
<td>Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td>Decision to proceed</td>
<td>Decision to start</td>
<td>Ongoing decision</td>
<td></td>
</tr>
<tr>
<td>Categories of resource/reserves</td>
<td>Resources</td>
<td>Resource/reserves</td>
<td></td>
<td>Reserves</td>
<td></td>
</tr>
</tbody>
</table>
Consideration of a proposal to establish a mineral resource/reserve classification system for the Area

- LTC noted the need for a classification for the Area. 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, 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.
### Proposal of mineral resource/reserves classification with the exploration results

<table>
<thead>
<tr>
<th>Resources/reserves Categories</th>
<th>Exploration Grid</th>
<th>Exploration Methods and Requirements</th>
<th>Exploration Results reflecting by Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferred resources (333)</td>
<td>10～25km</td>
<td>geological sampling, multi-beam survey, shallow profiling, single channel reflection seismic survey</td>
<td>1:1,000,000～1:500,000 Original data, Topographic…</td>
</tr>
<tr>
<td>Indicated resources (332)</td>
<td>5～7km</td>
<td>geological sampling, multi-beam survey, shallow profiling, single-channel reflection seismic survey, geotechnical property measuring on shipboard, and other geophysical survey methods</td>
<td>1:500,000～1:250,000 Original data, Topographic, Geological, Abundance and grade, Resource distribution…</td>
</tr>
<tr>
<td>Measured resources (331)</td>
<td>2.5～3.5km</td>
<td>geological sampling, deep-tow survey, AUV survey, geotechnical property measuring in situ, other geophysical survey methods fast to obtain the accurate topography and landform and distribution on nodules.</td>
<td>1:250,000～1:100,000 Original data, Topographic, Landform, Geological, Abundance and grade, Resource distribution…</td>
</tr>
<tr>
<td>Reserves</td>
<td>……</td>
<td>……</td>
<td>……</td>
</tr>
</tbody>
</table>
Thank You for Your Attention!