

Study to investigate state of knowledge of deep sea mining

Final report Annex 5 Ongoing and planned activity

FWC MARE/2012/06 – SC E1/2013/04

Client: DG Maritime Affairs and Fisheries

Rotterdam/Brussels,

15 October 2014



Study to investigate state of knowledge of deep sea mining

Final report Annex 5 Ongoing and planned activity

FWC MARE/2012/06 – SC E1/2013/04

Client: DG Maritime Affairs and Fisheries

Brussels/Rotterdam, 15 October 2014

About Ecorys and Consortium Partners



Consortium leader
Economic expertise, highest quality, wide geographical coverage & broad range of services

- One of the oldest and largest economic research and consulting firms in Europe
- International recognition, highest quality & independence – including a Nobel Prize
- Clients range from local governments to the European Commission and international financing institution medium-sized companies to the largest multinationals
- 16 permanent offices in 11 countries, worldwide experience in more than 140 countries including all sea basins
- Extensive project management experience
- Experience with structural and cohesion funds, Interreg, EDF, ERDF, TRD
- Services in the areas of real estate, property and housing, transport, infrastructure, infrastructure finance and investment, logistics, ports and shipping, industry and trade, macroeconomics and public finance, environment and energy, health care, labour and education, regional and urban development, social security, tourism, agriculture and rural development
- Involving skilled staff from offices in the Netherlands, Brussels, the UK and elsewhere. Additionally, introducing training services of the Ecorys Academy



Promoting sustainable use of aquatic resources through sound integrated management policies and practices

- Designing and implementing integrated resource management systems in marine, estuarine, riverine and floodplain environments
- Consideration of the physical, biological, technical, social, economic, and institutional elements of resource utilisation
- Worldwide experience -more than 60 countries including all sea basins
- Clients include government agencies, IFIs, the European Commission in general and the Directorate-General for Maritime Affairs and Fisheries in particular, non-governmental organisations and private sector companies
- Services include: Policy and Strategic Planning, Fisheries Management, Resource Assessment, Institutional Development, Technical Training, Chain of Custody Audits, Conference and Workshop Planning, Performance Monitoring and Evaluation, Data and Information Management, Information Review, Sharing & Co-operation, Monitoring, Control and Surveillance, Preparation work for Fisheries Certification



Communicate environmental information to policy-makers and facilitate environmental decision-making for change

- Official United Nations Environment Programme (UNEP) collaborating centre, supporting informed decision making and awareness-raising through:
- Environmental information management and assessment
- Capacity building services
- Outreach and communication tools, methodologies and products
- A dynamic portfolio of projects
- Initiatives in the Polar Regions and Outermost Regions, and sustainable development of the oceans and coasts elsewhere in the world.

Consortium Lead Partner
ECORYS Nederland BV
P.O. Box 4175
3006 AD Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E fwcbluegrowth@ecorys.com
Registration no. 24316726
www.ecorys.com

Table of contents

List of abbreviations	4
Summary	7
1 Project licences overview	9
2 Project sheets	16
2.1 Projects located in The Area (projects 01-26)	16
2.2 Projects located in EEZs (projects 27- 52)	84
2.3 European Innovation Partnership commitments/projects	145
References	171

List of abbreviations

ABNJ	Areas Beyond National Jurisdiction
AC	Auxiliary Cutter
Ag	Silver
ANU	Australian National University
APR	Accounting Profits Royalty
Au	Gold
AUV	Autonomous Underwater Vehicle
AVR	Ad Valorem Royalty
BC	Bulk Cutter
BGR	Federal Institute for Geosciences and Natural Resources
BMS	Benthic Multi-coring System
BMS	Boring Machine System
CCZ	Clarion-Clipperton Fracture Zone
CERENA	Center for Natural Resources and the Environment
CM	Collecting Machine
Co	Cobalt
COMRA	China Ocean Mineral Resources Research and Development Association
CSEM	Controlled source electromagnetics
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
Cu	Copper
CUT	Clausthal University of Technology
DEC	Department of Environment and Conservation
DORD	Deep Ocean Resources Development Co. Ltd
DP	Dynamic positioning
EDM	Empresa de Desenvolvimento Mineiro, S.A
EEZ	Exclusive Economic Zones
EIA	Environmental impact assessment
EL	Exploration Licence
EMEPC	Estrutura de Missão para a Extensão da Plataforma Continental
ERDEM	Environmentally Responsible Deep-sea Mining
EUROASSET	European Mineral Asset Definition and Valuation System
Fe	Iron
FEUP	Faculdade de Engenharia da
FOB	Free on board
FS	Feasibility study
Ga	Gallium
GEMINO	Geothermal Metallogenesis Indian Ocean
GeoZS	Geological survey of Slovenia
GFORCE	Governance Framework for Ocean Resources Sustainable Exploration and Extraction
GSR	G-TEC Sea Mineral Resources
GTK	Geological Survey of Finland

HCMR	The Hellenic Centre for Marine Research
IDL	Instituto Dom Luiz
IFREMERM	Institut français de recherche pour l'exploitation de la mer
IKS	Institut für Konstruktion
IMAR	Instituto do Mar
IOM	Interoceanmetal Joint Organization
IOM	Institute of Oceanography
IPMA	Instituto Português do Mar e da Atmosfera
IRR	Internal Rate of Return
ISA	International Seabed Authority
ISR	Institute for Systems and Robotics
IST	– Instituto Superior Técnico
JDN	Jan De Nul N.V.
JOGMEC	Japan Oil, Gas and Metals National Corporation
KCL	Keppel Corporation Limited
KDM	Konsortium Deutsche Meeresforschung e.V
Kiost	Korea Ocean Research and Development Institute
LMC	Lockheed Martin Corporation
LMUK	Lockheed Martin UK Holdings Ltd
LNEG	Laboratório Nacional de Energia e Geologia
LPP	Legal Platform of Portugal
LTC	Legal and Technical Commission
METI	Ministry of Economy, Trade and Industry
ML	Mining Lease
MLTM	Ministry of Land, Transport, and Maritime Affairs
MMT	Million metric tons
Mn	Manganese
MP	Mining permit
MPAs	Marine Protected Areas
MRA	Mineral Resource Authority).
MRS	Marine Scientific Researchers
MSV	Mining Support & Production Vessel
MUS	Maritime University of Szczecin
MWD	Measurement while drilling
Nb	Niobium
Ni	Nickle
NOAA	National Oceanic and Atmospheric Administration
NORA	Nordic Ocean Resources
NORI	Nauru Ocean Resources Inc
NPV	Net present value
NTNU	Norwegian University of Science and Technology
ODP	Ocean deep drilling
OFG	Ocean Floor Geophysics's
OFOS	Ocean Floor Observation System
OMA	Ocean Mining Associates
PLs	Prospecting Licences
PNG	Papua New Guinea

PPT	Pre-pilot mining test
PSV	Production Support Vessel
Pt	Platinum
R/V	Research vessel
RALS	Riser and lifting system
ROV	Remotely operated vehicles
RSC	Saudi-Sudanese Red Sea Commission
SBP	Sub-bottom profiling
SERADO	Seafloor Sulfides Research and Development Organization
SPCN	Sociedade Portuguesa de Ciências Naturais
SPT	Seafloor production tools
Ti	Titanium
TOML	Tonga Offshore Mining Limited
UB	University of Bremen
UKSRL	UK Seabed Resources Ltd
UNCLOS	United Nations Convention on the Law of the Sea
UPM	Universidad Politécnica de Madrid
W	Tungsten
YMG	Scientific & Production Association Yuzhmoregeologiya
ZFT	Zentrum für Telematik
Zn	Zinc

Summary

This report looks at the currently ongoing projects in Areas Beyond National Jurisdiction (ABNJ), these are waters under the supervision of the International Seabed Authority as well as those exploration activities that are currently taking place in the Exclusive Economic Zones (EEZ) of individual states. Projects are defined as licenced exploration and exploitation activities aimed at deep-sea minerals.

So far only exploration licences have been issued by the ISA. Up until May 2014, 19 applications have been approved out of which:

- 13 concern the exploration of polymetallic nodules, four for polymetallic sulphides and two the exploration of cobalt-rich polymetallic crusts;
- 12 of the exploration projects are located in the CCZ. This area is located in international waters of the Pacific Ocean. The remaining projects are located in the Indian Ocean (3), the Atlantic Ocean (2) and the north-western Pacific Ocean (2);
- These 19 approved projects cover an area of 1 million km². Six of these licenses will expire in 2016.

In 2013, seven additional applications, covering an area of around 234.000 km², were made to the ISA for exploration projects. These were discussed at the ISA's 20th annual session in July 2014, and were approved, but still need to be contracted out.. This means that by the end of 2014/beginning of 2015 there will be 26 approved projects by the ISA with a total covered area of around 1.2 million km². This is an area as big as Portugal, Spain and France together.

Generally applications can be submitted by national governments (e.g. China, India, Korea and Russia) as well as private enterprises.

Creating an overview of the licences granted within the national jurisdiction area of individual states' EEZ is more difficult as there is not a single source or database where this information can be gathered from. Extensive desk-research and interviews have been carried out to collect the relevant information, and we have identified 26 projects in EEZ areas. At the same time it must be stated that due to unavailability of data and information, specific projects in South America, Africa and Russia could not be identified. It is estimated however that the number of projects in the EEZ of these countries is limited since the two private companies that hold the majority of (exploration) licenses within EEZ zones (Nautilus Minerals and Neptune Minerals) do not hold any license in the EEZ zones of these two continents and Russia.

National governments have until now issued two deep sea marine exploitation (or mining) licenses: one by the government of Papua New Guinea (Solwara 1 project in the Bismarck Sea) and one by the governments of both Saudi Arabia and Sudan (Atlantis II project in the Red Sea). In both projects mining has not yet started. All other issued deep sea licenses by national governments concern exploration projects¹.

¹ Other mining licenses have been issued but these cannot be characterized as deep-sea mining licenses since the depth of these locations does not exceed 500 meters. This is for example the case for Sandpiper Marine Phosphate project off the coast of Namibia (depth of 180-300 meters) and the location Chatham Rise within the EEZ zone of New Zealand (depth of 350-450 meters).

The sizes of the areas granted for mining, exploration or areas under application in EEZs are not always known. Based on the information available we estimate the total area licensed or under application in EEZ areas of countries to be around 800 000 – 900 000 km². All EEZ licenses are for polymetallic sulphides deposits only.

1 Project licences overview

Table A.5.1 Overview of current deep sea exploration licenses issued by the ISA for polymetallic nodules, polymetallic sulphides and cobalt- rich ferromanganese crusts.

Contractor	Date of entry into force of contract	Date of expiry of contract	Sponsoring State	General location of the exploration area under contract	Type	Depth (meters)	Area (km2)	
1	Interoceanmetal Joint Organization	29-mrt-01	28-mrt-16	Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	4 000-5 000	75 000
2	Yuzhmorgeologiya	29-mrt-01	28-mrt-16	Russian Federation	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
3	Government of the Republic of Korea	27-apr-01	26-apr-16	Korea	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	3 000-6 000	75 000
4	China Ocean Mineral Resources Research and Development Association (COMRA)	22-mei-01	21-mei-16	China	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000-5 300	75 000
5	Deep Ocean Resources Development Co. Ltd. (DORD)	20-jun-01	19-jun-16	Japan	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
6	Institut français de recherche pour l'exploitation de la mer (INFRAMER)	20-jun-01	19-jun-16	France	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
7	Government of India	25-mrt-02	24-mrt-17	India	Indian Ocean	polymetallic nodules	5 000-5 700	150 000
8	Federal Institute for	19-jul-06	18-jul-21	Germany	Clarion-Clipperton Fracture	polymetallic	4 200-4 800	75 000

Contractor	Date of entry into force of contract	Date of expiry of contract	Sponsoring State	General location of the exploration area under contract	Type	Depth (meters)	Area (km2)
Geosciences and Natural Resources of Germany				Zone, (North) Pacific Ocean	nodules		
9 Nauru Ocean Resources Inc. (NORI)	22-jul-11	21-jul-26	Nauru	Clarion-Clipperton Fracture Zone (North) Pacific Ocean,	polymetallic nodules	4 000-5 000	75 000
10 Tonga Offshore Mining Limited	11-jan-12	10-jan-27	Tonga	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
11 Marawa Research and Exploration Ltd.	approved, to be signed		Kiribati	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
12 UK Seabed Resources Ltd.	8-feb-13	7-feb-28	United Kingdom of Great Britain and Northern Ireland	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	4 000	58 000
13 G-TEC Sea Mineral Resources NV	14-jan-13	13-jan-28	Belgium	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
14 China Ocean Mineral Resources Research and Development Association (COMRA)	18-nov-11	17-nov-26	China	Southwest Indian Ridge, Indian Ocean	polymetallic sulphides		10 000
15 Government of the Russian Federation	29-okt-12	28-okt-27	Russian Federation	Mid-Atlantic Ridge, Atlantic Ocean	polymetallic sulphides		10 000
16 Government of the Republic of Korea	1-may-14	30-apr-29	Korea	Central Indian Ridge, Indian Ocean	polymetallic sulphides		10 000
17 Institut français de recherche pour l'exploitation de la mer (INFREMER)	approved, to be signed		France	Mid-Atlantic Ridge, Atlantic Ocean	polymetallic sulphides	3 400	10 000
18 China Ocean Mineral Resources Research and Development Association (COMRA)	29-apr-14	28-apr-29	China	Western Pacific Ocean	cobalt-rich ferromanganese crusts	2 000-2 300	3 000

Contractor	Date of entry into force of contract	Date of expiry of contract	Sponsoring State	General location of the exploration area under contract	Type	Depth (meters)	Area (km ²)	
19	Japan Oil, Gas and Metals National Corporation (JOGMEC)	27-jan-14	26-jan-29	Japan	Western Pacific Ocean	cobalt-rich ferromanganese crusts	3 000-4 000	3 000
20	Government of India	approved, to be signed		India	Central Indian Ocean	polymetallic sulphides	3 000	10 000
21	Federal Institute for Geosciences and Natural Resources of Germany	approved, to be signed		Germany	Central Indian Ocean	polymetallic sulphides	2 600-3 300	10 000
22	Ocean Mineral Singapore Pte Ltd (OMS)	approved, to be signed		Singapore	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	4 000-5 000	58 280
23	UK Seabed Resources Ltd.	approved, to be signed		United Kingdom of Great Britain and Northern Ireland	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	4 800	75 000
24	Companhia de Pesquisa de Recursos Minerais S.A.	approved, to be signed		Brazil	Rio Grande Rise (about 1,100 km from the coast of the Rio Grande do Sul State (Brazil))	cobalt-rich ferromanganese crusts	1 000-5 000	3 000
25	Cook Islands Investment Corporation	approved, to be signed		Cook Islands	Clarion-Clipperton Fracture Zone, (North) Pacific Ocean	polymetallic nodules	5 000	75 000
26	Ministry of Natural Resources and Environment of the Russian Federation	approved, to be signed		Russian Federation	Western Pacific Ocean	cobalt-rich ferromanganese crusts	2 000-2 300	3 000

Source: International Seabed Authority website.

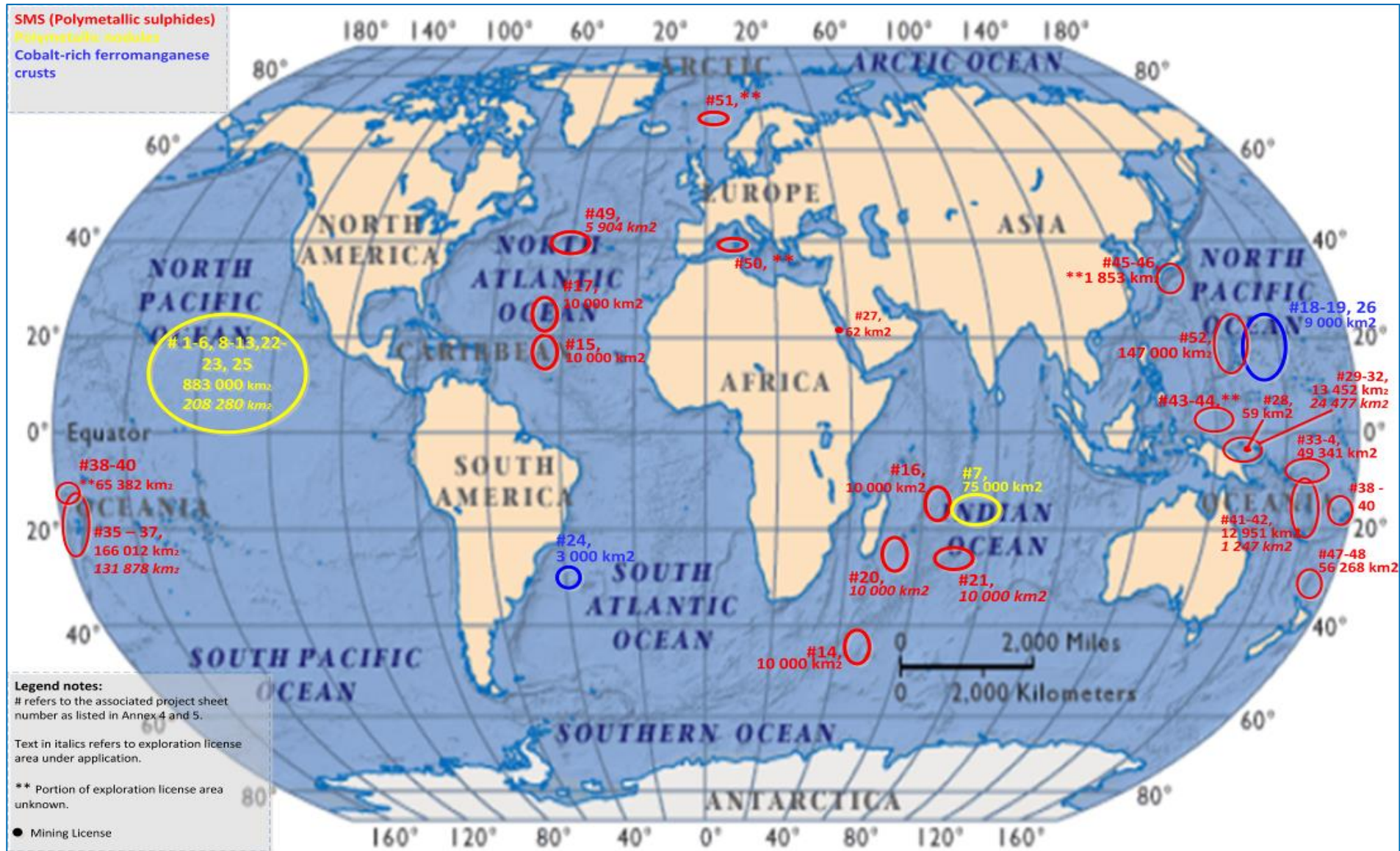
Table A.5.2 Overview of current deep sea exploration and mining licenses as well as applications for licenses issued by national governments for polymetallic nodules/SMS, polymetallic sulphides and cobalt- rich ferromanganese crusts.

Contractor		Date of entry into force of contract	Date of expiry of contract	General location of the exploration area under contract	Type	License	Depth	Area (km ²)
27	Diamond Fields International	2010	2040	Deep Sea II project, Red Sea	SMS	Mining	1 900 – 2 200	62
Pacific Islands								
28	Nautilus Minerals	2011	2030	Solwara 1 project, Manus Basin; Papua New Guinea	SMS	Mining	1 600	59
29	Nautilus Minerals Inc	Granted and under application		Papua New Guinea – Bismarck Sea (except Solwara 1)	SMS	Exploration	1 030 – 2 590	10 630 (Granted); 8 146 (under appl)
30	Nautilus Minerals	Granted and under application		Papua New Guinea – Woodlark Area	SMS	Exploration		255 (Granted); 3 543 (under appl.)
31	Nautilus Minerals Inc	Under application		Papua New Guinea – New Ireland Arc	SMS	Exploration	1 500 – 2 000	12 788
32	Neptune Minerals	2012	2014	Papua New Guinea	SMS	Exploration		2 568
33	Nautilus Minerals Inc	19 July 2011	18 July 2014	Solomon Islands	SMS	Exploration		39 500
34	Bluewater Metals (Neptune Minerals subsidiary)	2007	2014	Solomon Islands	SMS	Exploration		9 840
35	Nautilus Minerals Inc	Granted, year unknown		Kingdom of Tonga	SMS	Exploration	965 – 2 360	77 563 (granted); 131 878 (under appl.)
36	Neptune Minerals	2008	2014	Kingdom of Tonga	SMS	Exploration		63 949
37	Korean Institute of Ocean Science and Technology (KIOST)	2008	2014	Kingdom of Tonga	SMS	Exploration		24 500
38	Nautilus Minerals	2014	2016	Fiji		Exploration		60 370
39	Bluewater Metals (Neptune subsidiary)	2012	2014	Fiji	SMS	Exploration		5 012
40	Korean Institute of Ocean	2011		Fiji	SMS	Exploration		

Contractor	Date of entry into force of contract	Date of expiry of contract	General location of the exploration area under contract	Type	License	Depth	Area (km ²)
Science and Technology (KIOST)							
41	Nautilus Minerals Inc	Granted, year unknown	Vanuatu	SMS	Exploration	1 000 – 3 000	2 768 (granted); 1 247 (under appl.)
42	Bismarck (Neptune subsidiary)	2011 & 2012	2014 & 2015	Vanuatu	SMS	Exploration	10 183
43	Neptune Minerals	Under application		Federated States of Micronesia	SMS	Exploration	
44	Neptune Minerals	Under application		Palau	SMS	Exploration	
Japan							
45	Japan Oil, Gas & Metals National Corp (JOGMEC)	2008		Izu & Ogasawara Island Chain & SW Okinawa Islands, Japan	SMS & Crusts	Exploration	
46	Neptune Minerals	Under application		Japan		Exploration	1 853
New Zealand							
47	Nautilus Minerals Inc	Under application		Bay of Plenty, New Zealand (Permit Number 39348)	SMS	Exploration	52 820
48	Neptune Resources	Under application		Gisborne, New Zealand (permit Number 53828)	SMS	Exploration	1 000-1 800 3 448
Europe							
49	Nautilus Minerals Inc	Under application		Azores	SMS	Exploration	5 904
50	Neptune Minerals	Under application		Italy (Tyrrhenian Sea)	SMS	Exploration	500 – 1 000
51	Nordic Ocean Resources AS (NORA)	Under application		Norway (Norwegian sector of the Mid-Atlantic Ridge)	SMS	Exploration	
US/Commonwealth							

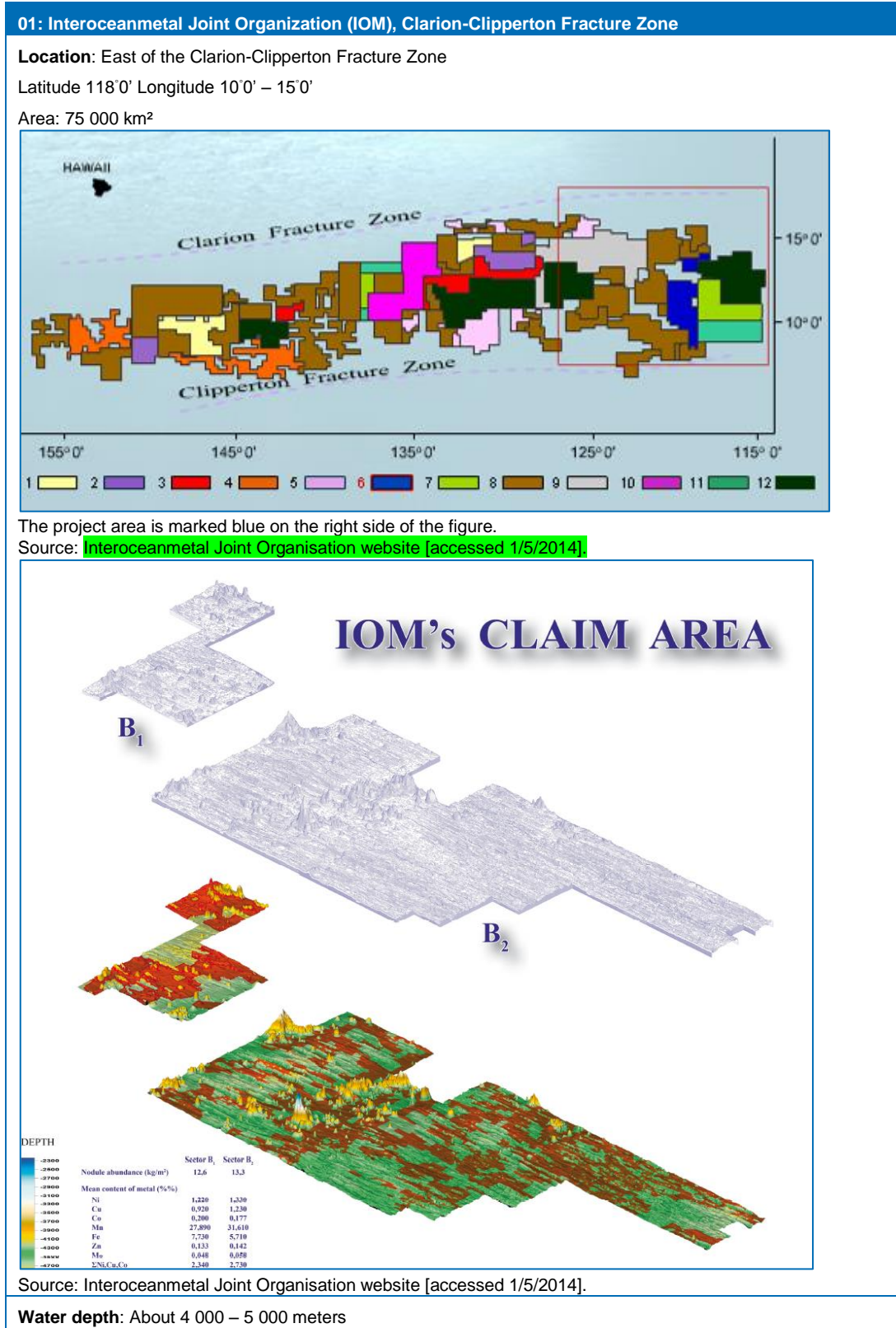
	Contractor	Date of entry into force of contract	Date of expiry of contract	General location of the exploration area under contract	Type	License	Depth	Area (km ²)
52	Neptune Minerals	Under application		Commonwealth of the Northern Mariana Islands (CNMI), Back-arc basin	SMS	Exploration		147 000

Figure A.5.1 Current licenses and applications for licenses for the exploration and mining of polymetallic nodules, polymetallic sulphides/SMS and polymetallic crusts below a depth of 500 meters



2 Project sheets

2.1 Projects located in The Area (projects 01-26)



01: Interoceanmetal Joint Organization (IOM), Clarion-Clipperton Fracture Zone

Consortia members

Contractor	Representative Organisations in the Member States	Individual Contact Persons
Interoceanmetal Joint Organization (IOM)	Ministry of Economy and Energy of the Republic of Bulgaria	Valery Trendafilov
	Ministry of Industry and Trade of the Czech Republic	Pavel Kavina
	Caribbean Nickel SA, Ministry of Mining and Energy of the Republic of Cuba	Mario Cabello Marante
	Polish Geological Institute, Ministry of Environment of the Republic of Poland	Andrzej Przybycin
	Ministry of Natural Resources and Environment of the Russian Federation	Boris K. Shiryayev
	Slovak State Geological Institute of DionyzStur, Government of Slovakia	Peter Baláž

The Interoceanmetal Joint Organization (IOM) is an intergovernmental consortium certified by the governments of Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia. The Interoceanmetal Joint Organization was formed on 27 April 1987, based on the Intergovernmental Agreement and started operations in December that year.

Type of contract: Exploration license

Time scale:

29/03/2001: license into force

28/03/2016: expiry date of license

For a number of years, since its establishment, the IOM has been focusing mainly on carrying out regional geological and geophysical surveys in the Clarion-Clipperton Fracture Zone of the Pacific Ocean. The IOM's claim concerned 300 000 km² area, in the eastern part of the CCZ, within a total of 540 000 km² swath surveyed.

The Preparatory Commission for the ISA decided to register IOM as a pioneer investor, based on recommendations from the Group of Technical Experts which were issued after IOM's application had been made and the detailed geological data collected by the Organization examined. On 30 July 1992, the General Secretary of the UN awarded IOM and its member states the Certificate of Registration, whereby the IOM's status has become that of the pioneer investor. The registered pioneer area of IOM covered 150 000km².

Following this, IOM applied for exploration license in the area in the beginning of the new century. On 29 March 2001, the IOM signed such a contract for exploration for polymetallic nodules with the ISA within a 75 000 km² area situated in the CCZ. Current IOM's activity is mostly aimed to fulfil the approved 15-year plan of work for exploration and includes at-sea geological survey as well as development and testing of mining and processing technologies, environmental research, economic and other appropriate studies necessary to commence nodule exploitation and deep sea mining operations.

Financing:

The governments involved finance the project (see IOM member states).

Government involvement:

All representing organisations are either national ministries or state geological institutes.

01: Interoceanmetal Joint Organization (IOM), Clarion-Clipperton Fracture Zone

Type of material to be collected:

polymetallic nodules.

Size of expected deposit:

Data collected at the 2001 cruise of R.V. Yuzhmorgeologiya showed the following outcome:

Basic characteristics (mean values) of the diagenetic nodule types in the IOM exploration area²

Parameter	Type		Entire exploration area (324)
	Dr (148)	Dr ₁ (96)	
Wet weight-based abundance (kg/m ²)	12.9	7.3	10.2
Dry weight-based abundance (kg/m ²)	8.8	5.0	7.0
Ni (%)	1.37	1.25	1.31
Cu (%)	1.26	1.34	1.23
Co (%)	0.18	0.16	0.18
Mn (%)	31.90	31.48	30.80
Moisture content (%)	31.6	32.0	31.7

The richest deposits are formed by large (6-12 cm) type Dr nodules (weighing up to 2.6 kg), their abundance reaching 28.4 kg/m². Nodules of this type are encountered throughout the area surveyed and occur under various conditions in terms of seafloor morphology and depth.

A characteristic feature in the eastern area of the CC nodule region is a relatively high Mn-Cu content at a lower Co concentration, compared to the central area the nodules of which show lower Mn-Cu contents and higher Ni and Co ones. A trend involving a westward increases in the contents of Co and Ni and a decrease in those of Mn and Cu is observed in the region.

Technology used:

The prior area was surveyed in 1999 with a SIMRAD multibeam echo sounder. The survey resulted in the compilation of 1:200 000 maps of bottom relief, slope angles, and bathymetry; side-scan sonar images of the bottom were collated as well.

Further emphasis of IOM is given on processing technology and mining technology.

Processing technology

The focus of IOM in processing technology is not a development of their own technology, but the assessment of the feasibility of existing technology. IOM conducted research on processing technologies for nodules which included processing schemes of hydrometallurgical, pyro-hydrometallurgical, acid and ammonia leaching methods. Together with alternative methods for nodules treatment, pre-feasibility studies based on the previously selected and partly optimized technologies were accomplished.

Furthermore, the work on nodule processing technologies also involved the optimisation of the existing technological schemes for extracting valuable components from polymetallic nodules, and development of the basic technological schemes for polymetallic nodules processing.

Mining technology

² Kotlinski, R. et al. (2003): Relationships between nodule genesis and topography in the Eastern area of the C-C region, http://www.iom.gov.pl/uploads/iom_attachment-95635.pdf.

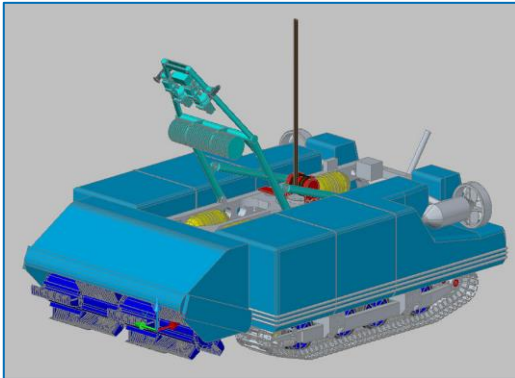
01: Interoceanmetal Joint Organization (IOM), Clarion-Clipperton Fracture Zone

The IOM strategy to conduct research on and to develop nodules mining technology includes the following activities:

- pre-feasibility study based on existing mining technologies;
- development of a site-specific conceptual design;
- modelling and testing of the most important sub-systems and components;
- developing an engineering design of a pilot integrated mining complex for pilot-scale experiments.

Therefore, IOM works were focused on the analysis of existing subsea engineering practices and development of a conceptual design for mining system applicable for the IOM's exploration area. Moreover, IOM made a comparison of alternative design variants for the assessment of technical requirements for basic components of mining technology. The development of a system of the mining complex includes mathematical modelling of mining complex systems and computer simulations of control process. Computer simulations included assessment of effects of the marine environment like waves and currents on the mining complex, movement of the mining vessel and nodule miner and effects of the movement on the vertical transport riser and its deformation. Additionally, to estimate slip velocity and experimental verification of nodules vertical flow on selected lifting sub-systems IOM conducted laboratory tests.

Example of a mining collector



According to IOM, the crucial requirement to development of a deep seabed mining system is the technical and technological adaptation of equipment characteristics to geological, geotechnical and environmental conditions of the IOM exploration area.

Obstacles:

The main obstacle is that commercial viability of nodule mining has yet to be established.

Sources:

Interoceanmetal Joint Organisation (2014) website <http://www.iom.gov.pl/welcome.htm>;

http://www.iom.gov.pl/files/IOM_Claim_Area_and_Bathymetry_Poster.pdf; [accessed 5/1/2014]

ISA (2014a) International Seabed Authority website: <http://www.isa.org.jm/en/scientific/exploration/contractors> [accessed 5/1/2014].

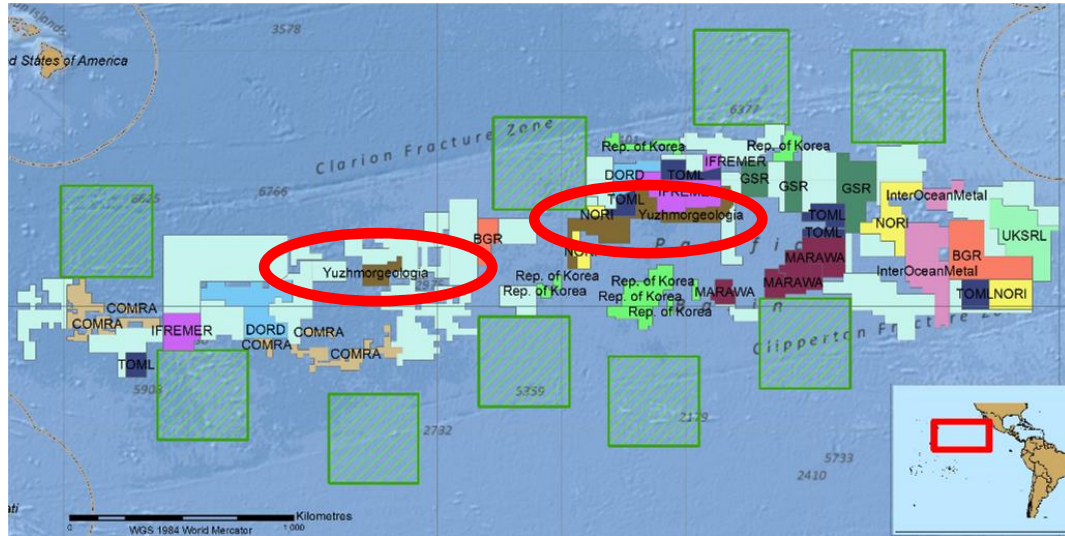
Kotlinski, R. et al. (2003): Relationships between nodule genesis and topography in the Eastern area of the C-C region, http://www.iom.gov.pl/uploads/iom_attachment-95635.pdf.

02: Yuzhmoregeologiya, Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

Latitude 140°0'0" - 145°0'0" and around 130°0'0". Longitude 10°0'0"

Area: 75 000 km²



Source: ISA (2014a). International Seabed Authority website, <http://www.isa.org.jm/en/scientific/exploration/contractors>

Water depth: about 5 000 meters

Consortia members

Yuzhmoregeologiya

Main contractor

Yuzhmoregeologiya is a state company of the Republic of Russia. It comprises of 9 divisions and laboratories, 3 subsidiaries, design facilities and construction workshops. In 1973 the company was named Production Association and then in 1978 changed into Scientific & Production Association Yuzhmoregeologiya (YMG). During the 1980s — YMG experienced a period of intense growth and the accumulation of equipment and the research fleet. The Ministry of Natural Resources gave YMG the status of a state research centre in 1998.

Type of contract: Exploration license

Time scale:

29/03/2001: license into force

28/03/2016: expiry date of license

In 2001 the contract with the ISA was issued. The second five-year period of this contract ended in 2011. The aim in the Clarion-Clipperton-Fracture Zone is the creation of a geological model of the area. To do so the following tasks are conducted:

- Multi beam echo sounding;
- Geological interpretation with construction of preliminary geomorphologic maps and structural maps of ore fields;
- Near-bed acoustic, photo and TV surveys;
- Gathering geological samples and seabed photographs;
- Determination of physical and mechanic properties of sediments and nodules;
- Chemical and analytical studies;
- Final geological interpretation with evaluation of resources and identification of the prospective areas.
-

Financing:

Yuzhmoregeologiya is 100% financed by the Russian government. The project is therefore financed by the

02: Yuzhmorgeologiya, Clarion-Clipperton Fracture Zone

Russian government

Government involvement:

Yuzhmorgeologiya is 100% owned and financed by the Russian government

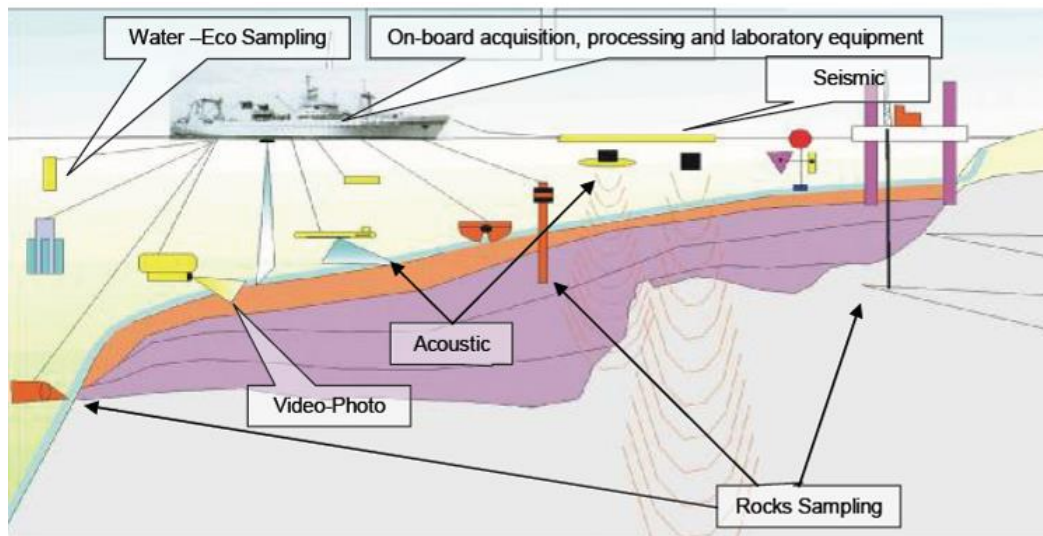
Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used:

The technology involved includes a series of studies for the determination of the composition, physical and mechanical properties of sediments and nodules and the dating of sedimentary formations in specialized shipboard and stationary chemical and analytical laboratories.



Main types used in the CCZ:

1) **MAK-1M acoustic system (designed by SSC YMG)**

MAK-1M is a multi-purpose, efficient geo-acoustic system for sonar survey and seismoacoustic profiling of seabed designed and constructed by YMG to be applied for detailed geological and site surveys at depth up to 6 000 m, exploration of solid minerals, environmental monitoring of water areas, control over underwater construction, search for sunken objects.



2) **NEPTUNE-C photo and TV system (designed by SSC YMG);**

3) **Samplers and corers of various configurations (designed by SSC YMG) e.g.**

- OKEAN-0.25 grab sampler;
- KADR-1 Self-contained sea-floor coring system.
-

02: Yuzhmoregeologiya, Clarion-Clipperton Fracture Zone

Obstacles:

Only Russian scientific company representing Russia in the UNO International Seabed Authority, which grants Russia the rights to explore and develop the ore-bearing territory of 75 000 of square kilometers in the Pacific Ocean.

Sources:

Polymetallic Nodules Exploration Areas in the Clarion-Clipperton Fracture Zone, ISA website,

<http://www.isa.org.jm/files/images/maps/CCZ-Sep2012-Official.jpg>;

ISA (2014a) Contracts for exploration for polymetallic nodules, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Yuzhmoregeologiya website – Programs and Projects, http://en.ymg.ru/w/Programs_and_projects;

State Scientific Center Of The Russian Federation Federal State Unitary Geological Enterprise,

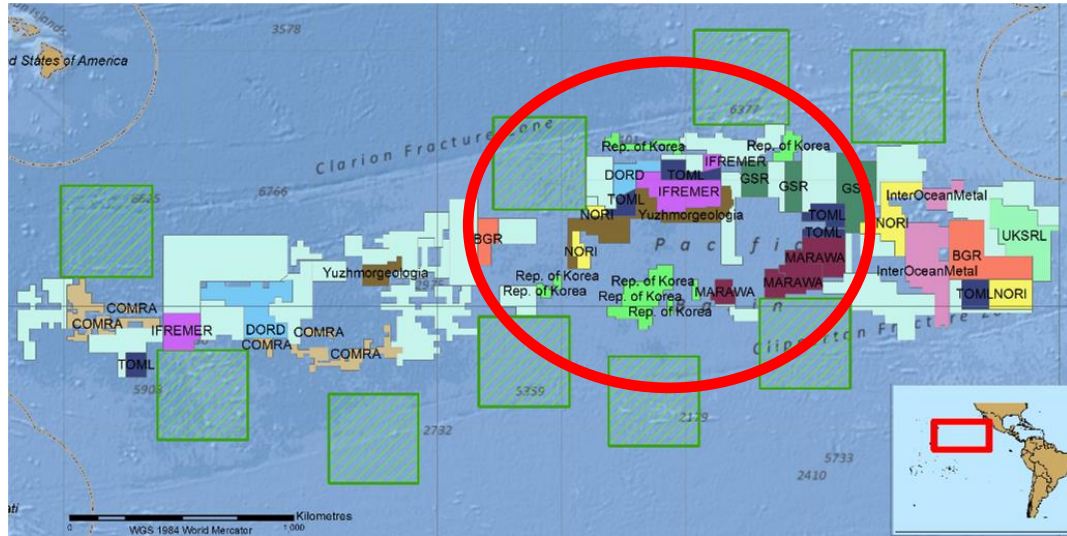
<http://en.ymg.ru/pdf/ymg.pdf>.

03: Government of the Republic of Korea, Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

Latitude 130°0'0". Longitude 10°0'0", 2,000 km southeast of Hawaii

Area: 75 000 km²



Source: ISA (2014a). International Seabed Authority website <http://www.isa.org.jm/en/scientific/exploration/contractors>.

Water depth: Water depth in the east area ranges from 3 901.8 meters to 5 590.7 meters. The west area ranges in depth from 2 969.1 meters to 5 986.6 meters.

Consortia members

Government of the Republic of Korea	Main contractor	
-------------------------------------	-----------------	--

Type of contract: Exploration license

Time scale:

27/04/2001: license into force

26/04/2016: expiry date of license

Financing:

The government of Korea finances the project

Government involvement: The Korean Government holds the contract and finances the project

Type of material to be collected:

polymetallic nodules

In contrast with the northern block, the southern block (KR5) is characterized by relatively low nodule abundances, high Mn/Fe ratio, Cu, and Ni, and low Fe and Co contents. Differing from the northern block, rough-surface and dimorphic (rough on one side, smooth on the other), discoidal and ellipsoidal nodules are the dominant morphological and textural nodule types in the southern block.

Size of expected deposit:

560 million tons of manganese nodules worth some US\$370 billion

Technology used:

The Korea Institute of Ocean Science & Technology (KIOST), is testing technology which is supposed to serve also in the CCZ. It has successfully carried out a deep-sea path following test of Minero, a mining robot, weighing 28 tons, used to collect manganese nodules within its exclusive economic zone. The test was the first of its kind ever attempted in the world. The test was carried out at a location 130 km southeast of Pohang, and 1 370 m below the surface of the ocean, between July 19th and July 26th 2013.

03: Government of the Republic of Korea, Clarion-Clipperton Fracture Zone

KIOST, jointly with the Ministry of Maritime Affairs and Fisheries, is planning to develop the technology for commercial production of their robot extraction technology by 2015, including the technology for extracting strategic metals from manganese nodules and the technology for mining at a depth of 2 000m.

Obstacles: -

Sources:

ISA (2014a). Contracts for exploration for polymetallic nodules, ISA website,
<http://www.isa.org.jm/en/scientific/exploration/contractors>;

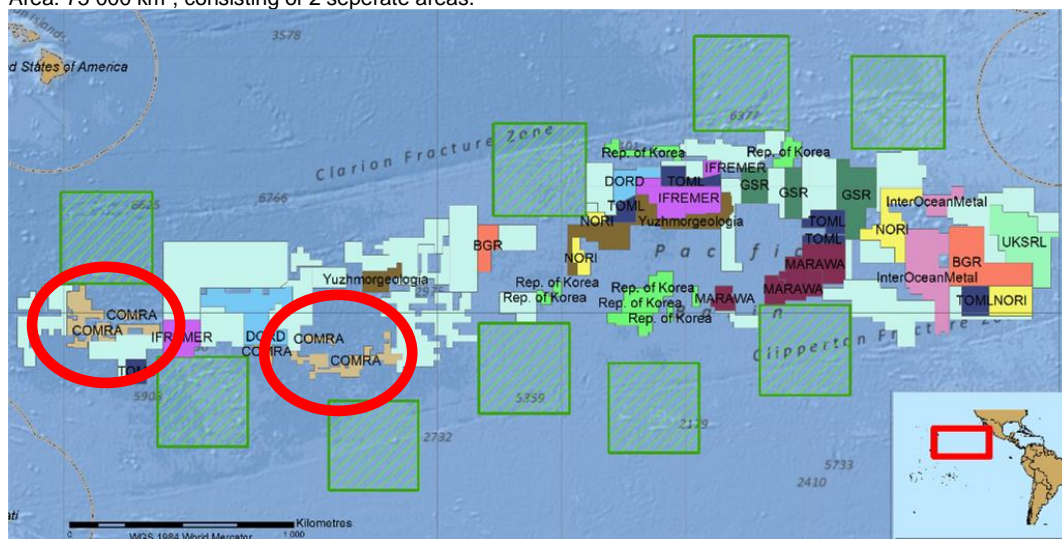
ISA (2010): A Geological Model Of Polymetallic Nodule Deposits in the Clarion-Clipperton Fracture Zone,
<http://www.isa.org.jm/files/documents/EN/Pubs/GeoMod-web.pdf>.

04: China Ocean Mineral Resources Research and Development Association (COMRA), Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

Latitude 155° 0'0" – 140°0'0". Longitude 10°0'0".

Area: 75 000 km², consisting of 2 separate areas.



Source: ISA (2014a). International Seabed Authority website
<http://www.isa.org.jm/en/scientific/exploration/contractors>.

Water depth:

Water depth in the east area ranges from 3 901.8 m to 5 590.7 m. The west area ranges in depth from 2 969.1 m to 5 986.6 m. The area deeper than 5 300 m in water depth covers about 8.5% of the east area and about 11% of the west area. Water depth in the COMRA area, in both portions of the area, is mostly between 5 000 m to 5 300 m.

Consortia members

China Ocean Mineral Resources Research and Development Association (COMRA)	Main contractor
--	-----------------

In 1984 China drew its oceanic mine resources plan. This plan was gained further traction with the establishment of COMRA in 1990. COMRA is governmental organizations to coordinate the activities of deep-sea bed exploration and exploitation in China as well in the international sea.

Type of contract: Exploration license

Time scale:

22/05/2001: license into force

21/05/2016: expiry date of license

Financing:

COMRA is financed by the government of China.

Government involvement:

China has committed huge investment on deep sea exploration. Dolma Tsering describes three different phases within the deep sea exploration of China:

Phase I: (1995-2005)

In this quest for mineral resources, the first major development for China's deep sea exploration was the launch of its most advanced scientific research vessel "Dayang Yihao" in 1995. "Dayang Yihao" is the only open-ocean going vessel designated and equipped for deepsea research in China. This vessel is equipped with the most advanced global positioning and communication systems plus scientific research equipment on board. It conducts deep sea sampling, drilling and videotaping at the water depth of over few thousand meters. In 1996,

04: China Ocean Mineral Resources Research and Development Association (COMRA), Clarion-Clipperton Fracture Zone

the research on oceanography was strengthened with an allocation of more than 800million yuan for oceanographic research under “Ninth Five Year Plan” (1996-2000). During this period the Chinese government formulated the National Plan for implementing the “Program for Marine Development by Reliance on Science and technology”. This program emphasis on research, development and dissimilation of the technologies of marine reproduction, fine processing of marine biological resources, exploration and extraction of marine pharmaceuticals and exploitation of chemical resources in seawater. Another major development during this period was the launch of “Jiaolong” manned submersible in 2002. China unveiled its most advanced submersible in August 2010 after eight years of secretive development. The “Jiaolong” manned submersible is a China’s manned deep-ocean submersible. Like many other submersibles, the Jiaolong ” manned submersible operates with a mother ship, “Xiangyanghong 09”, an oceanographic researchship subordinate to the North Sea Branch of StateOceanic Administration (SOA). It was designed toreach a maximum depth of about 7,000 meters, making it capable of reaching 99.8 percent of the world’s sea areas. Till date “Jiaolong” manned submersible completed 17 dives in South ChinaSea, 5 188 meters below sea level in the PacificOcean and the latest with 7 020 meters at MarianaTrench, West Pacific “Jiaolong” manned submersible has become integral tool for China’s scientific expedition on deep sea resources.

Phase II: 2005-2012

The second major development in China’s project on deep sea exploration was achieved when China embarked on its first around-the-world oceanographic sailing mission by “Dayang Yihao” an oceanographic research ship in 2005-06. During this global expedition, scientists found tantalizing evidence of active hydrothermal vent lying at Southwest IndianRidge (SWIR). They gathered critical data that led them back to the site in 2007. A remarkable achievement was made in 2007 where Chinese scientist aboard “Dayang Yihao” anoceanographic research ship, discovered hot liquid at SWIR independently for the first time. In 2010-2011 “Dayang Yihao” an oceanographic research ship attempted China’s largest and most expansive global expedition at Indian, Pacific and Atlantic oceans. The scientists at the expedition discovered 16 hydrothermal vents out of which 5 were found in South Atlantic Ocean and 11 in the East Pacific Ocean. China has now discovered 33 hydrothermal deposits comprising one tenth of the discovered submarine hydrothermal deposits, in the last three decades.

Phase III-2012 onward

The third phase of China’s research and capacity building on deep sea exploration began in 2012. On 18 April, 2012, the State Oceanic Administration (SOA) announced the establishment of a national maritime survey fleet in an effort to improve China’s ability to conduct maritime survey and research. The fleet consists of 19 survey vessels, 11 of which are oceangoing research ships with a displacement of more than 1 500 tonnes. The ships are separately owned by the SOA, the Chinese Academy of Sciences (CAS), the Ministry of Education (MOE) and other government sectors and institutes with maritime interests.”³

Type of material to be collected:

polymetallic nodules

There are generally four types of sediments in the surface layer of the seafloor of the COMRA area, including siliceous clay, siliceous ooze, siliceous calcareous ooze and calcareous ooze. Siliceous sediments are the most abundant sedimentary types in the east area. Siliceous clay covers 72% of the area and siliceous ooze 22%. Siliceous clay is mainly distributed in abyssal hills and plains with an average water depth of 5,096 m. Siliceous ooze is mostly distributed in transitional areas between siliceous clay and calcareous ooze in the south eastern part of the east area. Calcareous sediment is limited to seamounts in south eastern and western parts of the east area. In general, calcareous sediments confined to the tops of seamounts, while the siliceous sediments

³ Tsering, D. (n.d.): China’s Deep Sea Exploration: Research and Capacity Building, http://www.academia.edu/2482772/Chinas_deep_sea_exploration#

04: China Ocean Mineral Resources Research and Development Association (COMRA), Clarion-Clipperton Fracture Zone

cover the lower regions.

Size of expected deposit: -

Technology used:

Data collected from 1 606 stations by grab samplers; 849 stations are from the East Area and 757 stations from the West Area

Obstacles: -

Sources:

ISA (2014a). Contracts for exploration for polymetallic nodules, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

ISA (2010): A Geological Model Of Polymetallic Nodule Deposits in the Clarion-Clipperton Fracture Zone,

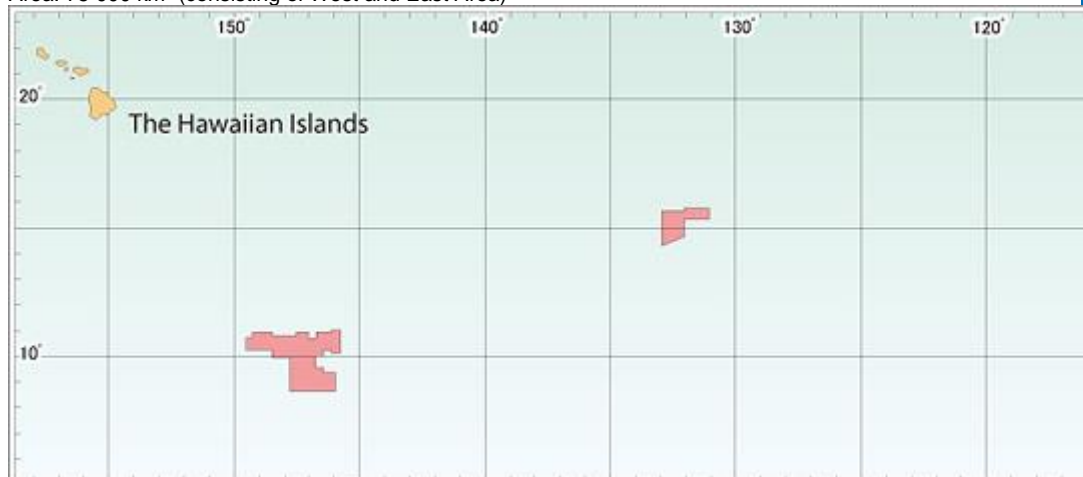
<http://www.isa.org.jm/files/documents/EN/Pubs/GeoMod-web.pdf>;

Tsering, D. (n.d.): China's Deep Sea Exploration: Research and Capacity Building,

http://www.academia.edu/2482772/Chinas_deep_sea_exploration#

05: Deep Ocean Resources Development Co. Ltd (DORD), Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone
 Latitude 150° - 130° Longitude 10°-15', South-East Hawaii
 Area: 75 000 km² (consisting of West and East Area)



Source: JOGMEC website , [<http://www.jogmec.go.jp/english/> accessed 5/1/2014].

Water depth: about 5 000 meters

Consortia members

Deep Ocean Resources Development Co. Ltd (DORD)	Main contractor	
JOGMEC	Since 2001, JOGMEC has been conducting exploration based on the contract of DORD, although JOGMEC had completed reconnaissance of the entire mine site by 1997. JOGMEC has collated and analyzed existing data and used it to establish a future development plan.	

Deep Ocean Resources Development Co., Ltd. was established in September 1982 under a state-private cooperative framework with the goal of securing a stable supply of mineral resources. Japan Oil, Gas and Metals National Corporation (JOGMEC, a state owned company) owns 75.83% of the shares, 43 private-sector companies including six non-ferrous metal companies own the other 24.17%.

Type of contract: Exploration license

Time scale:

22/05/2001: license into force
 21/05/2016: expiry date of license
 Since December 1987 DORD has been conducting surveys in the selected area

Financing:

The greatest shareholder in DORD is the Japanese government. The greatest part of the necessary investments are therefore expected to be made by the Japanese government.

Government involvement: state-private cooperative framework

Type of material to be collected:

polymetallic nodules

Size of expected deposit:

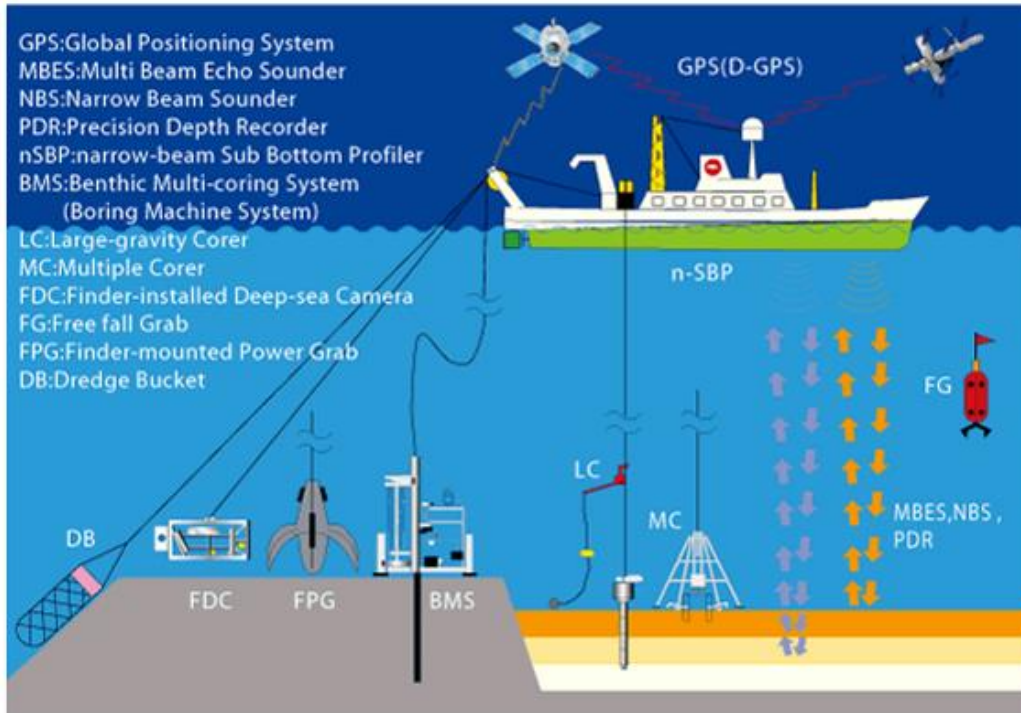
Wet resources of both areas were calculated to be 513 million ton and 170 million ton, respectively, for West and East Areas

Technology used:

JOGMEC constructed a research vessel (R/V) to explore for deep-sea mineral resources. Using this vessel, R/V Hakureimaru No. 2, JOGMEC initiated full-fledged surveys of manganese nodules. Instruments for Navigation,

05: Deep Ocean Resources Development Co. Ltd (DORD), Clarion-Clipperton Fracture Zone

Exploration and Geological Sampling on board of the R/V Hakureimaru No. 2. can be seen in the next picture:



Source: JOGMEC website.

An AUV (Autonomous Underwater Vehicle) was used for the first time. Seafloor topographic map with 1 meter contour line was produced in two areas of about 20 km² each by AUV survey equipped with MBES. Photographs, continuously covering the seafloor taken by AUV, together with seafloor topographic map produced from MBES of the AUV enabled DORD to understand the manner of distribution of polymetallic nodules.

Obstacles: -

Sources:

Offshore Manganese Nodule Exploration Southeast of Hawaii, JOGMEC website,

http://www.jogmec.go.jp/english/metal/financial_015.html;

Deep-Sea Mineral Resources: Exploration Objectives and Survey Methods, JOGMEC website,

http://www.jogmec.go.jp/english/metal/technology_018.html?recommend=1;

Contracts for exploration for polymetallic nodules, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Deep Ocean Resources Development (DORD) website, <http://www.dord.co.jp/english/corporate/index.html>

Okazaki, Masatsugu and Tsune, Akira (2013). "Exploration of Polymetallic Nodule Using AUV in the Central Equatorial Pacific (2013): Proceedings of the Tenth ISOPE Ocean Mining and Gas Hydrates Symposium (September 22-26, 2013),

http://www.isopec.org/publications/proceedings/ISOPE_OMS/OMS%202013/data/papers/M13-42Okasaki.pdf.

06: Institut français de recherche pour l'exploitation de la mer (IFREMER), Clarion-Clipperton Fracture Zone

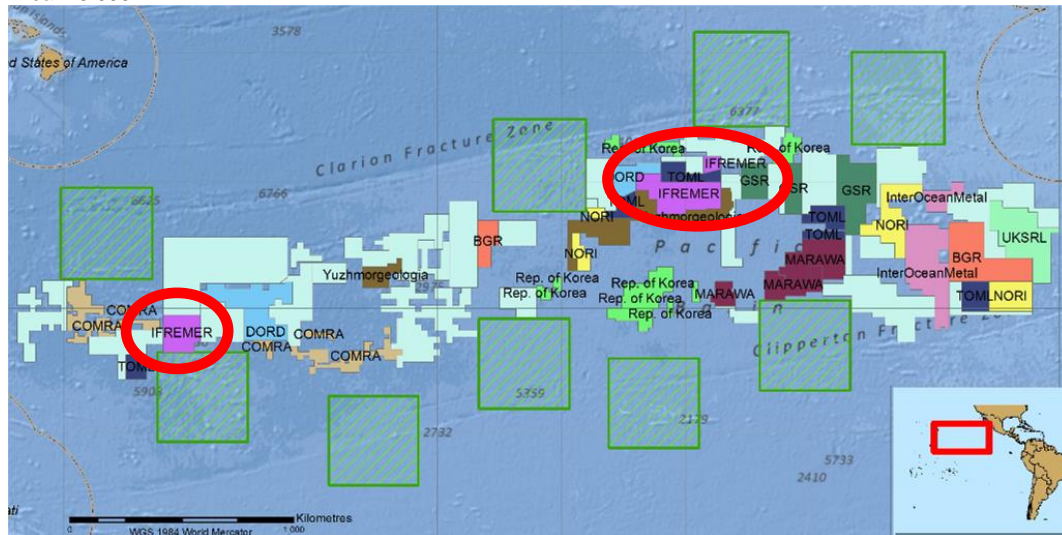
Zone

Location: Clarion-Clipperton Fracture Zone

Part A: Latitude 130°0'0" W. Longitude 15°0'0" N

Part B: Latitude 150°0'0" W Longitude 10°0'0" N

Area: 75 000 km²



Source: ISA (2014a). International Seabed Authority website
<http://www.isa.org/jm/en/scientific/exploration/contractors>.

The parts of IFREMERs license are located in the north east of the CCZ as well as in the west. The block in the west is one connected area while the parts in the north east are separated by a license of TOML (Tonga Offshore Mining Limited).

Water depth: about 5 000 meters

Consortia members

Institut français de recherche pour l'exploitation de la mer (IFREMER)

Main contractor

IFREMER is a Government Research Institute, created in 1984. It is supervised jointly by the Ministry of Higher Education and Research and the Ministry of Ecology, Sustainable Development and Energy. IFREMER owns 8 research vessels (including 4 ocean-going ships), 1 manned submarine, 1 remotely-operated vehicle for deep sea explorations (- 6 000 m) and 2 AUVs (Autonomous Underwater Vehicle).

Type of contract: Exploration license

Time scale:

20/06/2001: license into force

19/06/2016: expiry date of license.

Financing: The company is financed by the French government

Government involvement: The French government finances (indirectly) the project

Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used: -

Obstacles:

The area of IFREMER has an extremely high biodiversity. The aim is to get sufficient scientific knowledge to extract deep sea resources in the area without harming the environment.

06: Institut français de recherche pour l'exploitation de la mer (IFREMER), Clarion-Clipperton Fracture Zone

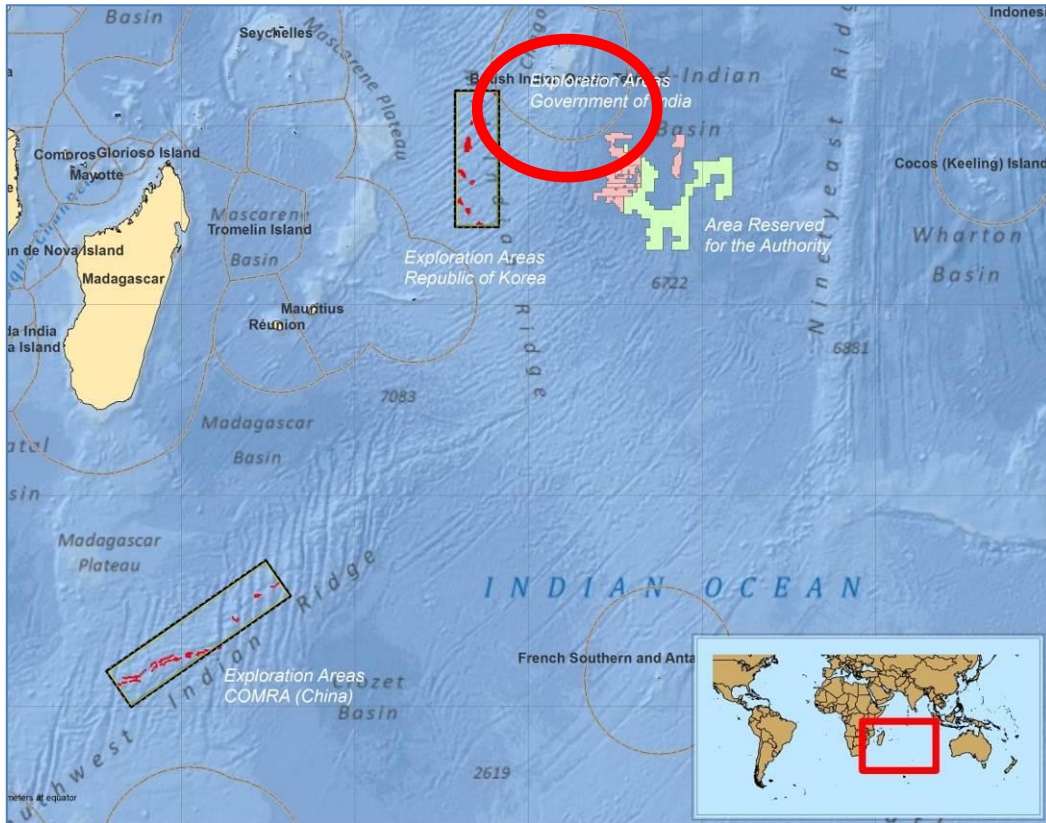
Sources:

ISA (2014a). Contracts for exploration for polymetallic nodules, ISA website,
<http://www.isa.org.jm/en/scientific/exploration/contractors> [accessed 5/1/2014].
IFREMER website,
http://wwz.ifremer.fr/institut_eng/content/download/57277/797335/file/12_03_23_CP_BIONOD.pdf;
ISA (2011): Selected Decisions and Documents of the Seventeenth Session,
<http://www.isa.org.jm/files/documents/EN/SeIDecisions/EN12-Web.pdf>.

07: Government of India, Indian Ocean

Location: Indian Ocean, North-East of Madagascar

Area: 75 000 km²



Source: ISA (2014a). International Seabed Authority website
<http://www.isa.org.jm/en/scientific/exploration/contractors>.

Water depth: 5 000 – 5 700 meters

Consortia members

Government of India	Main contractor	
---------------------	-----------------	--

The Government of India is the sole contractor. However, the responsible Ministry of Earth Sciences has entrusted the task of Exploration, Environmental Impact assessment, Mineral Processing, Metallurgy and development of Deep Sea Mining Technology to different institutes in the country.

Type of contract: Exploration license

Time scale:

25/03/2002: license into force

24/03/2017: expiry date of license

India is carrying out the exploration and technology development for exploitation under the Polymetallic Nodules program of the Ministry of Earth Sciences.

India was registered as Pioneer Investor in 1987 along with Japan, France and Soviet Union.

Financing:

The project is financed by the Indian government

Government involvement:

The Indian government is holding the contract and finances the project.

07: Government of India, Indian Ocean

Type of material to be collected:

polymetallic nodules

Size of expected deposit:

The following table shows the estimated expected deposit in the licensed area in million metric tons (MMT):

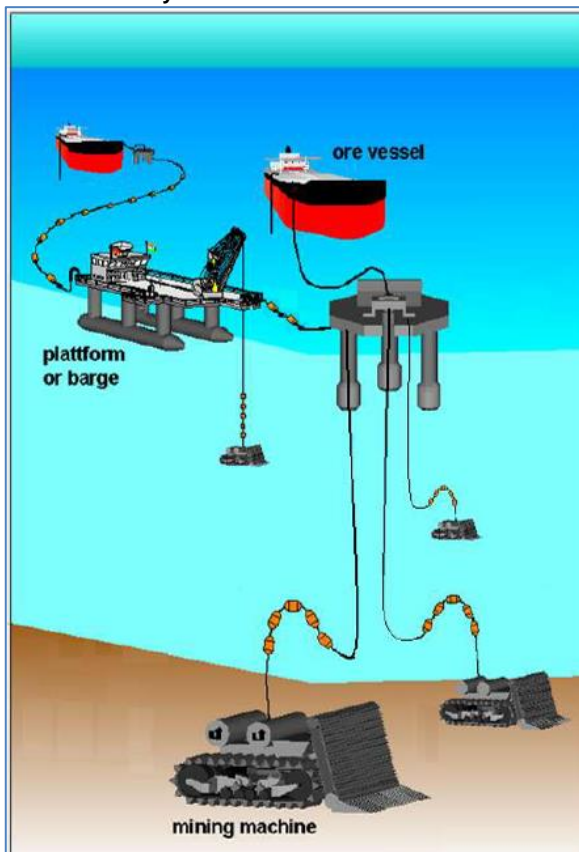
Type	Quantity
Wet Nodules	759.00 MMT
Dry Nodules	607.00 MMT
Manganese	144.00 MMT
Cobalt	0.85 MMT
Nickel	7.00 MMT
Copper	6.50 MMT
Total Metal	158.35 MMT

In total, estimated reserves in the Indian Ocean amount to 0.15 trillion tons.

Technology used:

Demonstrated extraction of metals in Pilot Plant Scale using a flexible riser mining system concept at 500 m depth.

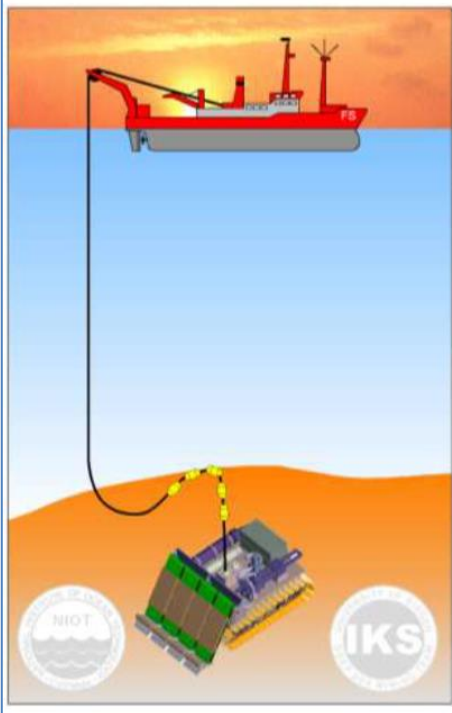
Flexible Riser System



Multiple mining machines connected to mother station;

Self propelled amining machine that pumps nodules through a flexible riser using a single positive displacement pump.

The following figure is an illustration for a Flexible Riser Concept for underwater mining for 6,000 metre depth.



Currently, India is in the third phase of validation of the flexible riser concept for manganese nodule mining operations in the Central Indian Ocean Basin using one mining machine and other subsystems (2010 – 2015).

India teamed up with the Institut für Konstruktion (IKS) of University of Siegen (Germany) and NIOT and jointly developed the crawler based underwater mining machine. Testing so far until 500 m depth.

Mining System Description:

Overall length	3400 mm
Overall Width	3450 mm
Weight in air	10 tons
Weight in water	8 tons
Depth of operation	500 m
Operational speed	0.5 m/s
Max speed	0.75 m/s
Max slope	8.5°
Slurry Discharge	upto 45 m ³ /h
Concentration	30 % (max.)
Mining Output	12 t/h (max.)
Particle Size (max.)	8 mm
Flexible Riser System	
Hose size	75 mm
Hose Spool length	100 m
Hose-cable joints	at 6m intervals
Hose Winch	500 kg (SWL)
Hose Spool Speed	0.5 m/s (max.)
Power Supply, Control and Instrumentation System	
Cable	Electro-mechanical multi-conductor
Breaking strength	400 kN
Power	120 kW at 3000 V
Signal Transmission	2 optical lines TCP/IP
Data Acquisition	PXI based system
Transducers	Velocity, heading, pitch, roll, vision
Winch for Cable	1.6 m dia.x 1.4 m length
Cable Spool Speed	0.5 m/s

07: Government of India, Indian Ocean

Obstacles: -

Sources:

Polymetallic Nodules Exploration Areas in the Indian Ocean, ISA website,

<http://www.isa.org.jm/files/images/maps/IndianOcean.jpg>;

Contracts for exploration for polymetallic nodules, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Atmanand, Director National Institute of Ocean Technology (2011): Presentation on Status of India's

Polymetallic Nodule Mining Programme, ISOPE-2011 Maui Conference,

<http://www.deepoceanmining.org/docs/atmanand.pdf>.

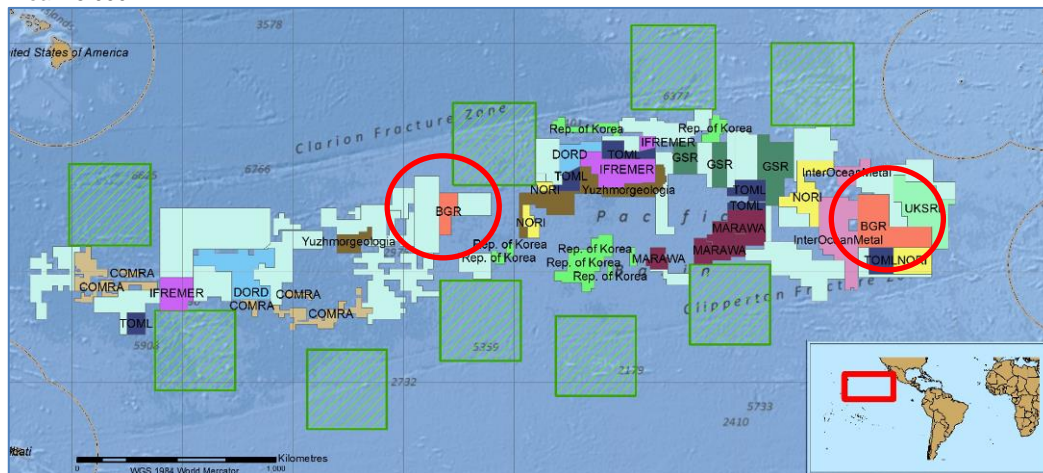
08: Federal Institute for Geosciences and Natural Resources of Germany, Clarion-Clipperton Fracture Zone

Zone

Location: Clarion-Clipperton Fracture Zone

Latitude 118°0'0"W Longitude 12°0'0"N

Area: 75 000 km²



Source: ISA (2014a). International Seabed Authority website
<http://www.isa.org/im/en/scientific/exploration/contractors>.

Water depth: 4 200 to 4 800 meters on average

Consortia members

Federal Institute for Geosciences and Natural Resources of Germany

Main contractor

The Federal Institute for Geosciences and Natural Resources of Germany is a company that is 100% financed by the German government. In order to perform the exploration other companies are contracted. For example a private vessel is contracted in order to be able to do the actual exploration works and the Senckenberg Institute to perform the environmental study. The resource assessment will be done by the University of Bielefeld.

Time scale:

19/07/2006: license into force

18/07/2021: expiry date of license

The area has been explored before by other companies like Preussag up to a status of pilot mining. Due to the political and economic situation in the early 1980's further developments stopped.

Financing:

Government of Germany finances (indirectly) the exploration.

Government involvement:

The German government finances the Federal Institute for Geosciences and Natural Resources of Germany. The reason why the German government is (indirect) involved is because they want to give German companies/industries the opportunity to step in/to attract them.

Type of material to be collected:

Polymetallic nodules

Size of expected deposit:

Confidential

The size of the expected deposit is assessed by the University of Bielefeld (prof. Nattkämper)

Technology used:

First the prime sites for mining have been established within the exploration area. This is based on hull mounted multibeam survey systems (mapping). This however has limited resolution because it is deployed at the sea surface. Currently the size of the deposit is estimated as well as the current environmental situation including

08: Federal Institute for Geosciences and Natural Resources of Germany, Clarion-Clipperton Fracture Zone

movement of the water (currents). This is done using random sampling of selected areas, high resolution mapping and photo's with deep-towed systems like a sidescan, photo sledge; it also includes moorings with long-term recording of various parameters.

Obstacles:

Potential influence on metal prices if a mined component will dominate the global market (e.g. cobalt; huge production might potentially damage the cobalt market);

Technically: Avoid 'Left overs' from previous exploration period to prevent damaging your mining equipment (excellent, detailed maps required);

Metallurgical extraction for Mn-nodules not yet established (metal extraction accounts for 2/3 of the total costs of deep-sea mining).

Public opposition is rising in Germany.

Sources:

Polymetallic Nodules Exploration Areas in the Clarion-Clipperton Fracture Zone, ISA website, <http://www.isa.org.jm/files/images/maps/CCZ-Sep2012-Official.jpg>;

ISA (2014a) Contracts for exploration for polymetallic nodules, ISA website, <http://www.isa.org.jm/en/scientific/exploration/contractors>;

Interview with the Federal Institute for Geosciences and Natural Resources of Germany (Mr. M. Wiedicke-Hombach).

09: Nauru Ocean Resources Inc. (NORI), Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

The area of NORI lies within the reserved areas and is divided into four regions: Area A is located within Block 13 and covers an area of 8 924 km²; Area B is located within Block 15 and covers an area of 3 519 km²; Area C is located within Block 22 and covers an area of 37 227 km²; and Area D is located within Block 25 and covers an area of 25 160 km².

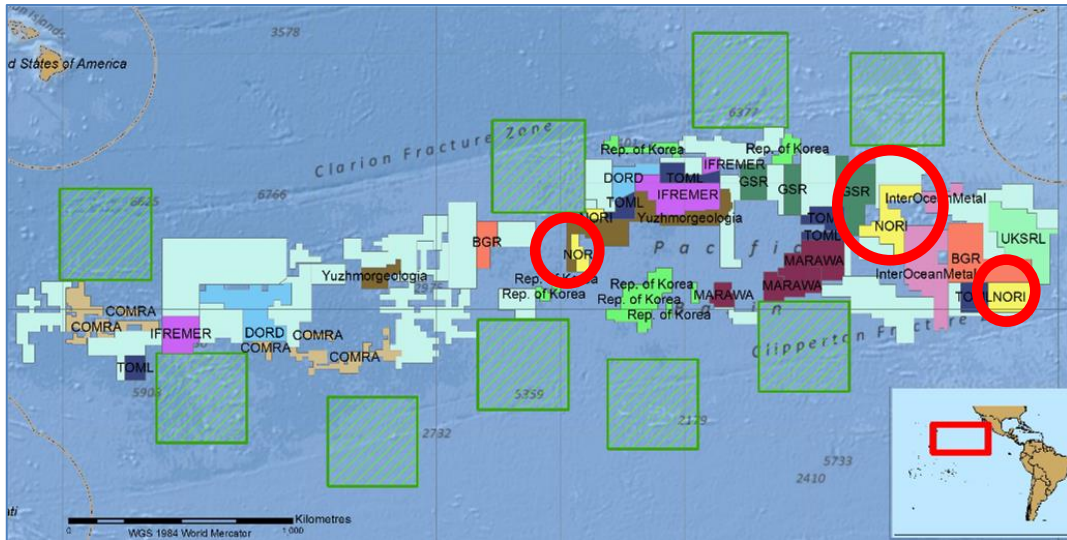
Area A: Latitude 13.0000 N Longitude -134.583 W

Area B: Latitude 14.0000 N Longitude - 134.0000 W

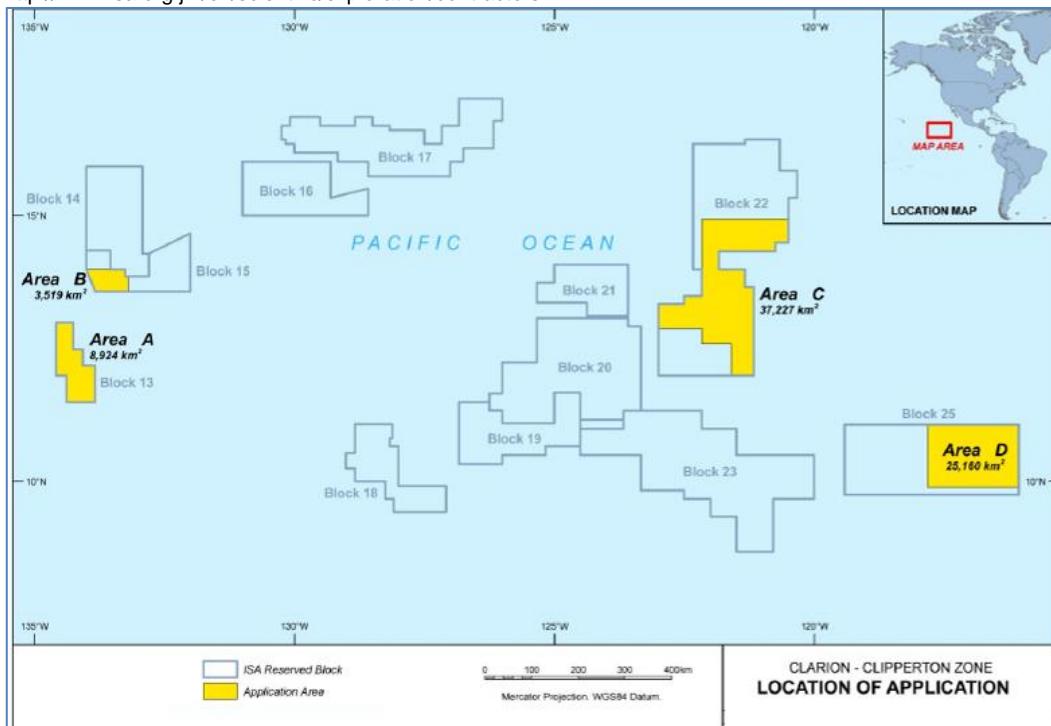
Area C: Latitude 14.9350 N Longitude -122.1667 W

Area D: Latitude 11.08333 N Longitude -117.816670 W

Area: 74 830 km² in total



Source: ISA (2014a). International Seabed Authority website
<http://www.isa.org.jm/en/scientific/exploration/contractors>.



International Seabed Authority (2011d).

Water depth: 4 000m to 5 000 meters

09: Nauru Ocean Resources Inc. (NORI), Clarion-Clipperton Fracture Zone

Consortia members

Nauru Ocean Resources Inc. (NORI)	Main contractor	
-----------------------------------	-----------------	--

In 2008 NORI was a subsidiary of Nautilus Minerals Inc. (“Nautilus”). Since that time Nautilus has sold all of its ownership and interest in NORI. NORI is now wholly owned by the Nauru Education and Training Foundation and the Nauru Health and Environment Foundation; two Nauruan foundations which own NORI in equal shares.

NORI has obtained the services of key leaders of four major international consortiums that developed and successfully trial-mined deep sea mining systems to harvest polymetallic nodules in the Clarion-Clipperton Zone in the late 1970s, including from Ocean Management Incorporation, Kennecott Exploration Consortium, Ocean Minerals Company and Ocean Mining Associates.

NORI’s technical alliance also includes the following world leading international organizations: Cellula Robotics Ltd., Derrick Offshore Ltd., LongReach Marine Pte Limited, Sound Ocean Systems Inc. and Williamson & Associates Inc.

Type of contract: Exploration license

Time scale:

22/07/2011: license into force

21/07/2026: expiry date of license

In 2008 the Republic of Nauru sponsored an application by Nauru Ocean Resources Inc. for a plan of work to explore for polymetallic nodules in the Area:

Date of receipt of application: 10 April 2008;

Previous contracts with the Authority: the applicant has not been previously awarded any contract with the Authority;

Undertakings: the applicant submitted a written undertaking dated 21 April; 2011 and signed by the Director of NORI, Dominic J. Tabuna.

In 2012 NORI completed a polymetallic nodule exploration cruise in the NORI area aboard the vessel RV Mt. Mitchell, which sailed from the port of Seattle. NORI conducted extensive seafloor mapping and nodule sampling.

Financing:

Nauru’s sponsorship of Nauru Ocean Resources Inc. was originally premised on the assumption that Nauru could effectively mitigate the potential liabilities arising from its sponsorship. In contrast to terrestrial mining, if a State can be held liable for activities in the Area, the State may potentially face losing more than it actually has. Therefore, throughout the application process Nauru was aiming at finding a solution to mitigate these risks. However, ultimately was decided that, if sponsoring States are exposed to potential significant liabilities, Nauru, as well as other developing States, may be precluded from effectively participating in activities in the Area.

Finally, in its application Nauru declared that it has the necessary financial resources to meet the estimated costs of the proposed plan of work for exploration. The ISA also noted that the activities will be financed by a guaranteed minimum budget of \$10 million, which the applicant has proposed to finance through borrowing.

NORI has so far spent approximately \$5 million on polymetallic nodule exploration activities. Exploration expenditure is subject to exploration results and to developments in the preparation of regulations on exploitation for nodules by the Authority.

Government involvement: Republic of Nauru is the sponsoring state

Nickel, copper and manganese do not occur economically in Nauru’s jurisdiction, and this license is seen as an opportunity for Nauru to participate in the development of these key resources. Nauru does not have any

09: Nauru Ocean Resources Inc. (NORI), Clarion-Clipperton Fracture Zone

commercially prospective non-living seafloor minerals in its EEZ, thus it must look to the international seabed area.

The State has implemented a comprehensive legal framework to regulate NORI's activities in the international seabed area. The State will monitor seabed mining activities to enforce the legislation, the regulations issued pursuant thereto and the terms, conditions and restrictions imposed on any licensee.

Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used:

Nauru benefits in its technical team from the experience of leaders of four international consortiums (Ocean Management Incorporation, Kennecott Exploration Consortium, Ocean Minerals Company and Ocean Mining Associates) which developed and successfully carried out trial deep-sea mining systems to collect nodules in the Clarion-Clipperton Zone in the 1970s.

NORI employs leading deep sea nodule polymetallic nodule exploration technology applicable to the Clarion Clipperton Zone deposit.



Source: Nauru Ocean Resources website, <http://www.nauruoceanresources.com/>

Obstacles:

The cost of capital for deep sea mineral development is higher than that for terrestrial mining.

Sources:

Contracts for exploration for polymetallic nodules, ISA website, <http://www.isa.org.jm/en/scientific/exploration/contractors>;
Nauru Ocean resources website, <http://www.nauruoceanresources.com/>;
ISA (2010): Proposal to seek an advisory opinion from the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea on matters regarding sponsoring State responsibility and liability, <http://www.isa.org.jm/files/documents/EN/16Sess/Council/ISBA-16C-6.pdf>;
ISA (2011d). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration by Nauru Ocean Resources Inc. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011:

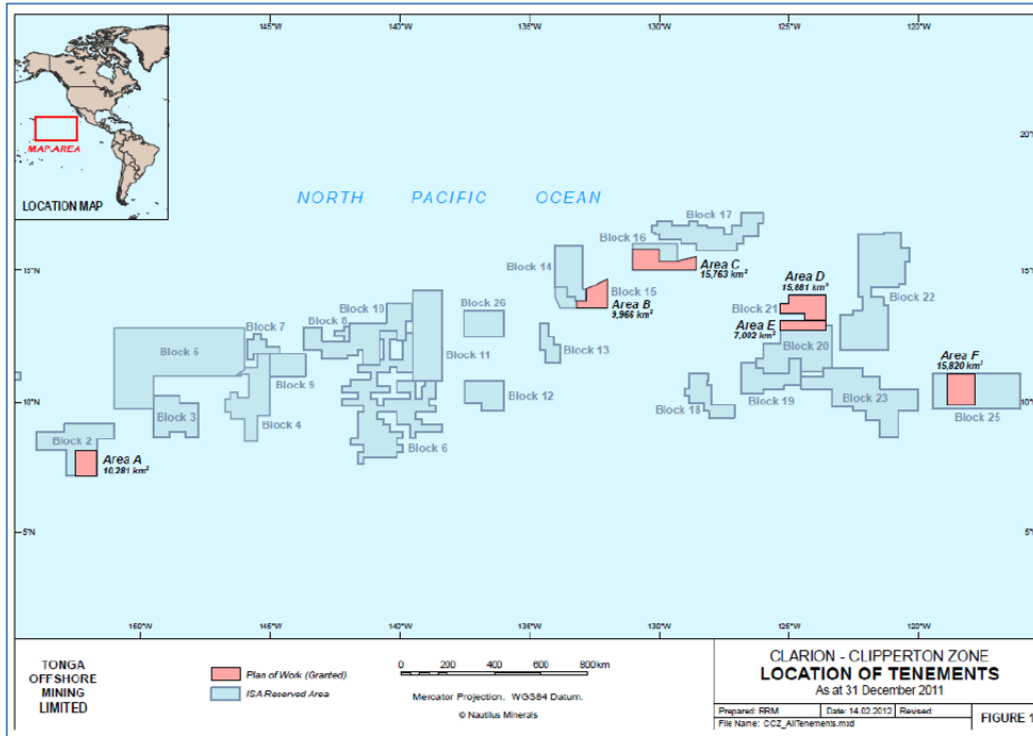
10: Tonga Offshore Mining Limited, Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

Between Longitude 110°W and 160°W and Latitude 5°N and 20°N

Tonga Offshore Mining Ltd has obtained an exploration area that consists of six separate areas (termed areas A to F in the figure below) in the Clarion Clipperton Zone of the Pacific Ocean. (Area A 10 281 km², Area B 9 966 km², Area C 15 763 km², Area D 15 881 km², Area E 7 002 km², Area F 15 820 km²).

Area: Total area amounts to around 74 713 km²



Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA.

Water depth: about 5 000 meters

Consortia members

Tonga Offshore Mining Limited	Main contractor	
-------------------------------	-----------------	--

Tongan Offshore Mining Ltd (TOML) is a subsidiary of Nautilus Minerals and has been sponsored by the Government of Tonga in its application for approval by the International Seabed Authority. Tonga Offshore Mining Limited was incorporated in the Kingdom of Tonga on 7 May 2008 and is a Tongan incorporated subsidiary of Nautilus Minerals Incorporated.

Type of contract: Exploration license

Time scale:

11/01/2012: license into force

10/01/2027: expiry date of license

Application

The application was first heard by the ISA Legal and Technical Commission (LTC) in mid-2008, although the LTC was unable to reach a decision on the application at that time. In July 2011, the ISA approved the Contract. TOML was therefore one of the first private sector organizations to be granted exploration licences in the CCZ. At the 11th of January 2012, a Contract of Work was signed by the ISA and TOML.

Exploration

In 2013 TOML completed a 54 day exploration cruise. Work was completed by the oceanographic survey vessel

10: Tonga Offshore Mining Limited, Clarion-Clipperton Fracture Zone

'MV Mt Mitchell', which departed from Seattle, Washington on August 22, 2013. The work program comprised 64 000 km² of multibeam mapping and the collection of 2 090 wet kilograms of polymetallic nodules. It is part of a two stage multi-beam and sampling program designed to upgrade a significant portion of the current 440 million tonne inferred resource to an indicated status, to allow for preliminary engineering, metallurgy and cost studies.

Nautilus reported that approximately 64 000 km² of MBES and backscatter were so far collected over about 85% of the granted contract area. The data collected allow for detailed geological mapping of terranes, seafloor composition, and nodule distribution and relative nodule abundance. The results of the work will be used to focus future work.

Fourteen deployments of an epibenthic sled were made by TOML during the 2013 cruise to the CCZ, recovering some 2.1 tonnes of mineralised nodules. The sled was towed across the sea-floor and then retrieved to the vessel with sample caught in a net. Thirteen samples were of sufficient size (40 to 370 kg) to use for analytical and test purposes.

The sled samples were taken to be used for metallurgical testwork and so were not subjected to crushing and splitting. Small sub-samples were collected by hand from each sled sample with discrimination of nodules from nodule crusts when both were present. Nodule crusts are a sub-type of nodule that includes some proportion of benthic seafloor sediment. A carefully hand split duplicate sub-sample was included per group of sled samples.

Each sub-sample (302 plus 16 duplicates in total) was analysed separately and averages (excluding duplicates).

Thirty sub-samples (including seven duplicates) were selected based on a range of chemistry and sample locations, and submitted for analysis for rare earth elements.

Financing:

The project is sponsored by the Government of Tonga

TOML has agreed to a royalty with the Tongan government as part of its sponsorship agreement of US\$1.25 per dry ton for the first 3 million dry tons of nodules mined per year, and US\$0.75 per dry ton for all subsequent tons mined thereafter in that same year.

Government involvement:

See 'Financing'

Type of material to be collected:

polymetallic nodules

The following table 1 presents a summary assays for dredge sample composites from TOML within the CCZ published by Nautilus:

Area / Sled ID	Lithology	# sub-samples	Latitude (WGS84)	Longitude (WGS84)	Depth (mbsl)	Ni %	Cu %	Co %	Mn %	Fe %
B1	Nodule	20	13.663	-132.876	4800	1.50	1.17	0.245	30.3	5.65
D1	Nodule	20	13.487	-124.668	4600	1.39	1.19	0.200	30.2	5.29
D2	Nodule	20	13.440	-124.662	4700	1.40	1.20	0.214	30.8	5.59
D4	Nodule	20	13.723	-123.966	4700	1.28	1.17	0.225	30.3	5.16
D5	Nodule	20	13.785	-124.293	4600	1.47	1.27	0.211	30.6	5.11
D6	Nodule	17	13.883	-124.318	4400	1.39	1.18	0.224	30.5	5.51
D7	Nodule	20	13.883	-124.326	4400	1.44	1.27	0.233	29.9	5.38
D8	Nodule	20	14.031	-124.956	4400	1.35	1.22	0.213	29.0	5.63

10: Tonga Offshore Mining Limited, Clarion-Clipperton Fracture Zone

D9	Nodule	20	14.031	-124.956	4400	1.41	1.21	0.218	29.6	5.67
F1	Nodule	20	10.296	-118.506	4200	1.36	1.17	0.143	32.0	6.16
F2	Nodule	21	10.669	-118.626	4400	1.33	1.38	0.130	31.8	5.12
F3	Nodule	21	10.680	-118.625	4400	1.42	1.33	0.137	32.0	5.07
F4	Nodule	20	10.987	-118.846	4300	1.36	1.34	0.157	32.4	5.14
D4	Crust	20	13.723	-123.966	4700	0.30	0.34	0.065	8.17	4.61
D6	Crust	14	13.883	-124.318	4400	1.23	0.99	0.188	27.1	5.60
D8	Crust	9	14.031	-124.956	4400	1.01	0.88	0.219	21.4	6.90

The sample composites in the table above were collected using an epibenthic sled. These samples were taken for preliminary chemical investigation and bulk metallurgical test-work and were not collected in a manner that can support any type of quantitative assessment of the mineral resource estimate.

The next table 2 shows the average Molybdenum and REE assays for a dredge sample composite (23 samples) from TOML Areas B, D, F within the CCZ published by Nautilus:

Element	Symbol	Average (ppm)
Molybdenum	Mo	552
Scandium	Sc	11.8
Yttrium	Y	74.1
Lanthanum	La	88.4
Cerium	Ce	257
Praseodymium	Pr	28.1
Neodymium	Nd	112
Samarium	Sm	28.7
Europium	Eu	7.01
Gadolinium	Gd	27.7
Terbium	Tb	4.20
Dysprosium	Dy	24.2
Holmium	Ho	4.30
Erbium	Er	11.9
Thulium	Tm	1.59
Ytterbium	Yb	11.4
Lutetium	Lu	1.67

Size of expected deposit:

Inferred mineral resources of approximately 410 million wet tonnes at 1.2% Ni, 1.1% Cu, 0.24% Co and 26.9% Mn at an average surface abundance of 9.4 wet kg/m². This estimation is based on a Technical Report (by Golder Associates Pty Ltd). Full details are within the knowledge of the company and the ISA, but are confidential.

Technology used:

Kongsberg EM120 (12 kHz) Multibeam echosounder.

To date, Nautilus's activities have focused on pioneering the commercial development of seafloor polymetallic sulphides within the exclusive economic zones of south-west Pacific island nations, and is currently preparing for commercial extraction of polymetallic sulphides on the Solwara 1 project in Papua New Guinea.

The key data behind the estimate for expected deposit size are surface samples obtained by free-fall grab samplers, although a few results from box corers were also included. Free-fall grab samplers are believed to underestimate the actual abundance, as smaller nodules may escape some grabs during ascent and larger

10: Tonga Offshore Mining Limited, Clarion-Clipperton Fracture Zone

nodules around the edge of the sampler may be knocked or fall out during the sampling process. Despite this, they are the standard sampling method as they are the most productive and proven tool available, because several can be deployed at any one time independently of the survey vessel (from deployment to recovery is several hours).

Laboratory Analysis:

Analysis of the nodules was done by two leading laboratories, with techniques refined so as to apply to the nodules' physical and chemical nature. A multi-element analysis method (reviewed by Mathew Nimmo of Golder Associates) has now been developed, which will be used for future nodule sampling programs and to support any future mineral resource updates.

The laboratory analyses results (table 1 under type of material collected) were completed by the ALS Laboratory Group in Brisbane, Australia. ALS Brisbane has extensive experience in the analysis of high manganese materials by the XRF method. ALS operates quality systems based on international standards ISO/IEC17025:1999 "General requirements for competence of calibration and testing laboratories" and ISO9001:2000 "Quality Management Systems -- Requirements".

Nickel (Ni), copper (Cu), cobalt (Co), manganese (Mn), and iron (Fe) were determined using a chromite/manganese ore fused disk XRF method (ME-XRF26s).

The laboratory analyses results in (table 2 under type of material collected) were completed by a laboratory operated by the Integrated Environmental Studies Program Group, Earth and Space Sciences Program, at Jacobs University in Bremen, Germany. This group has been involved in nodule analysis and study for over 10 years and has been integral to much of the development of nodule standards used in the industry. All of the elements reported in Table 2 were determined using a nitric acid digest ICP MS method.

Obstacles:

Nautilus lists and describes in its annual report many risks related to their work in general which are mainly based on experiences from the SOLWARA 1 project, but may in many cases also be relevant for their future work in the CCZ. The risks mentioned are:

- Financial resources (high expenditures already made);
- Future funding requirements and risk;
- Exploration risk (majority of companies fail to ever locate an economic deposit);
- Mining and recovery risk;
- Estimates of grades from samples (estimates may not reflect the absolute truth);
- No production history;
- No pre-feasibility study or feasibility study;
- Inability to find a suitable site for the concentrator or a toll concentrator;
- Dependence on a small number of projects;
- Reliance on strategic relationships;
- Default by partners;
- Litigation;
- Grade, tonnage and resources;
- Metallurgy and treatment;
- Operational costs;
- Disruption from non-governmental organisations;
- Safety at sea;
- Maritime piracy;
- Equipment risk;
- Renewal of Tenements and Tenement applications;

10: Tonga Offshore Mining Limited, Clarion-Clipperton Fracture Zone

Dependence on the Directors and officers;
Dependence on key personnel;
Dependence on other contractors;
Increases in capital and operating costs;
Ability to exploit successful discoveries;
Insurance risk;
Political instability;
Management of growth;
Labour and employment matters;
Currency risk;
Lack of recognition of risks;
Conflicts of interest.

Sources:

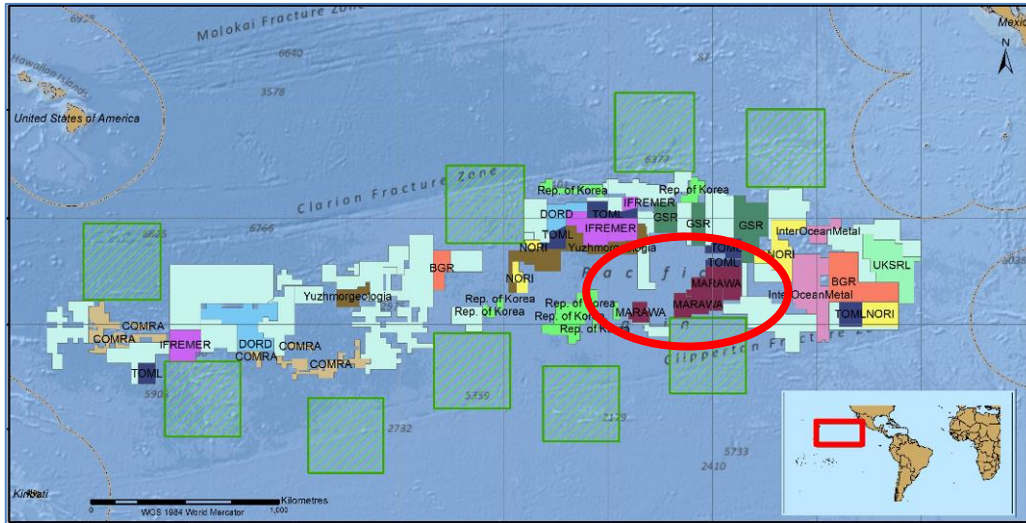
Contracts for exploration for polymetallic nodules, ISA website,
<http://www.isa.org.jm/en/scientific/exploration/contractors>;
Nautilus Minerals Inc (2014): Nautilus Confirms Grade and Extent of CCZ Nodule Deposit, Nautilus Minerals Press release (19 March 2014), <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=643004>;
Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013, <http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>;
Nautilus Minerals Inc. (2012): Nautilus Minerals Defines 410 million tonne Inferred Mineral Resource*, Nautilus Minerals Press release (18 September 2012), see: <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=548462>;
SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA;
ISA (2011c). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by Tonga Offshore Mining Limited. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011:
<http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-10.pdf>.

11: Marawa Research and Exploration Ltd., Clarion-Clipperton Fracture Zone

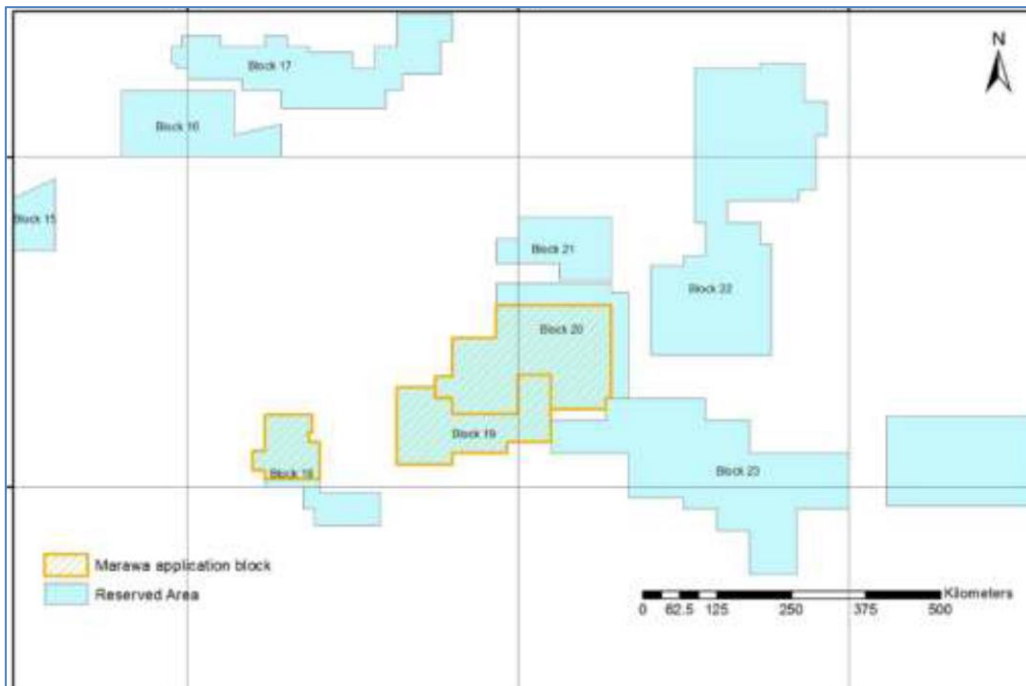
Location: Clarion-Clipperton Fracture Zone

Latitude 130°0'0"W – 123°0'0"W. Longitude 10°0'0"N - 13°0'0"N

Area: 74 990 km². The area is divided into three regions: the first area covers 9 810 km²; the second area covers 24 410 km²; and the third area covers 40 770 km².



ISA (2014a) website.



Source: ISA (2012a), 18th Council Session.

Water depth: 5 000 meters

Consortia members

Marawa Research and Exploration Ltd.	Main contractor
--------------------------------------	-----------------

Marawa Research and Exploration Ltd. is a State enterprise owned and controlled by the Republic of Kiribati. The Board of Directors is composed only of nationals from the Republic of Kiribati. It comprises Hon. Tinian Reiher, Minister of Fisheries and Marine Resources Development, Hon. Tiarite Kwong, Minister of Environment, Lands and Agricultural Development, and Hon. Titabu Tabane, Attorney-General.

Type of contract: Exploration license

11: Marawa Research and Exploration Ltd., Clarion-Clipperton Fracture Zone

Time scale:

License is not signed yet (24 June 2014)

On 30 May 2012, the Secretary-General of the International Seabed Authority received an application for the approval of a plan of work for exploration for polymetallic nodules in the Area. The application was submitted by Marawa Research and Exploration Ltd. The reserved areas in the application were contributed by the Government of the Republic of Korea.

Marawa's proposed scientific research and exploration program will involve seafloor mapping, polymetallic nodule sampling as well as environmental baseline studies and environmental impact assessments in international waters.

Financing:

The Republic of Kiribati had provided a statement dated 18 April 2012 certifying that the State enterprise Marawa Research and Exploration Ltd. had the necessary resources to meet the estimated costs of the proposed plan of work for exploration.

Government involvement: The sponsoring State is the Republic of Kiribati.

The application of Marawa Research and Exploration Ltd for an exploration license in the CCZ is part of the national commitment of Kiribati to creating initiatives to meet the social and economic development needs of Kiribati, as well as secure Kiribati's long-term sustainability. Whilst many countries rely upon mining to underpin their national economies, Kiribati is geologically disadvantaged and does not possess any significant economic mineral deposits on land. Providing a means for countries without terrestrial mineral resources to participate in the benefits of mineral development, the United Nations Convention on the Law of the Sea ("UNCLOS") encourages countries to obtain rights to explore for minerals in the international seabed area, as it is recognized that such mineral development is important for mankind as a whole. However, to date only developed countries have participated in such activities.

Marawa's exploration application has been in the CCZ, as Kiribati has naturally been interested in the CCZ exploration activities given that this region extends into Kiribati's own Exclusive Economic Zone, and the ISA Contractor/Reserved Area blocks are situated only 80 nautical miles from Kiribati's EEZ boundary; making Kiribati the closest State in the world to these ISA blocks, and giving Kiribati a heightened interest to ensure that the activities in the CCZ are carried out in an environmentally responsible manner to ensure no adverse impacts are caused to Kiribati's own marine environment. Indeed, the manganese nodule belt in Kiribati waters is an extension of the deposits found in the CCZ, and increasing the knowledge of the minerals and environment in the CCZ will simultaneously increase Kiribati's knowledge of the minerals and deep-sea environment within its own EEZ. By joining other States in the deep sea exploration effort, Kiribati intends to advance its knowledge of deep sea manganese nodules as well as contribute to the advancement of scientific knowledge in the international seabed area.

Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used:

As a State enterprise, Marawa Research and Exploration Ltd. stated in its application that it would draw on the expertise and skills of the government departments of the the Republic of Kiribati. It further indicated that it would engage world experts and utilize leading technology sourced from around the globe. Marawa outlined the equipment that would be used for its activities and stated that it would hire (and where equipment is unavailable, purpose build) the equipment necessary to carry out the relevant exploration activities.

The ISA was provided with information relating to the prevention, reduction and control of pollution and other

11: Marawa Research and Exploration Ltd., Clarion-Clipperton Fracture Zone

hazards to and possible impacts on the marine environment. Marawa also noted that an Environmental Impact Assessment would be submitted prior to any test mining in accordance with the Regulations of the Authority. The Environmental Impact Assessment will provide greater detail on the potential impacts and proposed mitigation measures. Furthermore, Marawa committed to apply best environmental practices for sampling and preservation of samples and best available technology for conducting physical oceanographic studies and collecting data.

Obstacles: -

Sources:

Polymetallic Nodules Exploration Areas in the Clarion-Clipperton Fracture Zone, ISA website, <http://www.isa.org.jm/files/images/maps/CCZ-Sep2012-Official.jpg>;

Contracts for exploration for polymetallic nodules, ISA website, <http://www.isa.org.jm/en/scientific/exploration/contractors>;

ISA (2012a). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by Marawa Research and Exploration Ltd. 18th Council Session Kingston, Jamaica 9th-27th July 2012: <http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-18.pdf>.

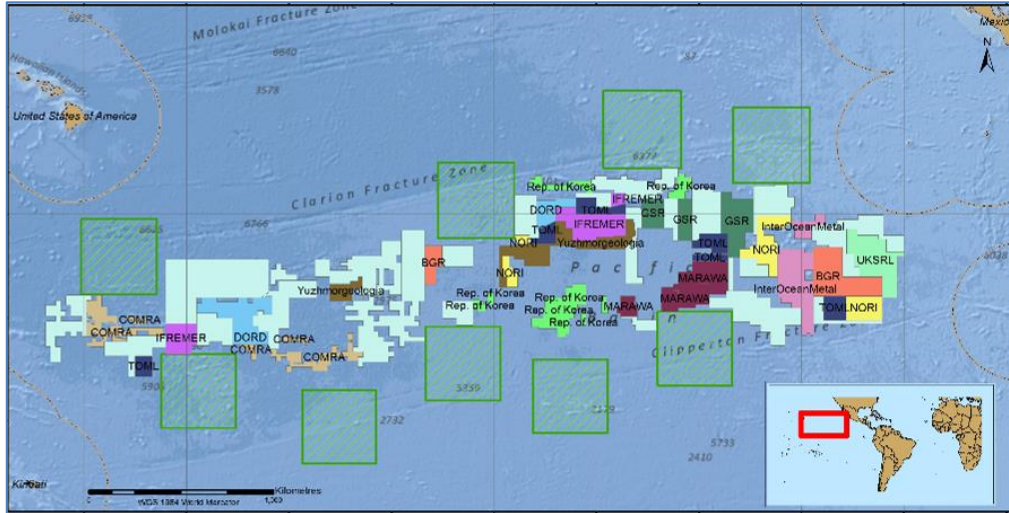
Marawa Research and Exploration Ltd. website, <http://marawaresearch.com/index.html>.

12:UK Seabed Resources Ltd (UKSRL), Clarion-Clipperton Fracture Zone

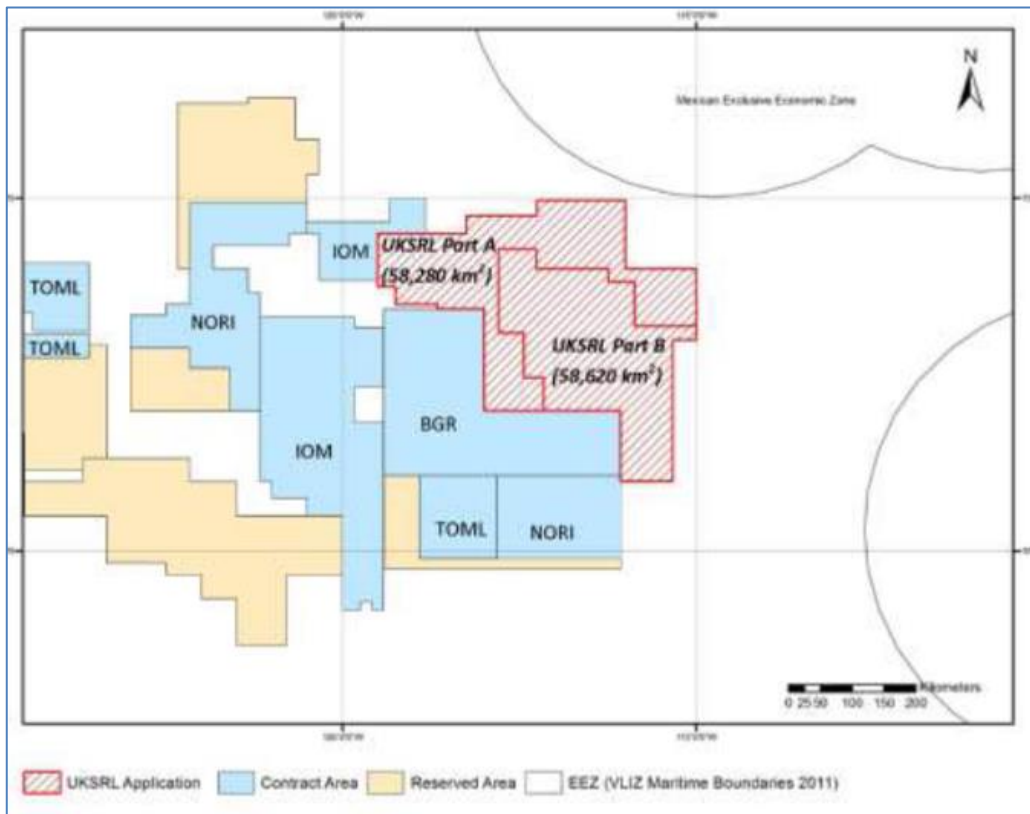
Location: Clarion-Clipperton Fracture Zone

Latitude 120°0'0"W - 115°0'0"W. Longitude 10°0'0"N - 15°0'0"N

Area: 58 000 km². The original application area covered a total of approximately 116 000 km² in the eastern part of the Clarion-Clipperton Zone. The application area was divided into two parts labelled part A (58 280 km²) and part B (58 620 km²), which are contiguous and nested together.



Source: ISA (2014a) website.



Source: ISA (2012b), 18th Council session.

Water depth: The water depths within the area under application varies between about 2 600 to 4 400 meters, with most of the seafloor close to 4 000 meters.

Consortia members

UK Seabed Resources Ltd.	Main contractor	
--------------------------	-----------------	--

12:UK Seabed Resources Ltd (UKSRL), Clarion-Clipperton Fracture Zone

UK Seabed Resources Ltd. (UKSRL) is a wholly owned subsidiary of Lockheed Martin UK Holdings Ltd. (LMUK) and was founded in May 2012. Both UK Seabed Resources Ltd. and LMUK are companies formed under the laws of the United Kingdom and based in the United Kingdom. Lockheed Martin UK, part of Lockheed Martin Corporation, is dealing with in systems integration, working on major programmes spanning the aerospace, defence and civil sectors.

Type of contract: Exploration license

Time scale:

08/02/2013: license into force

09/02/2028: expiry date of license

On 23 May 2012, the Secretary-General of the International Seabed Authority received an application for the approval of a plan of work for exploration for polymetallic nodules in the Area.

The ISA considered the application in closed meetings on 9, 10, 13 and 17 July 2012.

Prior to commencing a detailed examination of the application, the ISA invited representatives of UK Seabed Resources Ltd. to make a presentation of the application. Following its initial consideration, the ISA also decided to request the Chair of the Commission to transmit a list of questions to UKSRL in writing through the Secretary-General. The written responses provided by UKSRL were taken into account by the ISA in its subsequent consideration of the application.

On March 14, 2013 Lockheed Martin UK announced that UK Seabed Resources, a wholly owned subsidiary of Lockheed Martin UK, in partnership with the Department for Business Innovation and Skills, has received a licence and contract to explore a 58 000 km² area of the Pacific for mineral-rich polymetallic nodules.

Financing:

The sponsoring State is the United Kingdom of Great Britain and Northern Ireland.

In a letter describing the financial capabilities of UK Seabed Resources Ltd., its designated representative states that if necessary, they may seek to draw upon Lockheed Martin Corporation, of which LMUK is a component.

Government involvement: The sponsoring State is the United Kingdom of Great Britain and Northern Ireland. UK Seabed Resources Ltd. Is not sponsored by the UK.

Type of material to be collected:

polymetallic nodules

Size of expected deposit:

The data in the two areas (part A and part B) have been analysed by the ISA and the following observations were made with regard to the nodule abundance, metal content and seafloor morphology:

- a) The available bathymetric data indicate that the topography of the seafloor is less rough in part A than in part B, which contains several seamounts in its central and southern areas;
- b) Part A (58 280 km²) and part B (58 620 km²) have an aggregate area of 116 000 km²;
- c) Part A has a total of 283 sampling stations while part B has 242 stations (stations located on the boundaries between the two parts are counted twice). UKSRL also included 322 sampling stations adjacent to the application area for the purpose of avoiding boundary effects from the interpolation between stations;
- d) The spatial distribution of metal content and abundances formed the basis for the estimation of commercial values of the two parts; The average abundance (from non-interpolated data) in part A is slightly higher (13.72 kg/m²) than in part B (13.45 kg/m²) with comparable standard deviation;
- e) Taking into account that nickel concentration in the nodules is mostly between 1.2 wt% and 1.5 wt% throughout the application area, the abundance is used as a proxy for the commercial value of the two

12:UK Seabed Resources Ltd (UKSRL), Clarion-Clipperton Fracture Zone

parts, A and B. The frequency diagrams with regard to nickel content show that part A has a slightly higher frequency of nickel concentration above 1.2 wt% than part B;

- f) The spatial distribution of the nodule abundance data shows that part A has a larger number of pockets of high abundance (3) than part B (1).

Technology used:

If mining seems profitable UK Seabed Resources intends to suck the nodules, which sit at a depth of 4km, through a slurry pump before piping them to a ship for transportation.

At time of the application, UKSRL stated that it held rights granting it access to certain data, resources and subject matter expertise of Lockheed Martin Corporation (LMC) related to polymetallic nodule resource surveying, analysis and recovery methods. Furthermore, they stated that LMC was the prime contractor and the technology provider for the Ocean Minerals Company (OMCO) consortium, which was one of the leading participants in seabed minerals efforts in the 1970s and 1980s. In addition, LMC has more than 50 years of experience in large-scale ocean systems design and development, including multiple deep water efforts. Therefore, UKSRL may seek to capitalize upon the extensive polymetallic nodule experience and technical capabilities developed through the historical work, recent analyses and ongoing efforts of LMC.

Obstacles: -

Sources:

Contracts for exploration for polymetallic nodules, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Lockheed Martin seabed mining venture set to explore Pacific, in *The Engineer*, 13 March 2013, see:

<http://www.theengineer.co.uk/channels/policy-and-business/lockheed-martin-seabed-mining-venture-set-to-explore-pacific/1015815.article>;

UK government backs seabed mining sector, *Financial Times*, 14 March, 2013, see:

<http://www.ft.com/cms/s/0/52cdac0e-8cbe-11e2-8ee0-00144feabdc0.html#axzz31VIMVQh6>;

ISA (2012b). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by UK Seabed Resources Ltd. 18th Council Session Kingston, Jamaica 9th-27th July 2012:

<http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-17.pdf>

Lockheed Martin (2013): UK Government sponsors Lockheed Martin UK subsidiary for licence to harvest Polymetallic Nodules, Press release,

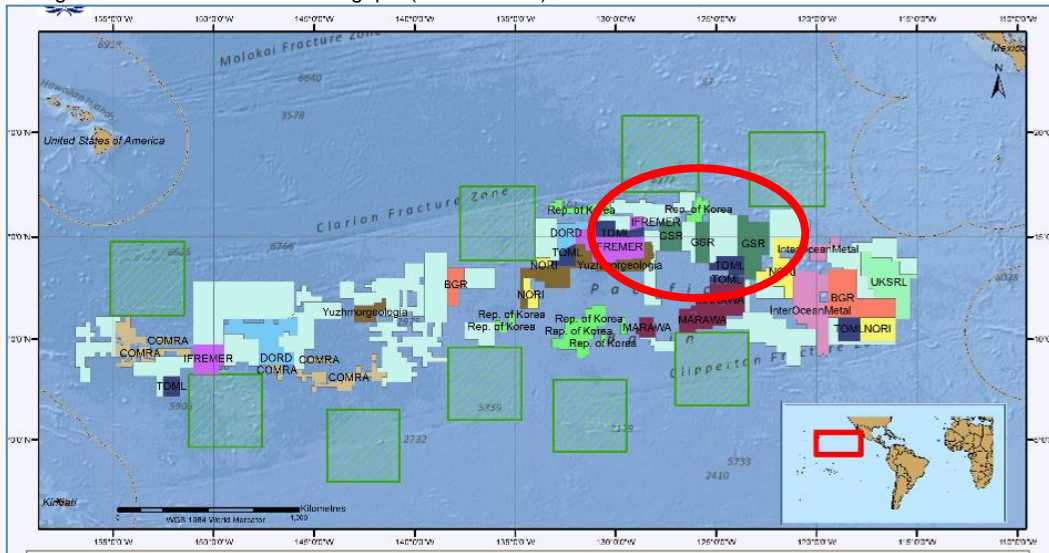
<http://www.lockheedmartin.co.uk/uk/news/press-releases/2013-press-releases/uk-government-sponsors-lockheed-martin-uk-subsiidiary-for-licence.html>.

13: G-TEC Sea Mineral Resources NV, Clarion-Clipperton Fracture Zone

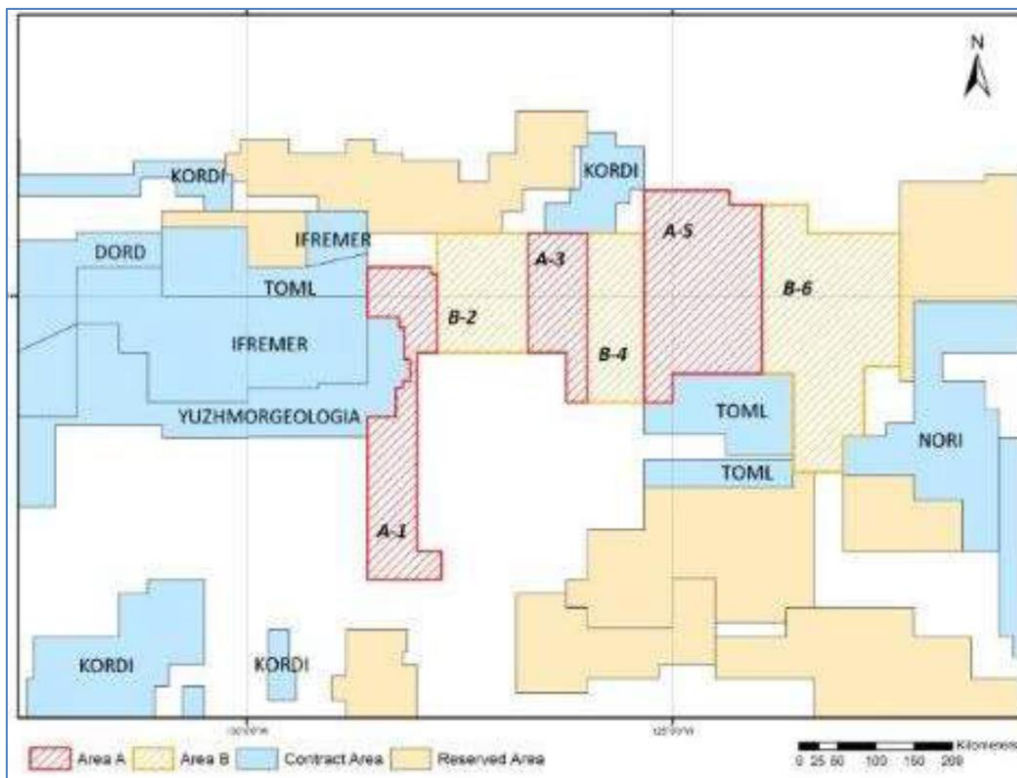
Location: Clarion-Clipperton Fracture Zone

Latitude 130° 0' 0" - 123° 0' 0" W'. Longitude 15° 0' 0" N

Area: 75 000 km². The area under application comprises the area B in the map below. It is based on a part of the seabed where a licence was formerly granted by the United States of America to Ocean Mining Associates (OMA) in 1974 and was referred to as USA-3. OMA was composed of Tenneco (USA), US Steel (USA), Japan Mining Co. and Union Minière de Belgique (now Umicore).



Source: ISA (2014a) website.



Source: ISA (2012c), 18th Council session.

Water depth: about 5 000 meters

Consortia members

G-TEC Sea Mineral Resources NV

13: G-TEC Sea Mineral Resources NV, Clarion-Clipperton Fracture Zone
G-TEC Sea Mineral Resources NV is a private company incorporated in Belgium. The application is sponsored by the Government of Belgium.
Type of contract: Exploration license
Time scale: 14/01/2013: license into force 13/01/2028: expiry date of license
Financing: G-TEC, submitted with its application a declaration by Deloitte confirming that the application by G-TEC Sea Mineral Resources NV was part of an exclusive agreement with a Belgian industrial partner, which was not Umicore, whereby all costs incurred by G-TEC for fulfilling its obligations under the exploration contract would be entirely borne by its Belgian industrial partner.
Government involvement: Belgium
Type of material to be collected: polymetallic nodules
Size of expected deposit: G-TEC has access to historical data from Umicore. On the basis of such data and published sources on the CCZ, G-TEC created maps of abundance and grade to estimate the commercial value expressed as recoverable metals in mineable areas using the following procedure. The globally averaged nodule abundance shown on the maps is regridded using standard kriging in a geographical (latitude/longitude) coordinate system. The grid size is 0.1° longitude x 0.07° latitude. The nodule abundance on mineable fields is computed assuming the following hypotheses: the mineable areas represent 60 per cent of the total surface and the average nodule abundance of the non-mineable areas is estimated at 5 kg/m ² . All the abundances, elemental content and values shown on the maps are expressed “per square km of mineable fields”, in other words, 60 per cent of the total surface only. The recoverable metals used for computation are nickel (Ni), cobalt (Co) and copper (Cu). Manganese (Mn) is not used for computation of the commercial value. Should manganese be recovered in the future, it is assumed that the corresponding commercial value will add equally to all parts of the area under application, and thus have no influence on the proposed division into two parts of equal estimated commercial value. The elemental content maps are regridded using the above-mentioned technique for nodule abundance. It is assumed that there is no significant difference between the elemental contents in mineable or non-mineable fields. Such differences would produce lower order variations only. The average nodule abundance on the mineable fields is multiplied by the elemental content in order to produce grids and maps of recoverable metal (Mn, Ni, Cu and Co) per m ² . The metal content is expressed in g/m ² or metric tons/km ² , which is equivalent.
Technology used: G-TEC is known for the development of geophysical applications targeting specific issues. Developments concern advanced software and system for data acquisition, data processing and interpretation. Some examples are the development of our Underwater Towed Seismic Refraction system, the monitoring of jet grouting operations, the acquisition and processing of magnetometric data, multisensor depth controlled tow fish operations, specific navigation software, etc.
Obstacles: -
Sources: Contracts for exploration for polymetallic nodules, ISA website, http://www.isa.org.jm/en/scientific/exploration/contractors ; ISA (n.d.): G-TEC Sea Mineral Resources NV (GSR) of Belgium signs exploration contract, http://www.isa.org.jm/en/node/801 ; G-tec website, http://www.g-tec.eu/innovation.html ; ISA (2012c). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for

13: G-TEC Sea Mineral Resources NV, Clarion-Clipperton Fracture Zone

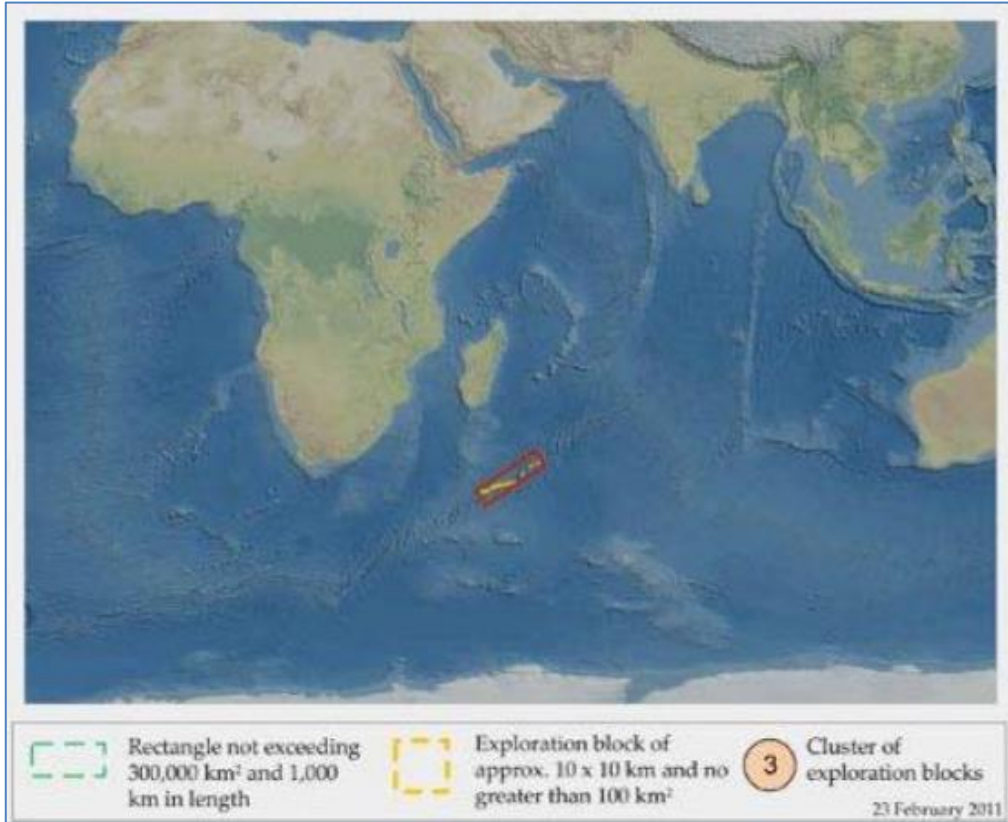
polymetallic nodules by G TEC Sea Mineral Resources NV. 18th Council Session Kingston, Jamaica 9th-27th July 2012: <http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-19.pdf>.

14: China Ocean Mineral Resources Research and Development Association, Indian Ocean

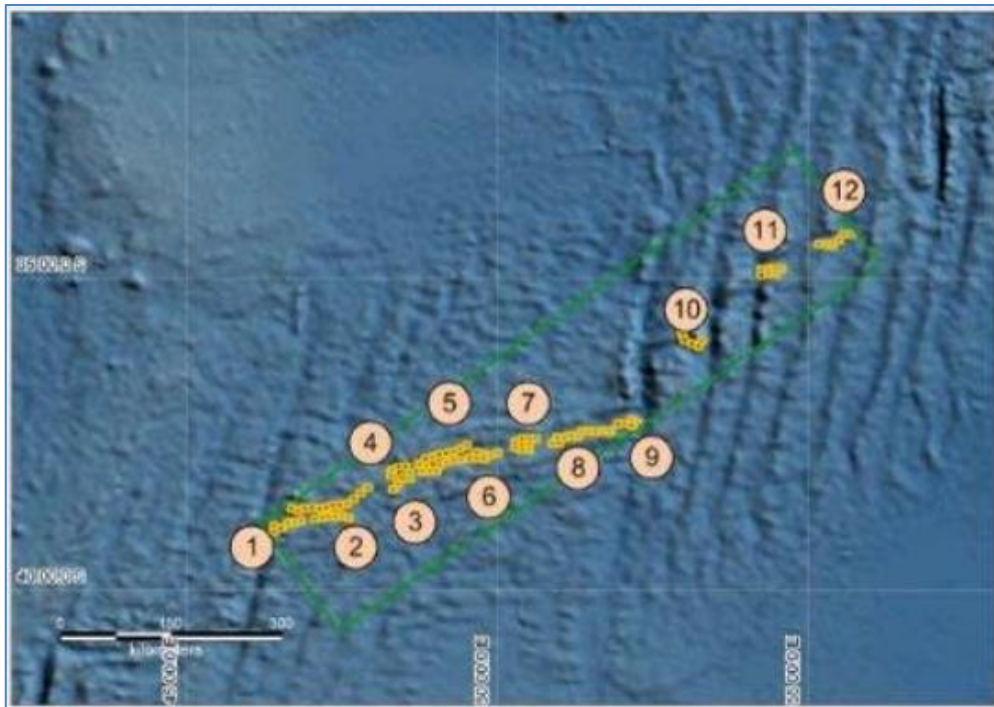
Location: Southwest Indian Ridge

Latitude 34°20'37" - 39°6'31" Longitude 46°21'28" - 55°44'25"

Area: 10 000 km²



Source: ISA (2011a), 17th Council session.



Source: ISA (2011a), 17th Council session.

Water depth: -

14: China Ocean Mineral Resources Research and Development Association, Indian Ocean

Consortia members

China Ocean Mineral Resources Research and Development Association	Main contractor	
--	-----------------	--

In 1984 China drew its oceanic mine resources plan. This plan was gained further traction with the establishment of COMRA in 1990. COMRA is governmental organizations to coordinate the activities of deep-sea bed exploration and exploitation in China as well in the international sea.

Type of contract: Exploration license

Time scale:

18/11/2011: license into force

17/11/2026: expiry date of license.

Financing:

The application was sponsored by China. In a verifying certificate, the State Oceanic Administration, acting on behalf of China, and as authorized by the State Council of China, stated that COMRA is under the effective control of China. Since COMRA is a state-owned company, the government of China finances the project

The ISA was provided with a statement dated 6 May 2010 and signed by Mr. Xie Xuren, Minister of Finance of China, certifying that the applicant would have the necessary funds to meet the estimated minimum expenditures under the proposed plan of work and fulfil its financial obligations to the Authority.

Government involvement:

Sponsoring State is China. China has committed huge investment on deep sea exploration. Dolma Tsering describes three different phases within the deep sea exploration of China:

Phase I: (1995-2005)

In this quest for mineral resources, the first major development for China's deep sea exploration was the launch of its most advanced scientific research vessel "Dayang Yihao" in 1995. "Dayang Yihao" is the only open-ocean going vessel designated and equipped for deepsea research in China. This vessel is equipped with the most advanced global positioning and communication systems plus scientific research equipment on board. It conducts deep sea sampling, drilling and videotaping at the water depth of over few thousand meters. In 1996, the research on oceanography was strengthened with an allocation of more than 800million yuan for oceanographic research under "Ninth Five Year Plan" (1996-2000). During this period the Chinese government formulated the National Plan for implementing the "Program for Marine Development by Reliance on Science and technology". This program emphasis on research, development and dissimulation of the technologies of marine reproduction, fine processing of marine biological resources, exploration and extraction of marine pharmaceuticals and exploitation of chemical resources in seawater. Another major development during this period was the launch of "Jiaolong" manned submersible in 2002. China unveiled its most advanced submersible in August 2010 after eight years of secretive development. The "Jiaolong" manned submersible is a China's manned deep-ocean submersible. Like many other submersibles, the Jiaolong "manned submersible operates with a mother ship, "Xiangyanghong 09", an oceanographic researchship subordinate to the North Sea Branch of StateOceanic Administration (SOA). It was designed to reach a maximum depth of about 7,000 meters, making it capable of reaching 99.8 percent of the world's sea areas. Till date "Jiaolong" manned submersible completed 17 dives in South ChinaSea, 5 188 meters below sea level in the PacificOcean and the latest with 7020 meters at MarianaTrench, West Pacific "Jiaolong" manned submersible has become integral tool for China's scientific expedition on deep sea resources.

Phase II: 2005-2012

The second major development in China's project on deep sea exploration was achieved when China embarked on its first around-the-world oceanographic sailing mission by "Dayang Yihao" an oceanographic research ship in 2005-06. During this global expedition, scientists found tantalizing evidence of active hydrothermal vent lying

14: China Ocean Mineral Resources Research and Development Association, Indian Ocean

at Southwest Indian Ridge (SWIR). They gathered critical data that led them back to the site in 2007. A remarkable achievement was made in 2007 where Chinese scientist aboard "Dayang Yihao" an oceanographic research ship, discovered hot liquid at SWIR independently for the first time. In 2010-2011 "Dayang Yihao" an oceanographic research ship attempted China's largest and most expansive global expedition at Indian, Pacific and Atlantic oceans. The scientists at the expedition discovered 16 hydrothermal vents out of which 5 were found in South Atlantic Ocean and 11 in the East Pacific Ocean. China has now discovered 33 hydrothermal deposits comprising one tenth of the discovered submarine hydrothermal deposits, in the last three decades.

Phase III-2012 onward

The third phase of China's research and capacity building on deep sea exploration began in 2012. On 18 April, 2012, the State Oceanic Administration (SOA) announced the establishment of a national maritime survey fleet in an effort to improve China's ability to conduct maritime survey and research. The fleet consists of 19 survey vessels, 11 of which are oceangoing research ships with a displacement of more than 1,500 tonnes. The ships are separately owned by the SOA, the Chinese Academy of Sciences (CAS), the Ministry of Education (MOE) and other government sectors and institutes with maritime interests.⁴

Type of material to be collected:

polymetallic sulphides

Size of expected deposit:

The area is estimated to have reserves of 420 million tons of polymetallic nodules,

Technology used:

COMRA has previous experience and skills in the field of exploration for polymetallic nodules and scientific research on polymetallic sulphides deposits.

Obstacles: -

Sources:

Contracts for exploration for polymetallic sulphides, ISA website, <http://www.isa.org.jm/en/scientific/exploration/contractors>;
Southern Fried Science (2013): One-fifth of all known hydrothermal vents are threatened by deep-sea mining, <http://www.southernfriedscience.com/?p=15951>;
ISA (2011a). Report and recommendations to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the China Ocean Mineral Resources Research and Development Association. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011: <http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-11.pdf>.

⁴ Tsering, D. (n.d.): China's Deep Sea Exploration: Research and Capacity Building, http://www.academia.edu/2482772/Chinas_deep_sea_exploration#.

15: Government of the Russian Federation, Atlantic Ocean

Location: Mid-Atlantic Ridge in the Atlantic Ocean

Latitude 12° 53' 50" N - 20° 49' 24.82" N. Longitude 44° 50' 9" W - 45° 43' 22 " W

Area: 10 000 km²



Source: ISA (2011b), 17th Council session.

Water depth: -

Consortia members

Government of the Russian Federation

Main contractor

Type of contract: Exploration license

Time scale:

29/10/2012: license into force

28/10/2027: expiry date of license

Financing:

The ISA was provided with a statement dated 29 October 2010 and signed by the designated representative of the Russian Federation, certifying that the Russian Federation would have the necessary funds to meet the estimated minimum expenditures under the proposed plan of work and to fulfil its financial obligations.

Government involvement:

The Russian Federation is holding the license and finances the project.

Type of material to be collected:

polymetallic sulphides

Size of expected deposit: -

Technology used:

The Russian Federation stated in its application that specialized Russian institutes and the Russian Academy of Sciences had been conducting marine scientific studies of polymetallic sulphides in the Area since 1993. Moreover, in recent years, the Russian Federation itself has carried out studies of the ore-bearing capacity of the axial zone of the Mid-Atlantic Ridge, including the location of the proposed application area, almost every year.

The PP Shirshov Institute in Russia operates the Mir 1 and Mir 2 submersibles. These are 6 000 m rated deep ocean research vehicles that have been in use since 1987. The submersibles gained great fame in their many

15: Government of the Russian Federation, Atlantic Ocean

dives and filming activities for the film Titanic. The twin submersibles are three-person vehicles and are classed by the Germanischer Lloyds group in Germany. In 2010 the submersibles completed a three-year research expedition on Lake Baikal in Siberia. The expedition made a total of 178 dives, the deepest of which was to 1 640 meters.

Obstacles: -

Sources:

Contracts for exploration for polymetallic sulphides, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>.

The Hindu (2013): Soon nodules to be mined from seabed,

<http://www.thehindu.com/sci-tech/science/soon-nodules-to-be-mined-from-seabed/article4577372.ece>.

Southern Fried Science (2013): One fifth of all known hydrothermal vents are threatened by deep-sea mining,

<http://www.southernfriedscience.com/?p=15951>.

ISA (2011b). Report and recommendations to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the Government of the Russian Federation. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011:

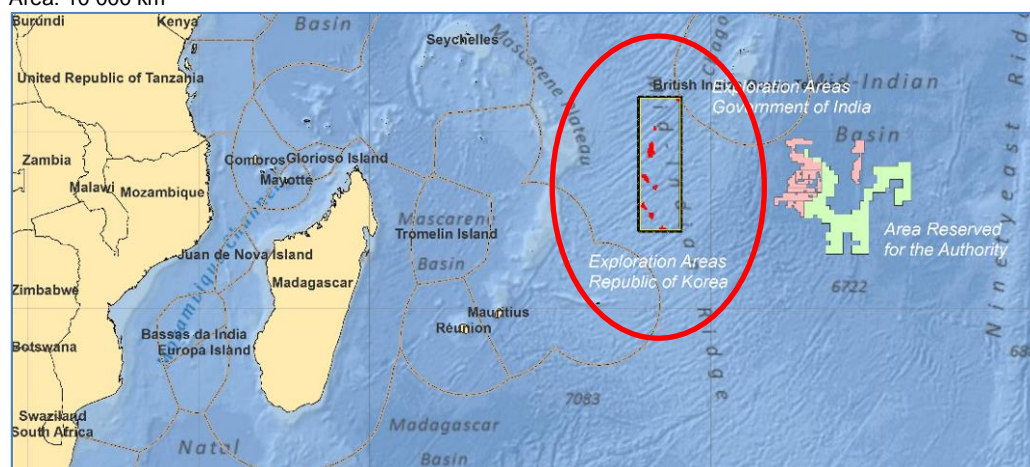
<http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-12.pdf>.

16: Ministry of Land, Transport and Maritime Affairs of the Government of the Republic of Korea, Indian Ocean

Location: Mid-Indian Ridge, Indian Ocean

Latitude 70°0'0" E. Longitude 10°0'0" S

Area: 10 000 km²



ISA (2014a) website.

Water depth: -

Consortia members

Ministry of Land, Transport and Maritime Affairs of the Government of the Republic of Korea

Main contractor

Type of contract: Exploration license

Time scale:

24 June 2014: license officially signed. License started on 1 May 2014

30/04/2029: expiry date of license

Financing:

The project is financed by the Korean government

Government involvement:

Republic of Korea is the contractor

Type of material to be collected:

polymetallic sulphides

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

Polymetallic Nodules Exploration Areas in the Indian Ocean, ISA website,

<http://www.isa.org.jm/files/images/maps/IndianOcean.jpg>;

Contracts for exploration for polymetallic sulphides, ISA website,

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Yonhap News Agency (2014): S. Korea gains right to explore deep-sea mines in Indian Ocean. 25 June 2014,

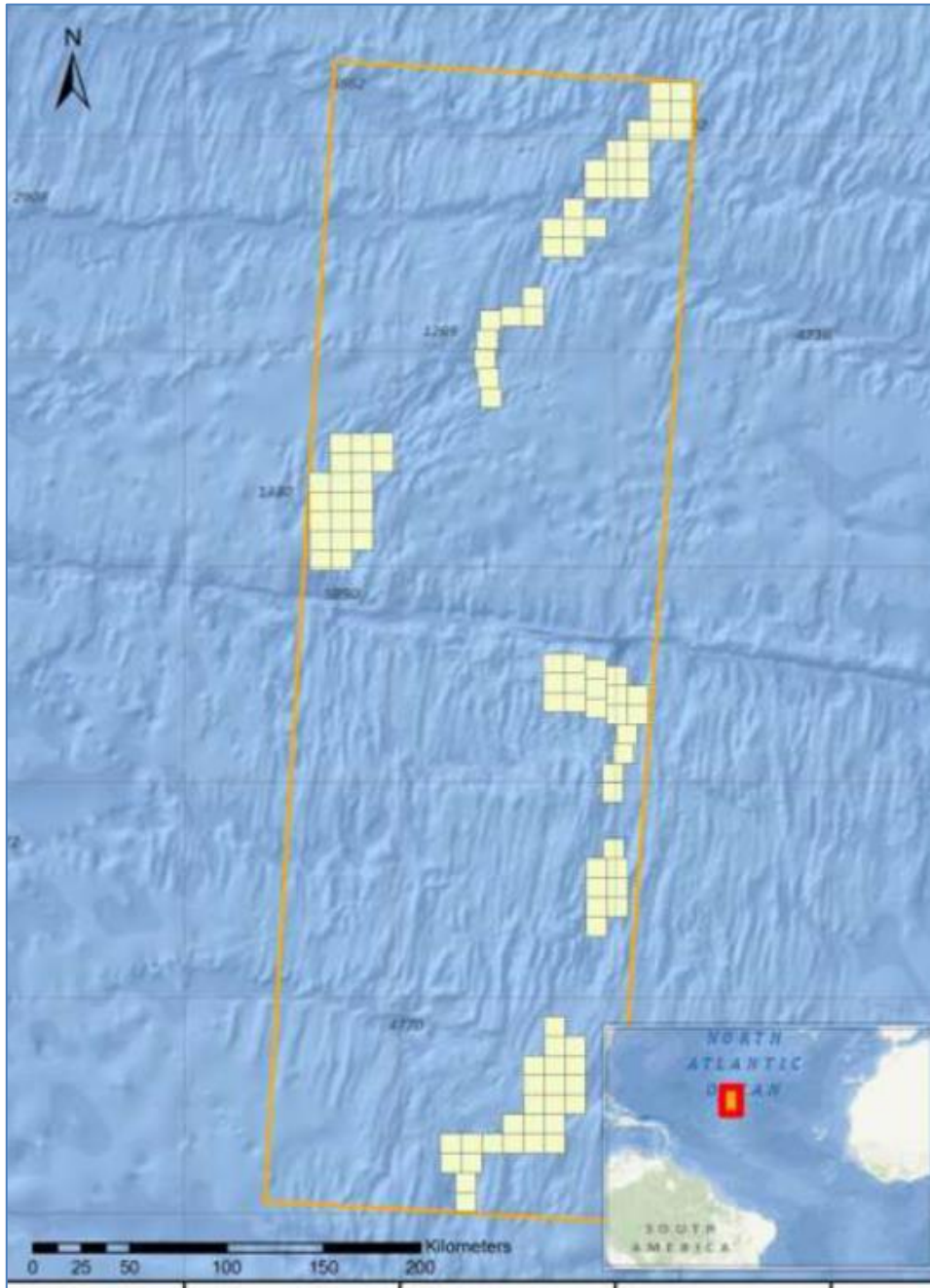
<http://www.globalpost.com/dispatch/news/yonhap-news-agency/140625/s-korea-gains-right-explore-deep-sea-mines-indian-ocean>.

17: Institut français de recherche pour l'exploitation de la mer, Mid-Atlantic Ridge

Location: Mid-Atlantic Ridge

Latitude 20°57'46"N - 26°20'29"N Longitude 46°37'42"W - 44°37'20"W

Area: 10 000 km²



Source: ISA (2012d), 18th Council session.

Water depth: 3 400 meters

Consortia members

Institut français de recherche pour l'exploitation de la mer

Main contractor

IFREMER is a Government Research Institute, created in 1984. It is supervised jointly by the Ministry of Higher Education and Research and the Ministry of Ecology, Sustainable Development and Energy. IFREMER owns 8 research vessels (including 4 ocean-going ships), 1 manned submarine, 1 remotely-operated vehicle for deep sea explorations (- 6 000 m) and 2 AUVs.

Type of contract: Exploration license

17: Institut français de recherche pour l'exploitation de la mer, Mid-Atlantic Ridge

Time scale:

The license is approved however not signed yet. The contract will be valid for 15 years.

Financing: The company is financed by the French government.

Included in the application IFREMER also submitted audited financial statements. IFREMER stated that it had protection and indemnity liability insurance for damage caused by the operation of its research vessels and a specialist operation clause guarantee for damage, including environmental damage, caused by equipment deployed from its research vessels.

Government involvement:

The French government finances the project (indirectly)

Type of material to be collected:

polymetallic sulphides

Size of expected deposit: -

Technology used:

IFREMER had been involved in hydrothermal vents research from their discovery and had conducted extensive studies in the North Atlantic, and specifically in the area under the application.

IFREMER is hoping to develop within this time frame the necessary means to extract resources in the Area.

Already in other exploration missions, IFREMER operates Nautile, a deep ocean research submersible rated to a maximum depth of 6 000 meters. The submersible was launched in 1987 and accommodates a cabin for three occupants. It operates from a mothership.

Obstacles: -

Sources:

Contracts for exploration for polymetallic sulphides, ISA website, see:

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

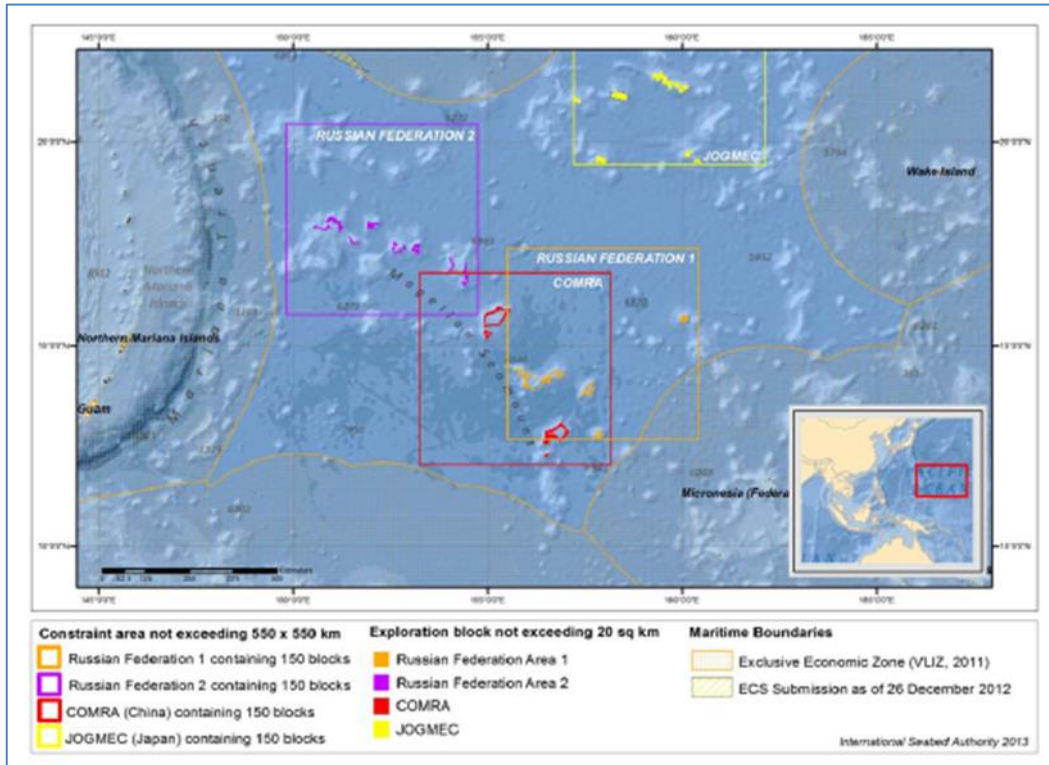
ISA (2012d). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the Institut français de recherche pour l'exploitation de la mer. 18th Council Session Kingston, Jamaica 9th-27th July 2012: <http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-16.pdf>.

Actu-environnement (2012) : Vers une exploitation minière des grands fonds marins, <http://www.actu-environnement.com/ae/news/exploitation-miniére-fonds-marins-ifremer-permis-16321.php4>;

18: China Ocean Mineral Resources Research and Development Association (COMRA), Western Pacific Ocean

Location: Western Pacific Ocean, the area is illustrated in red below

Area: 3 000 km²



Source: ISA (2014a) website.

Water depth: around 2 000 -2 300 meters

Consortia members

China Ocean Mineral Resources
Research and Development
Association (COMRA)

Main contractor

COMRA is established in 1990. COMRA is governmental organizations to coordinate the activities of deep-sea bed exploration and exploitation in China as well in the international sea.

Type of contract: Exploration license

Time scale:

29/04/2014: license into force

28/04/2029: expiry date of license

COMRA is the fifteenth entity to be granted exploration licences by the International Seabed Authority and the second entity to sign a contract for exploration for cobalt crusts.

Financing:

COMRA is financed by the government of China.

Government involvement: The Chinese government owns COMRA and as result finances the project. China has committed huge investment on deep sea exploration. Dolma Tsering describes three different phases within the deep sea exploration of China:

Phase I: (1995-2005)

In this quest for mineral resources, the first major development for China's deep sea exploration was the launch of its most advanced scientific research vessel "Dayang Yihao" in 1995. "Dayang Yihao" is the only open-ocean going vessel designated and equipped for deepsea research in China. This vessel is equipped with the most

18: China Ocean Mineral Resources Research and Development Association (COMRA), Western Pacific Ocean

advanced global positioning and communication systems plus scientific research equipment on board. It conducts deep sea sampling, drilling and videotaping at the water depth of over few thousand meters. In 1996, the research on oceanography was strengthened with an allocation of more than 800million yuan for oceanographic research under "Ninth Five Year Plan" (1996-2000). During this period the Chinese government formulated the National Plan for implementing the "Program for Marine Development by Reliance on Science and technology". This program emphasis on research, development and dissimilation of the technologies of marine reproduction, fine processing of marine biological resources, exploration and extraction of marine pharmaceuticals and exploitation of chemical resources in seawater. Another major development during this period was the launch of "Jiaolong" manned submersible in 2002. China unveiled its most advanced submersible in August 2010 after eight years of secretive development. The "Jiaolong" manned submersible is a China's manned deep-ocean submersible. Like many other submersibles, the Jiaolong "manned submersible operates with a mother ship, "Xiangyanghong 09", an oceanographic researchship subordinate to the North Sea Branch of StateOceanic Administration (SOA). It was designed to reach a maximum depth of about 7,000 meters, making it capable of reaching 99.8 percent of the world's sea areas. Till date "Jiaolong" manned submersible completed 17 dives in South ChinaSea, 5,188 meters below sea level in the PacificOcean and the latest with 7020 meters at MarianaTrench, West Pacific "Jiaolong" manned submersible has become integral tool for China's scientific expedition on deep sea resources.

Phase II: 2005-2012

The second major development in China's project on deep sea exploration was achieved when China embarked on its first around-the-world oceanographic sailing mission by "Dayang Yihao" an oceanographic research ship in 2005-06. During this global expedition, scientists found tantalizing evidence of active hydrothermal vent lying at Southwest IndianRidge (SWIR). They gathered critical data that led them back to the site in 2007. A remarkable achievement was made in 2007 where Chinese scientist aboard "Dayang Yihao" an oceanographic research ship, discovered hot liquid at SWIR independently for the first time. In 2010-2011 "Dayang Yihao" an oceanographic research ship attempted China's largest and most expansive global expedition at Indian, Pacific and Atlantic oceans. The scientists at the expedition discovered 16 hydrothermal vents out of which 5 were found in South AtlanticOcean and 11 in the East Pacific Ocean. China has now discovered 33 hydrothermal deposits comprising one tenth of the discovered submarine hydrothermal deposits, in the last three decades.

Phase III-2012 onward

The third phase of China's research and capacity building on deep sea exploration began in 2012. On 18 April, 2012, the State Oceanic Administration (SOA) announced the establishment of a national maritime survey fleet in an effort to improve China's ability to conduct maritime survey and research. The fleet consists of 19 survey vessels, 11 of which are oceangoing research ships with a displacement of more than 1 500 tonnes. The ships are separately owned by the SOA, the Chinese Academy of Sciences (CAS), the Ministry of Education (MOE) and other government sectors and institutes with maritime interests.⁵

Type of material to be collected:

cobalt-rich ferromanganese crusts

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

Contracts for exploration for cobalt-rich ferromanganese crusts, ISA website, see:

⁵ Tsering, D. (n.d.): China's Deep Sea Exploration: Research and Capacity Building, http://www.academia.edu/2482772/Chinas_deep_sea_exploration#.

18: China Ocean Mineral Resources Research and Development Association (COMRA), Western Pacific Ocean

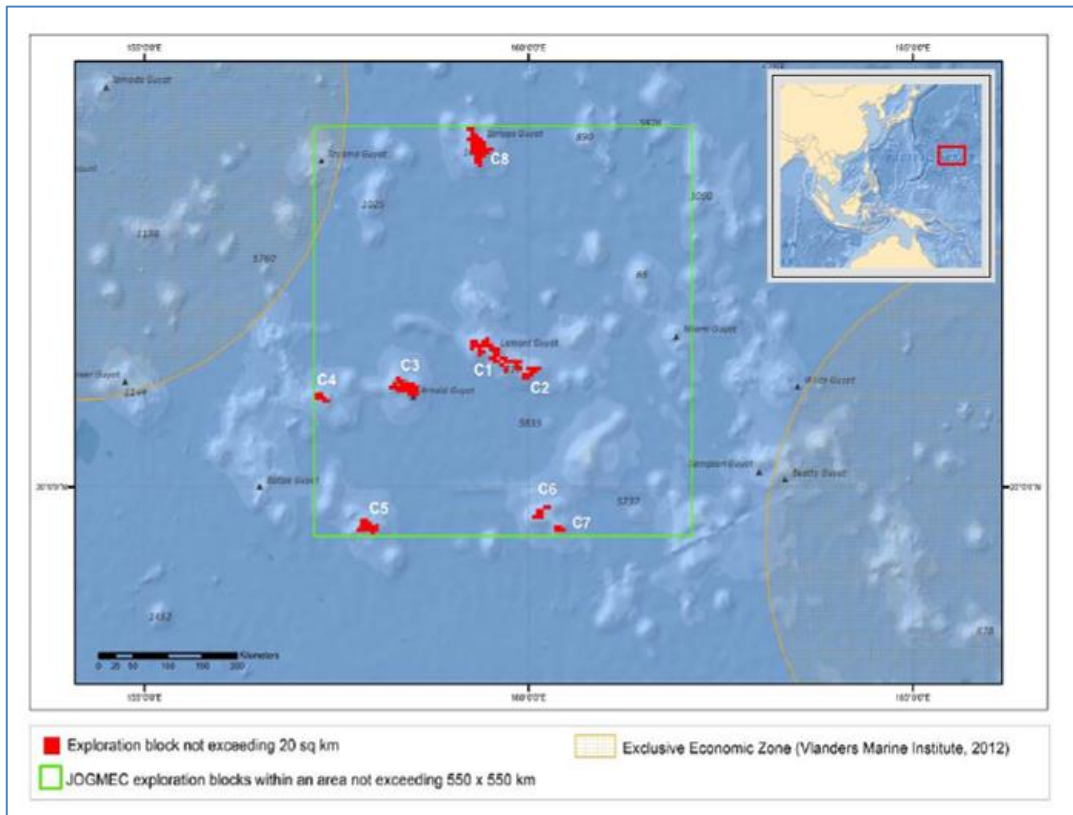
<http://www.isa.org.jm/en/scientific/exploration/contractors>;

Tsering, D. (n.d.) China's Deep Sea Exploration: Research and Capacity Building,

http://www.academia.edu/2482772/Chinas_deep_sea_exploration#.

19: Japan Oil, Gas and Metals National Corporation (JOGMEC), Western Pacific Ocean

Location: Western Pacific Ocean
 Latitude 19-23 Longitude 157-160
 Area: 3 000 km²



Source: ISA (2014a) website.

Water depth:

3 000-4 000 meters

Consortia members

Japan Oil, Gas and Metals National Corporation (JOGMEC)	Main contractor
---	-----------------

JOGMEC is a State entity which implements national policies on natural resources and energy as an agency of the Government of Japan. JOGMEC was established on February 29, 2004 and integrates the functions of the former Japan National Oil Corporation, which was in charge of securing a stable supply of oil and natural gas, and the former Metal Mining Agency of Japan, which was in charge of ensuring a stable supply of nonferrous metal and mineral resources and implementing mine pollution control measures.

Type of contract: Exploration license.

Time scale:

27/01/2014: license into force
 26/01/2029: expiry date of license

Since 1987: JOGMEC has been conducting studies of cobalt-rich ferromanganese crusts in the high seas of the Northwest Pacific under consignment contract with Ministry of Economy, Trade and Industry (METI), aimed at understanding its resource potential.

In the first five years of the contract (years 2014-2018) core sampling will take place with geological and geographical surveys (data collection). Also an environmental baseline study will take place. In the second stage (year 6-10) detailed resource evaluation will take place. This is illustrated in the figure below.

19: Japan Oil, Gas and Metals National Corporation (JOGMEC), Western Pacific Ocean

Stage year	Exploration work	Environmental survey	R&D
Stage 1 (year 1-5) (2014-2018)	Preparatory work		
	Resources evaluation Core sampling with geological and geographical surveys (Collection of data)	Environment baseline study	Pre- R/D in Mining, ore beneficiation, Metallurgical technologies
	Training Four training opportunities(on-board and on-land) between 2014 and 2018 12 trainees will be accepted		
Stage 2 (year 6-10)	Detailed resource evaluation of the proposed blocks. (Choose promising blocks 1/3)	Continuing environmental study.	R/D in mining, ore beneficiation, metallurgical technologies
Stage 3 (year 11-15)	Further resource evaluation of promising blocks to be exploited from ten years evaluation. (Choose developing blocks)	EIA	Verification of technologies

Financing:

The Government of Japan (Ministry of Economy and Energy) finances (indirectly) the current exploration

Government involvement:

JOGMEC is 100% financed by the Japanese government

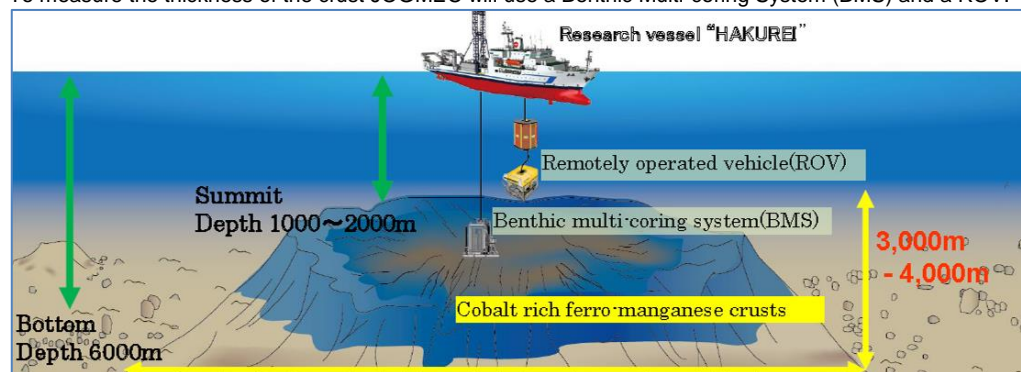
Type of material to be collected:

cobalt-rich ferromanganese crusts

Size of expected deposit: -

Technology used:

To measure the thickness of the crust JOGMEC will use a Benthic Multi-coring System (BMS) and a ROV.



Obstacles: -

Sources:

Contracts for exploration for cobalt-rich ferromanganese crusts, ISA website, see:

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

JOGMEC website, see: <http://www.jogmec.go.jp/english/about/about001.html>;

Offshore Manganese Nodule Exploration Southeast of Hawaii, JOGMEC website, see:

http://www.jogmec.go.jp/english/metal/financial_015.html;

Deep-Sea Mineral Resources: Exploration Objectives and Survey Methods, JOGMEC website, see:

http://www.jogmec.go.jp/english/metal/technology_018.html?recommend=1;

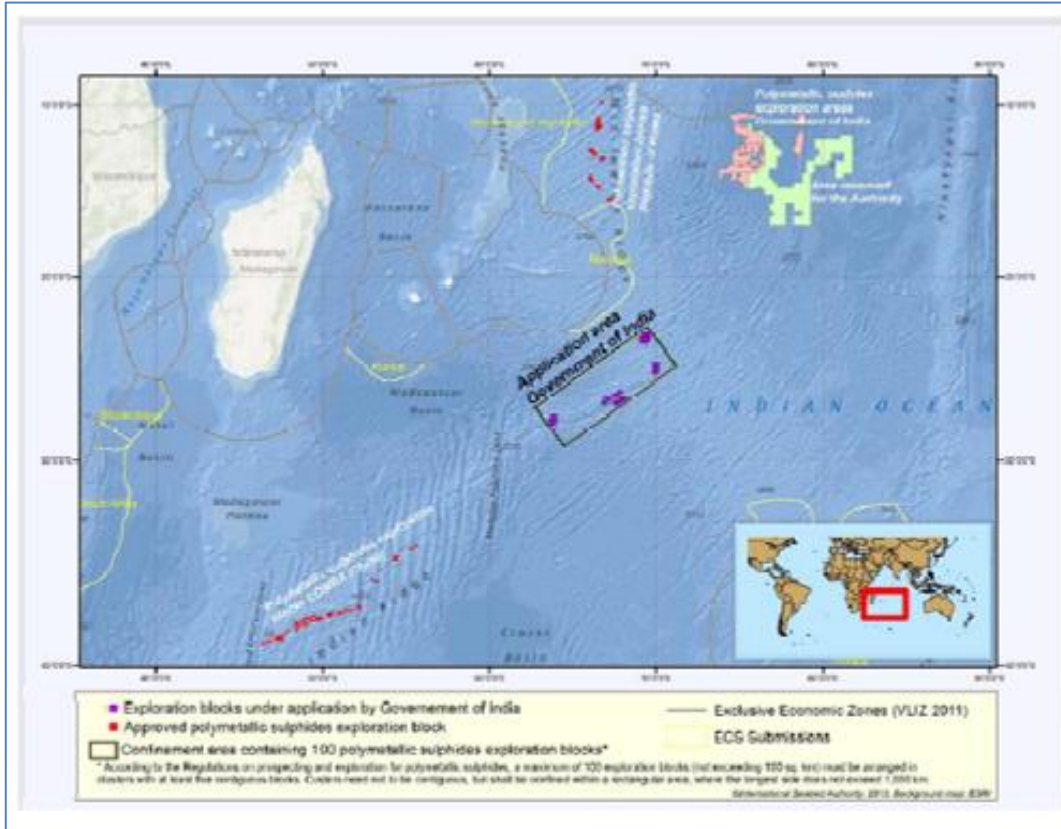
ISA (2014): <http://www.isa.org.jm/files/documents/EN/Seminars/2014/NatsumiNYC.pdf>.

20: Government of India, Earth System Science Organization, Ministry of Earth Sciences, Indian Ocean

Location and area:

The area under application is located in the Central Indian Ocean and forms part of the Indian Ocean ridge.

Area: Total area is 10 000 km²



ISA (2014a) website.

Water depth: -

Consortia members

Earth System Science Organization, Ministry of Earth Sciences	Main contractor
--	-----------------

Type of contract: application for an exploration license

Time scale:

26 March 2013: application is received

The proposed activities are scheduled in three five-year phases and will include mapping, geological sampling and environmental baseline data collection and assessment.

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the International Seabed Authority. The license is awaiting to be signed.

Financing:

The government of India finances the project.

Government involvement:

The government of India is the owner of the license and finances the project.

Type of material to be collected:

Polymetallic sulphides.

Size of expected deposit: -

Technology used: -

20: Government of India, Earth System Science Organization, Ministry of Earth Sciences, Indian Ocean

Obstacles:

Part of the area included in the application is also in an application license issued by the German government. The ISA requested both governments to negotiate this issue but the reaction of the Indian government is pending. The overlap could occur because the German government announced that they were performing prospecting activities in the Indian Ocean. The Indian government in return included the same area in their application.

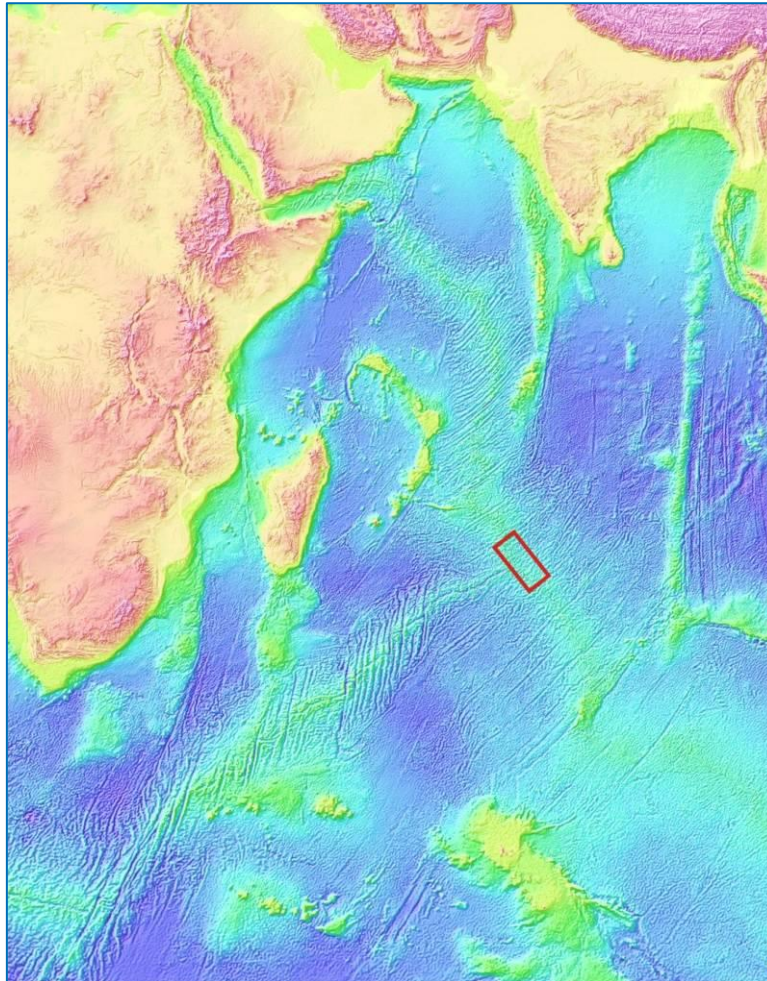
Sources:

Contracts for exploration for polymetallic sulphides, ISA website,
<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-6.pdf>.

21: Federal Institute for Geosciences and Natural Resources of Germany, Indian Ocean

Location and area: Indian Ocean

Area: 10 000 km²



Water depth: 2 600 to 3 300 meters on average

Consortia members

Federal Institute for Geosciences and Natural Resources of Germany

Main contractor

The Federal Institute for Geosciences and Natural Resources (BGR) of Germany is an institute that is 100% financed by the German government (Ministry of Economy and Energy). Exploration activities are organized and operated by BGR. Experts and facilities are contracted for specific exploration-relevant topics. For example private and institutional vessels are contracted (via tender) in order to conduct the cruises, the DZMB/Senckenberg Institute to perform environmental studies. Equipment (ROV, HyBIS) is hired from Geomar as well as a bathymetric expert, when needed. For future resource assessment external expertise will be contracted for modelling. BGR also adapts and develops new exploration methods involving universities (e.g. Univ. Bielefeld: automatic analysis of sea floor photos).

Type of contract: Application for an exploration license

Time scale:

1983, 1986, 1987: The area under application was investigated during the GEMINO project (Geothermal Metallogenesis Indian Ocean, University of Aachen) This was the first large-scale exploration program for polymetallic sulphide deposits in the Indian Ocean. Identification of sulphide fields and hydrothermal activity.
1993, 1995: Subsequent research activities by the University of Berlin; first sampling of polymetallic sulphides.

21: Federal Institute for Geosciences and Natural Resources of Germany, Indian Ocean

2011: The Federal Institute for Geosciences and Natural Resources (BGR) of Germany investigates the area. Three prospecting cruises (INDEX 2011 to INDEX 2013) are conducted to date. A notification of intention to engage in prospecting" is addressed to the Authority on 16 September 2011.

2013: An application for an exploration license is submitted to the ISA by BGR.

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the ISA. The license is awaiting to be signed.

A number of sulphide exploration cruises are scheduled for the first five years for high resolution deep-towed mapping and magnetic measurements. The cruises will exclusively aim at defining exploration strategies for inactive polymetallic sulphides.

Financing:

The funding of the GEMINO and subsequent research projects was done by a grant from the Bundesminister für Forschung und Technologie, Bonn to G.H. Friedrich (University of Aachen) and to Prof. P. Halbach (University of Berlin).

The Government of Germany (Ministry of Economy and Energy) finances (indirectly) the current exploration.

Government involvement:

The German government finances the Federal Institute for Geosciences and Natural Resources of Germany. Exploration by BGR is intended to attract companies to this future theme and get them involved before mining will start.

Type of material to be collected:

SMS

Size of expected deposit:

Confidential but not known yet

Technology used:

The GEMINO project made use of bathymetric mapping carried out using the Seabeam sonar system on board of the research vessel. The Ocean Floor Observation System (OFOS) was available for camera tows. In addition to a real-time black and white TV camera, the OFOS carries a 35-mm still camera, and a color-video system. TV-guided grabs and conventional chain-bag dredges were used for rock sampling. Sediment sampling was carried out with box and gravity corers.

The BGR uses bathymetric mapping, including backscatter and water column imaging, magnetics, gravimetry, electromagnetic, dredging, boxscoring, water sampling, videosledge and a ROV.

Obstacles:

- Part of the area included in the application is also in an application license issued by the Indian government. The ISA requested both governments to negotiate this issue but the reaction of the Indian government is pending. The overlap could occur because the German government announced that they were performing prospecting activities in the Indian Ocean. The Indian government in return included the same area in their application;
- Limited availability of modern and state-of-the-art research vessels in the Indian Ocean;
- On-going development of appropriate exploration tools and exploration concepts. The exploration activities are research-motivated rather than industry;
- Public opposition is rising in Germany. Extended need for public relation.

Sources:

Interview with the Federal Institute for Geosciences and Natural Resources of Germany (Mr. Dr. U.Schwarz-Schampera);

Herzig, P.M, Plüger W. L. (1988): Exploration for hydrothermal activity near the Rodriguez triple junction, Indian Ocean, Canadian Mineralogist, Vol.26, pp. 721-736;

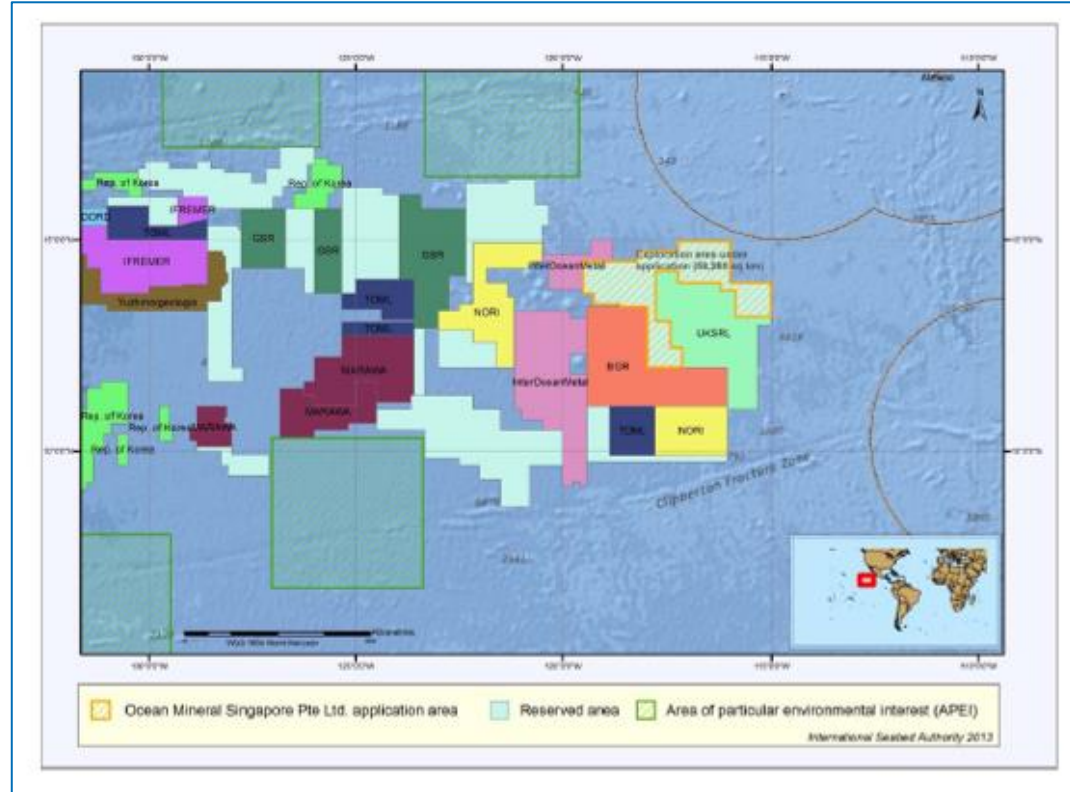
Source: ISA website (2013).

22: Ocean Mineral Singapore Pte Ltd (OMS), Clarion-Clipperton Zone

Location and area:

The area under application is located in the eastern part in the Clarion-Clipperton Zone in the Pacific Ocean. This is the reserved area contributed by UK Seabed Resources Ltd. (UKSRL). The area under application is adjacent to the UKSRL area under exploration contract.

Area: 58 280 km²



Source: ISA (2014b) 20th Council session.

Water depth: 4 000 – 5 000 meters

Consortia members

Ocean Mineral Singapore Pte Ltd (OMS)	Main contractor	
Tropical Marine Science Institute of the National University of Singapore	Key partner	
UK Seabed Resources	Possible partner to collaborate	

OMS is a subsidiary of Keppel Corporation Limited (KCL) which holds 78.1 per cent of the outstanding share capital of OMS. Lion City Capital Partners Pte Ltd. holds 2 per cent of the applicant's shares. KCL is managed by, and has a board of directors that includes, Singaporean citizens. Both OMS and KCL are companies incorporated and based in Singapore. KCL is a Singapore multinational conglomerate with businesses in offshore and marine, infrastructure and property development. The UK Seabed Resources (UKSRL) has been invited to be a minority, non-controlling, shareholder. Given the fact that the area under application and the area under UKSRL exploration contract are adjacent and constitute an ecological and geological continuum, the applicant intends to collaborate with UKSRL for the execution of the proposed plan of work for exploration. Both the applicant and UKSRL see advantages to collaborating on their respective exploration plans of work, such as leveraging the shared data and results, equipment and resources, including through multipurpose cruises, and note that the area under application is the reserved area surrendered by UKSRL. The commencement of the proposed plan of work is therefore subject to entry into the management services agreement between the OMS and UKSRL (or its affiliate) or failing that, entry into a similar exploration services agreement with a third party.

22: Ocean Mineral Singapore Pte Ltd (OMS), Clarion-Clipperton Zone

A Key partner will be Tropical Marine Science Institute of the National University of Singapore which has expertise in biodiversity and environmental research, including environmental impact assessment and monitoring.

Type of contract: application for exploration license

Time scale:

19 April 2013: application for an exploration license

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the International Seabed Authority. The license is awaiting to be signed.

In the first five years of the contract survey activities would take place, identifying potential commercial recovery sites and developing resource estimates for additional areas. The applicant would conduct two survey cruises, scheduled for 2017 and 2018/ Also environmental baseline studies are scheduled in the first five years of the contract.

Financing:

The applicant's parent company (Keppel Corporation) will provide funding support, be it direct or indirect, to the applicant for the implementation of the proposed plan of work for exploration for polymetallic nodules.

Government involvement:

The sponsoring State (Singapore) is planning to develop and enact domestic mining legislation and to regulate OMS based on the domestic legislations, once OMS enters into a contract with the Authority.

Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used:

OMS will leverage on the technical competencies of UKSRL, which it had invited to be a minority, non-controlling, shareholder. Given the fact that the area under application and the area under UKSRL exploration contract are adjacent and constitute an ecological and geological continuum, the applicant intends to collaborate with UKSRL for the execution of the proposed plan of work for exploration.

Both the applicant and UKSRL see advantages to collaborating on their respective exploration plans of work, such as leveraging the shared data and results, equipment and resources, including through multipurpose cruises.

Obstacles: -

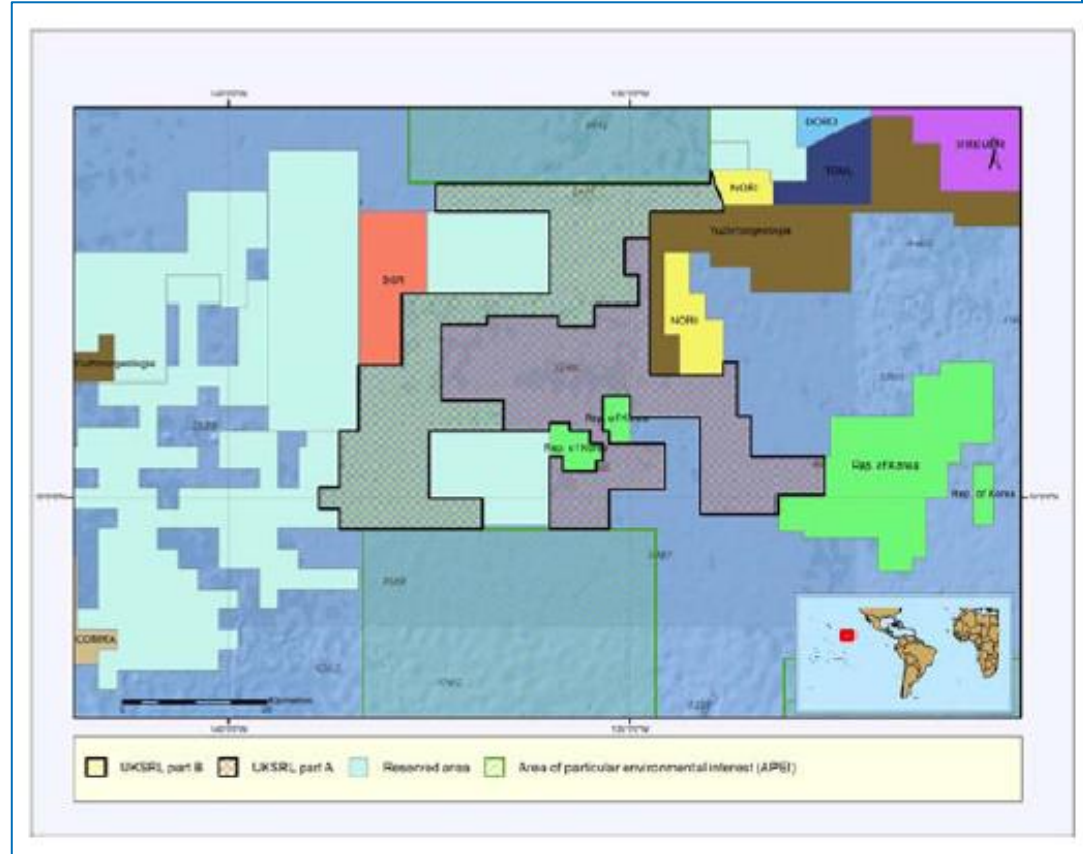
Sources:

ISA (2014b). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration by Ocean Mineral Singapore Pte Ltd. 20th Council Session Kingston, Jamaica 7-25 July 2014: <http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-7.pdf>.

23: UK Seabed Resources Ltd., Clarion-Clipperton Fracture Zone

Location: Clarion-Clipperton Fracture Zone

The application area is in the eastern part of the CCZ. The application area is contiguous and divided into two parts, labelled part A and part B, which are contiguous and nested together. Part A comprises 74 919 km² and part B comprises 74 904 km². The Commission recommends parts B as the area reserved for the Authority and part A as the exploration area for UK Seabed Resources.



Source: ISA (2014c), 20th Council Session.

Water depth:

The water depths in the area under application vary between about 2 100 and 5 200 meters, with the average depth being 4 800 meters.

Consortia members

UK Seabed Resources Ltd. (UKSRL)	Main contractor	
----------------------------------	-----------------	--

UK Seabed Resources Ltd. (UKSRL) is a wholly owned subsidiary of Lockheed Martin UK Holdings Ltd. (LMUK) and was founded in May 2012. Both UK Seabed Resources Ltd. and LMUK are companies formed under the laws of the United Kingdom and based in the United Kingdom. Lockheed Martin UK, part of Lockheed Martin Corporation, is a leader in systems integration, working on major programmes spanning the aerospace, defence and civil sectors.

Type of contract: Application for an exploration license

Time scale:

8 February 2013: application received by the ISA.

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the International Seabed Authority. The license is awaiting to be signed.

UKSRL intends to complete its exploration activities within six years. the plan of work has a twofold objective: the identification of one or more sites as potential recovery sites that could be used for subsequent testing of

23: UK Seabed Resources Ltd., Clarion-Clipperton Fracture Zone

commercial recovery systems; and the establishment of an environmental baseline for use in determining the environmental impact of the testing.

Financing:

UK Seabed Resources is a newly formed entity (founded in 2012). Should it be necessary, UK Seabed Resource may seek to draw upon funds from Lockheed Martin Corporation (LMC), of which LMUK is a component.

Government involvement:

The UK is the sponsoring state. The certificate of sponsorship states that the United Kingdom assumes responsibility for the activities of the company will require a licence under the deep-sea mining legislation of the United Kingdom. Accordingly, the UK declares that UK Seabed Resources is subject to the effective control and supervision of the Government of the United Kingdom.

Type of material to be collected:

polymetallic nodules

Size of expected deposit: -

Technology used:

UKSRL has access to certain data, resources and subject matter expertise of Lockheed Martin Corporation (LMC) related to polymetallic nodule resource surveying, analysis and recovery methods. The applicant notes that LMC was the prime contractor and the technology provider for the Ocean Minerals Company consortium, which was one of the leading participants in seabed minerals efforts in the 1970s and 1980s.

Obstacles: -

Sources:

Contracts for exploration for polymetallic nodules, ISA website, see:

<http://www.isa.org.jm/en/scientific/exploration/contractors>;

ISA (2014c). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by UK Seabed Resources Ltd. 20th Council Session Kingston, Jamaica 7-25 July 2014:

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-7.pdf>,

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-5.pdf>;

Lockheed Martin (2013): Lockheed Martin seabed mining venture set to explore Pacific, The Engineer,

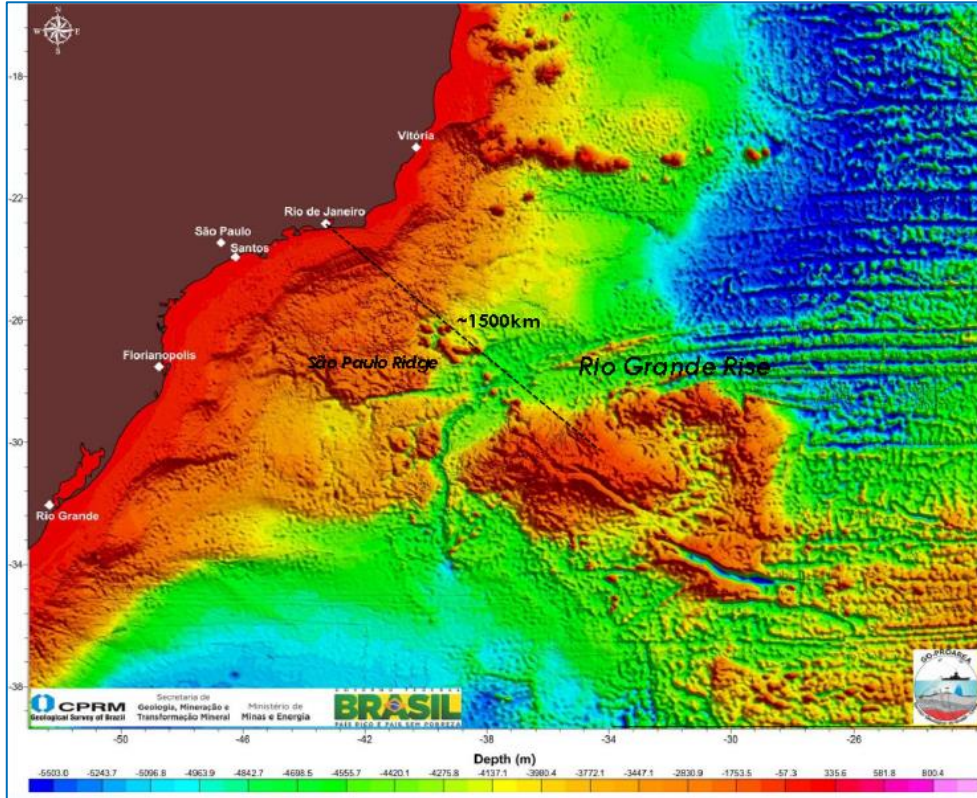
<http://www.theengineer.co.uk/channels/policy-and-business/lockheed-martin-seabed-mining-venture-set-to-explore-pacific/1015815.article>.

24: Companhia de Pesquisa de Recursos Minerais S.A., Atlantic Ocean

Location and area: Atlantic Ocean, Rio Grande Rise

The Rio Grande Rise is located south of Brazil. Rio Grande Rise is an area of uplifted seafloor off Brazil with a flat summit some 1 000 meters below sea level. There is an over 5 000-meter high vertical cliff at the center of the rise.

Area: 3 000 km²



Source: <http://www2.camara.leg.br/atividade-legislativa/comissoes/comissoes-temporarias/especiais/54a-legislatura/pl-0037-11-mineracao/audiencias-publicas/apresentacao-cprm>.

Water depth: between 1 000 and 5 000 meters

Consortia members

Companhia de Pesquisa de Recursos Minerais S.A. (CPRM)	Main contractor	
--	-----------------	--

Companhia de Pesquisa de Recursos Minerais or CPRM is the Geological Survey of Brazil and acts as Brazil's official agency for collecting information on the country's geology, minerals and water resources. It manages and makes available a complex set of databases and theme-based georeferenced information systems, as well as a vast collection of documents, maps and images.

Type of contract: application for an exploration license

Time scale:

April, May 2013: Surveys in Rio Grande Rise at depths of 650 to 1 200 meters. This comprised both geological surveys as well as a survey on biological communities in various habitats.

31 December 2013: application for a license was received by the ISA.

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the International Seabed Authority. The license is awaiting to be signed.

Financing:

CPRM is a governmental organisation. It is therefore expected that the project is financed by the Brazilian government since no other partners are mentioned.

24: Companhia de Pesquisa de Recursos Minerais S.A., Atlantic Ocean

Government involvement:

Brazil is the sponsoring State.

Since its creation in 2009, the Programme for Prospecting and Exploration of Mineral Resources in the Equatorial and South Atlantic International Area (PROAREA), within the Interministerial Commission on Sea Resources of Brazil, has expanded its research activities on marine geology and biodiversity in the Equatorial and South Atlantic. PROAREA activities are developed by the Companhia de Pesquisa de Recursos Minerais S.A. (CPRM), under the coordination of the Ministry of External Relation. Many other governmental organizations participate in PROAREA, such as research institutions and members of the scientific community.

PROAREA has been developing activities in order to identify and assess the mineral potential of areas with economic and political strategic importance for Brazil, located beyond the limits of Brazilian national jurisdiction.

Type of material to be collected:

Cobalt-rich ferromanganese crusts.

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

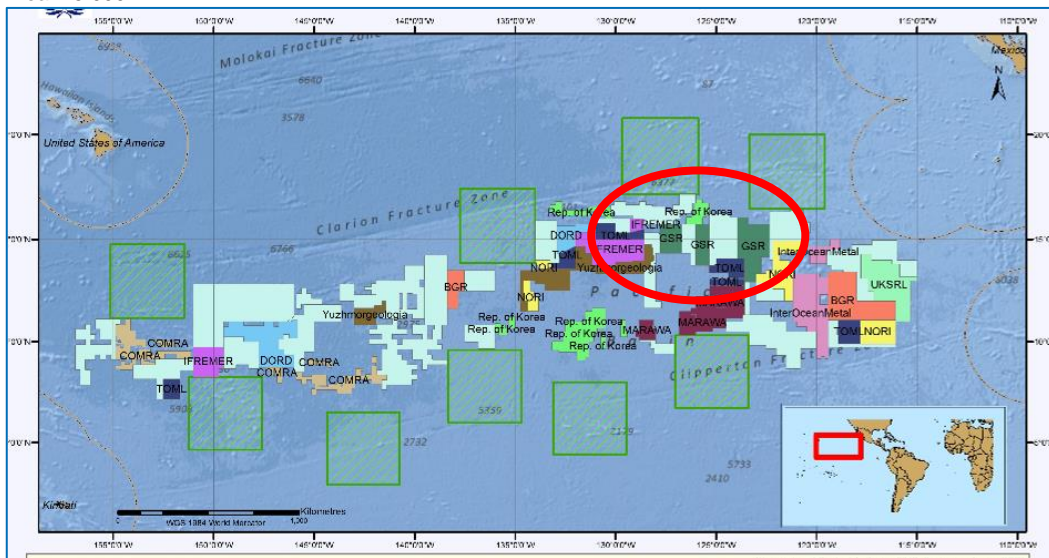
ISA (2014d). Application for approval of a plan of work for exploration for cobalt-rich ferromanganese crusts by the Companhia de Pesquisa de Recursos Minerais S.A. 20th Council Session Kingston, Jamaica 7-25 July 2014: <http://www.isa.org.jm/files/documents/EN/20Sess/LTC/ISBA-20LTC-2.pdf>.

Oancea, D. (2011): Mining in Brazil, <http://www.infomine.com/countries/SOIR/brazil/welcome.asp?i=brazil-soir-2>.

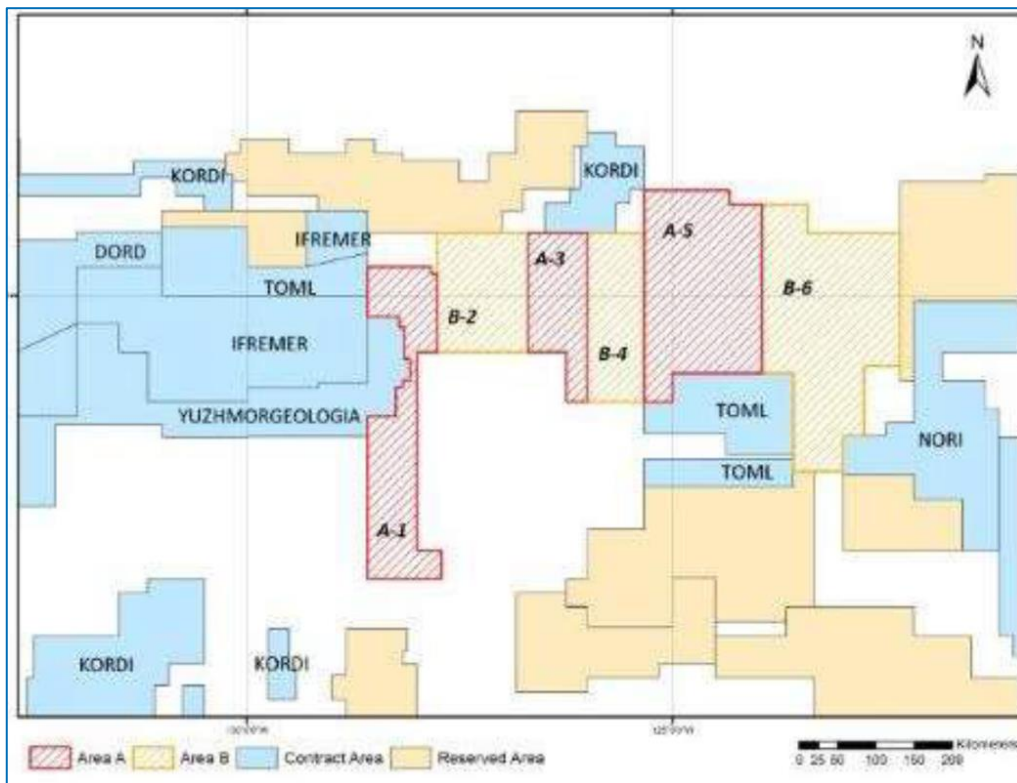
25: Cook Islands Investment Corporation, Clarion-Clipperton Fracture Zone

Location and area:

The area is situated within the Clarion-Clipperton Fracture Zone of the Pacific
 Latitude 130°0'0" - 123°0'0" W'. Longitude 15° 0'0"N
 Area: 75 000 km²



Source: ISA (2014a) website.



Source: ISA (2014e), 20th Council session.

The area under application comprises the Area A in the map above (parts labelled part A-1 plus A-3 plus A-5). Part B (B-2, B-4 and B-6) was allocated to G-TEC in 2013 (14 January) as its exploration area.

Water depth:

Around 5 000 meters

25: Cook Islands Investment Corporation, Clarion-Clipperton Fracture Zone

Consortia members

Cook Islands Investment Corporation	Main contractor	
G-TEC Sea Mineral Resources NV		

The Cook Islands Investment Corporation is a Cook Islands State-owned enterprise. The application by the Cook Islands Investment Corporation is supported by CI-GSR, an equal and equitable arrangement between the Cook Islands Government and G-TEC Sea Mineral Resources NV (GSR) of Belgium. GSR signed a contract for the exploration of polymetallic nodules with the Authority on 14 January 2013. The formal arrangement between the Government of the Cook Islands and GSR allows for parties to jointly undertake exploration of the reserved area under application. The Cook Islands Investment Corporation and GSR endeavour to align their respective plans of work for exploration in order to improve the efficiency of the campaigns and to achieve a better understanding of the environmental conditions by integrating results covering a larger area. This complementary approach will allow for a more logical scientific approach, minimize costs and prevent overlapping studies and undue environmental impact.

Type of contract: application for an exploration license

Time scale:

The reserved area under this application was studied and defined by G-TEC Sea Mineral Resources NV.

The Cook Islands Investment Corporation has developed a 15-year plan for exploration work, divided into three phases, each phase builds on the work of the previous and follows a logical progression from better understanding of the environment in the allocated area through development of mining technologies, to full mining tests. This programme aims to arrive at the right technology and methods to take forward an effective and efficient future exploitation programme. The anticipated expenditure of the defined programme of activities is \$1.5 million for year one, \$0.5 million for years two, three and five and \$4.0 million for year four; totalling \$7.0 million for the immediate five-year period.

15 – 24 July 2014: the application is approved at the 20th Council session of the Assembly of the International Seabed Authority. The license is awaiting to be signed.

Financing:

The project will be (indirectly) financed by the government of the Cook Islands since the Cook Islands Investment Corporation is a Cook Islands State-owned enterprise.

Government involvement:

The Cook Islands Investment Corporation is a Cook Islands State-owned enterprise. The government is involved in the Area in order to access the fees, royalties and other revenue from such activities and to build experience and expertise in the management of seabed mining activities in the Area that will be highly relevant to the management of seabed mining activities on the Cook Islands Continental Shelf.

Type of material to be collected:

Polymetallic nodules

Size of expected deposit: -

Technology used:

The Cook Islands Investment Corporation will apply scientific and industry standard and proven techniques to the exploration programme.

Obstacles: -

Sources:

ISA (2014e). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by the Cook Islands Investment Corporation. 20th Council Session Kingston, Jamaica 7-25

25: Cook Islands Investment Corporation, Clarion-Clipperton Fracture Zone

July 2014: <http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-18.pdf>.

ISA (2014f): Application for approval of a plan of work for exploration for polymetallic nodules by the Cook Islands Investment Corporation, Executive summary,

<http://www.isa.org.jm/files/documents/EN/20Sess/LTC/ISBA-20LTC-3.pdf>;

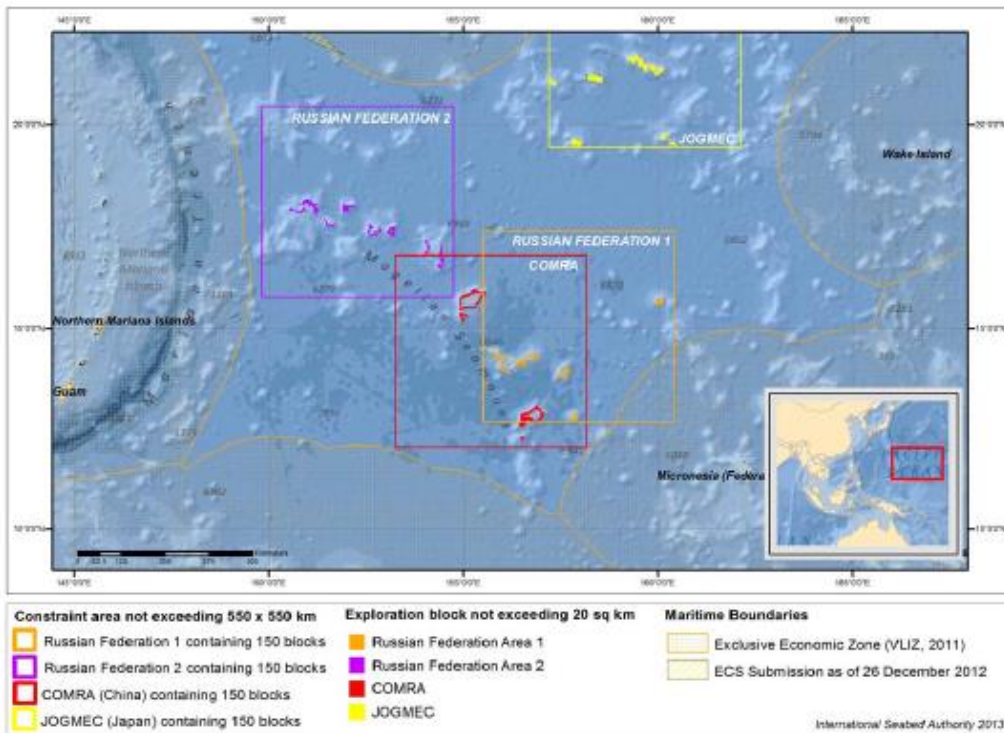
Cook Islands National Seabed Minerals Policy 2014, March 4, 2014.

Location and area:

The application covers a total surface area of 6,000 square kilometres, located in the Western Pacific Ocean. It consists of two groups of 150 blocks each, which the applicant named area 1 and area 2. Each of the two groups of 150 blocks has a size of 3,000 km². The Council of the ISA, on the recommendation of the Commission, shall designate one of these parts as the area reserved for the Authority. The other part will become the applicant's exploration area (part 2 is the recommended by the Commission for exploration). This will be decided in July 2014.

Area: 3.000 km²

Map of the general location of the proposed reserved area (area 1) and exploration area (area 2)



Water depth:

Average water depth in area 1 is 2.063 meters and in area 2 2.314 meters

Consortia members

Ministry of Natural Resources and Environment of the Russian Federation

Main contractor

Type of contract: application for an exploration license

Time scale:

On 6 February 2013, the Secretary-General of the International Seabed Authority received an application from the Government of the Russian Federation for approval of a plan of work for exploration for cobalt-rich ferromanganese crusts in the Area. Amendments to the application were received on 29 April 2013.

On 25 February 2014 the Commission recommends to the Council that it designate area 1 within the application for approval of the plan of work for exploration as the area reserved for the Authority and that it allocate area 2 to the applicant as its exploration area. This will be decided during the meeting of 14-25 July 2014 of the Council.

The exploration activities would take place in three five-year phases of the plan of work. The objective of the first phase was to define priority areas in order to conduct further detailed exploration with a view to demarcating

26: Ministry of Natural Resources and Environment of the Russian Federation , Western Pacific Ocean

potential cobalt-rich ferromanganese crusts deposits. It can be mentioned that from 1999-2006 the Russian state company Yuzhmorgeologiya (YMG) has already been performing comprehensive prospecting of the Magellan Mountains in the Pacific Ocean for cobalt-bearing crusts.

The second phase would aim at allocating the deposits and crusts reserves which were viable for mining; upon its completion, the applicant planned to conduct a feasibility study to determine the commencement of mining. For the last phase, the objective was to select sites for potential exploitation, taking into account a number of parameters, such as the seabed gradient, ruggedness, physical obstacles, and physical and mechanical properties of the substrate. The applicant also planned to conduct a feasibility study at the end of the last phase.

Financing:

The government of the Russian Federation finances the project

Government involvement:

The government of the Russian Federation finances the project

Type of material to be collected:

Cobalt-rich ferromanganese crusts

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for cobalt-rich ferromanganese crusts by the Ministry of Natural Resources and Environment of the Russian Federation, 25 February 2014, <http://www.isa.org.im/files/documents/EN/20Sess/Council/ISBA-20C-4.pdf>

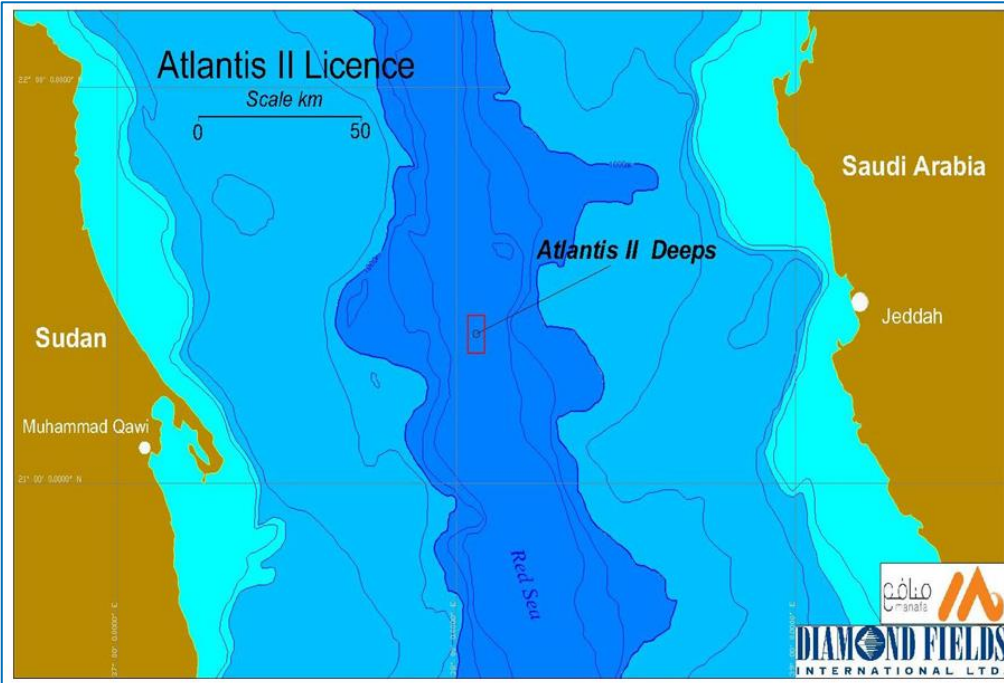
2.2 Projects located in EEZs (projects 27- 52)

27: Diamond Fields International, Atlantis II Deep project

Location and area: Red Sea, between Saudi Arabia and Sudan, ~115 km west of Jeddah

Latitude: 21°23' N. Longitude: 38°04' E

Area: 62 km²



Source: Diamond Fields International Ltd website.

Water depth:

1 900 – 2 200 meters

Consortia members

Diamond Fields International Ltd.	Core company/contractor	
Manafa International	Joint venture partner	

Diamond Fields International is a Canadian mining company with land and marine mining licenses in several areas of the world.

Manafa International Trade Company is a Saudi Arabia based company.

Type of contract: exploitation license

Time scale:

2010: license into force

2040: expiry date of license

1965: Discovery of base and precious metal mineralization contained within the sediments of the Atlantis II basin deposit. Throughout the 1970s, more than USD28 million was spent exploring the deposit. Evidence is shown of extensive and continuous mineralization of zinc, copper, silver, gold, lead and other metals.

Mid 1970's: Saudi-Sudanese Red Sea Commission (RSC) is established with the decree to assess the economic potential of these resources.

27: Diamond Fields International, Atlantis II Deep project

1979-1982: RSC commissions Preussag A.G. (German mining and metalliferous processing company with knowledge of Atlantis II Deep) to carry out a 5-year geological exploration program and technical feasibility study. A pre-pilot mining test (PPMT) is successfully carried out from March to June 1979, establishing the technical feasibility and environmental acceptability of metalliferous muds mining below 2000m in the Red Sea. This early exploration work demonstrated that the metal-rich sediments could be successfully raised from the sea floor and processed. 589 cores are collated during early exploration work.

2010: The DFI/Manafa joint venture was granted the world's first deep water marine mining license extending over the Atlantis II Deeps by the Red Sea Commission in May 2010 for a period of 30 years. The project is to be developed in defined stages, commencing immediately with a Scoping Study to test the accuracy of the historic data collected on the deposit by Pressuag AG (DFI News Release, 4 June 2010).

2011:

- February 11, 2011, the Company announced the marine research vessel RV POSEIDON is to conduct a walk-away, sub-bottom profiling ("SBP") survey on the Company's Atlantis II joint venture concession. The survey is conducted pursuant to a collaborative agreement between DFI and Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel ("IFM-GEOMAR"). The survey has already for the first time, using specially adapted cameras operating within the brine pool, managed to obtain detailed photographs and video of the Atlantis II Deeps surface⁶.
- 26 July 2011, the Company announces world's first NI 43-101 compliant resource estimate for a marine sedimentary exhalative ("SEDEX") deposit, which was completed on its Atlantis II seafloor deposit. ACA Howe International Ltd. Compiled the report based on the 589 cores collated by Pressuag AG⁷. (;
- November 2011, an update to the NI 43-101 Technical Report on the resource estimate in its Atlantis II deposit is announced, to include manganese. The updated resource statement estimates the deposit to contain approximately 80.9 million tonnes of sediment grading 2.69% manganese at the Inferred resource level, amounting to a total of 2.18 million tonnes of manganese. DFI begins examining the feasibility of recovering the manganese by froth flotation as an additional metal credit to the base and precious metals contained within the deposit.

January 2014: DFI invokes binding arbitration to resolve dispute with Manafa over the latter's compliance with obligations under the Joint Venture Agreement. According to DFI news release, Manafa has purportedly cancelled the Agreement citing DFI's failure to perform.

Financing:

Under the terms of the joint venture agreement, DFI owns 50.1% of the venture, and Manafa owns 49.9%.

DFI negotiated a private placement with Spirit Resources SARL for gross proceeds of Cdn\$200,000; \$35,000 will be used for exploration and development in the Company's offshore marine Red Sea concession.⁸

Government involvement: -

Type of material to be collected:

Metallic sulphide deposits

Size of expected deposit:

A historical resource figure estimated the deposit to contain 89.5 million tonnes of sediment at a grade of 2.06% Zinc, 0.45% Copper and 38.4ppm Silver on a dry salt free basis ("DSF"). This estimate is based on the Pressuag coring program's (1979-82) 587 core samples taken from only the uppermost 8.5 meters of sediment. The Company has not done sufficient work to classify the historical estimate as current mineral resources.

⁶ DFI website, DFI News Release 11 February 2011

⁷ DFI News Release, 26 July 2011

⁸ DFI website, DFI News Release 13 May 2013.

27: Diamond Fields International, Atlantis II Deep project

Accordingly the Company is not treating the historical estimate as current mineral resources, and the historical estimate should not be relied upon.

Technology used:

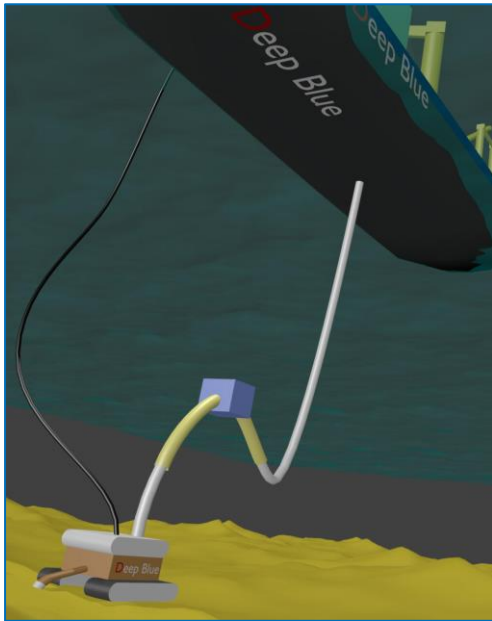
Pre-mining, February 2011 Sub-bottom profiling survey:

The marine research vessel RV POSEIDON conducts a walk-away, sub-bottom profiling ("SBP") survey, pursuant to a collaborative agreement between DFI and Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel ("IFM-GEOMAR"), using the state-of-the-art Abyss 6 000 unmanned autonomous vehicle ("UAV").

The program also includes collating a high precision bathymetric survey over the structure as part of the marine research project "Jeddah Transect" conducted by IFM-GEOMAR and King Abdulaziz University of Jeddah, Saudi Arabia. During this two-month project, marine scientists from Saudi Arabia and Kiel perform joint biological, geological and geophysical studies on Atlantis II and other parts of the Red Sea in three legs from an area off the coast up to the trench axis of the Red Sea at two kilometers depth. The Jeddah Transect Project includes a broad range of scientific activity, including the investigation of the Atlantis II Deeps⁹

Mining:

The main components of the system include: the seabed mining machine, the riser, the deep sea mining pump, the floating platform, the vessel positioning and the energy supply system.



The seafloor mining machine that is used is a collection machine comprised of 5 sub-systems: the collecting system (equipped with an auger device for channelling the ore to a large centrifugal dredge pump and a cutter head); the electro-hydraulic system; the movement system (one pair of tracks that can be electrically powered from the surface, fitted with buoyancy and thrusters); the power supply system and the control system.

To transfer the mineral ore particles mined from the seabed sulphide deposits to the floating vessel, a Steel Catenary Risers (SCRs) system is utilized.

On the vessel, a dual gradient pump is used to transfer the mud from the vessel through a pipe to the drill bit and also back up the wellbore annulus and the return riser.

The subsea component consists of a pumping chamber and actuated isolation valves which are driven by a subsea hydraulic system.

The floating support vessel utilized is similar in design to the floating units that service the drilling and production of offshore oil fields. It will include dewater ore storage and tailings dewater tanks.

A dynamic positioning (DP) system that does not require the use of anchors is used to ensure that the floating vessel maintains its position over the mine site for the duration of the operation. The proposed DP is comprised

⁹ DFI News Release, 2011a

27: Diamond Fields International, Atlantis II Deep project

of 6 elements: Environment reference system; position reference system; heading reference system; control system; thrusters and propulsion system, and; power supply system.

The relevant technologies for deep sea mining and exploration are detailed further in Task 1¹⁰.

Obstacles:

Technical obstacle: The design of the seafloor tool faces a number of obstacles in the Red Sea. (1) The equipment must be resistant to high ambient pressures. For every 10 meters, the pressure in the water column increases by one bar, which means that at a depth of more than 2 000m, this results in ambient pressure of more than 200 bars. (2) Equipment must function in a brine environment with extreme high salinity. (3) Equipment must be reliable considering the depth that the machinery is operating within¹¹.

A number of potential legal and environmental issues:

1. Exclusive economic zones in the red sea – The Atlantis II Deep deposits are shared by Saudi Arabia and Sudan;
2. A network of Marine Protected Areas (MPAs) was established in the Red Sea and the Gulf of Aden, which includes 12 sites;
3. Finally, the Atlantis II Deep is located along a major transportation route¹²

DFI invokes binding arbitration to resolve dispute with Manafa over the latter's compliance with obligations under the Joint Venture Agreement. According to DFI news release, Manafa has purportedly cancelled the Agreement citing DFI's failure to perform (DFI News Release, 2014).

Sources:

Diamond Fields website, <http://www.diamondfields.com/s/AtlantisII.asp>;

Egorov L., Elostaa H., Kudla N. L. , Shan S, Yang K.K. . (2012): Sustainable Seabed Mining: Guidelines and a new concept for Atlantis II Deep, The LRET Collegium 2012 Series, Volume 4; p. 85-116, 135-147.

Diamond Fields (2010a): Joint Venture Company Granted Mining License over World Class Zinc, Copper, Silver and Gold Project. *DFI News Release*,

[http://www.diamondfields.com/s/NewsReleases.asp?ReportID=403052&_Type=News-](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=403052&_Type=News-Releases&_Title=Diamond-Fields-Joint-Venture-Company-Granted-Mining-License-over-World-Clas)

[Releases&_Title=Diamond-Fields-Joint-Venture-Company-Granted-Mining-License-over-World-Clas](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=403052&_Type=News-Releases&_Title=Diamond-Fields-Joint-Venture-Company-Granted-Mining-License-over-World-Clas);

Diamond Fields (2011a): Survey Ship Begins Work on Diamond Fields' Atlantis II JV Mining License. *DFI News Release*, 14 February 2011:

http://www.diamondfields.com/s/NewsReleases.asp?ReportID=442386&_Type=News-Releases&_Title=Survey-Ship-Begins-Work-on-Diamond-Fields-Atlantis-II-JV-Mining-License;

Diamond Fields (2011b): D.F.I.'s Red Sea Silver/Zinc/Copper Polymetallic Deposit Becomes First Marine Sedex in History to have Third Party National Instrument 43-101 Resource Report Completed. *DFI News Release*, 26 July 2011: [http://www.diamondfields.com/s/NewsReleases.asp?ReportID=468610&_Type=News-](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=468610&_Type=News-Releases&_Title=D.F.Is-Red-Sea-SilverZincCopper-Polymetallic-Deposit-Becomes-First-Marine-S)

[Releases&_Title=D.F.Is-Red-Sea-SilverZincCopper-Polymetallic-Deposit-Becomes-First-Marine-S](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=468610&_Type=News-Releases&_Title=D.F.Is-Red-Sea-SilverZincCopper-Polymetallic-Deposit-Becomes-First-Marine-S);

Diamond Fields (2011c): Updated NI 43-101 Resource Estimate for Atlantis II Deposit to Include Manganese Values. *DFI News Release*, 1 November 2011:

[http://www.diamondfields.com/s/NewsReleases.asp?ReportID=488267&_Type=News-](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=488267&_Type=News-Releases&_Title=Updated-NI-43-101-Resource-Estimate-for-Atlantis-II-Deposit-to-Include-Mang)

[Releases&_Title=Updated-NI-43-101-Resource-Estimate-for-Atlantis-II-Deposit-to-Include-Mang](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=488267&_Type=News-Releases&_Title=Updated-NI-43-101-Resource-Estimate-for-Atlantis-II-Deposit-to-Include-Mang);

Diamond Fields (2014): Diamond Fields in Dispute with Red Sea Joint Venture Partner. *DFI News Release*,

[http://www.diamondfields.com/s/NewsReleases.asp?ReportID=621783&_Type=News-](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=621783&_Type=News-Releases&_Title=Diamond-Fields-in-Dispute-with-Red-Sea-Joint-Venture-Partner)

[Releases&_Title=Diamond-Fields-in-Dispute-with-Red-Sea-Joint-Venture-Partner](http://www.diamondfields.com/s/NewsReleases.asp?ReportID=621783&_Type=News-Releases&_Title=Diamond-Fields-in-Dispute-with-Red-Sea-Joint-Venture-Partner).

¹⁰ LRET, p. 85-116

¹¹ p. 86, LRET

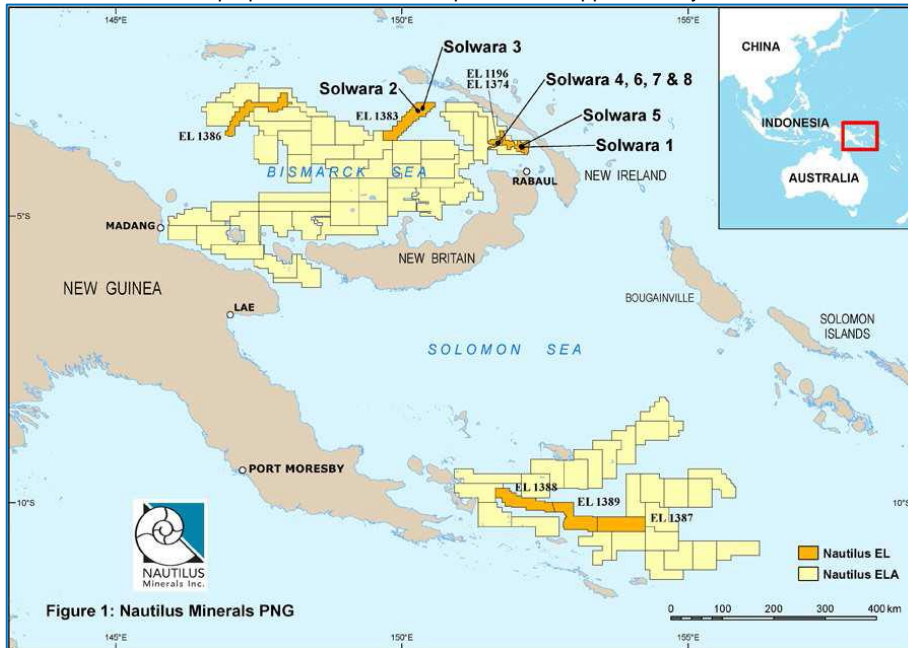
¹² LRET, p. 135-137

28: Nautilus Minerals, Solwara 1 project

Location: EEZ of Papua New Guinea (Bismarck Sea), 30 km off the coast of New Ireland Province.

Latitude 3°47'25.06"S. Longitude 152°05'41.65"E.

Size: 59 km² The area proposed for extraction operations is approximately 0.112 km²



Source: Hegedus N., D'Elia, P., Sloan M., (2010): Seafloor Mining of Massive Sulfide Deposits.

Water depth: 1 600 meters

Consortia members

Nautilus Minerals	Core company	
Nautilus Alliance Group	Supporting company	Supporting Nautilus technically
Placer Dome	Supporting company	Supporting Nautilus financially and technically

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: Exploitation license

Time scale:

2010: license into force

2030: expiry date of license

1985: The first discovery of submarine hydrothermal sulfide deposits and black smokers in the southern Pacific Ocean when the US research vessel *RV Moana Wave* photographed seafloor sulfides at the Solwara 2 site in the Bismarck Sea. Since then, occurrences of submarine sulfides in the Bismarck and Solomon Seas, have been studied by research groups from many countries, including France, Germany, Canada, USA, Japan, Korea, UK and Australia.

1996: the hydrothermal field of the Solwara 1 project area are first discovered by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) during the 1996 "PACMANUS III" cruise.

1997: The Exploration Licence (EL) known as EL1196 is first granted to Nautilus Minerals Niugini Ltd (a wholly owned subsidiary of Nautilus Minerals Inc) for a term of two years. EL1196 has undergone a number of statutory reductions during the life of the tenement, effectively reducing from the original size of 750 sub-blocks

28: Nautilus Minerals, Solwara 1 project

at 2 546km², to below the minimum size for any further such reductions in accordance with the Mining Act 1992. The tenement has been renewed on every consecutive anniversary date and is current to November 2009. The Solwara 1 deposit is located within the Eastern segment. In addition to the Solwara 1 deposit, EL1196 contains four other known sulfide occurrences, Solwara's 4, 5, 6, 7, and 8.

2005: exploration works by Placer Dome Inc (subsequently bought out by Barrick Gold Corporation (Barrick)) with ROV dive videos and bathymetric surveys. Dredge samples are collected.

2006: exploration works by Placer Dome Inc. 34 diamond core holes are drilled from the surface. The drillholes demonstrated the presence of widespread massive sulfide mineralization. In addition to the core drilling data, chimney samples were collected from the seafloor. These also demonstrated high grade Cu, Au, Zn and Ag mineralization. The drilling methodology employed in 2006 presented significant challenges for the ship-based drilling system and resulted in poor sample recovery.

Also in 2006 a non-binding deal is signed with Jan De Nul, a Belgium-based international dredging company. Jan de Nul will construct, at its cost, a specialized deep-sea mining vessel for Nautilus's Solwara project in Papua New Guinea (PNG). The 191-metre vessel, to be named the Jules Verne, is expected to be completed in 2009.

2007: A six-month field campaign by Nautilus. A 111 whole drilling program was completed using drill rigs mounted on remote operated vehicles (ROVs) lowered onto the seabed. The drilling operations were managed by Canyon Drilling Inc. (Canyon). In addition over 80 chimney samples were collected. This data was supplemented by a high resolution 20cm x 20cm bathymetric survey, and the world's first underwater EM campaign. An extensive geotechnical testing program on drill core and chimney samples provided confidence on average density and geotechnical parameters of the mineralization at Solwara 1. Over 600 dry bulk density measurements were made on core samples from the 2007 drilling:

- July 2007, Nautilus announced it would take over the offshore development aspects of the Solwara 1 project following the lapse of an agreement with Jan de Nul. The companies had signed a non-binding deal for a tentative partnership, under which Jan de Nul was to build a platform for operations at Solwara 1, off the coast of Papua New Guinea. Those plans failed when Jan de Nul proposed Nautilus pay certain development costs.

2008: The Mining Lease ("ML") application and the development proposal were both submitted to the Government of PNG (3 October 2008). An environmental impact statement for the Solwara Development was submitted by Nautilus to the Department of Environment and Conversation.

2009: Between January and April 2009, a commercial review of Solwara 1 was carried out to identify potential capital and operating cost savings in regards to the global financial downturn. Shipping market enquires were also investigated to identify various mining support vessel options.

2010: The Environmental Permit for the development of the Solwara 1 Project was granted by the Department of Environment and Conservation ("DEC") of Papua New Guinea for a term of 25 years, expiring in 2035. (January 5, 2010).

2011: - The ML was granted by the Government of Papua New Guinea (January 17, 2011):

- March 29, 2011, the Company announced that the State of PNG had signed an agreement and exercised its option to acquire a 30% stake in Nautilus' Solwara 1 Project in the Bismarck Sea. The agreement contemplates the formation of an unincorporated joint venture to hold the mining assets of the Solwara 1 Project, with Nautilus to retain a 70% holding and the State of PNG to acquire a 30% share. The State's

28: Nautilus Minerals, Solwara 1 project

interest in the Mining JV will be held through Petromin PNG Holdings, a wholly owned company of the State, and which holds the State's mining and petroleum assets;

- April 13, 2011 the Company announced the agreement to form a strategic partnership with German shipping company, Harren, to own and operate a PSV, which would serve as the operational base for Nautilus to extract high grade copper and gold at its first development, the Solwara 1 Project, in the Bismarck Sea of PNG. The Vessel JV is to charter the PSV to the Mining JV to carry out its seafloor production operations with Harren to provide crewing, logistics and ship management services to the Vessel JV.

2012: - Nautilus secured its first customer for the product extracted from Solwara 1, Tongling Nonferrous Metals Group Co. Ltd. Tongling is based in China and is one of the world's leading copper smelting groups (April 2012):

- Nautilus announces that it is in dispute with the Independent State of Papua New Guinea ("State") (June 1, 2012);
- Nautilus announces that there may be a delay in the finalisation of funding for the vessel to be used in connection with the Project and consequently, a potential delay to the program for the vessel build and ultimately the commencement of operations at Solwara 1. The two companies begin negotiations on the terms of third party financing related to the PSV after Harren advises Nautilus that it will no longer be able to contribute the full amount of the equity to the Vessel JV as contemplated by the Agreement signed by the parties in 2011 (1 June 2012);
- The shipyard proposed by Harren under the Vessel JV announces insolvency, undergoes an administration process (29 August 2012);
- Nautilus announced that Management and the Board of Directors of Nautilus decided to terminate construction of its Seafloor Production System in order to preserve cash. This was as a result of a dispute with the Independent State of Papua New Guinea ("State") over costs that Nautilus says the government is obliged to meet for the project (13 November 2012).

2013: - Arbitration commenced by the Independent State of Papua New Guinea against Nautilus takes place on August 26, 2014:

- the arbitrator has issued an award in Nautilus' favour in respect of the issues that were the subject of the Notice of Arbitration initiated by the Independent State of Papua New Guinea. The arbitrator's award includes an order that the State is required to comply with its obligations under the agreement to complete the purchase of the 30% interest in the Solwara 1 Project and pay 30% of all project expenditure incurred to date within a reasonable time after the award (October 2013).

2014 - Nautilus Minerals announces that contrary to the arbitrator's award of 2 October 2013, the Independent State of Papua New Guinea has not completed the purchase of its 30% interest in the Solwara 1 Project. In accordance with the State Equity Option Agreement signed by the parties in March 2011, Nautilus has terminated the Agreement and will now claim damages (13 February 2014):

- The Company announces that the Company and the State have signed an agreement (the "Agreement") enabling the Solwara I Project to move forward so long as the conditions of the Agreement are satisfied. Under the Agreement, the State is entitled to an initial 15% interest in the Project, with the option to take up a further 15% interest within 12 months of the Agreement becoming unconditional. The conditions of the Agreement specify that the State, through a subsidiary of Petromin PNG Holdings Limited, must secure the funding for its 15% share (US\$113 000 000) of the capital required to complete the development phase of the Project through to first production by 31 July 2014. If the conditions are satisfied and the State completes the purchase of its 15% interest in the project, then the Arbitration is to be dismissed. If the conditions are not satisfied, then the parties with return to the position they were in prior to the signing of the Agreement (24 April 2014);
- The State of PNG, through its nominee for participation in the Project, Eda Kopa Ltd., has placed the US\$113 000 000 into escrow in advance of its 31 July 2014 deadline. The funds are to be released to the

28: Nautilus Minerals, Solwara 1 project

Company upon its satisfaction of two conditions: (1) the Company must secure a Production Support Vessel; (2) the Company must secure certain intellectual property rights within 6 months. (9 May 2014).

Financing: Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. Shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

The Government of PNG has a legal right to acquire up to 15% equity in the project.

Nautilus raised an additional US\$100 million in 2011 to fund the development of the mine, with contracts let for construction of all facets of the project. Anglo American (11%) and Russian Metalloinvest (21%) contributed to the fundraising, maintaining their equity stake in Nautilus, and were joined by the MB Holding Company LLC from Oman, which invested US\$50 million for a 10% interest.

Nautilus raised approximately C\$34 million through a private placement of Common Shares to assist with the continued funding of its Seafloor Production System. The placement involved the issue of approximately 37.7 million shares to a number of investors at a price of C\$0.90 (US\$0.91) per share. Existing Nautilus strategic shareholders, MB Holding, Metalloinvest and Anglo American participated in the private placement. MB Holding, through its subsidiary Mawarid Offshore Mining Ltd., subscribed for 20.0 million shares, increasing its stake to 16.9%, Metalloinvest subscribed for approximately 8.3 million shares to maintain its interest in Nautilus at 21% and Anglo American subscribed for approximately 4.4 million shares on the basis that its stake be maintained at 11.1%. Other large investors subscribed for the remaining 5 million shares issued.

Government involvement:

Subject to any agreement made under Section 17, of the Papua New Guinea Mining Act 1992, the Independent State of Papua New Guinea reserves the right to elect at any time, prior to the commencement of mining, to make a single purchase up to 15% equity interest in any mineral discovery arising from the license, at a price pro-rated to the accumulated exploration expenditure and then contribute to further exploration and development in relation to the lease on a pro-rata basis unless otherwise agreed.

The royalty payable to the State of PNG under the Papua New Guinea Mining (Royalties) Act 1992 is 2% of the net smelter return on all minerals produced. A further 0.25% royalty is payable to the MRA (Mineral Resource Authority).

Type of material to be collected: polymetallic sulphides (SMS)

Size of expected deposit:

Indicated Mineral Resource: 1,030kt @ 7.2% Cu, 5.0 g/t Au, 23 g/t Ag, 0.4 % Zn;

Inferred Mineral Resource: 1,540kt @ 8.1 % Cu, 6.4 g/t Au, 34 g/t Ag, 0.9% Zn.

The zone of mineralization classified as Indicated Mineral Resource was tested by drillholes spaced from less than 10 m to a maximum of approximately 50 m. In the area classified as Inferred Mineral Resource the drillhole spacing ranges up to 200 m, but is generally less than 100 m, and the core recovery was more variable.

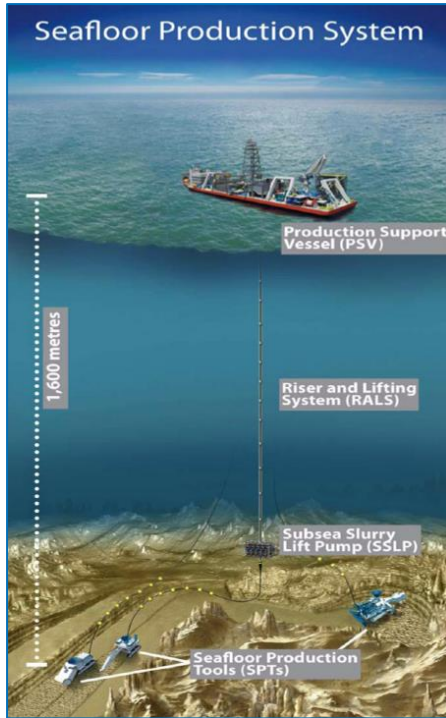
Technology used:

Exploration phase

The Solwara 1 project has been explored by ROV dive videos, bathymetric surveys, surface sampling and by core drilling. ROVs fitted with robotic arms were used in 2006 and 2007 to collect samples of chimneys. During the 2007 campaign, Nautilus successfully trialed and then deployed an ocean floor electromagnetic system over Solwara 1 designed by Ocean Floor Geophysics's (OFG). The system is a controlled source method that measures electromagnetic fields associated with induced subsurface electrical currents. It was designed and built for the purpose of delineating areas of near-surface massive sulfides on the seafloor.

Mining phase

The offshore production system comprises three main components: the seafloor production tools (SPTs), the riser and lifting system (RALS), and the production support vessel (PSV). Using the SPTs, rock is disaggregated by two large robotic machines that excavate material using a continuous cutting process, not unlike coal or other bulk continuous mining machines on land.



The Auxiliary Cutter (AC) is a preparatory machine that deals with the initial terrain and creates benches for the other machines to work. It will operate on tracks with spud assistance and has a boom-mounted cutting head for flexibility. The second machine, the Bulk Cutter (BC), has higher cutting capacity and will be limited to working benches created by the AC. Both machines leave cut material on the seafloor for collection by the Collecting Machine (CM).

The CM, also a large robotic vehicle, will collect the cut material by drawing it in as seawater slurry with internal pumps and pumping it through a flexible pipe to the RALS. The RALS comprises a large pump and rigid riser pipe hanging from a vessel which delivers the slurry to the surface. Technip, an integrated group providing engineering, technologies and construction services to the oil/gas and petrochemical industry worldwide was awarded the contract for engineering, procurement and construction management

of Nautilus's Solwara 1 Riser and Lifting System ("RALS"). GE Oil&Gas was awarded the contract to build the subsea slurry pump for the RALS, using their Hydril Pressure Control subsea pumping technology.

On deck of the PSV, the slurry is dewatered by conventional methods. The dewatered solid material is transferred to a transportation barge moored alongside the PSV. The return seawater is pumped back to the seafloor through the riser pipes, which also provides hydraulic power to operate the RALS pump. Discharge of the return water close to the seafloor helps to minimize impacts to surface waters. The German shipping company Harren & Partner will design and construct the PSV.

Obstacles:

The drilling methodology employed in 2006 presented significant challenges for the ship-based drilling system and resulted in poor sample recovery. The diamond core holes were drilled by a Seacore R100 Marine Drill mounted on the DP Hunter. This equipment was designed for ocean deep drilling (ODP) programs rather than the relatively short drillholes required for exploration of SMS deposits. Coring (61mm diameter) started at the seafloor surface; however recovery was generally very poor, averaging 41% with better core recovery in consolidated massive sulfide rather than the interbedded unconsolidated sulfidic sediments. Much of the recovered material was in a disaggregated state (broken pieces, loose sands and sludge). The recovery was somewhat better towards the end of the program as the operators became more experienced in drilling the substrate. Eight of the shallow holes had to be abandoned after the first few meters because of in-fill and collapse of unconsolidated sediments.

Nautilus announced on June 1, 2012 that it was in *dispute with the Independent State of Papua New Guinea* ("State") as to the parties' obligations to complete the Agreement entered into in March 2011. A further announcement was made on June 20, 2012 confirming that the State had issued a Notice of Arbitration to the Company. Nautilus considers that the State has a contractual obligation to pay an amount of approximately

28: Nautilus Minerals, Solwara 1 project

\$23.5 million in respect of costs incurred in the development of the Solwara 1 Project up to January 2011, and to make pro-rata capital contributions in respect of subsequent Project development costs which, at the end of September 2012 totalled approximately \$51.5 million (excluding interest). The State disputes that it is required to meet such obligations at this time. On November 13, 2012 Nautilus Minerals Inc. announces it has decided to preserve its cash position by terminating the construction of the equipment for its Seafloor Production System.

Opposition from the public: in November 2013 it is mentioned that a coalition of NGOs is mounting a legal challenge to the Solwara 1 project. One of the NGOs which is taking the government to court over the seabed mining project is Stop Experimental Seabed Mining in the Pacific. "The fact that this license was granted without the Free Prior and Informed Consent of the communities that will be affected has created a storm of public protest. This was undoubtedly a significant factor in Nautilus' decision to suspend operations a year ago," stated Ms Rosenbaum (campaign coordinator for the Deep Sea Mining campaign in Australia –red).

Sources:

Nautilus Minerals website: <http://www.nautilusminerals.com/s/Projects-Solwara.asp>;

Nautilus Minerals Inc. (2008): Mineral Resource Estimate Solwara 1 Project Bismarck Sea Papua New Guinea for Nautilus Minerals Inc, Ian Lipton, BSc (Hons), FAusIMM, Principal Geologist, Golder Associates Pty Ltd, http://www.nautilusminerals.com/i/pdf/2008-02-01_Solwara1_43-101.pdf;

Solwara Project, Papua New Guinea, [mining-technology.com](http://www.mining-technology.com),

<http://www.mining-technology.com/projects/solwara-project/>;

<http://magazines.marinelink.com/Magazines/MarineTechnology/201106/flash/?page=12#>.

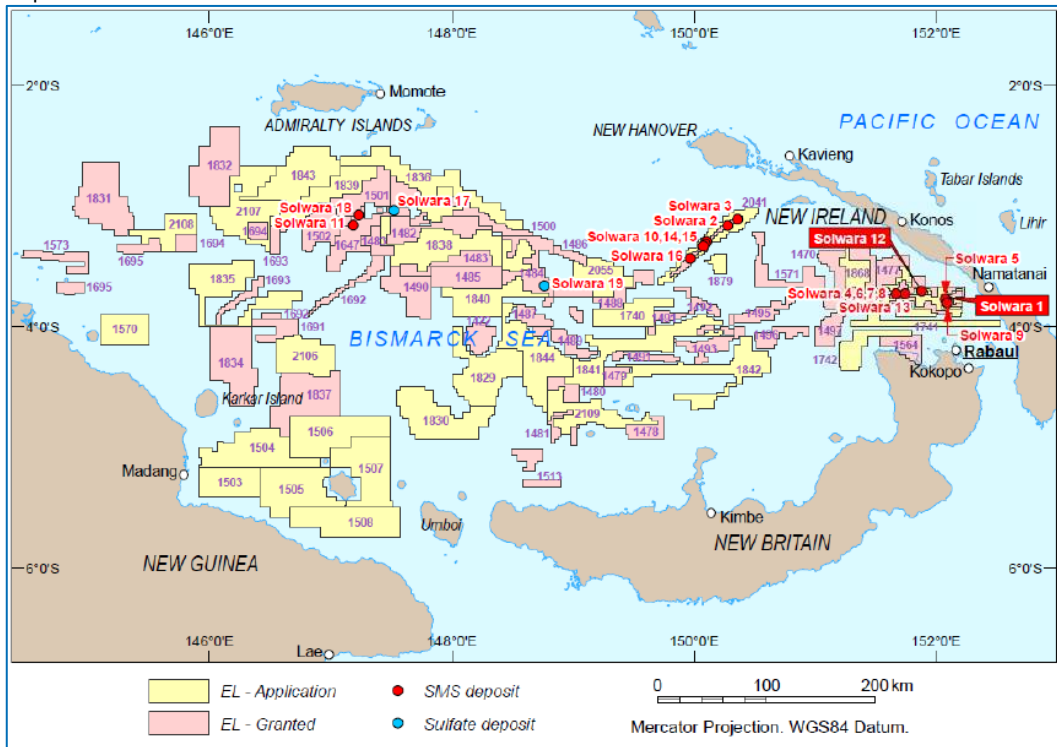
29: Nautilus Minerals, Papua New Guinea – Solwara 2-19

Location and area: PNG Bismarck Sea

28 Granted = 10 630 km² (includes Solwara 1)

18 applications = 8 146 km²

Map of all ELs as of March 2013¹³

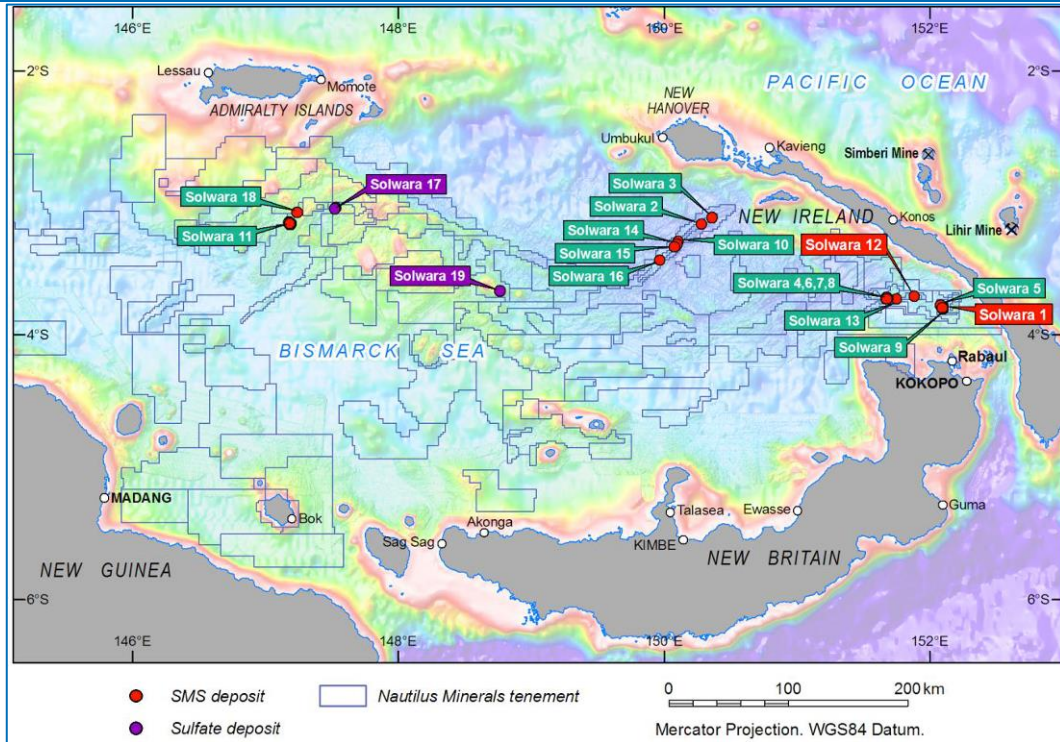


Location of Nautilus Bismarck Sea property as at the date of the Solwara 1 and 12 Report

Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA.

¹³ (Source: Golder Report, p. 11)

29: Nautilus Minerals, Papua New Guinea – Solwara 2-19



Source: Nautilus Minerals Inc. (2014). Annual Information Form for the Fiscal Year ended 31 December 2014.

Water depth:

Water depth of Solwara prospects in Bismarck Sea range from 1 030 to 2 590 meters.

Consortia members

Nautilus Minerals Inc	Core company/contractor	
-----------------------	-------------------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: exploration license

Time scale:

1985: First discovery of submarine hydrothermal sulfides and black smokers in PNG EEZ waters at what would become Solwara 2 deposit when seafloor sulfides were photographed there by US research vessel RV Moana Wave. Occurrences of submarine sulfides in the Bismarck Sea have since been researched by study groups from many different countries, including USA, France, Germany, Canada, Japan, Korea, Australia.

1993: intense particulate plume detected during PACMANUS II cruise, which prompted researchers towards the NNW-trending volcanic edifice that is now the host of Solwara 1.

1996: first discovery of the hydrothermal field at Solwara 1 made by CSIRO during PACMANUS III cruise aboard RV Franklin the far eastern sector of the Eastern Manus Basin.

1997: Nautilus is granted the first ever exploration license for the exploration of SMS deposits by the government of Papua New Guinea.

2000: a series of partially cored holes were drilled as part of the Ocean Drilling Program (Leg 193) at three of the active Solwara 4 fields. The purpose was to investigate geological and geophysical conditions up to 370m depths below the seafloor.

2002: an initial phase of drilling was conducting during the German/UK Research Cruise “Condrill” to 5m depths

29: Nautilus Minerals, Papua New Guinea – Solwara 2-19

into the surface of the Solwara 4 hydrothermal fields. Drilling services of the British Geological Survey were employed to drill a total of 10 holes. Of these, three yielded massive chalcopyrite mineralization, and six recovered sphalerite-rich chimney material.

2007: Nautilus launches world's largest commercial exploration program for high-grade seafloor massive sulphides systems in the EEZ waters of PNG. The program deployed 2 vessels to undertake the exploration and environmental baselines studies: the 50m vessel "Aquila" and the 141m vessel "Wave Mercury". The program involved technical input from representatives seconded to Nautilus from Teck Resources. It included extensive environmental studies, resource definition drilling, sampling and related metallurgical and production development studies on Solwara 1.

- June-July 2007: Nautilus discovers 4 new prospects during the 30-day Greenfield exploration program: Solwara 5, 6, 7, 8.

2008: Two new prospects identified, Solwara 9 and 10.

2009: Nautilus executed an exploration program to expand its SMS prospect inventory. Fugro provided the vessel MV Fugro Solstice, a 70.25 metre long, 2,397 tonne, DP2 (dynamically positioned), ROV support vessel for this 132-day campaign. Seven highly prospective areas were identified during the first two weeks of its MV Fugro Solstice exploration campaign. The areas were identified using enhanced target generation techniques and technology developed by Nautilus' exploration team over the last two years. The areas were followed up later in 2009 and early 2010, using an ROV to test for seafloor massive sulphides systems. Five new SMS systems (Solwara 12, 13, 14, 16 and 18) were sampled.

2010-11: Drilling campaign initiated on Nautilus' wholly owned exploration and mining licenses in Bismarck Sea. In addition to drilling at Solwara 1, the campaign focused on enabling a maiden resource estimate at Solwara 12 of 230,000 tonnes, grading 7.3% copper and 3.6 g/t gold; and included also some drilling at Solwara 5 to test the extent of mineralization. The declaration of a maiden resource at Solwara 12 initiated the process of building a pipeline of projects for Nautilus in the region, and confirmed the prospectivity of the Bismarck Sea where 16 additional prospects have been identified.

The 2010 drilling campaign was operated for Nautilus Minerals by TS Marine (a subsea oil and gas contractor) and Seafloor Geoservices (a drilling contractor), aboard the marine vessel REM Etive.

2012: Nautilus undertook a program of multibeam echo sounding (MBES), sub-bottom profiling and seismic survey throughout the Bismarck Sea from February to April 2012. The program took place aboard the vessel *MV Duke* and was designed to map and test prospective sites within the company's tenement package. The results were anticipated for 2013.

2013 - 2014: As of January 1, 2013, Nautilus had 49 exploration licenses and one Mining Lease granted, for a total of 33,031 km². The prospects Solwara 1 to 19 are located within these ELs and ML. As at January 1, 2014, Nautilus had 28 granted exploration licenses and one Mining Lease granted, for a total of 10,885 km², representing more than 2/3 reduction in total tenement area during 2013. This is the result of ongoing rationalization on the continued analysis of tenement prospectivity (Lipton 2012, p. 26).

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

29: Nautilus Minerals, Papua New Guinea – Solwara 2-19

Program launched in 2007 was executed with a budget of US\$23 million ¹⁴

Government involvement:

Subject to any agreement made under Section 17, of the Papua New Guinea Mining Act 1992, the Independent State of Papua New Guinea reserves the right to elect at any time, prior to the commencement of mining, to make a single purchase up to 30% equity interest in any mineral discovery arising from the license, at a price pro-rated to the accumulated exploration expenditure and then contribute to further exploration and development in relation to the lease on a pro-rata basis unless otherwise agreed.

The royalty payable to the State of PNG under the Papua New Guinea Mining (Royalties) Act 1992 is 2% of the net smelter return on all minerals produced. A further 0.25% royalty is payable to the MRA

Type of material to be collected: seafloor massive sulphides

Size of expected deposit:

Average compositions of grab subsamples from the Solwara Prospects

Prospect	Cu%	Zn%	Au g/t	Ag g/t	Samples	Exploration Stage
Solwara 2	1.1	24.2	10.8	345	67 chimney samples	Target testing
Solwara 3	0.5	11.0	30.6	3375	2 chimney samples	Target testing
Solwara 4 + 8	11.1	23.0	14.9	259	54 chimney samples	Prospect delineation
Solwara 5	6.0	8.3	14.6	282	12 chimney samples	Prospect delineation
Solwara 6	11.7	18.4	16.1	203	7 chimney samples	Target testing
Solwara 7	5.1	21.5	15.0	359	8 chimney samples	Target testing
Solwara 9	6.3	10.6	19.9	296	17 chimney samples	Target testing
Solwara 10	7.7	15.2	2.5	165	12 chimney samples	Prospect delineation
Solwara 11	1.6	16.9	1.2	180	26 chimney samples	Target testing
Solwara 13	9.1	30.7	4.7	546	7 chimney samples	Target testing
Solwara 14	1.4	19.2	3.3	97	14 chimney samples	Target testing
Solwara 15*						
Solwara 16	2.1	18.6	2.8	105	6 chimney samples	Target testing
Solwara 17	0	0.2	0.2	110	2 chimney samples	Target testing
Solwara 18	0.3	19.6	0.2	110	2 chimney samples	Target testing
Solwara 19	0	0.3	1.2	6	1 chimney sample	Target testing

* No sample taken.

[Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, p. 70]

Technology used:

Solwara exploration projects have employed the following exploration techniques: ROV video dives, bathymetric surveys, geophysical techniques (OFEM, CHIRP sub-bottom profiler), surface sampling and by core drilling.

The 2007 exploration campaign deployed 2 vessels to undertake exploration in the EEZ waters of PNG: the 50m vessel "Aquila" and the 141m vessel "Wave Mercury":

- The *Aquila*, operated by Williamson and Associates, focused on identifying new seafloor sulphide mineralisation systems by undertaking mapping and geophysical surveys of the ocean floor. A total of 4,150 line km of surveying was planned for 5 blocks in the Bismarck and Solomon Seas. At the point of the mission, surveying of 4 of the 5 blocks had been completed with approximately 1,000 line km of surveying remaining;
- The *Wave Mercury* was contracted to Nautilus from Canyon Offshore, a member of the Helix Group, and

¹⁴ Nautilus website

29: Nautilus Minerals, Papua New Guinea – Solwara 2-19

a leading provider of ROVs to the offshore oil and gas industries. The *Wave Mercury* has onboard two Triton 200 ROVs to extract drill samples of up to 17m in length on the ocean floor;

- Remote Operated Vehicle (ROV) Drill: The 111-hole drilling program employed “state of the art” ROV mounted drill rigs that were deployed on the sea floor, capable of drilling up to 19 meters. Canyon Offshore Inc was the lead contractor for the Remote Operated Vehicle (ROV) and other deck equipment;
- Deep Ocean Electromagnetic (EM) Exploration technology. Nautilus partnered with Teck Resources and Vancouver-based Ocean Floor Geophysics Inc to develop, deploy and test this new exploration technique.

Discovery and mapping of Solwara 5-10, 17 SMS systems done using T200 ROV; mineralisation exposed using a hand-held XRay florescence (XRF) instrument. The hand-held XRF instrument (Niton XLT 592) was used to obtain initial indications of the grade of materials recovered from the seafloor.

2009 exploration program: Fugro provided the vessel MV Fugro Solstice, a 70.25 metre long, 2,397 tonne DP2 (dynamically positioned), ROV support vessel for the 2009 exploration campaign. It is fitted with both Fugro's own navigation/positioning systems and 3,000 metre capable, permanently installed FCV3000 ROV. The vessel and ROV deployed a range of geophysical, geochemical and sampling instruments. The techniques employed involve the adaptation of the deep towed sensor package, which enabled turbidity, oxidation reduction potential, water sampling and multibeam back scatter responses through the water column to be recorded at significantly faster survey speeds than comparable equipment packages. Combined with a commercial laboratory approach to geochemical assaying of water samples, these improved techniques of data collection and analysis enable a shortened target testing cycle with greater chance of success. The net result is improved target quality and reduction in targeting costs¹⁵).

Mapping work on SMS prospects 12-18 completed using a Fugro FCV3000 series ROV, which is equipped with sensors used to map the seafloor. These include several video cameras and two magnetometers provided by Ocean Floor Geophysics Inc. In addition, high-res mapping sonars located on the ROV were successfully used for the first time to identify real-time sea floor features in front of-, and to the sides of the ROV beyond the range of the video camera systems previously used.

The 2010 drilling campaign was operated by *TS Marine* (a subsea oil and gas contractor) and Seafloor Geoservices (a drilling contractor), aboard the marine vessel REM Etive. A second generation seafloor drilling system was used called Rovdrill 3. It has the ability to drill 70 millimetre core and wireline holes to a design specification depth of 80 meters below the seafloor. The drilling spread also collected geotechnical data to optimise equipment design and advance the production plan at Solwara 1¹⁶

Obstacles: -

Sources:

PNG Mining Cadastre Portal;

Nautilus Minerals Inc (2014): Annual Information Form for the Fiscal Year ended December 31, 2013;

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA Lipton, I.(2012). Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101.

Nautilus website, 2007 - 2012 programs: <http://www.nautilusminerals.com/s/2007Programs.asp>;

Nautilus Minerals Inc. (2007): Nautilus Launches World's Largest Commercial Exploration Program For High Grade Seafloor Massive Sulphide Systems, Nautilus News Release Number 2007-10, 21 March 2007.

¹⁵ Nautilus News Release, 9 September 2009

¹⁶ Lipton, I.(2012). Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101

29: Nautilus Minerals, Papua New Guinea – Solwara 2-19

http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=177849&_Type=News-Releases&_Title=Nautilus-Launches-Worlds-Largest-Commercial-Exploration-Program-For-High-Gr;
Nautilus Minerals Inc. (2007):, Programme Update, Nautilus News Release Number 2007-14,
http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=186621&_Type=News-Releases&_Title=Programme-Update;
Nautilus Minerals Inc. (2009): Drilling discovers new high-grade zones near solwara 1 resource, *Nautilus News Release*, 13 May 2009. <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=347637>.
Nautilus Minerals Inc. (2009). Nautilus Minerals - High Success Rates Exploring from MV Fugro Solstice, Nautilus News Release, 9 September 2009: http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=362542&_Type=News-Releases&_Title=Nautilus-Minerals-High-Success-Rates-Exploring-from-MV-Fugro-Solstice.

30: Nautilus, Papua New Guinea – Woodlark Area

1990: PACKLARK IV/SUPACLARK aboard RV Akademik Mstislav, Keldysh Leg 1; Western Woodlark Sea
2000: SHAARC, aboard RV Franklin: FR04/00.

2009: Nautilus executed an exploration program to expand its SMS prospect inventory with Fugro. Fugro provided the vessel *MV Fugro Solstice*, a 70.25 metre long, 2,397 tonne, DP2 (dynamically positioned), ROV support vessel for this 132-day campaign. Seven highly prospective areas were identified during the first two weeks of its *MV Fugro Solstice* exploration campaign. The areas were identified using enhanced target generation techniques and technology developed by Nautilus' exploration team. At the end of the exploration program, no live plumes were confirmed. However several subtle helium anomalies were indicative of historical activity (e.g., the Franklin Seamount, where previous MSR cruises had identified very small occurrence of AU-bearing sulphate chimneys).

In late 2009, a German research cruise detected a strong plume in the deep (>3000m) part of the rift which is a potential target.

2012: As of 1 January 2012, Nautilus Minerals' Woodlark Basin Project Area comprised 13 granted Exploration Licences and 3 Exploration Licence applications. The granted Woodlark Basin ELs cover approximately 13,609km² and the EL application areas cover approximately 7,672 km².

2014: As of 1 January 2014, Nautilus Minerals' Woodlark Basin project area comprise 1 granted Exploration license and 2 Exploration license applications. The granted Woodlark Basin ELs cover approximately 255 km², and the application area totals 3,543 km³.

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

Government involvement:

Subject to any agreement made under Section 17, of the Papua New Guinea Mining Act 1992, the Independent State of Papua New Guinea reserves the right to elect at any time, prior to the commencement of mining, to make a single purchase up to 30% equity interest in any mineral discovery arising from the license, at a price pro-rated to the accumulated exploration expenditure and then contribute to further exploration and development in relation to the lease on a pro-rata basis unless otherwise agreed.

The royalty payable to the State of PNG under the Papua New Guinea Mining (Royalties) Act 1992 is 2% of the net smelter return on all minerals produced. A further 0.25% royalty is payable to the MRA (Mineral Resource Authority).

Type of material to be collected: seafloor massive sulphides

Size of expected deposit:

"Marine science research cruises discovered active hydrothermal venting at the Franklin Seamount, a 250 m high basalt-basaltic andesite volcano (crest at 2,138 mbsl) lying at the western propagating end of the Woodlark Spreading Centre, with a breached collapse crater (~300 to 400 m across) at its summit¹⁷. Two sites on the seamount have been investigated: Beaujolais, which consists of extensive deposits of Fe-Mn-Si oxide with some active venting of a clear, low-temperature fluid; Chablis is a group of barite-silica chimneys with

¹⁷ Binns et al., 1993

30: Nautilus, Papua New Guinea – Woodlark Area

disseminated sulfides on the crater floor. Six grab samples from Chablis, acquired by manned submersible dives, contained anomalous gold assays of 21.0, 21.1, 8.1, 11.0, 13.7, and 3.8 ppm Au¹⁸. Zn, Cu and Pb were present only at trace levels. The chimneys' mineralogy consisted of fine-grained barite aggregates, botryoidal silica, pyrite, sphalerite, galena, chalcopyrite and cerussite.

The Woodlark Basin tenements are prospective for SMS deposits due to the combination of active spreading, active hydrothermal activity and known base-precious metal mineralisation¹⁹

Technology used:

2009 exploration program: Fugro provided the vessel *MV Fugro Solstice*, a 70.25 metre long, 2,397 tonne DP2 (dynamically positioned), ROV support vessel for the 2009 exploration campaign. It is fitted with both Fugro's own navigation/positioning systems and 3,000 metre capable, permanently installed FCV3000 ROV. The vessel and ROV deployed a range of geophysical, geochemical and sampling instruments. Fugro conducted target generation and target testing work. The techniques employed involve the adaptation of the deep towed sensor package, which enabled turbidity, oxidation reduction potential, water sampling and multibeam back scatter responses through the water column to be recorded at significantly faster survey speeds than comparable equipment packages. Combined with a commercial laboratory approach to geochemical assaying of water samples, these improved techniques of data collection and analysis enable a shortened target testing cycle with greater chance of success. The net result is improved target quality and reduction in targeting costs (Nautilus News Release, 9 September 2009).

Obstacles: -

Sources:

Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013, <http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>.

Lipton, I (Golder Associates).(2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012I

Nautilus Minerals Inc. (2009). Nautilus Minerals - High Success Rates Exploring from MV Fugro Solstice, Nautilus News Release, 9 September 2009: http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=362542&_Type=News-Releases&_Title=Nautilus-Minerals-High-Success-Rates-Exploring-from-MV-Fugro-Solstice.

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

¹⁸ Binns et al., 1993

¹⁹ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

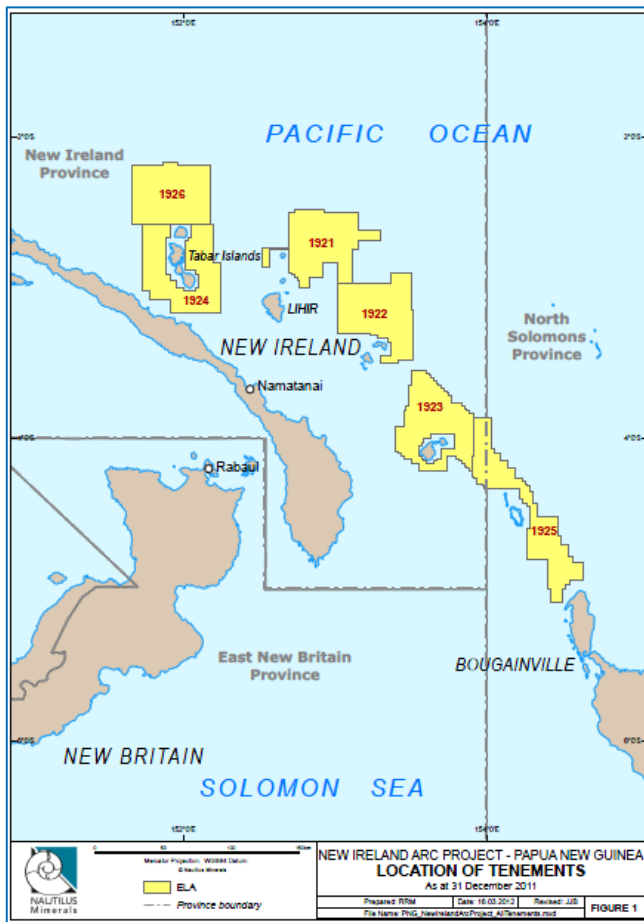
31: Nautilus Minerals, Papua New Guinea –New Ireland Arc

Location and area:

The area of interest in the New Ireland ‘back-arc’ is the Tabar-Lihir-Tanga-Feni arc, an island chain of young volcanoes which lies to the NE of New Ireland and SW of the inactive Manus-Kilinailau Trench in the New Ireland basin.

Area: 5 applications, 12 788 km²

EL	Name	Area	Date applied	Company
EL 1921	Mahur Island	2 223.32	18/11/10	Niugini 2 Ltd
EL 1925	Nissan Island	2 557.5	18/11/10	Niugini 2 Ltd
EL 2239		2 557.5	06/08/12	Niugini 2 Ltd
EL 2240		2 557.5	06/08/12	Niugini 2 Ltd
EL 2248		2 557.5	17/08/12	Niugini 2 Ltd



Note: This is an out of date map, situation as of 31 December 2011.

Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

Water depth:

1 500-2 000 meters

Consortia members

Nautilus Minerals Inc.	Core company/contractor	
------------------------	-------------------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investores are Anglo American and Teck.

Type of contract: exploration license

31: Nautilus Minerals, Papua New Guinea –New Ireland Arc

Time scale:

It is not known in when the application is made.

2000: Research cruise SHAARC, aboard RV Franklin: FR04/00.

By 1 January 2012, Nautilus Minerals' New Ireland Arc project area comprised 6 exploration licence applications covering approximately 15,345 km².

As of 1 January 2014, Nautilus Minerals' New Ireland Arc project area comprised 5 exploration licence applications covering approximately 12,788 km².

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants shareholder Epion Holdings Ltd.is a company owned by Russian investor Alisher Usmanov.

Government involvement:

Subject to any agreement made under Section 17, of the Papua New Guinea Mining Act 1992, the Independent State of Papua New Guinea reserves the right to elect at any time, prior to the commencement of mining, to make a single purchase up to 30% equity interest in any mineral discovery arising from the license, at a price pro-rated to the accumulated exploration expenditure and then contribute to further exploration and development in relation to the lease on a pro-rata basis unless otherwise agreed.

The royalty payable to the State of PNG under the Papua New Guinea Mining (Royalties) Act 1992 is 2% of the net smelter return on all minerals produced. A further 0.25% royalty is payable to the MRA (Mineral Resource Authority).

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit:

"This volcanic arc includes several significant mineral deposits that make this region very attractive for metal fertility. The largest is the Ladolam Au deposit on Lihir Island with ~40 Moz. The Panguna Cu-Au porphyry system has Cu reserves of 3 Mt and 40,000 oz Au/annum. Simberi Au mine has over 2 Moz Au reserves with total inferred out to 6 Moz at ~1.1 g/t oxide. There are several other Au occurrences in the region, one in particular is Ambitle Island, which has incredible pan concentrate Au values and a few shallow DDH revealed ~10 m at up to 10 g/t Au. High hydrothermal pressures limited drilling further. Off shore in ~30 m water a strong hydrothermal spring is driving ~1.5 kg of As into the ocean very day. This is a very active metal-rich zone.

Just south of Lihir is Conical Seamount, which is a submarine alkali basalt volcano with the summit at a water depth of ~1,050 m and slope angle of ~15°. It has been surveyed several times during MSR cruises with ~1.2 tonnes of material dredged and/ or TV grab extracted from the summit plateau (~100 x 200 m diameter). It can be categorised as a submarine epithermal system containing poly-metallic (Au-Zn-Pb-Ag) veins and pyritic stockwork in altered volcanic host rocks. There are several unexplored seamounts along this arc corridor that may be prospective. The areas of interest lie in variable water depths from 100 to 2 400 m as a series of seamounts and ridges.

With regard to tectonic setting, the island arc lies to the SW of the Ontong Java Plateau, which blocked a major Pacific Plate subduction zone below PNG ~15 Ma. The recent volcanism is suggested to be related to the subduction occurring under New Britain producing high K, alkaline, SiO₂ under-saturated magma, which are

31: Nautilus Minerals, Papua New Guinea –New Ireland Arc

highly oxidized and sulphur-rich. They are thought to be generated by partial melting of older metasomatised mantle wedge and extracted to surface through the old fore arc along reactivated transfer faults. A major driver for these systems is a hot mantle mix penetrating through a major slab tear from the northward subducting Solomon Sea Plate²⁰.”

Technology used:

Approximately a 5,500 km line of EM302 multi-beam mapping is planned over the exploration license application areas in the New Ireland Arc of Papua New Guinea, to be followed by a plume hunting tow-yo program over the best targets defined from the multi-beam program. Nautilus is also currently searching for similar targets to the Au-bearing Conical Seamount lying just south of the Ladolam Au mine on Lihir island²¹

Obstacles: -

Sources:

Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013, <http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>;

Lipton, I (Golder Associates).(2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012;

Jankowski, P.(2012): Nautilus Minerals Incorporated NI43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands New Zealand, Vanuatu and the ISA, Report prepared for Nautilus Minerals Inc., prepared by SRK Consulting, Doc No. NAT008, March 2012.

²⁰ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, p. 44.

²¹ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA.

32: Neptune Minerals, Papua New Guinea		
Location and area: Papua New Guinea, the exact location is not known Area: 2 568 km ²		
Water depth:		
Consortia members		
Neptune Minerals	Core company/contractor	
Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.		
Type of contract: exploration license		
Time scale: 2012: license into force 2014: expiry date of license 2007: Neptune lodges five Exploration Licence Applications. (EL 1554-EL 1558). 2007: 7 Exploration Licenses are granted covering an area of 13 345 km ² . Each has been granted for an initial 2-year period. Five tenements (EL 1554 to EL 1558) are part of the grant (12 850 km ²). The two other tenements are EL1541 Klotsu and EL 1542 Name (495 km ²). 2012: 1 Exploration license is granted for a two year period..		
Financing: Neptune is a public company. The project has to be financed by Neptune itself by raising money from investors/shareholders.		
Government involvement: Subject to any agreement made under Section 17, of the Papua New Guinea Mining Act 1992, the Independent State of Papua New Guinea reserves the right to elect at any time, prior to the commencement of mining, to make a single purchase up to 30% equity interest in any mineral discovery arising from the license, at a price pro-rated to the accumulated exploration expenditure and then contribute to further exploration and development in relation to the lease on a pro-rata basis unless otherwise agreed. The royalty payable to the State of PNG under the Papua New Guinea Mining (Royalties) Act 1992 is 2% of the net smelter return on all minerals produced. A further 0.25% royalty is payable to the MRA .		
Type of material to be collected: SMS and Epithermal Gold.		
Size of expected deposit: -		
Technology used: Exploration campaigns further investigate areas of the seafloor identified as being prospective by conducting hydrothermal plume surveys and performing higher resolution mapping. The technology used during the exploration campaigns include Remotely Operated Vehicles, Acoustic Multibeam mapping, a selection of high-tech oceanographic equipment, spot sampling using hydraulic grabs, robotic drills that sit on the seafloor and recover drill core up to 20 meters below surface, and oceanographic moorings to monitor environmental aspects of the seawater column ²² .		
Obstacles: -		
Sources: Neptunes Minerals website and interview		

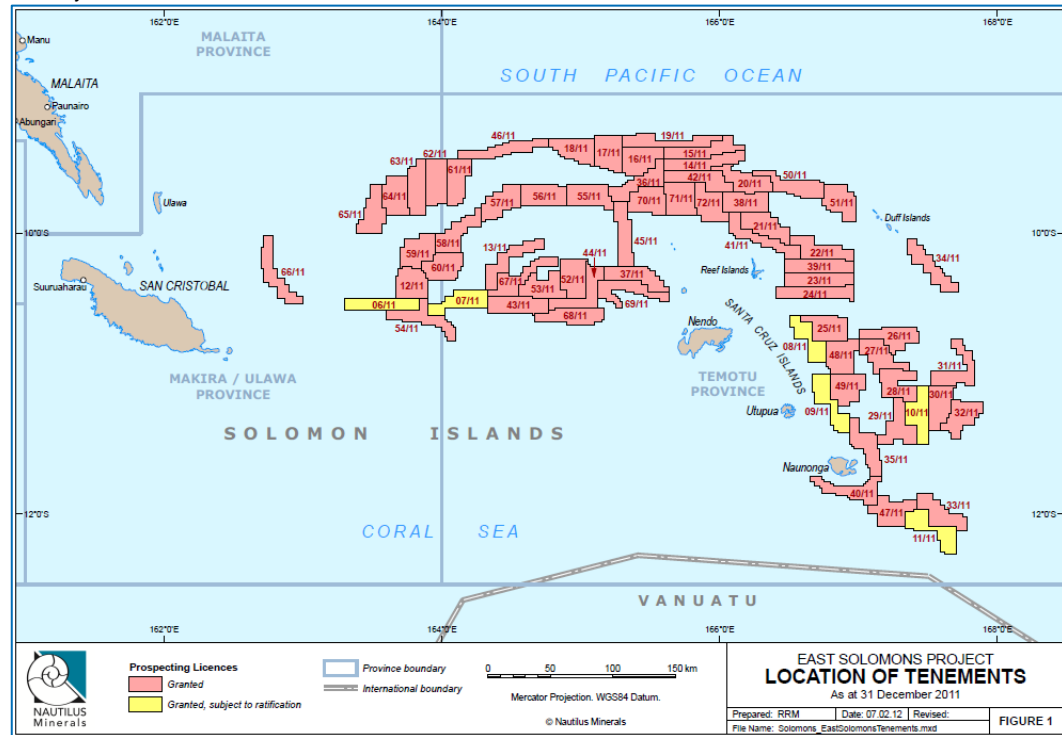
²²Neptune Mineals website

33: Nautilus Minerals, Solomon Islands

Location and area:

The project comprises 61 granted prospecting licenses covering an area of 39 500 km² in the east Solomon islands. No applications are running (per 1/1/2014)

The figure below shows the location of Nautilus Minerals' tenements in the east Solomon Islands, as per 1 January 2012.



Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

Water depth:

Consortia members

Nautilus Minerals Inc	Core company/contractor
-----------------------	-------------------------

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: exploration license.

Time scale:

19/07/2011: 61 prospecting license into force

18/07/2014: expiry date of the 61 prospecting licenses

1960 – present: More than 70 cruises have been carried out by Marine Scientific Researchers (MSRs) in the EEZ of Solomon Islands. Six of the known areas of hydrothermal venting and plumes that have been found throughout these cruises occur outside Nautilus Minerals' tenement areas.

2000: CSIRO-led SHAARC research cruise on board RV Franklin FR04/00 in the Tabar-Lihir-Tangi-Feni Chain found a significant plume within Nautilus' tenement area. This was a positive indicator for hydrothermal activity, and further demonstrated the prospectivity of the Nautilus tenements in the EEZ of Solomon Islands.

2009: Nautilus acquired water column and geochemical data in the Woodlark Basin and Solomon Islands in order to define prospective areas. To this end, Nautilus has continued to improve its technology for measuring

33: Nautilus Minerals, Solomon Islands

water column geochemistry so that it may identify anomalous plumes which might be related to active hydrothermal systems. It has collaborated with several academic research institutes to participate in AUVs and is able to identify prospective areas in its tenement holdings.

2011: As per 31 December 2011, Nautilus held 92 granted PLS covering an area of 50 102 km² in the Solomon Islands, to the west and south of the New Georgia group of islands. 61 of these PL were granted in July 2011, in the east Solomon islands.

2013: During 2013, there was approximately a 25% reduction in tenement area in the Solomon Islands. A total of nineteen tenements were surrendered in the Western Province, based on an ongoing assessment of prospectivity, and statutory reductions were also made in respect of each of the 61 prospecting licenses located in the east Solomon Islands²³.

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

Government involvement:

Under the Solomon Islands *Mines and Minerals Act 1990* and the *Mines and Minerals Regulations 1996*, every holder of a PL is required to report on prospecting activities quarterly and annually. A PL is granted for an initial period of three years, however at expiration a PL holder may apply for a renewal of up to half of the initial area of the PL for a further two years. The Minerals Board may authorise renewal over a larger area if, in its opinion such authorisation would be in the national interest.

A Mining Lease is required for production and may be granted for a maximum of 25 years and may be renewed for a further period not exceeding 10 years. Only the holder of a PL who has made a commercial discovery may apply for a Mining Lease over the area covered by their PL and in respect of a mineral allowed to be exploited under the PL. The grant of the mining lease is dependent on the Minister being satisfied that the proposed mining plan ensures the efficient and beneficial use of the mineral resources and adequate protection of the environment. The holder of a mining lease may be required to pay royalties, surface rental and compensation for damage, and a share of production, revenues, profits or equity capital to the Government of Solomon Islands. It may also be required to maintain an office in Solomon Islands with complete technical and financial records.

Type of material to be collected:

seafloor massive sulphides

Size of expected deposit:

Unknown – According to the NA008 Technical Report, three areas of hydrothermal venting and precipitates, including minor sulfides have been identified in the Grover, Stanton and Starfish seamounts, however they all fall under competitor's tenements.

Technology used:

Target generation technology and techniques used include geophysical and geochemical methods such as:

- Sidescan sonar;
- Mutli-beam bathymetry;
- Magnetics;

²³ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, Lipton (2012), Nautilus Minerals (2014), Nautilus Minerals website, various news releases.

33: Nautilus Minerals, Solomon Islands

- 3D plume mapping;
- Water chemistry testing;

Nautilus has continued to improve its methods for measuring water column geochemistry so that it may identify anomalous plumes which might be related to active hydrothermal systems has been used during exploration in the EEZ of Solomon islands.

Nautilus has collaborated with several academic research institutes to participate in autonomous underwater vehicles (AUVs) and is able to identify prospective areas in its tenement holdings.

Obstacles: -

Sources:

Information from the Ministry of Mines, Energy and Rural Electrification from the Solomon Islands;
Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013, <http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>;
Lipton, I (2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012;
SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

34: Bluewater Metals, Solomon Islands

Location and area:

18 prospecting licenses
 Area: 9 841 km².

Water depth:

Consortia members

Bluewater Metals

Core company/contractor

Bluewater Metals, based in Australia, is a subsidiary of Neptune Minerals Inc (USA).

Type of contract: exploration licence

Time scale:

2007: 18 prospecting licenses into force

2014: expiry date of the 18 prospecting licenses

2010: [Bluewater metals] retrieved seabed copper samples during a prospecting exercise in the Western Province in 2010²⁴.

Financing:

The project has to be financed by Bluewater/Neptune itself by raising money from investors/shareholders

Government involvement:

Under the Solomon Islands *Mines and Minerals Act 1990* and the *Mines and Minerals Regulations 1996*, every holder of a PL is required to report on prospecting activities quarterly and annually. A PL is granted for an initial period of three years, however at expiration a PL holder may apply for a renewal of up to half of the initial area of the PL for a further two years. The Minerals Board may authorise renewal over a larger area if, in its opinion such authorisation would be in the national interest.

A Mining Lease is required for production and may be granted for a maximum of 25 years and may be renewed for a further period not exceeding 10 years. Only the holder of a PL who has made a commercial discovery may apply for a Mining Lease over the area covered by their PL and in respect of a mineral allowed to be exploited under the PL. The grant of the mining lease is dependent on the Minister being satisfied that the proposed mining plan ensures the efficient and beneficial use of the mineral resources and adequate protection of the environment. The holder of a mining lease may be required to pay royalties, surface rental and compensation for damage, and a share of production, revenues, profits or equity capital to the Government of Solomon Islands. It may also be required to maintain an office in Solomon Islands with complete technical and financial records.

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit: -

Technology used:

Exploration campaigns further investigate areas of the seafloor identified as being prospective by conducting hydrothermal plume surveys and performing higher resolution mapping.

The technology used during the exploration campaigns include Remotely Operated Vehicles, Acoustic Multibeam mapping, a selection of high-tech oceanographic equipment, spot sampling using hydraulic grabs, robotic drills that sit on the seafloor and recover drill core up to 20 meters below surface, and oceanographic moorings to monitor environmental aspects of the seawater column²⁵.

²⁴ Greenpeace p.32.

²⁵ Neptunes website

34: Bluewater Metals, Solomon Islands

Obstacles: -

Sources:

Information from the Ministry of Mines, Energy and Rural Electrification from the Solomon Islands

<http://www.neptuneminerals.com/tenements/>;

<http://ramumine.wordpress.com/tag/bluewater-metals/>.

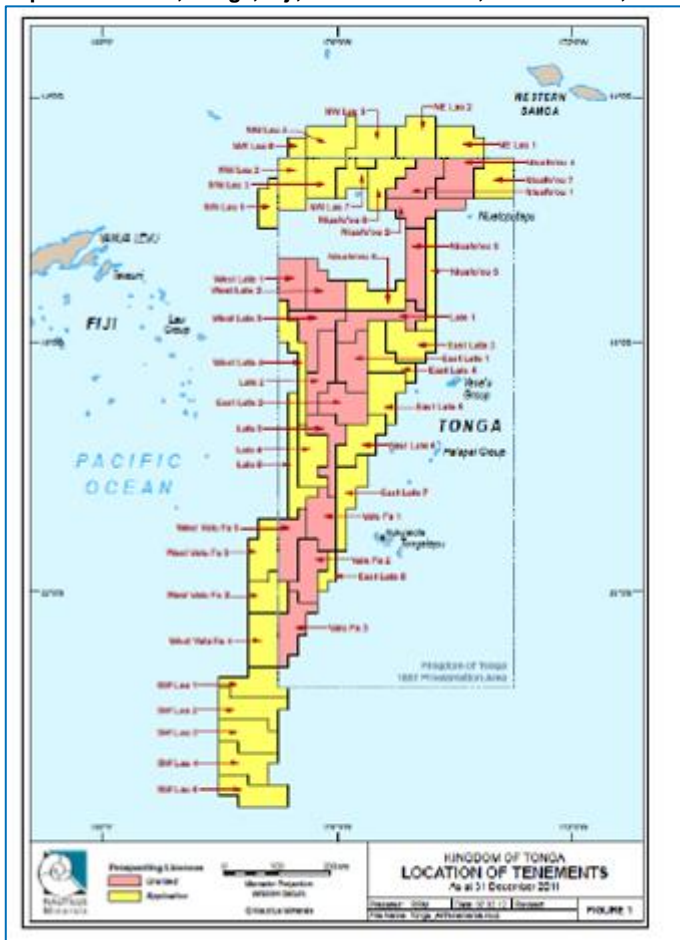
35: Nautilus Minerals, Kingdom of Tonga

Location and area:

The EEZ of Tonga is defined as being between latitude 15°S and 23°30'S, longitude 173°W and 177° according to the Royal Proclamation of 1887. Nautilus Minerals holds 16 granted Prospecting Licences (PLs) within the 1887 Proclamation Area, as well as an additional 30 applications for PLs, located both within and outside the 1887 Proclamation Area. [See table below].

The figure below shows the 16 granted tenements (in red) by Nautilus in the EEZ of Tonga, covering an area of 77 562 km², and the 30 licenses (in yellow) under application, covering 131 878 km² (situation by 31-12-2013).

Map of Nautilus Minerals' Prospecting Licenses in Tonga SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA



Map of the SMS systems identified in Tonga (Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA)

Water depth:

Water depth of Fonualei South 1 and 2 chimney fields: 965 m and 1550 m, respectively.

Water depth of North Mata Ua and Tolu chimney fields: 2360 and 1820, respectively.

Consortia members

Nautilus Minerals Inc	Core company/contractor	
-----------------------	-------------------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investores are Anglo American and Tec.

Type of contract: exploration license

35: Nautilus Minerals, Kingdom of Tonga

Time scale:

2006-2007: Nautilus lodges 18 Prospecting License applications within the EEZ of Tonga following a geological targeting program covering the SW Pacific.

2008: Nautilus conducted the first deep water commercial seafloor mineral resources exploration program in Tongan waters on board Nautilus' *MV Nor Sky* vessel. The exploration work led to the identification of 6 new SMS systems, named Tahī Moana 1 – 6. These were mapped by Nautilus itself during the program completed from *MV Norsky* in mid December 2008. A further 6 known seafloor massive sulphides systems were also characterized during this work program. Meanwhile, Teck Resources, under an exploration agreement with Nautilus, discovered 4 new additional systems.

2009 (Feb): Nautilus collaborates with the Australian National University (ANU), the CSIRO on board the Marine National Facility research vessel *Southern Survey* in May and June 2009 to increase the data coverage over its Tongan holdings. The exploration program is conducted in 2 phases. Phase 1 focused on Nautilus' Tongan tenements in the NE Lau basin and led to the discovery of new mineralized areas. Phase 2 of this 2009 Tongan exploration program comprised 27 days of water column sampling, bathymetric surveying, and rock sampling. 20 new water column anomalies were identified, requiring further exploration work.

2011: The company completed additional AUV programs on its Tongan tenements where previous campaigns identified highly prospective geochemistry anomalies.

2012: In September 2012, the Company participated in an 18-day marine scientific research cruise on board the *RV Roger Revelle* in the north east Lau Basin. The campaign comprised one leg of the National Oceanic and Atmospheric Administration (NOAA) extensive Submarine Ring of Fire 2012 program:

- 1 November: The Company announces the discovery of 2 high grade seafloor massive sulphides systems (Fonualei South and North Mata) on its wholly owned exploration tenements in the territorial waters of Tonga. Grab samples from these discoveries assayed up to 11.9% copper, 59.8% zinc, 28.6 g/t gold and 673 g/t silver.

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov. The Minerals Act 1988 requires a TOP500 application fee for each PL. The work program for 2010 and 2011 covered all 16 granted PLs, with proposed expenditure of USD 2M in each year²⁶.

Government involvement:

Under the Minerals Act 1988, in order for a PL to authorize the holder to exclusive occupancy of the area of a PL for exploration purposes, the PL holder must be either a Tongan citizen or company, or a citizen of a company registered in the British Commonwealth. All applications by Nautilus in the EEZ of the Kingdom of Tonga have therefore been made through Nautilus Minerals Offshore, a 100% owned subsidiary registered in Vanuatu.

The Minerals Act 1988 does not specify an annual rental fee for PLs beyond the TOP500 application fee for each PL. Mining royalties are payable to the Kingdom of Tonga under the Minerals Act 1988 based on the value of production net of all mining, processing, transportation, marketing and related costs. The rates are set at 5%

²⁶ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

35: Nautilus Minerals, Kingdom of Tonga

net value for gold, and 1% net value for other minerals.

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit:

Grab samples from the 2 seafloor massive sulphides systems discovered in 2012 assayed up to 11.9% copper, 59.8% zinc, 28.6 g/t gold and 673 g/t silver²⁷.

Technology used:

Target generation technology and techniques used include geophysical and geochemical methods such as:

Sidescan sonar;

Mutli-beam bathymetry;

Magnetics;

3D plume mapping;

Water chemistry testing.

Target testing is conducted by direct inspection using an ROV and physical sampling of seafloor rocks. The latter may use:

ROV mapping using video cameras on a systematic grid or traverse through the target area;

Grab sampling from the ROV to select samples from the target area; or

Camera tows.

Prospect delineation entails detailed grid based mapping, sample collection, and ROV-based geophysical surveys such as electromagnetics and magnetics to define the approximate resource boundaries on the sea floor. High-resolution bathymetry surveys are also used.

The best prospects are advanced to resource status by undertaking systematic resource drilling and sampling, followed by resource estimate. Detailed bathymetry and grid-based geophysics are used here.

2008 MV Nor Sky Exploration program:

Nautilus Minerals' MV Norsky 2008 exploration cruise to Tonga was focused on rapid evaluation of seafloor massive sulphides targets using a ROV). Features indicative of seafloor massive sulphides mineralisation were identified from real-time video observations and were confirmed by geological logging and analysis of recovered samples²⁸).

2012 Exploration program:

Nautilus participated in the marine research cruise on board the *RV Roger Revelle* in the north east Lau Basin. Exploration techniques that were used include ROV, multibeam magnetics, and water chemistry plume hunting.

Target testing and sampling work conducted during the sampling program in the NE Lau Basin (2012) was completed using a Quest 4000ROV equipped with several video cameras and a forward looking sonar to identify features ahead and to the sides of the ROV. The ROV was additionally equipped with two manipulator arms and a custom-built sample tray, or "geo box" for storing up to 10 hand-sized grab samples or scoop samples for seafloor sampling.

Obstacles: -

Sources:

Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013,

²⁷ <http://www.nautilusminerals.com/i/misc/Table2Tonga.pdf>.

²⁸ Nautilus Press Release, 18 February 2009

35: Nautilus Minerals, Kingdom of Tonga

<http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>;

Lipton, I (2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012;

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA Nautilus Minerals Inc. (2007): "Prospecting License Applications Lodged in Tonga and Fiji, Nautilus Press Release No. 2007-02. 8 January 2007;

Nautilus Minerals Inc. (2009). Exploration Success Continues for Nautilus Minerals in Tonga. Nautilus Press Release 2009-03: 18 February 2009. http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=338585&_Type=News-Releases&_Title=Exploration-Success-Continues-for-Nautilus-Minerals-in-Tonga.

Nautilus Minerals Inc. (2012): Nautilus Minerals discovers more high grade systems in Tonga. Nautilus Press Release No. 2012-27, 1 November 2012.

36: Neptune Minerals, Kingdom of Tonga

Location and area: Area: 63 949 km ² . The area comprises 13 prospecting licenses.		
Water depth:		
Consortia members		
Neptune Minerals Inc	Core company/contractor	
Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.		
Type of contract: exploration license		
Time scale: 2008: granting of the 13 prospecting licenses 2014: expiry date of the 13 prospecting licenses		
Financing: Neptune is a public company. The project has to be financed by Neptune itself by raising money from investors/shareholders.		
Government involvement: Under the Minerals Act 1988, in order for a PL to authorize the holder to exclusive occupancy of the area of a PL for exploration purposes, the PL holder must be either a Tongan citizen or company, or a citizen of a company registered in the British Commonwealth. The Minerals Act 1988 does not specify an annual rental fee for PLs beyond the TOP500 application fee for each PL. Mining royalties are payable to the Kingdom of Tonga under the Minerals Act 1988 based on the value of production net of all mining, processing, transportation, marketing and related costs. The rates are set at 5% net value for gold, and 1% net value for other minerals.		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: Exploration campaigns further investigate areas of the seafloor identified as being prospective by conducting hydrothermal plume surveys and performing higher resolution mapping. The technology used during the exploration campaigns include Remotely Operated Vehicles, Acoustic Multibeam mapping, a selection of high-tech oceanographic equipment, spot sampling using hydraulic grabs, robotic drills that sit on the seafloor and recover drill core up to 20 meters below surface, and oceanographic moorings to monitor environmental aspects of the seawater column ²⁹ .		
Obstacles: -		
Sources: Neptunes website, interview with Neptune.		

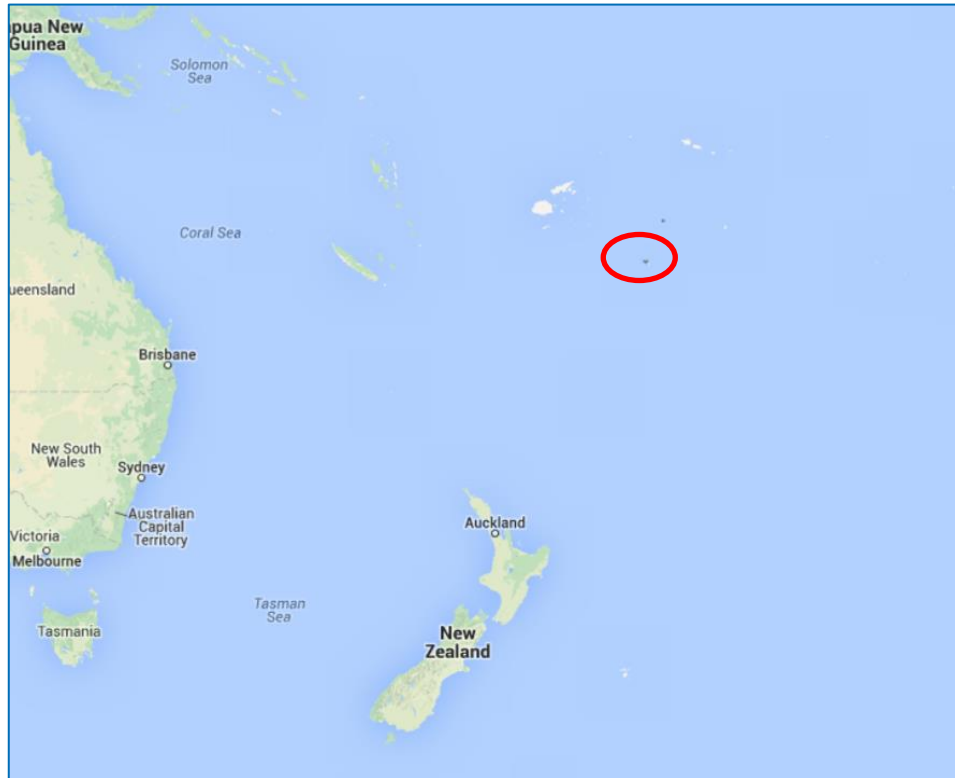
²⁹ Neptunes website

37: KIOST, Kingdom of Tonga

Location and area:

Kingdom of Tonga

Area: 24 500 km²



Water depth: -

Consortia members

Korea Ocean Research and Development Institute (KIOST)	Core company/contractor	
Samsung heavy industries	Building of vessels	Investment partner
Daewoo shipbuilding & marine engineering	building ships and offshore structures	Investment partner
LS-Nikko Copper	The world's No.1 copper smelter	Investment partner
SK Networks	A general trading company specialized in petroleum products and resources development	Investment partner
POSCO		Investment partner

KIOST is a governmental organization.

Type of contract: exploration license

Time scale:

2008: exploration license granted,

2014: expiry date of the license

2008: 1 exploration cruise made

2009: 2 cruises

37: KIOST, Kingdom of Tonga

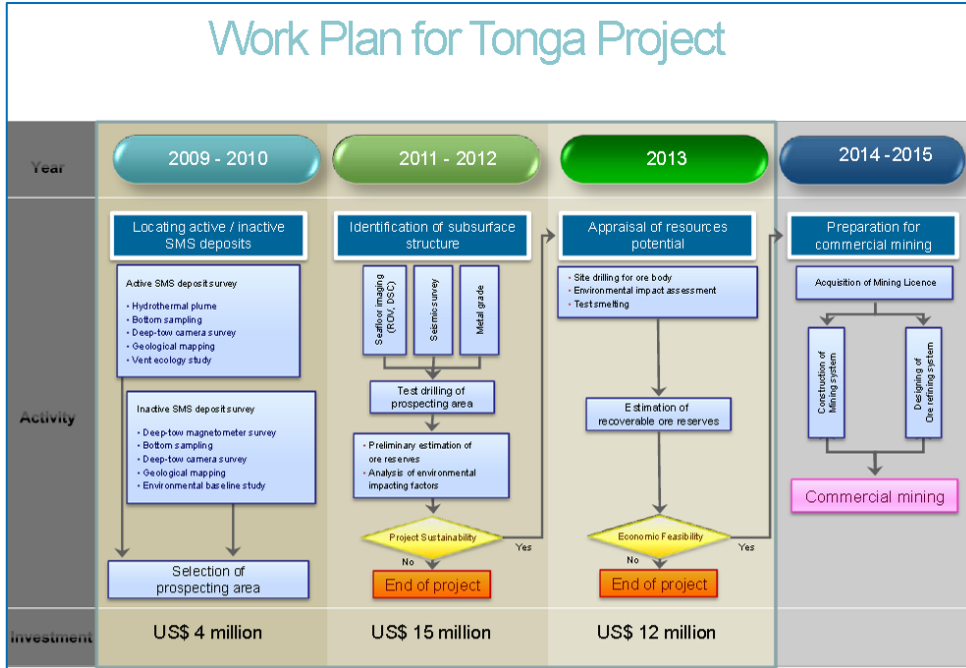
- January 2009, the Ministry of Land, Transport, and Maritime Affairs (MLTM) of the Republic of Korea established a special unit called the Seafloor Sulfides Research and Development Organization (SERADO) to manage the development of seafloor massive sulphides in Tonga. SERADO includes five private Korean companies (Daewoo Shipbuilding & Marine Eng., LS-Nikko Copper, SK Networks, Samsung Heavy Industries and POSCO).

2010: 2 cruises

2011: 2 cruises

2012: 2 cruises (+? a drilling programme)

The preparation for commercial mining that is expected to begin only after 2014.



Source: <http://www.sopac.org/dsm/public/files/countries/Kordi%20Presentation%2001%20Feb%202012.pdf>

Financing:

The consortium is a public-private consortium. The project will be financed by the government as well as by private parties. In total, US\$31M has been secured for the four-year exploration phase (2009-2012), with US\$13M from the Korean Government (MLTM) and US\$18M from the five joint investment partners.

Government involvement:

Under the Minerals Act 1988, in order for a PL to authorize the holder to exclusive occupancy of the area of a PL for exploration purposes, the PL holder must be either a Tongan citizen or company, or a citizen of a company registered in the British Commonwealth.

The Minerals Act 1988 does not specify an annual rental fee for PLs beyond the TOP500 application fee for each PL. Mining royalties are payable to the Kingdom of Tonga under the Minerals Act 1988 based on the value of production net of all mining, processing, transportation, marketing and related costs. The rates are set at 5% net value for gold, and 1% net value for other minerals.

Type of material to be collected: seafloor massive sulphides

Size of expected deposit: -

Technology used:

In 2011, intensive seabed observations and sampling operations were conducted to define active/inactive hydrothermal ore body structures using aROV in selected target areas.

Obstacles: -

37: KIOST, Kingdom of Tonga

Sources:

Mining Journal,

http://www.mining-journal.com/reports/marine-mining-rising-tide?SQ_DESIGN_NAME=print_friendly;

SOPAC website,

<http://www.sopac.org/dsm/public/files/countries/Kordi%20Presentation%2001%20Feb%202012.pdf>;

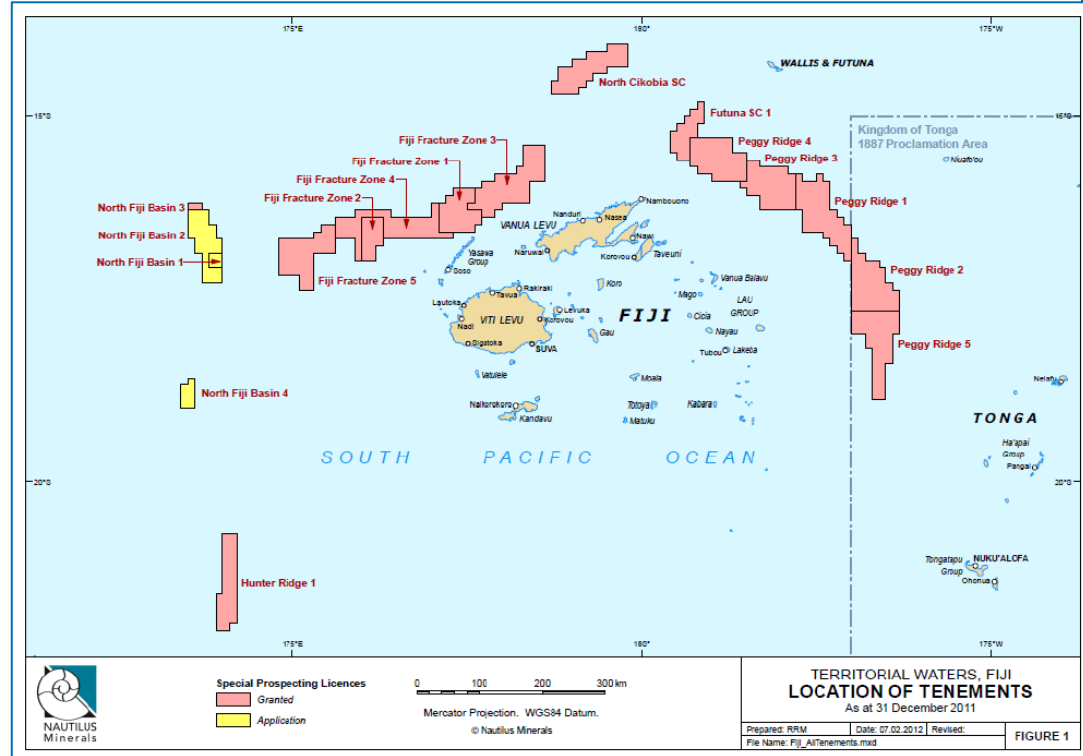
KIOST website,

http://eng.kiost.ac/kordi_eng/main.jsp?sub_num=354&state=view&idx=201&ord=0.

38: Nautilus Minerals, Fiji

Location and area:

As of 1 January 2014, the Fijian Government has granted the company 15 prospecting licenses with a total area of 60 370 km². The figure below gives an overview of the location of the licenses although the overview is not completely up-to-date since it comprises the licenses as per 31-12-2011 with an area of 58 243 km². As per 1-1-2014 there are no applications running.



Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

Water depth: -

Consortia members

Nautilus Minerals Inc.	Core company/contractor	
------------------------	-------------------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: exploration license

Time scale:

2014: exploration license comes into force

2016: expiry of the exploration license

late 1980s and early 1990s: marine research of the territory by Japanese, French and other scientific cruises
 1999: More than 2 000 kg of chimney fragments were recovered from SO99 by using the TV grab aboard the *RV Sonne*. The principle minerals observed include chalcopyrite, cubanite, bornite, covellite, pyrite, marcasite, sphalerite, wurtzite, greenockite and fahlore.

2001: Japanese researchers aboard the Jamstec marine science research cruise, drilled 22 shallow holes in the vicinity of the SO99 field (comprising the corner Mound and Yogi Mound Prospects) using the Boring Machine System (BMS) rig constructed by US Williamson and Associates. Of the holes drilled, 8 intersected massive sulfides, with thickness reaching up to 7 m.

2006-2007: Nautilus lodges 2 Special Prospecting License applications within the EEZ of Fiji following a

38: Nautilus Minerals, Fiji

geological targeting program covering the SW Pacific.

2011: Nautilus became the first private company to be granted offshore exploration licences in Fiji when 14 of the 17 Special Prospecting Licenses for which it had applied were granted for an initial period of 2 years. The PLs covered approximately 58 243 km². This development triggered Teck Resources Ltd's right to participate jointly in the exploration as per the December 2007 agreement. Teck opted out in February 2011.

2012: In May and June, the company participated in a 25-day marine science research campaign through Northern Fiji and Wallis & Futuna on board the RV Southern Surveyor. Multibeam, dredging and vertical cast plume hunting techniques were used to produce some of the first detailed bathymetry and geochemical data available on the area. The campaign helped Nautilus to develop priority targets for further seafloor massive sulphides exploration.

Teck, which gained the right to participate under a December 2007 agreement, elected not to participate³⁰.

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

Government involvement:

The Continental Shelf Act 1987 and the Fiji Constitution 1997 enables the Mining Act 1978 to control the exploration and exploitation of minerals within Fiji's EEZ. Under the Mining Act, an (special) Prospecting License authorises the holder to have exclusive occupancy for exploration purposes of the area identified in the SPL license, provided that the work is completed under the direction or supervision of the holder of a current Fiji Prospector's Right. The Prospecting License grants priority to the holder for the issuance of a Mining Lease, subject to submission of a comprehensive Feasibility Study that demonstrates the commercial and technical viability of the project. Submission of a Development Agreement is also required. Mining Leases can be granted for periods of between 5 and 21 years, and Prospecting Licenses can be granted for a period of up to two years, at the discretion of the Minister. There is a right to renew for both.

Under the *Fiji Mining Act 1978*, the royalty payable to the State entails both a royalty and Export tax, the combined total of which will not exceed 5% free on board (FOB) for all minerals other than iron and bauxite, for which the maximum is 3%. Gold and silver have a 3% FOB Export Tax payable on export, which is included as part of the overall 5% royalty rate.

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit: -

Technology used:

Target generation technology and techniques used include geophysical and geochemical methods such as:

Sidescan sonar;

Mutli-beam bathymetry;

Magnetics;

3D plume mapping;

Water chemistry testing.

³⁰ Nautilus site, Boring Machine System SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

38: Nautilus Minerals, Fiji

Target testing is conducted by direct inspection using an ROV and physical sampling of seafloor rocks. The latter may use:

ROV mapping using video cameras on a systematic grid or traverse through the target area;

Grab sampling from the ROV to select samples from the target area; or

Camera tows.

Prospect delineation entails detailed grid based mapping, sample collection, and ROV-based geophysical surveys such as electromagnetics and magnetics to define the approximate resource boundaries on the sea floor. High-resolution bathymetry surveys are also used.

The best prospects are advanced to resource status by undertaking systematic resource drilling and sampling, followed by resource estimate. Detailed bathymetry and grid-based geophysics are used here.

Obstacles: -

Sources:

Nautilus Minerals – Fiji tenements, <http://www.nautilusminerals.com/i/pdf/FijiTenementsAug11.pdf>;

Odyssey Marine,

<http://www.streetinsider.com/Corporate+News/Odyssey+Marine+%28OMEX%29+Acquires+Minority+Stake+in+SMM+Project+LLC/5131092.html>;

Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013,

<http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>;

Lipton, I (2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012;

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand,

Vanuatu and the ISA Nautilus Minerals Inc. (2007):“Prospecting License Applications Lodged in Tonga and Fiji,

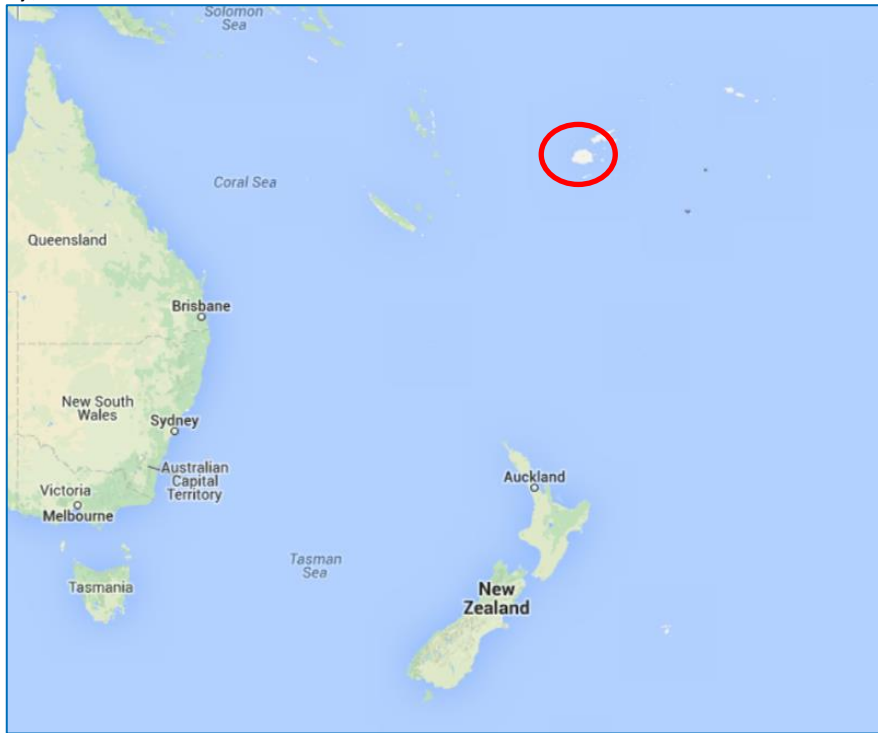
Nautilus Press Release No. 2007-02. 8 January 2007.

39: Bluewater Metals, Fiji		
Location and area: Fiji, exact location is not known. Area: 5 012 km ²		
Water depth: -		
Consortia members		
Bluewater Metals	Core company/contractor	
Bluewater Metals, based in Australia, is a subsidiary of Neptune Minerals Inc. (USA).		
Type of contract: exploration license		
Time scale: 2012: exploration license comes into force 2014: expiry of the exploration license		
Financing: The project has to be financed by Bluewater/Neptune itself by raising money from investors/shareholders.		
<p>Government involvement:</p> <p>The Continental Shelf Act 1987 and the Fiji Constitution 1997 enables the Mining Act 1978 to control the exploration and exploitation of minerals within Fiji's EEZ. Under the Mining Act, an (special) Prospecting License authorises the holder to have exclusive occupancy for exploration purposes of the area identified in the SPL license, provided that the work is completed under the direction or supervision of the holder of a current Fiji Prospector's Right. The Prospecting License grants priority to the holder for the issuance of a Mining Lease, subject to submission of a comprehensive Feasibility Study that demonstrates the commercial and technical viability of the project. Submission of a Development Agreement is also required. Mining Leases can be granted for periods of between 5 and 21 years, and Prospecting Licenses can be granted for a period of up to two years, at the discretion of the Minister. There is a right to renew for both.</p> <p>Under the <i>Fiji Mining Act 1978</i>, the royalty payable to the State entails both a royalty and Export tax, the combined total of which will not exceed 5% FOB for all minerals other than iron and bauxite, for which the maximum is 3%. Gold and silver have a 3% FOB Export Tax payable on export, which is included as part of the overall 5% royalty rate.</p>		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: -		
Obstacles: -		
Sources:		

40: KIOST, Fiji

Location and area:

Fiji, size of the area is not known



Water depth: -

Consortia members

KIOST	Core company/contractor	
-------	-------------------------	--

KIOST is a governmental company

Type of contract: exploration license

Time scale:

2011: KORDI acquires exclusive exploration licenses for SMS deposits in Fiji's EEZ in November 2011 (since 1 July 2012 KORDI changed its name into KIOST). It is not known when the license expires.

Financing: -

Government involvement:

The Continental Shelf Act 1987 and the Fiji Constitution 1997 enables the Mining Act 1978 to control the exploration and exploitation of minerals within Fiji's EEZ. Under the Mining Act, an (special) Prospecting License authorises the holder to have exclusive occupancy for exploration purposes of the area identified in the SPL license, provided that the work is completed under the direction or supervision of the holder of a current Fiji Prospector's Right. The Prospecting License grants priority to the holder for the issuance of a Mining Lease, subject to submission of a comprehensive Feasibility Study that demonstrates the commercial and technical viability of the project. Submission of a Development Agreement is also required. Mining Leases can be granted for periods of between 5 and 21 years, and Prospecting Licenses can be granted for a period of up to two years, at the discretion of the Minister. There is a right to renew for both.

Under the *Fiji Mining Act 1978*, the royalty payable to the State entails both a royalty and Export tax, the combined total of which will not exceed 5% FOB for all minerals other than iron and bauxite, for which the maximum is 3%. Gold and silver have a 3% FOB Export Tax payable on export, which is included as part of the overall 5% royalty rate.

40: KIOST, Fiji
Type of material to be collected: Seafloor massive sulphides
Size of expected deposit: -
Technology used: -
Obstacles: -
Sources: KIOST website, http://eng.kiost.ac/kordi_eng/main.jsp?sub_num=354&state=view&idx=176&ord=0 ; Green light given to explore for minerals in Fiji's seabeds, 30 May 2013, http://www.deepseaminingoutofourdepth.org/green-light-given-to-explore-for-minerals-in-fijis-seabeds/ ; Deep sea mining tests planned, May 23, 2013, http://www.fbc.com.fj/fiji/10492/deep-sea-mining-tests-planned .

41: Nautilus Minerals, Vanuatu

Location and area:

As of 1 January 2014, Nautilus Minerals holds 41 granted Prospecting licenses in Vanuatu on the easter side of the main islands. In addition, 14 prospecting licenses are under application. The area of interest to survey in Vanuatu constitutes a series of small, linked back-arc basins with associated volcanic features. The exposed island chain that constitutes Vanuatu represents the main volcanic arc which is formed during subduction of oceanic crust from the west.

Area: 41 Prospecting licenses granted with a total area of 2 768 km² and 14 prospecting licenses under application with a total area of 1 247 km²

The location of Nautilus Minerals' tenements in Vanuatu is as follows:



Source: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA

Water depth:

1 000-3 000 meters

Consortia members

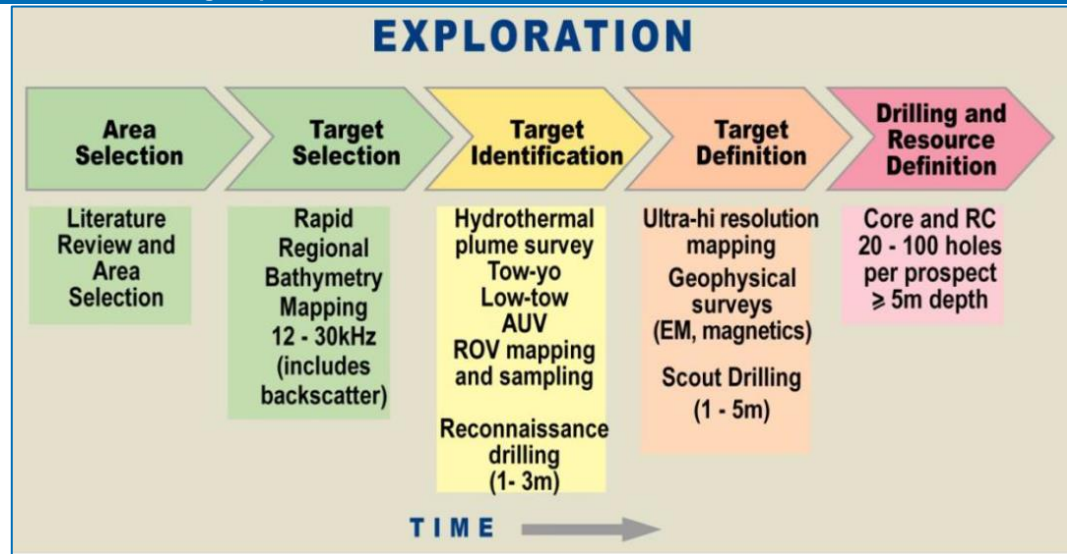
41: Nautilus Minerals, Vanuatu		
Nautilus Minerals	Core company/contractor	
Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.		
Type of contract: exploration licenses and application for exploration licenses		
Time scale: It is not known when the license has come into force, nor when it expires. Since 1979, there have been a number of marine science research cruises in Vanuatu. Early research cruises, including an Ocean Drilling Program (e.g. OPD Leg 134, 1990) primarily investigated the hydrocarbon potential of shallower areas near the island chain. More recently, research has been focused on seafloor geology and mineralisation in the spreading troughs to the east of the New Hebrides Arc ³¹ .		
Financing: Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.		
Government involvement: Under the Vanuatu <i>Mines and Minerals Act</i> , every holder of a PL is required to report on prospecting activities quarterly. A PL is granted for an initial period of three years, however at expiration a PL holder may apply for a renewal of up to half of the initial area of the PL for a further two years. A PL gives the holder, subject to the Act and the conditions specified in the licence, the exclusive right to carry out prospecting operations in or in relation to the prospecting area for any mineral to which the licence relates, and to undertake in the prospecting area such works as are necessary for that purpose. A Mining Licence is required for production and may be granted for a maximum of 25 years. It may be renewed for a further period, not exceeding 25 years. Only the holder of a PL who has made a commercial discovery may apply for a Mining Licence over the area covered by their PL, and only in respect of a mineral permitted to be explored for under the PL. The grant of the Mining Licence is dependent on the Minister for Lands and Natural Resources being satisfied that the proposals of the applicant ensure the most efficient, beneficial and timely use of the mineral resources concerned ³² .		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: Seafloor mineralization research has included dredging, plume mapping and sampling, water chemistry analysis, seafloor towed camera and submersible observation, sediment coring, multi-beam bathymetric and sidescan sonar surveys.		
Obstacles: -		
Sources: SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf .		

³¹ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf, p. 40.

³² SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf

42: Bismarck Mining Corporation, Vanuatu		
Location and area: The exact location of the area is unknown Area: 10 183 km ²		
Water depth: -		
Consortia members		
Bismarck Mining Corporation (Vanuatu) Limited	Core company/contractor	
Bismarck Mining Corporation (Vanuatu) Limited is part of the Bluewater/Neptune Minerals Group.		
Type of contract: exploration license		
Time scale: 2011 and 2012: exploration licenses are granted 2014 and 2015: expiry date of the exploration licenses 2004: exploration of the area by CSIRO. 2007: ten exploration licenses are granted to Neptune, each for an initial three-year period with a work commitment during that time to complete high resolution surface mapping and geophysics and to collect surface and sub-surface samples.		
Financing: The project has to be financed by Bismarck/Bluewater/Neptune itself by raising money from investors/shareholders.		
Government involvement: Under the Vanuatu <i>Mines and Minerals Act</i> , the holder of a Mining License must pay a royalty in respect of minerals recovered from the mining area. The royalty is fixed in, or calculated in accordance with the provisions of the Mining License concerned, or if no rate is fixed or provision so made in the Mining License concerned; pursuant to the rate prescribed ³³ .		
Type of material to be collected: SMS		
Size of expected deposit: -		
Technology used:		

³³ SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA



Exploration is done using multibeam 40Khz mapping, hydrothermal plume survey, follow up mapping and sampling with Remotely Operated Vehicle (ROV), spot sampling, drilling, and validation sampling.

Obstacles: -

Sources:

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf.

Presentation by Bismarck Mining Corporation (Vanuatu) Limited, see:

<http://www.sopac.org/dsm/public/files/meetings/Wednesday%2012th/Session%2011Neptune%20Vanuatu%20SOPAC%20Presentation.pdf>.

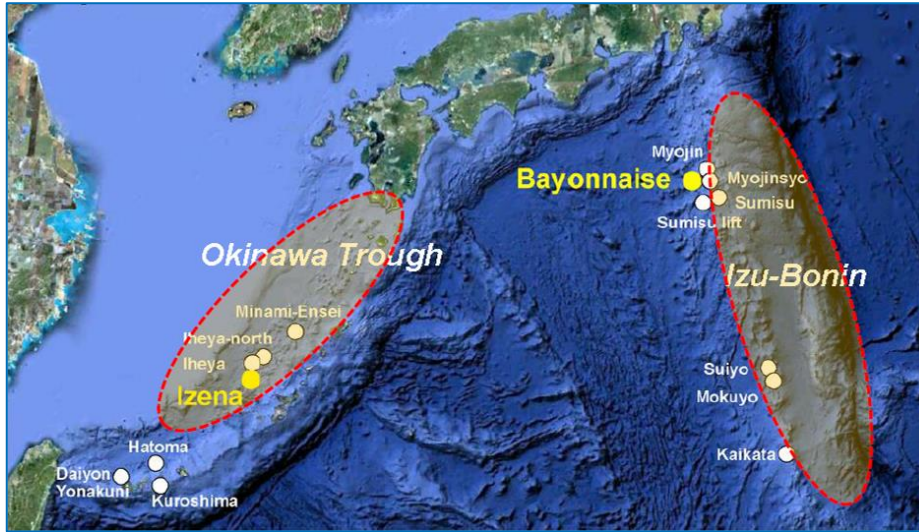
43: Neptune Minerals, Federated States of Micronesia		
Location and area: Federated States of Micronesia belong to the Pacific Islands Exact location and size of the area is unknown.		
Water depth: -		
Consortia members		
Neptune Minerals	Core company/contractor	
Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.		
Type of contract: application for an exploration license		
Time scale: It is not known when Neptune Minerals has applied for an exploration license. In 2007 Neptune Minerals has already been granted a Foreign Investment Permit to undertake exploration for and development of seafloor massive sulphides mineralization over an area of 200.000 km ² within the EEZ of the Federated States of Micronesia. The Permit is for a four year period commencing April 9, 2007 with possible extensions for up to 25 years. Possibly the new application is for the renewal of this license.		
Financing: Neptune is a public company. The project has to be financed by Neptune itself by raising money from investors/shareholders.		
Government involvement: -		
Type of material to be collected:		
Size of expected deposit: -		
Technology used: -		
Obstacles: Due to the absence of the prerequisite Legal framework the application is still pending.		
Sources: Website of Neptune.		

44: Neptune Minerals, Palau		
Location and area: Palau belongs to the Pacific Islands. The exact location and size of the area is unknown.		
Water depth: -		
Consortia members		
Neptune Minerals	Core company/contractor	
Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.		
Type of contract: application for an exploration license		
Time scale: -		
Financing: Neptune is a public company. The project has to be financed by Neptune itself by raising money from investors/shareholders.		
Government involvement: -		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: -		
Obstacles: -		
Sources: Website of Neptune.		

45: JOGMEC, Japan

Location and area:

Izu & Ogasawara Island Chain & SW Okinawa Islands



Water depth: -

Consortia members

Japan Oil, Gas & Metals National Corporation (JOGMEC)

Core company/contractor

JOGMEC is a State entity which implements national policies on natural resources and energy as an agency of the Government of Japan. JOGMEC was established on February 29, 2004 and integrates the functions of the former Japan National Oil Corporation, which was in charge of securing a stable supply of oil and natural gas, and the former Metal Mining Agency of Japan, which was in charge of ensuring a stable supply of nonferrous metal and mineral resources and implementing mine pollution control measures.

Type of contract: exploration license

Time scale:

2008: license into force. It is unknown when the license expires.

Financing:

JOGMEC is a state funded company. Therefore the project is financed by the Japanese government

Government involvement:

The government finances the project

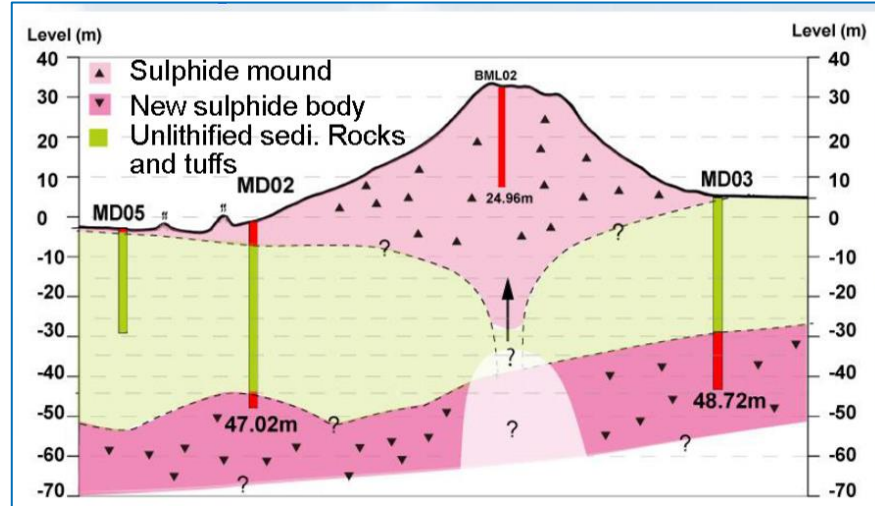
Type of material to be collected:

Seafloor massive sulphides and Cobalt rich ferromanganese crusts

Size of expected deposit:

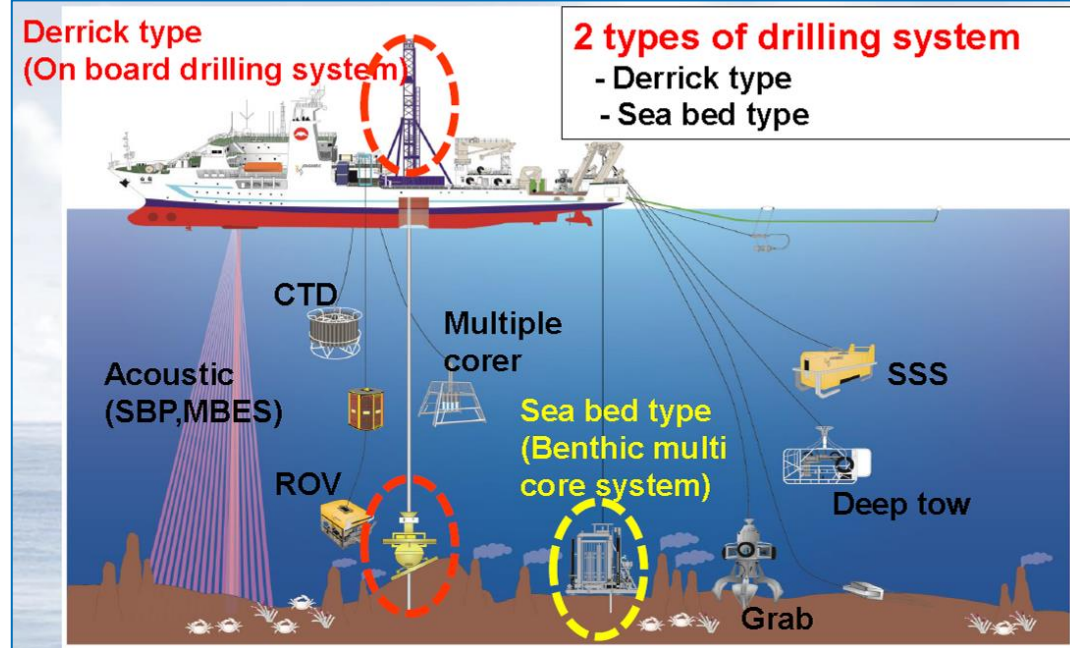
During a 2013 drilling cruise new hidden sulphide bodies have been discovered at around 30 m or deeper under the sea-floor in Izena and, Okinawa.

45: JOGMEC, Japan



Technology used:

On board to the Hakurei ship of Jogmec the following survey tools are available:



The on-board drilling system has a maximum drill length of 400 m and can drill up to 2 000 meters of water depth. The sea-bed drilling system has a maximum drill length of 50m and drill up to 3 000 meters of water depth.

Obstacles: -

Sources:

Phys Org (2011): Japan deep-sea robots to seek minerals: report, <http://phys.org/news/2011-01-japan-deep-sea-robots-minerals.html>;

Kamiya, N. (2014): Japan's Work of Cobalt Rich Crusts Exploration And Technology Development, <http://www.isa.org.jm/files/documents/EN/Seminars/2014/NatsumiNYC.pdf>.

46: Neptune Minerals, Japan

Location and area:

2007: 32 applications totaling 110 km² are located in the Okinawa Trough, 101 applications totaling around 400 km² are located in the Izu-Bonin Arc.

2008: 405 applications totaling around 1 400 km² are located in the Izu-Bonin-Arc. These applications are adjacent to the Izu-Bonin-Arc applications in 2007.

Total area: 1 853 km²

Water depth: -**Consortia members**

Neptune Minerals

Core company/contractor

Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.

Type of contract: application for an exploration license

Time scale:

2007: Neptune lodges 133 exploration licenses to Japan's Ministry for Economy, Trade and Industry (METI).

2008: Neptune lodges 405 exploration licenses.

No decision has been made yet by the Japanese government (24 June 2014)

Financing:

Neptune is a public company. The project has to be financed by Neptune itself by raising money from investors.

Government involvement: -**Type of material to be collected:**

Seafloor massive sulphides

Size of expected deposit: -**Technology used: -****Obstacles: -****Sources:**

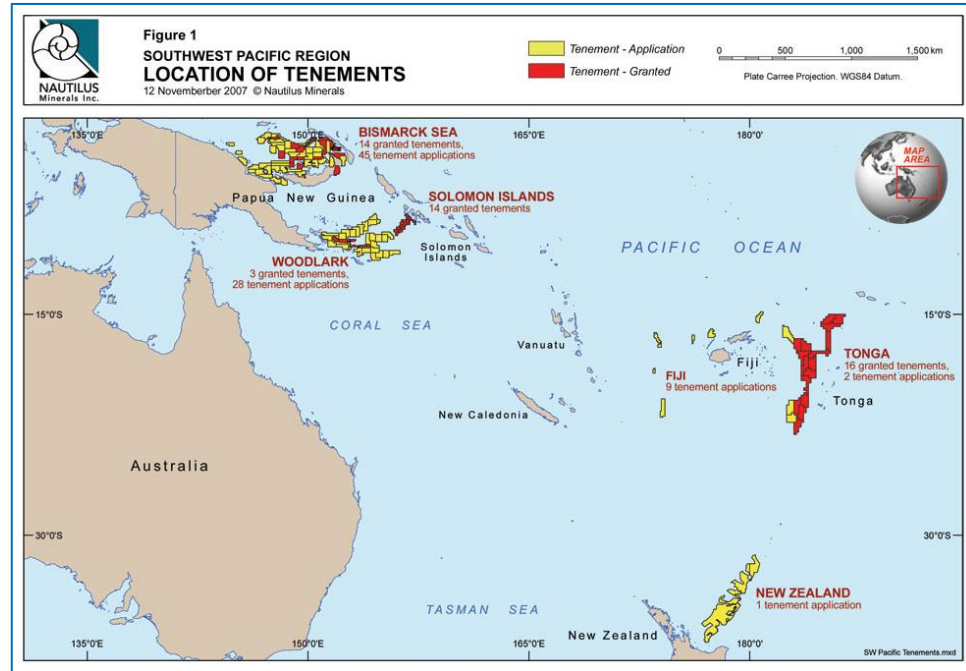
Press releases by Neptune.

47: Nautilus Minerals, New Zealand

Location and area:

The area of application is in the Bay of Plenty, New Zealand (permit 39348), indicated in yellow at the bottom of the next figure.

Area: 52 820 km²



Water depth: -

Consortia members

Nautilus Minerals Inc.	Main contractor	
------------------------	-----------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: application for a prospecting license

Time scale:

18-05-2007 application for the prospecting license. License is not granted yet due to administrative delays at the side of the New Zealand government as well as due to the fact there is a Moratorium on granting licenses along the Kermadec Ridge in effect for environmental reasons.

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd. is a company owned by Russian investor Alisher Usmanov.

Government involvement:

In New Zealand, the Crown Minerals Act 1991 provides for three types of permit: Prospecting, Exploration and Mining. Under draft Standard Terms and Conditions prepared by the authorities in 2010, an offshore Prospecting License (PL) is granted for an initial period of four years under the Continental Shelf Act. A PL allows geological, geochemical, and geophysical surveys; sampling by hand or handheld methods; and serial surveys. An Exploration Permit is initially granted for a period up to five years and is for the purpose of identifying mineral deposits and evaluating the feasibility of mining.

The annual rent on a PL is NZD 5.00 per km². Holders of PLs are required to file annual technical and financial

47: Nautilus Minerals, New Zealand

summaries to the Ministry of Economic Development.

Mining requires a Mining Permit (MP), where the nature and extent of a mineral deposit needs to be clearly defined during exploration. A Mining Permit can be granted for a period of up to forty years depending on the size of the resource. It is more common for MPs to be granted for periods of less than twenty years.

In New Zealand, a royalty is payable on all coal or minerals produced from the permit that are sold, disposed of or used in production (if the minerals are not sold, disposed of or used a royalty is no payable). The amount of royalty payable is based on the net sales revenues (the value of production sold, disposed of or used) from the permit. The royalty regime provides for two rates of royalty; the ad valorem royalty (AVR) which is 1% of the net sales revenues and the Accounting Profits Royalty (APR) which is 5% of the accounting profits from the permit.

If annual net sales revenues are less than \$100 000 or average monthly net sales revenues are less than \$8 333 royalty is not payable.

If annual net sales revenues are \$100 000 or more and not greater than \$1 million or average monthly net sales revenues are \$8 333 or more but not greater than \$83 333 1% AVR only is payable.

If annual net sales revenues are greater than \$1 million or average monthly net sales revenues are greater than \$83 333, 1% AVR or 5% APR, whichever is greater, is payable.

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

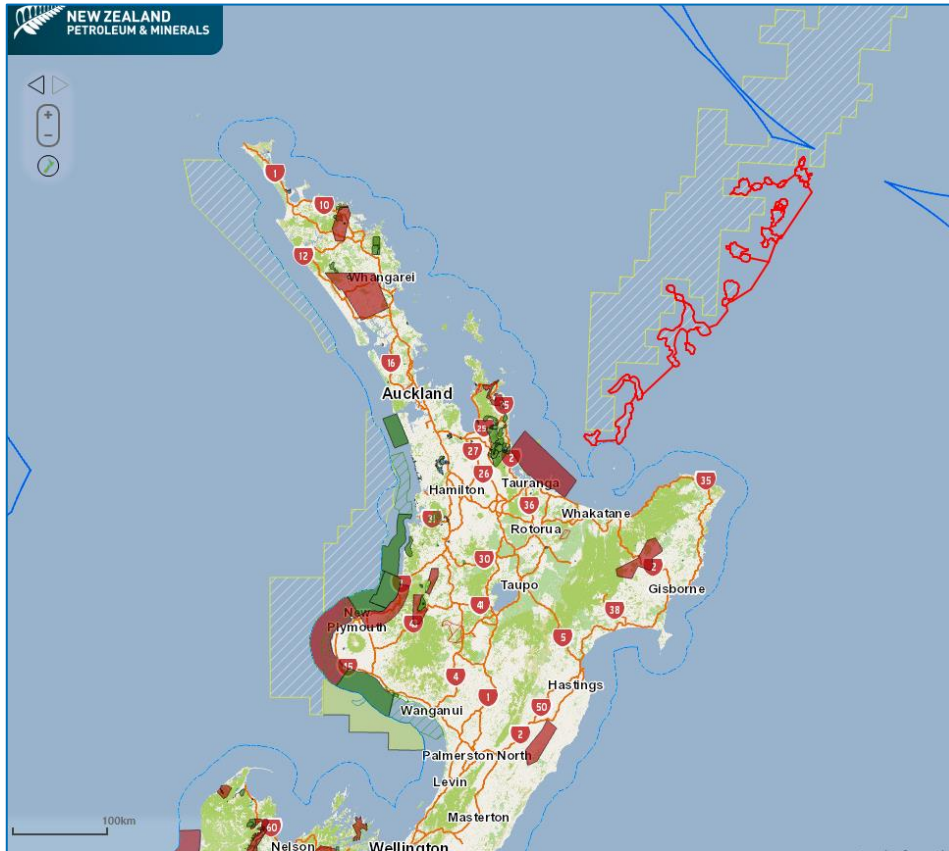
SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf.

48: Neptune Resources, New Zealand

Location and area:

The location is called Gisborne (permit 53828) and indicated in red in the figure below.

Area: 3 448 km²



Source: <http://data.nzpam.govt.nz/permitwebmaps?commodity=minerals>.

Water depth:

Around 1 000-1 800 meters

Consortia members

Neptune Resources

Main contractor

Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.

Type of contract: application for a prospecting license

Time scale:

2000: application for a Prospecting License.

2002: In October Neptune is granted the Kermadec Prospecting License (PL 39-195)). Rights will expire in October 2010. The tenement is about 8 000 km². After 4 years the tenement can be renewed as a PL with a 50 reduction in area, or a Mining License may be applied for over the area.

2005: The first exploration drilling programme for seafloor massive sulphides starts. Samples of 11.2g/t gold, 122g/t silver, 8.1% copper, 5% zinc and 0.5% lead was also discovered from drilling samples of seafloor massive sulphides chimneys submitted for metallurgical properties.

2006: Kermadec PL 39 195 was renewed to cover 3 447km² area (November 2006)

Neptune Minerals signed a contract with Norway's Geo Subsea to proceed with the exploration of the Kermadec area.

48: Neptune Resources, New Zealand

2007: exploration by Geo Subsea starts in May and is completed by August. The company discovered two new hydrothermally inactive seafloor massive sulphides zones at Rumble II West, with sulphide chimneys up to 13m high and mounds 100m long.

2011: application for a renewal of the Kermadec prospecting license. Not granted yet due to administrative delays at the side of the New Zealand government as well as due to the fact there is a Moratorium on granting licenses along the Kermadec Ridge in effect for environmental reasons.

Financing:

The project has to be financed by Neptune itself by raising money from investors.

Government involvement:

In New Zealand, the Crown Minerals Act 1991 provides for three types of permit: Prospecting, Exploration and Mining. Under draft Standard Terms and Conditions prepared by the authorities in 2010, an offshore PL is granted for an initial period of four years under the Continental Shelf Act. A PL allows geological, geochemical, and geophysical surveys; sampling by hand or handheld methods; and serial surveys. An Exploration Permit is initially granted for a period up to five years and is for the purpose of identifying mineral deposits and evaluating the feasibility of mining.

The annual rent on a PL is NZD5.00 per km². Holders of PLs are required to file annual technical and financial summaries to the Ministry of Economic Development.

Mining requires a MP, where the nature and extent of a mineral deposit needs to be clearly defined during exploration. A Mining Permit can be granted for a period of up to forty years depending on the size of the resource. It is more common for MPs to be granted for periods of less than twenty years.

In New Zealand, a royalty is payable on all coal or minerals produced from the permit that are sold, disposed of or used in production (if the minerals are not sold, disposed of or used a royalty is no payable). The amount of royalty payable is based on the net sales revenues (the value of production sold, disposed of or used) from the permit. The royalty regime provides for two rates of royalty; the AVR which is 1% of the net sales revenues and the APR which is 5% of the accounting profits from the permit.

If annual net sales revenues are less than \$100 000 or average monthly net sales revenues are less than \$8 333 royalty is not payable.

If annual net sales revenues are \$100 000 or more and not greater than \$1 million or average monthly net sales revenues are \$8 333 or more but not greater than \$83 333 1% AVR only is payable.

If annual net sales revenues are greater than \$1 million or average monthly net sales revenues are greater than \$83 333, 1% AVR or 5% APR, whichever is greater, is payable.

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit: -

Technology used:

Exploration

In 2005 during the exploration programme 23 14m-deep core holes were drilled and 29 sea-floor samples were collected. Complete analysis, petrophysical measurements and high resolution core mineralogy were also undertaken during the drilling programme.

48: Neptune Resources, New Zealand

In 2006 Neptune Minerals signed a contract with Norway's Geo Subsea to proceed with the exploration of Kermadec 07. The exploration comprised high resolution sea-floor mapping and seafloor massive sulphides sampling operations over numerous targets. Geo Subsea oversaw the offshore survey, maintenance, construction and subsea engineering operations along with high resolution acoustic and geophysical mapping of SMS targets in PL 39 195.

Mining

The Technic-Genesis study Neptune commissioned recommended a mining system incorporating a dynamically positioned production vessel on the surface, a flexible production riser and an airlift pumping system connected at the seafloor to an ore-crusher and seafloor miner. Operations would commence with pilot, mining to optimize technologies before operations are increased to an anticipated production of 2 million tonne per annum.

Obstacles: -

Sources:

Ministry for the Environment, New Zealand (2007): Improving Regulation of Environmental Effects in New Zealand's Exclusive Economic Zone: Discussion Paper, www.mfe.govt.nz/publications/oceans/nz-exclusive-economic-zone-discussion-paper-aug07/html/page4.html;

Kermadec Licence, Neptune Minerals, New Zealand, [mining-technology.com](http://www.mining-technology.com), see:

<http://www.mining-technology.com/projects/kermadec-neptune/>;

First day of dealing, FEInvestigate, 10 October 2005,

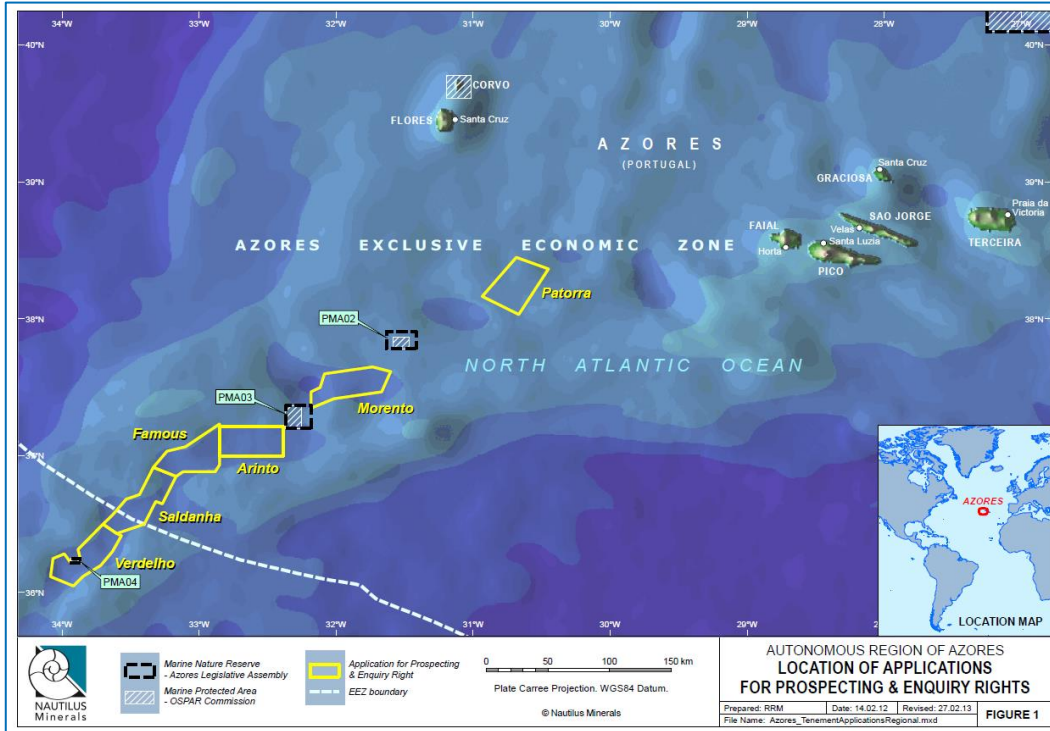
<http://www.investigate.co.uk/article.aspx?id=200510100700043912S>.

49: Nautilus Minerals, Azores

Location and area:

Nautilus has made an applications for six exploration licenses

Area: 5 904 km².



Source: Nautilus Minerals website.

Water depth: -

Consortia members

Nautilus Minerals	Core company/contractor	
-------------------	-------------------------	--

Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.

Type of contract: Application for a exploration license

Time scale:

2012: the application is made. No decision is made yet by the Portugese government (24 June 2014).

Financing:

Nautilus, a Canadian company with headquarters in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. Since October 2006 the Company has attracted Anglo American, Teck Cominco and Epion as major shareholders, raised significant capital (US\$270 million of cash in the bank). Anglo American and Teck Cominco are mining giants. shareholder Epion Holdings Ltd.is a company owned by Russian investor Alisher Usmanov.

Government involvement: -

Type of material to be collected:

Seafloor massive sulphides

Size of expected deposit: -

Technology used: -

Obstacles: -

Sources:

Nautilus Minerals website

<http://www.economistasmadeira.org/files/Apresentacoes%20CAT/Apresentacoes%20CAT%20VII/3->

NautilusMinerals_Madeira_Lowe_20130503.pptx;

49: Nautilus Minerals, Azores

Lowe, J. (2013): Nautilus Minerals, Global Vision,
http://www.economistasmadeira.org/files/Apresentacoes%20CAT/Apresentacoes%20CAT%20VII/3-NautilusMinerals_Madeira_Lowe_20130503.pptx.

50: Neptune Minerals, Italy		
Location and area: Tyrrhenian Sea, Italy		
Water depth: 500-1 000 meters		
Consortia members		
Neptune Minerals	Core company/contractor	
Nautilus is a Toronto listed company. The biggest shareholders are Metallo invest and MB holdings. Other investors are Anglo American and Teck.		
Type of contract: application for an exploration license		
Time scale: 2007 or earlier: Application for an exploration license. This application is still pending In 2007 Neptune participates in a German-Canadian research program in Neptune's Italian application area.		
Financing: The project has to be financed by Neptune itself by raising money from investors.		
Government involvement: -		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: -		
Obstacles: -		
Sources: Neptune Minerals (2007): Preliminary results for year ended 30 June 2007, http://www.mineweb.net/mineweb/content/en/mineweb-company-releases?oid=37118&sn=Detail .		

51: Nordic Ocean Resources (NORA), Norway		
Location and area: Norway, Mid-Atlantic ridge		
Water depth: -		
Consortia members		
Nordic Ocean Resources (NORA)	Main contractor	
NORA is owned by Nordic Mining ASA (85) and by Ocean Miners AS (15%).		
Type of contract: application for an exploration license		
Time scale: 2012: The Norwegian University of Science and Technology (NTNU), Statoil and Nordic Ocean Resources enter into a cooperation regarding seabed mineral resources. The project is targeting knowledge increase within marine mineral resources and will focus on current knowledge and future areas for research.		
Financing: The project has a total budget of NOK 2 million.		
Government involvement: -		
Type of material to be collected: SMS		
Size of expected deposit: A probabilistic estimate of the amounts of metal of copper (Cu), zinc (Zn), silver (Ag), and gold (Au) in known and undiscovered seabed massive sulphide vent fields on the Mid-Atlantic ridge within the Norwegian EEZs made by the Norwegian University of Science and technology. The total inferred, and postulated undiscovered metal amounts to an expected endowment of 6.4 million metric tonnes of copper metal in addition to zinc (6.5 million metric tonnes), gold (170 metric tonnes), and silver (9901 metric tonnes). Due to the lack of detailed data along this frontier exploration area a large uncertainty is attached to these results with a huge upside potential. There is accordingly a 5% probability of having metal resources of more than or equal to 20 million metric tonnes of copper metal, 21 million metric tonnes of zinc, 652 metric tonnes of gold, and 32 883 metric tonnes of silver.		
Technology used: -		
Obstacles: -		
Sources: Norwegian University of Science and technology (n.d.) Seabed massive sulphide (SMS) resource assessment within the Norwegian Economic Exclusive Zone (NEEZ), http://www.nordicmining.com/getfile.php/Bilder/Operations/NORA/Reports%20NORA/Seabed%20massive%20sulphide%20%28SMS%29%20resource%20assessment%20within%20the%20Norwegian%20Economic%20Exclusive%20Zone%20%28NEEZ%29..pdf .		

52: Neptune Minerals, Commonwealth of the Northern Mariana Islands		
Location and area: Back-arc basin, Commonwealth of the Northern Mariana Islands Area: 147 000 km ²		
Water depth: -		
Consortia members		
Neptune Minerals	Core company/contractor	
Neptune, an US company, is a public company. The company has only one large (not controlling) shareholder: Odyssey Marine Exploitation Inc.		
Type of contract: application for an exploration license		
Time scale: 2006: The application for an exploration license has been made but no decision has been made yet by the government (24 June 2014).		
Financing: The project has to be financed by Neptune itself by raising money from investors/shareholders.		
Government involvement: -		
Type of material to be collected: Seafloor massive sulphides		
Size of expected deposit: -		
Technology used: -		
Obstacles:-		
Sources: Eugenio, H.V. (2014): Sitting on a gold mine, CNMI may have gold, silver, oil deposits waiting to be explored, http://www.saipantribune.com/index.php/sitting-gold-mine/ .		

2.3 European Innovation Partnership commitments/projects

Environmentally Responsible Deep-sea Mining (ERDEM)

Objectives of the commitment:

ERDEM will embrace pro-active engagement of scientists, social scientists, policy makers and industry to collaboratively develop a Framework for Sustainable Deep Sea Mining. This will comprise innovative technologies and integrated management practices outputting renewed environmental impact assessment method and updated standards and legal instruments to achieve economically viable, environmentally sound and socially acceptable exploration and extraction of EU's mineral resources. ERDEM promotes international cooperation in R&D on best practice sharing with Japan. ERDEM aspires to develop a novel set of solutions for exploration, extraction and in-situ pre-processing of deep-sea ores and integrated robotic and sensor technologies to achieve lower cost and more efficient real time monitoring of environmental impact. It will assess the resilience of Deep Sea Ecosystems and of biodiversity to resource extraction activities and it will provide advanced understanding of deep sea mining associated geological processes.

Description of the activities:

The vision is to link an ecosystem based approach in managing the exploitation of deep-sea resources and innovative technological monitoring capabilities with broader EU economical perspectives, targeting at enhancing EU industry competitiveness: 1. Develop and pilot a novel cost-effective, remote and immersive set of exploration and exploitation solutions allowing a tele-mining system concept. A new class of multipurpose mining system comprising robots and tools (jet-streams, grabbers, excavators, collectors and transporters) for low-impact larger-scale mining operations will be designed, prototyped and tested, based on functional specialization associated with a systemic cooperation which will provide teaming capabilities, necessary to operate in extreme hostile environments. The aim is to support remote mining and in - situ prospecting by deploying different sensing capabilities (e.g. fusion between vision, sonar and laser – green or blue- and chemical information in underwater environment) to provide situational awareness and for the continuous real-time evaluation of the produced ores. 2. Deliver a mobile, wireless environmental impact monitoring system. Develop, test and evaluate in real scenarios functional prototypes of integrated robotic and sensor technologies to achieve a lower cost and more efficient real time monitoring of environmental impact, via innovative adaptation of existing subsystems and by exploiting key technologies such as: wireless energy transfer; wireless communications; extended area geo-referencing; and environment sensors (acoustic, biogeochemical, and multi-parameter). Design, develop, integrate, and test solutions for extended area deep water geo-referencing of collected data required for mining environmental impact assessment. 3. Assess resilience of Deep Sea Ecosystems and of biodiversity to resource extraction activities, using new monitoring technologies. Assess the environmental impact of deep sea mineral resources mining, by studying the effects of extraction activities on the deep sea habitats. Advance the current knowledge on deep sea and sub-sea floors environments, by studying and analysing environmental dynamics, population variability and connectivity of communities in deep sea habitats where such resources are found. Providing: • The expansion on the knowledge of natural variability in European deep sea ecosystems. • Extend methodological concepts developed for the management of coastal ecosystems to the deep-sea. • Standardise methods and tools and terminologies for impact assessment, monitoring and decision support. 4. Deliver and contribute to advanced understanding of geological processes associated to the minerals' extraction. • Provide baseline information about the geological environment and its dynamic behaviour through time by allowing proper evaluation of pressures and vulnerabilities in a context of exploration and exploitation of its resources. • Contribute to a better understanding of under-laying processes and their variability leading to submarine resources formation and the biogeochemical links that exist at the lithosphere-ocean interface with the deep biosphere. • Quantify the potential sphere of interference of mining activities to evaluate primary effects and secondary effects considering different technological approaches. • Develop and test new and advanced technologies and methods for investigating potential geological impacts. • Develop protocols for the quantification of geological impacts. 5. Develop a Holistic Governance Framework for Ocean Resources Sustainable Exploration and Extraction (GFORSE) including Governance, Legal instruments and Management Practices, Policy Recommendations and

Environmentally Responsible Deep-sea Mining (ERDEM)

Standardization of tools and methods for assessing the environmental impact of such exploitation activities. GFORSE will involve stakeholders in an ecosystem approach and consolidate findings from all previous activities, in a web-based decision support system. Promote and support diffusion of the Framework, by bringing to the commitment new stakeholders and creating a solid basis for sustainable development on global scale and practicable for a broad range of cases across European member states. Promote international cooperation in R&D on best practice sharing with Japan.

Consortia members

<i>Name</i>	<i>Country</i>	<i>Task</i>
BMT Group Ltd	United Kingdom	Coordinator
Fugro EMU Limited	United Kingdom	Fugro Group is currently actively involved in R&D to provide environmental survey, monitoring and EIA for deep sea resource exploration as part of the MIDAS and other UK funded projects. Fugro will build on this knowledge, further developing acoustic and optical sensors, increasing AUV capabilities, improving the efficacy of environmental survey and monitoring, and supporting the development of robust policy and legislation.
Soil Machine Dynamics Ltd (SMD)	United Kingdom	Direct involvement in the development and piloting of the remote and immersive set of exploration and exploitation solutions resulting in a multipurpose mining system. Will provide assistance and advice to other activities and be the contact for multiple offshore operators that have relevant base knowledge that is not in the public domain.
Sandvik Mining and Construction G.m.b.H.	Austria	Direct involvement in the development and piloting of the remote and immersive set of exploration and exploitation solutions resulting in a multipurpose mining system.
Damen Dredging Equipment BV	The Netherlands	Damen Dredging Equipment supplies tools and equipment that is normally used in the dredging industry, to excavate and transport sediments. Therefore we have expertise and facilities to develop and test products that will have a similar purpose in the proposed project. Also, with our knowledge on the process and the operation of these machines, we can advise the partners on certain aspects that are unfamiliar for them.
Instituto de Engenharia Sistemas e Computadores	Portugal	Development of: • a new class of robots for low-impact larger-scale mining. • innovative sensing capabilities (e.g. fusion between vision, sonar and laser and chemical information in underwater environment) to produce overall quality of 4D data. • integrated robotic and sensor technologies to achieve a lower cost and more efficient real time monitoring of environmental impact.
University College Dublin	Ireland	The expansion on the knowledge of natural variability in European deep sea ecosystems, facilitating better management decisions
Consortio para el diseño, construcción, equipamiento y explotación de la Plataforma Oceánica de Canarias (PLOCAN)	Spain	PLOCAN will contribute to activities 2, 3 and 5 providing support and facilities for testing sensors and devices at test sites; compile and provide biogeochemical data from the Central Atlantic oceanic waters; apply for ship time and provide support for oceanic transects in Atlantic waters.

Environmentally Responsible Deep-sea Mining (ERDEM)		
University of Bergen; Department of Earth Science	Norway	Contribute to activity 4 on advancing the understanding of geological processes associated with the deep sea minerals' extraction
BioID LTD	Ireland	Activity 5 • Creation of a document outlining best practices for Environmental Impact Assessment • Creation of a document outlining state of the art technologies in deep sea environmental monitoring Activity 1 • Consulting on minimising the environmental foot-print of extraction platforms and the outfit of the extraction platform Activity 2 • Consulting on the development integrated robotic and sensor technologies to achieve a lower cost and more efficient real time monitoring of environmental impact Activity 3 • Development of a document outlining how to extend methodological concepts developed for the management of coastal ecosystems to the deep-sea. • Development of a document that standardises methods and tools and terminologies for impact assessment, monitoring and decision support. • Provide guidelines for conducting environmental impact assessment of deep sea resources' mining, advancing ISA's guidelines, via a process which will ensure stakeholder consensus.
The Hellenic Centre for Marine Research (HCMR)	Greece	The Institute of Oceanography (IO) will collaborate and will contribute to: a. Assess the environmental impact of deep-sea mineral resources mining. The IO-HCMR has carried out numerous environmental impact assessments, i.e. mineral dumping, hydrocarbon exploration in E. Mediterranean, oil spills. b. Assess Deep Sea Ecosystems' Resilience and biodiversity to resource extraction activities. The IO-HCMR was recently finalised the strategic impact assessment regarding hydrocarbon extraction in the Greek EEZ. c. Advance the current knowledge on deep-sea and sub-sea floors environments and the associated geological processes, with special focus on mud volcanism and associated gas-hydrate resources in the Eastern Mediterranean. d. Develop a Framework for the sustainable exploitation of deep-sea resources, capitalising the great experienced gained through other scientific projects.
Ocean Scientific International Ltd	United Kingdom	Contribute to the development, test and evaluation of the real time environmental impacts monitoring system.
La Palma Research S.L	Spain	Support ERDEM with its expertise in mapping emerging trends in deep-sea mining research. Such mapping will include the organisation of targeted workshops, the development of internet-based surveys and other activities that will mobilise the scientific community. These activities will support a „Horizon scanning and Research road mapping” subtask for ERDEM with the overall goal of identifying new research challenges, and linking these research challenges to existing research roadmaps, such as the one developed by ETPSMR (European Technology Platform on Sustainable Mineral Resources).
University College Cork	Ireland	Assess plume fallout relative to background hydrothermal plume sedimentation to evaluate impact of mining and habitat disturbance. High resolution multibeam mapping (ROV or AUV based) to characterise site geomorphology and seabed rugosity which will feed into hydrodynamic plume models, enabling venting dynamics, down-core diagenetic geochemical overprinting and natural plume fallout to

Environmentally Responsible Deep-sea Mining (ERDEM)		
		be constrained. Appraise the impact of creating artificial plumes as a deviation from historic hydrothermal plume sedimentation histories.
Technical University of Catalonia, BarcelonaTech, UPC	Spain	Use and adaptation of the LIDO network for real-time acoustic monitoring of deep-sea mining. - Development of classifiers and noise measurement modules to characterize the effects/impact of Deep-Sea mining on the environment. - Modeling of the noise foot-print of the Deep-Sea mining activities.
Centre for Geobiology	Norway	Provide regional geological mapping and characterization of deposits through deep-sea resource exploration using state-of-art technology. Define new exploration targets using innovative approaches on the detection of local and distal footprints of ore-forming systems. Assess potential impact of seabed mining via plume dispersal studies, in-situ experiments and possible release of toxic elements into the seawater. Contribute to the understanding of geological processes capable of forming deep-sea deposits.
CHRISAR SOFTWARE TECHNOLOGIES	France	To advise in design and preparation of all acoustic aspects offering experience, knowledge and understanding in cetacean and acoustic domains. Including: - acoustic measurement to supervise and control anthropic noise levels, - definition of detection/behavioural/physiological criteria and thresholds of cetacean species - definition of environmental acoustic parameters - propagation performances - Identification of a security perimeter and definition of a « code of conduct » to minimize acoustic disturbance.
Aarhus University	Denmark	Providing expertise in benthic ecology, benthic hydrodynamics, ecosystem modelling, deep-sea habitats. AU will contribute to expand knowledge of structure and variability of European deep-sea ecosystems and habitats with a focus on seamounts and continental margins. AU will also contribute to evaluate methods and tools for impact assessments, monitoring and deep-sea ecosystem management.
Geological survey of Slovenia (GeoZS)	Slovenia	GeoZS will mainly deliver advanced understanding of geological processes associated to the minerals' extraction.
TÉCNICAS Y MONTAJES SUBACUÁTICOS S.L.	Spain	R&D, Design and development of subsea technologies and machinery.
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Japan	Data sharing on deep-sea environments and biodiversity and knowledge for EIA, and the cooperation for research cruise. Explore synergies with the "Submarine Resources Research Project" with regards to exploration, extraction and processing to replicate successes and avoid failures. Strengthen academic collaboration.
Montanuniversitaet Leoben	Austria	Montanuniversitaet Leoben is a mining, metallurgical and material science oriented university working along the value chain from primary and secondary resources to materials and products; special competence in mining/mineral extraction is on excavation engineering (mechanical and blast induced excavation) rock mechanics and mine planning; expertise will be provided to the consortium in the fields of rock excavation on the sea bed, on remote mining and on the development of concepts for sub-sea in-situ mining.

Environmentally Responsible Deep-sea Mining (ERDEM)		
Marine Minerals Ltd	United Kingdom	Marine Minerals will provide the tin recovery site in Cornwall as a test environment for the intelligent mining system that will be developed within ERDEM. Marine Minerals will also transfer their knowledge and experience on EIA regarding seabed mining.
Zentrum für Telematik (ZFT)	Germany	Contribute to the remote intelligent mining system and the wireless environmental impact monitoring system by providing competencies on like remote actuation, cross-linking, pre-processing (e.g. filtering or compression) and fusion of sensor data as well as the evaluation of sensor systems.
Period to implement the commitment: 1 June, 2014 to 31 May, 2019		
Financing: No existing EU contribution		
Expected impacts: <ul style="list-style-type: none"> • Creation of concerted effort leading to increased European competitiveness in the raw materials and marine technology sector. • Promote, by good governance, the investment into minerals sector. • Enhanced knowledge on environmental impacts and processes of deep sea exploitation activities; improve the environmental management, including the EIA. • Definition of boundary conditions for environmentally sustainable exploitation activities. • Contribution to the implementation of EU initiatives: Integrated Maritime Policy, 'A Resource - Efficient Europe' roadmap and the Marine Strategy Framework Directive. • New and improved knowledge on the measurement techniques for, and detailed characteristics of noise produced by mining operations; improved knowledge on the impacts of noise on deep sea ecosystems, and best practice guidance how to manage the noise footprint. • New and improved knowledge on geological aspects of deep sea mineral sites describing the key physical parameters and characteristics and contextual settings. Focal topics include: Baseline studies, geomorphology, sediment distribution and sedimentation history, seabed and sub-seabed geochemical properties, habitat types and maps. • Compiled overview maps of deep- sea minerals distribution in Europe with quantitative resource potential estimates, adding to the transparency of EU raw materials information. • Increase EU materials knowledge for different stakeholders. • Create new jobs in mining and equipment manufacturing industries in many regions of the EU. • Exploit the synergies in R&D with regards to exploration, extraction and processing including technological solutions for intelligent mining, safety and automation and create joint expert systems based on "lessons learnt" to replicate successes and avoid failures; strengthen international academic cooperation.: 		
Sources: https://ec.europa.eu/eip/raw-materials/en/content/environmentally-responsible-deep-sea-mining .		

Alternative Blue Advanced Technologies for Research On Seafloor Sulfides, ALBATROSS

Objectives of the commitment:

This project contributes to develop cost-effective technologies to evaluate SMS, considered as “the most promising” by Blue Growth, and enables sustainable access to resources in EU States EEZ. Wallis and Futuna EEZ potential was confirmed by large scale mapping in previous campaigns. More biodiversity studies, monitoring, high resolution mapping and developments for seafloor geophysical and water column analysis are required to locate inactive areas. Evaluation requires 3D geometallurgical models. As current drilling tools need long campaigns and do not fit for chaotic seafloor or dispersed ore, development is needed. Sea cruises will give EU a chance to prove the potential of its EEZ and its ability to perform exploration through an integrated tool, perfectly fit for any seafloor massive sulphides, based on collaboration.

Description of the activities:

ALBATROSS activities will consist of 5 different phases: specifications, design, manufacturing, offshore campaigns and ore evaluation. 1/ Specification, phase 1, will consist in a review of 3 first campaigns results and the requirements for the whole exploration and evaluation method. A collaboration of all participants is needed for this task. • Strategy of exploration and evaluation of deep-sea seafloor massive sulfides will be the first step and will be updated thanks to the technology proposal of each member. • This phase will describe all data necessary to locate inactive deposits, to estimate the thickness of the ore body and to provide all information needed to characterize the deposit vertically. • The geological setting (volcanic and tectonic), topography and specificity of the potential areas to be explored will be attentively studied. • Objective in terms of quality and cost will be set at this level. A benchmark will be suitable. • Particular attention will be paid on environmental requirement to ensure minimum impact during exploration. 2/ During the second phase, the partners will prepare the technical conceptions needed for the exploration and the evaluation of deposits: • Water column data processing • Development and integration of real-time exploration technique based on electrical plasma • Drilling ROV • Geophysics Acquisition Instrument, ROV or AUV • Environmental Survey and monitoring Systems 3/ Construction of prototype will be carried out during phase 3 for the purpose of the offshore demonstration in Wallis and Futuna. 4/ Phase 4, consists of sea operations during four exploration campaigns in Wallis and Futuna. Campaigns are expected to last between one and one and a half month. • Campaign A, will consist in a high resolution geological cartography of 10 prospective targets in non-active areas with AUV and manned submersibles for systematic sampling, to be analyzed at sea-surface. First tests of the Geophysics Acquisition Instrument could also take place. A preliminary environmental survey will be set up on the seafloor and the water column. Detailed mineralogical, chemical and geotechnical studies will be done on mineralized samples. Chemical studies will be done on hydrothermal fluids and water samples from the hydrothermal plume to quantify natural chemical input in the water column and prepare the impact studies. • Campaign B: Near seafloor geophysics acquisition will be performed on around 6 different mineralized zones. Environmental Survey will be reinforced in the most prospective sites. • Campaign C and D: drilling will be accomplished in the two to three most prospective deposits. Environmental survey will be reinforced if necessary in the drilled areas. Geophysics complementary acquisition could be necessary to have a good overlap with drillings. 5/ The last phase consists of finalizing geochemical and mineralogical analyses and to correlate drilling results with geophysics result. A geological conceptual model and then a 3D numerical model will be built on one selected site. A technical and economical evaluation of the deposit will be performed. Drilling samples will be used to accomplish preliminary beneficiation tests. These data will be used in the final evaluation of the deposit. Data from the environment survey will be picked up and analyzed one year after the drilling campaigns.

Consortia members

<i>Name</i>	<i>Country</i>	<i>Task</i>
ERAMET SA	France	Will perform the multidisciplinary interfaces management and coordination. After determination of the strategy and specifications, ERAMET will focus on data quality acquisition by fulfilling the best practice standards of ore deposit evaluation. ERAMET, as for the 3

Alternative Blue Advanced Technologies for Research On Seafloor Sulfides, ALBATROSS		
		first campaigns, intends to participate financially to the scientific cruises and will achieve preliminary process studies, 3D mining models and evaluation.
University of Bremen (UB)	Bremen	UB is responsible for design, realization and implementation of a geophysical exploration system with controlled source electromagnetics (CSEM), optical, magnetic and acoustic sensing for ROV and submersible enabling joint detection, volume estimation and environmental assessment of seafloor massive sulphides. We will model and specify CSEM sensor, conduct field trials with existing CSEM, and develop and validate methods for data acquisition, processing and analysis.
IFREMER	France	Ifremer will coordinate the exploration cruises and the study of active and inactive sulfide deposits. Ifremer will also coordinate the geological, geochemical and ecological studies with existing and arising tools as deep sea AUVs and innovative geophysical payloads. The objective is to build conceptual 3D geological model for each sulfide deposit. Moreover, Ifremer will participate in the design and validation of the EBS protocols.
TECHNIP FRANCE	France	TECHNIP participated as a financial contributor to the 2010, 2011 and 2012 explorations campaigns led by Eramet and Ifremer offshore Wallis & Futuna. Technip intends to do the same for the upcoming campaigns proposed in that project.
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	Germany	BGR will develop concepts and general requirements for the seafloor CSEM sensing system, and guide the development of the new CSEM-ALBATROSS Profiler, including data modelling and simulations. BGR will also adapt its own marine CSEM systems for seafloor massive sulphides exploration and organize and participate in field trials and data analysis.
Geological Survey of Finland (GTK)	Finland	GTK will carry out preliminary beneficiation studies and mineralogical characterization in cooperation with Eramet. GTK will be in charge to transfer the data acquired in this preliminary stage into the SEAFLORES project related to the extraction and beneficiation of seafloor massive sulphides deposits.
GA Drilling	Slovakia	GA Drilling will be focused on R&D of innovative method for drilling and real-time geochemical analysis of target rocks. This approach introduces an innovative way of material analysis during a concurrent drilling operation enabling analysis of material using atomic and molecular spectrometry. The method of concurrent drilling and sensing would considerably enhance the entire exploration process efficiency and profitability.
DCNS	France	DCNS will design, qualify and operate a dedicated seafloor drilling and sampling system. This system will feature cutting edge innovations in terms of in-situ analysis of the samples and early recovery of all or part of them, easy integration on a support ship, safe and secure deployment from the deck, efficiency in operations, thus providing the project with a cost-effective tool and eventually enabling a better scheduling of the campaigns.

Alternative Blue Advanced Technologies for Research On Seafloor Sulfides, ALBATROSS		
HERIOT-WATT UNIVERSITY	United Kingdom	<ul style="list-style-type: none"> • Adapt, develop, provide and operate instrumental equipment for deep-sea mining environmental monitoring, • Prepare monitoring and survey program in order to conduct baseline environmental studies • Prepare and operate environmental survey for drilling operation • Participate to campaign (3 to 4) • Analyze data collected during a four years monitoring and survey.
AURUBIS	Germany	AURUBIS is the leading integrated copper group and the world's largest copper recycler. We produce some 1 million t of copper cathodes each year and from them a variety of copper products. Production expertise is our strength and the driving force of our success. AURUBIS will capitalize on its experience and know-how to contribute to the project.
Louis Dreyfus Armateurs (LDA)	France	As an experienced shipowner, Louis Dreyfus Armateurs "LDA" will share its expertise in maritime operations, offshore operations and surface transportation. LDA Group will participate to specification phase, modeling of maritime operations to validate the industrial solution and business plan.
Period to implement the commitment: 1 January, 2015 to 31 December, 2020		
Financing: No existing EU contribution		
Expected Impacts: At the end of the project, EU partners will be able to propose proven and cost-effective technologies and methodology to explore and evaluate seafloor massive sulphides deposits. The services range from regional exploration – through an access to the 3D modeling with drilling & geophysics methods – and environmental survey to recovery, process development and ore deposit evaluation This project intends to reduce the exploration and evaluation costs for deep-sea deposits and will push Europe to the forefront of technologies and related services in this domain. Environmental survey and monitoring at an early stage will be a significant step to build a strong baseline necessary to develop an undersea mining operation with minimum impact on natural life. This aspect is integrated in the methodology to provide a comprehensive range of services in accordance with international standard (ie: ISA) This project and the extraction project being submitted to the call for commitment called SeaFlores aim at demonstrating by a state of the art evaluation the undersea mining potential in a European EEZ. It represents a new step to access to new metal sources not discovered yet. The technologies improved or developed in this project are essential for Europe to evaluate other deposits in the EEZ of its members but also in international waters. Newly developed methods could be used by authorities to improve Land Use Planning. The success of such an innovative project relies on an effective and intimate coordination of European-wide industrials and academics skills and resources, along with a good coordination of each initiative. All improvements and collaborations proposed here are a first essential step to deep-sea mining development in Europe.		
Sources: https://ec.europa.eu/eip/raw-materials/en/content/%E2%80%9Calternative-blue-advanced-technologies-research-seafloor-sulfides%E2%80%9D-securing-long-term-raw .		

Securing the supply of Primary resources, SecPRIME

Objectives of the commitment:

The consortium behind this commitment has the ambition to work for an integrated, systemic view on Primary resources technologies and related non-technology actions as defined below. The systemic view means that both products focused and process focused actions are planned. We make the commitment based on the scope of the knowledge triangle where education, research and innovations within both the technology and non-technology pillars are tackled. The consortium behind the commitment is composed of key European industry, academia and institutes with a proven track record of excellence in RDI actions related to Primary resources. The consortium has especially identified the priority areas IB (2-4), IIC (9-10), III (4) with the following content: • Advanced technologies, materials and equipment for tooling, engineering, mining and metal producing industries, • Development of innovative platforms for cooperation between Primary resources industry, SME and academia; large-scaled pilots, demonstrators, • Mineral processing and metallurgy; energy efficiency, low grade ores, • Exploration (including geometallurgy) and mining technologies; deep mining, mining methods and processes, ground control including seismicity and automation, • ICT processes and modelling for Primary resources industry, • Green mining and CRS enabling social licence to operate; low environmental impact, emissions, vibrations and disturbances, zero accidents, integration, gender and diversity.

Description of the activities:

We will tackle challenges related to Primary resources based on the following activities: Exploration • Develop Common Exploration Models - Build 3/4D and numerical modeling capacity • Develop projects which aims at a systemic thinking from exploration to products • Innovation for new deep exploration drilling technologies and tools • Development within 3D visualization and numerical modeling • Develop real or near-real time data acquisition methods • Develop real or near real-time analyzing methods • Exploit the numerical modeling software used in high-tech industry for deep exploration • Development of a geodata framework to enhance exploration investments • Facilitate reopening of old economically sustainable deposits • Research improvement or development of new geophysical methods with higher resolution and penetration depth • Targeted ore genetic research and structural/tectonic studies to enable development of conceptual 3D/4D models • Develop methods for resource characterization already at exploration stage Extraction • Develop energy efficient mining systems with low CO2 emissions • Plant-wide studies of energy consumption, related to tribology and inefficient use of materials in tooling and transportation • Develop an expert system, which includes all necessary questions and guidance to actions and solutions for several different sizes of plants and needs • Develop new mining concepts, tools, machinery and technologies for extreme conditions • Increasing automation in European mines • Research to minimize the need for maintenance, develop service free and self-sustaining machines, predictable process oriented maintenance • Develop image analysis for mining applications • Develop traffic management and dispatch systems to enable full process control • Develop tools and other components that are exposed to more or less severe contact with rock throughout the mining process with longer lifetime of tools • Develop more robust handling and transportation processes, methods, systems and equipment • Develop rock mechanics knowledge; secure rock, rock reinforcement that can cope with all situations • Develop tools and methods for prediction of production conditions • Develop of measurement while drilling (MWD) and analysis while drilling (AWD) techniques • Develop optimized particle packing models for crushed rock of variable sizes, shapes and composition • Develop concrete and asphalt rheology models and simulation with alternative aggregate materials Mineral Processing • Develop energy and water saving technologies in mineral processing • Develop combined pre-treatment methods • Modelling and simulation of flotation process • Compile a comprehensive dataset on existing mining waste deposits, including chemical characteristics • Increase efficiency of polymetallic concentrate treatment • Improvements in flotation of ores posing difficulties in treatment Metallurgy • Develop holistic design and optimisation of an integrated metallurgical system (including pyro-, hydro-, bio-, electro-chemistry) for further primary and secondary metals processing and refining • Develop carbon saving technologies in metallurgy • Optimize mining and processing via geometallurgy and linking to extractive metallurgy • Valorisation of current wastes by recovery of secondary products in combination with primary raw materials • Develop alternative reduction processes which allow for production of metals without agglomeration • Valorisation of process flue gases • Control of impurities in closed water cycles

Securing the supply of Primary resources, SecPRIME		
Consortia members		
Name	Country	Task
KGHM Cuprum	Poland	Identification, analysis and finding innovation solutions to problems of mining industry. Development and implementation of projects in the aspects of prospecting, exploration and mining of mineral deposits. Searching for sources of critical raw materials (CRM). Development of recovery technologies of critical metals or their substitutes. Sourcing materials for research. Basic and advanced studies of mineral and rock materials and waste products. Data treatment and interpretation.
Uppsala University	Sweden	UU will provide data, existing and new analysis tools relevant for natural and induced seismicity and structural studies in mining areas. New and advanced geophysical instrumentation and processing methods will be developed within the project, especially aimed at detailed microseismic studies and mine stability.
Clausthal University of Technology (CUT)	Germany	Clausthal University of Technology (CUT) is a renowned technical university in research, education and innovation along the Primary resources value chain. CUT is committed to be an active research and education partner in projects, esp. in the fields of international cooperation between education/research facilities and industry, mining methods and equipment, mine health and safety, sustainability, automation of processes as well as in the field of material development for new wear protection layers.
Fraunhofer-Gesellschaft (Association)- Primary Resources	Germany	Fraunhofer is Europe's largest application-oriented research organization. The research efforts are geared entirely to people's needs: health, security, communication, energy and the environment. As a result, the work undertaken by our researchers and developers has a significant impact on people's lives. Fraunhofer will contribute with skills in the fields of Resource Strategies, Exploration and Analysis, Exploitation, and Minerals Processing.
ENEA - Italian National agency for new technologies, Energy and	Italy	ENEA can develop knowledge in the field of Raw Materials by to hydrometallurgical processes of recovery and recycling of raw materials: 1) Study new processes, separation and purification of strategic critical raw materials high value-added: rare earth; 2) boost innovation and create networks between industry, SMEs and academia; 4) Share expertise, laboratories and large-scale pilot plant.
Atlas Copco Rock Drills AB	Sweden	Project sponsor and provider of technology and test site. Atlas Copco Rock Drills AB is a technology provider to the European and Global mining industry including exploration equipment and tools.
Universidad Politécnica de Madrid (UPM) / Public University	Spain	UPM / ETSIME provides a wealth of relationships and over 25 years experience of cooperation in high-level education and research with most Latin American countries and Africa, through international networks funded by public programs as EU_ALFA / EuropeAid, AECID or CYTED, and by private companies.
Instytut Metali Nieżelaznych (Institute of Non-Ferrous Metals)	Poland	IMN will run activities related to laboratory and pilot scale studies into ore treatment and metallurgical metal recovery.

Securing the supply of Primary resources, SecPRIME		
Boliden Mineral AB	Sweden	The focus of Boliden's exploration is on zinc, copper and precious metal-bearing ores. The exploration is conducted in the vicinity of existing mines, in order to increase their lifespan, and in new areas to expand our mine portfolio with new deposits. Zinc-, copper-, lead-, gold- and silver-bearing ores are mined in Boliden's four mining areas.
LKAB	Sweden	LKAB will work with innovation and research and be a partner for product and technology development that leads to efficiency throughout the value chain. Our customer offer is Performance In Ironmaking and climate-friendly Green Pellets. LKAB is a high-tech minerals group renowned for its internationally world-class R&D.
AGH-University of Science and Technology, Kraków	Poland	AGH is a technological university with worldknown expertise in mining technology, rock mechanics, machinery constructions and geology: Develops new concepts and working cost-effective and environmentally-responsible winning of rocks for deep-sea mining technology. Develops cost-effective and environmentally sound concepts and solutions for exploitation of small or low-grade mineral deposits with a new borehole technology. Provides relatively cheap access to small deposits, use of technology based on non-destructive tool, reducing costs and increasing work safety. Based on the hitherto experience, a feasibility study will be developed, laboratory tests and preliminary in situ experiments. A new winning method would be applied as well for underground deposits as for concretions.
Liège University	Belgium	The ULg - University of Liège (Belgium) has a long tradition in educating Mining and Geological Engineers. ULg is the coordinator of the only Erasmus Mundus explicitly dedicated to raw materials (EMerald - Master in Georesources Engineering). With about 40 PhD students and research engineers, the GeMMe research group (ULg) will contribute to the development of innovative, sustainable and automated processes for an efficient management, characterization and processing of mineral resources.
Sandvik Mining	Sweden	To contribute in developing technologies and methods for exploration, underground and surface mining, comminution and processing. To provide energy efficient mining and comminution technologies towards sustainability.
RISE Research Institutes of Sweden AB	Sweden	To participate in joint research projects, large-scale pilot trials and other activities related to pyrometallurgy. Develop innovative platforms for cooperation between Primary resources industries, research institute and academia in the metallurgical field contributing to a holistic design and optimisation of an integrated metallurgical system.
Montanuniversitaet Leoben	Austria	Montanuniversitaet Leoben is a mining, metallurgical and material science oriented university working along the value chain from Primary and Secondary resources to materials and products; special competence is on projects in East and South East Europe; expertise will be provided to the consortium in the fields of surface an underground mining, processing, metallurgy, mineral economics and mineral policy issues.

Securing the supply of Primary resources, SecPRIME

Period to implement the commitment:

1 January, 2014 to 31 December, 2020

Financing:

Existing EU contribution: FP 7, Cohesion Policy Funds: European Regional Development Fund

Expected Impacts:

It is foreseen that the activities mentioned above will have the following impact: • Increased recovery of metals and minerals from depths below 500 • Reduced cost €/drillmeter for discovery of new deposits • More energy efficient exploration technologies • Better depth penetration of geophysical methods • By unlocking deeper deposits in the EU, increasing resource efficiency and by lower energy consumption by produced tonnes contribute to a lower import dependency at the same time as primary extraction in Europe will be more sustainable; • Create new jobs in mining and equipment manufacturing industries • Global leadership in areas of extraction concepts, technologies and related services; • Reduce both the environmental impact of mining and improve the social license to operate • Reduce energy and water consumption • Improve productivity in harvesting and significantly reduce the risk for soil disturbances from forest machines • Improved resource efficiency in mineral processing leading to decreased waste and turning waste into products • A global leadership in the area of raw materials processing technologies • Increased EU raw materials knowledge on available resources leading to an improved mineral intelligence in Europe • Maximised resources efficiency along the entire raw materials value chain • Increased number of highly qualified professionals in the raw materials sector.

Sources:

<https://ec.europa.eu/eip/raw-materials/en/content/securing-supply-primary-resources>.

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,

Objectives of the commitment:

Blue Atlantis will establish the world's only deep-sea mining test facility, covering RTD, mining tests, standards development and market access support. The consortium has 45 partners from 8 European countries along the entire value chain. Deep-sea mining has gone from a distant possibility to a likely reality within just a decade. There is a growing imperative for a better defined EU policy in this area. There are three good reasons why a deep-sea mining test in Europe would be important. First, securing raw materials for European industry, which depends on importing most strategic and critical metals, including: Co, Cu, Ga, Nb, Pt group metals, Ti, W, Zn, Au, Ag and Rare Earths. Second, Europe's leadership in advanced deep-sea technologies will be further enhanced on a global scale. Third, new education, skills and knowledge will be offered by universities and research centers.

Description of the activities:

The seafloor around the Azores Archipelago provides an ideal location as a deep-sea mining test facility in European waters. Analyses show that the Mid-Atlantic ridge system near the Azores hosts seafloor massive sulfides deposits. South of the Azores, between 36°N and 40°N, there are four known fields of hydrothermally active vents within the actual Portuguese EEZ on the Mid-Atlantic Ridge. Furthermore, there are manganese nodules and cobalt-rich crusts to be found within the Portuguese EEZ and extended continental shelf, which may be an additional source for deep-sea minerals. Blue Atlantis partners cover the entire deep-sea mining value chain with the following unique selling propositions: • Strategic European leadership • Strong industry partners with comprehensive marine mineral resource expertise • Strong innovation-orientation combining the technical, scientific, and logistic resources of major universities and marine RTD institutions. • Strong backing of national governments • Strong environmental credentials. Only non-active SMS-sites will be considered for the mining test • Expertise in risk assessment and standards development

Work Packages for a large-scale European Marine Mining Pilot Project: 1. Project management (Portuguese and German co-coordinators) 2. MetOcean studies 3. Environmental monitoring and assessment, incl. new technologies and early warning capacities during exploration, mining, and post-mining activities. 4. Exploration activities, especially of relevant non-active mining sites. Tools will include submersibles (AUV and ROV), high definition geophysical tools, thematic mapping, mineralogy and geochemistry as well as core drilling (e.g. with MeBo and Rockdrill). 5. Mining equipment development, including R&D projects and design activities related to: • Mining tools incl. shallow water tests • Intelligent detection supported by ROVs and AUVs • Buffer incl. seafloor massive sulphides storage and flexible pipe/tube • Airlift- and/or slurry pump systems • Riser concept incl. tailing dumping pipe (design, dimension, material) • Energy supply • Underwater communication • Design and concept for surface vessel and/or floating structure • Tailing processing unit onboard surface vessel, incl. in recirculation in greater depths • Systems control and monitoring center • Test on land (LAB) 6. Evaluation of the R&D preparation projects • Main mining components and tools • Modification and realisation of selected components and tools • Construction 7. Mining test preparation 8. Mining support and production vessel preparation 9. Mining test operation 10. Processing concepts and technologies for marine mineral resources 11. Standards and risk assessment Deep-sea mining is dependent on new technologies and processes developed in a highly competitive world market. For this reason, the test facility will be complemented by the systematic development of standards (e.g. environmental, safety, technology, etc.) as well as a comprehensive risk assessment analysis of all aspects of deep-sea mining and technology deployment. 12. Education and Training Programmes 13. Dialogue with Stakeholders, including with: • regulators (e.g. government agencies) tasked with such issues environmental, safety and other agencies) • policy makers from environmental, trade and resources areas • industry regarding the strategic interests of European industry), and • NGOs and societal groups on issues related to public perception and acceptance. A specific Working Group will be set-up to liaise with local governments in Portugal and the EU Institutions.

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,

Consortia members		
<i>Name</i>	<i>Country</i>	<i>Task</i>
Working Group Marine Mineral Resources; German Association for Marine Technology	Germany	
Konsortium Deutsche Meeresforschung e.V. (KDM)	Germany	To contribute to providing support functions to the participating research community and contribute to building relations with stakeholder communities, especially at the European level.
Bundesanstalt fuer Geowissenschaften und Rohstoffe (BGR)	Germany	Development and testing of new exploration methods (e.g., controlled source electromagnetic).
Fundacao da Faculdade de Ciencias da Universidade de Lisboa (FFCUL)	Portugal	Participation in exploration and site selection and characterization, partly for automated (robotized) mining. Specific contribution will be the study of ores and cover rocks in real time. Later in-house validation and complementing the field data with measurements not possible to perform during cruises. Another subject of participation will be a close cooperation regarding the coordination of portuguese activities and the especially those activities within the Portuguese EEZ.
IST – Instituto Superior Técnico; ISR - Institute for Systems and Robotics and CERENA - Center for Natural Resources and the Environment.	Portugal	1) ISR targets the development of cooperative marine robotic systems - with particular focus on Navigation and vehicle systems – optimized to substantially increase the efficacy of seafloor remote sensing operations for mining-related exploration and environmental impact assessment; 2) CERENA contributes with new mathematical and geostatistical methodologies for deepsea ore reserves and resource characterization in extreme environments, like deep and ultra-deep waters.
Laboratório Nacional de Energia e Geologia (LNEG)	Portugal	Participation in the site's exploration and contribution to field data acquisition: ores and igneous rocks textural and mineralogical studies; geological interpretation of sonar data and ROV imagery. Contribution to ore characterization through post-cruise analytical work, by obtainment total rock and mineral chemical analyses; mineral processing (flotation bench tests and pilot plant). Collaboration in the geophysical and geochemical data interpretation.
SPCN - Sociedade Portuguesa de Ciências Naturais	Portugal	To bring together a multidisciplinary group of experts (Physical, Geological, Biological oceanographers and Sustainability scientist), to work with the objective to enable application of available science and technology that allow resource use while protecting and preserve the marine environment and to promote the cooperation among explorers and between explorers and the scientific community and civil society. Field work in test sites of seafloor massive sulfides .
MARINTEK	Norway	MARINTEK's primary interest lies in the potential for innovation within Marine Operations, and potential for technology transfer and cross-pollination between offshore oil&gas operations and marine mining operations. However, the challenges inherent in marine mining will

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
		require new knowledge and tools which can only be rationally answered by research and development. Marintek will contribute to WP 2, 3, 5 and 6.
SINTEF	Norway	As a research institute with extensive experience with offshore/subsea oil & gas production, our role is to generate research based innovation solutions on subsea mining processes, automatization of them, transport solutions, and the development of robust equipment based on advanced materials science and design solutions. On top of our agenda will be to utilize our marine environmental technology competence base for securing environmental sustainability.
Norwegian University of Science and Technology (NTNU)	Norway	NTNU has in cooperation with Statoil and Nordic Ocean Resources recently finalized a project to establish the potential of seabed mineral resources in Norway. A special focus was the massive sulfide mineralization along the Mid-Atlantic Ridge. NTNU would like to contribute to several of the proposed work packages and can offer substantial experience and expertise in the fields of exploration, marine engineering, marine operations and resource evaluation.
CGB - Centre for Geobiology, University of Bergen	Norway	Taking part on seafloor exploration through acoustics, hydrothermal plume detection, seafloor mapping and site characterization. Contributing to the regional and global understanding of seafloor massive sulphides genesis, using geochemical and isotope data. Assessing potential impact of seabed mining via plume dispersal studies, in-situ experiments on seafloor weathering of newly exposed sulfide surfaces and possible release of toxic elements into the water column.
University of Southampton	United Kingdom	Role within the commitment: Scientific research partner. Ore deposit formation, resource/reserve evaluation, sub-surface exploration, environmental impact, engineering, biosphere and ecosystem impacts, seafloor mining and extraction engineering sciences and the environmental impact of engineered systems.
Natural Environment Research Council (NERC)	United Kingdom	The NERC partnership will bring research into resource validation and assessment, environmental impacts, sustainability of exploitation, and renewable and low carbon mineral production. We will do this through the deployment of 3 man years of research scientist staff time, deploying one of our ocean research vessels with AUV and ROV operations, seafloor drilling rig and wire-line logging, and on shore geochemical and biology laboratories.
Lloyd's Register EMEA	Germany	To ensure that the entire supply chain is safe, responsible and sustainable by securing high technical standards of design, manufacture, construction, maintenance, operations and performance.
Soil Machine Dynamics Ltd. (SMD)	United Kingdom	Direct involvement in some work packages (WP 3, 5, 6, 7, 8, 9, 10 and 12) – assistance and advice in others – contact for multiple offshore operators that have relevant base knowledge that is not in the public domain.

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
Sandvik Mining and Construction G.m.b.H.	Austria	Depending on the finally available partners either the development of a sub-sea mining cutting system or of a sub-sea mining base machine unit focusing on mining massive polysulfide and alternatively on mining manganese nodules and manganese crusts. The idea is to develop a multipurpose machine which can either be generally used for mining one of the above mentioned types of submarine ore deposits or it can easily and quickly adapted for it.
Jan De Nul N.V. (JDN)	Belgium	JDN's decade long experience in dredging projects has resulted in a continuous evaluation, adaptation and improvement of equipment and techniques. All these techniques - cutting, fluidisation, hydraulic transport and dewatering of solid material - are applicable to marine minerals mining. Experience with the general aspects related to mass transport in marine environment and working at sea are primary inputs in a successful pilot test.
Technische Universität Clausthal	Germany	Innovative extraction of Raw Materials.
MBT GmbH	Germany	MBT is focused on oceanographic, marine geophysical and hydrographic sensor integration, underwater infrastructure technologies such as cable and connector systems including the design of high-speed broadband data telemetry system based on FO-technology. In addition, MBT is involved in the design of swell compensation for launch and recovery systems. Another focus area is data management solutions for marine environmental monitoring systems.
EDM - Empresa de Desenvolvimento Mineiro, S.A	Portugal	Evaluation of the interaction, between environment, mining strategy and technical definition. The basic exploitation scenario will be evaluated. The studies will form a reliable basis for performance predictions and the estimation of mining costs. A profitability analysis will be carried out. Participation in the geological, geophysical and geochemical exploration surveys.
GEOMAR, Helmholtz Centre for Ocean Research, Kiel	Germany	Resource identification and characterization; environmental baseline studies; resource modelling, including numerical modelling fluid flow for exploration targeting; geological mapping, structural analysis, axis and off-axis settings; target definition including ROV mapping and sampling; resource characterization, including geometallurgical studies, physical rock properties studies; drilling and "reserve" estimation; ore characterization for geotechnical applications
ENITECH Energietechnik - Elektronik GmbH	Germany	ENITECH is specializes in supplying fluid free pressure tolerant systems. The new technology protects the electronic components with specially elastomer molds. We provide compact, lightweight, robust, and cost-effective components for diving depths of up to 6,000 m. - electric underwater drives - Power electronics, DC / DC converter - Power supply systems, Li-Po battery systems - Control systems
DNV GL	Germany	DNV GL envisions a commitment to perform Classification, Certification, and Advisory Services in the form of management system verification, environmental assessments, feasibility studies, Approval in Principle of underwater vehicles and mining tool concepts

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
		prior to detail design, support vessel integration, safety analysis, development of the mining standard, and training services with respect to Work Packages: 3, 4, 5, 6, 8, 11 and 12.
RWTH Aachen University, Institute of Mining Engineering	Germany	WP4: Within the exploration stage of any mining project feasibility studies including economic feasibility (based on Cash Flow Models and expressed in Net Present Value (NPV), Internal Rate of Return (IRR) and other economic indicators) are a key aspect. WP12: BBK I plans to develop a pilot course "Planning of Deep Sea Mining Projects" to be included in the existing MSc program "Mineral Resources Engineering" at RWTH Aachen University.
Aker Solutions GmbH	Germany	Aker Solutions will participate in the proposed project with main focus on the interface components for riser system for vertical transport of cuttings from the offshore mining process. Among the main interfaces are joint connections at topside level and buffer systems at sea bed level integrated to ensure a continuous feeding of the mining system.
Helmholtz Center Dresden Rossendorf / Helmholtz Institute Freiberg for Resource Technology	Germany	Contribution to WP10 "Processing concept and technology for marine mineral resources" with the development of new processing schemes/concepts and applying new technologies.
DFKI GmbH, RIC – Robotics Innovation Center, Bremen	Germany	Research partner, focus on Artificial Intelligence, mobile autonomous robotic systems, software frameworks (e.g. navigation, mapping, control, MMI). Contribution from WP3 to WP10 and WP13. Provision of test infrastructure for underwater vehicles as well subsystems. Provision of submersible autonomous robotic testing platforms. Development of mobile, intelligent underwater robotic and subsystems.
BAUER Maschinen GmbH	Germany	A fast and reliable geotechnical characterization and mineral assessment of the seafloor is mandatory. For this purpose, BAUER aims at upgrading its seabed drilling rig MeBo200 with new geophysical measurement methods in order to provide an exploration engine for seafloor massive sulphides deposits able to gather information regarding the extension and properties of the seafloor massive sulphides sediments directly during the deployment of the drill rig.
EvoLogics GmbH	Germany	<ul style="list-style-type: none"> • Wireless UW Communion, Navigation & Monitoring Network, acoustic ultra-broadband telemetry with integrated UW-GPS, LBL & USBL functionality • New techniques for quality and quantity assessments of raw materials: high resolution sub-bottom profiler with acoustic spectral analyses, Neutron Impulse Technique • Bionic robots – AUV "Task Force" for survey, inspection and environmental monitoring • System improvement for serial production
Fraunhofer IOSB	Germany	Under the umbrella of Fraunhofer IOSB several Fraunhofer institutes will contribute to this EIP in the field of maritime technologies, such as <ul style="list-style-type: none"> • Fraunhofer IGD: Maritime graphics • Fraunhofer IOSB: Autonomous and remotely operated underwater vehicles, exploration, inspection, vehicle guidance as well as underwater vision. Furthermore, other

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
		Fraunhofer institutes which deal with acoustic sensors, materials, production and process engineering can contribute to this EIP (e.g. Fraunhofer UMSICHT and IBMT).
ATLAS MARIDAN Aps	Denmark	R&D deep diving 6.000m AUV, long endurance system, new sonars and new sensors, system structure design, realisation easy-quick battery change, precise deep sea navigation, compact LARS, real environment tests, partner in pilot mining testphase.
KGHM Polska Miedz S.A.	Poland	Partner's role is focused on idea (concept) and implementation (e.g. prototype construction) of high-energetic jetting technologies for machining and/or output collecting, having in mind it's advantages, e.g. minimization of complicated mechanisms in hard to reach work conditions, and positive aspects of environmentally friendly technology.
University of Szczecin	Poland	.- Complex mineralogical and geochemical polymetallicore/sediment description. - Mining impact on a seabed environment. - Metals transport/remobilization within water and nearby sediments caused mining processes. Sediment contamination. - Geomodelling and metal resources estimations using geostatistical methods. - Complex geological data acquisition and processing (seismo-acoustics, drilling logs). - Preparation of educational/training courses concerning necessity of marine mining.
University of Wrocław, Dept. Applied Geology and Geochemistry	Poland	Stable isotopic studies on ore-forming processes, mass balances, contamination and environmental variations. Legal and business aspects of exploration and exploitation activities.
Maritime University of Szczecin (MUS)	Poland	Deliver the knowledge on offshore technology. MUS is research ship Navigator XXI owner. The ship could be applied for preliminary and monitoring researches.
Estrutura de Missão para a Extensão da Plataforma Continental (EMEPC)	Portugal	The EMEPC will contribute to the exploration effort to find the suitable places on the oceanic floor to develop a pilot plant and to monitor the marine environment during pilot mining. The EMEPC will take advantage of the operational capabilities at sea, which were acquired through the development of the Luso ROV (rated to 6000 m below sea level).
IDL- Instituto Dom Luiz	Portugal	Participation in the geological/geophysical surveying sustaining the evaluation and selection of key target areas. Specific contribution will include combine interpretation of available (and to be acquired) geophysical data (e.g. swath bathymetry, reflection seismics, back-scatter) to produce detailed morphotectonic maps, conveying a specific structural insight of key problems for a better assessment of the regional/local geotectonic setting.
IMAR - Instituto do Mar	Portugal	The operation of the regional research vessel and the use of the University of the Azores, Campus of Horta, infrastructures is secure through the commitment of IMAR. The permanent team existing in Campus of Horta will also be devoted the fulfillment of the objectives of Atlantis.
FEUP – Faculdade de Engenharia da	Portugal	The role of FEUP relies on i) LSTS (http://lsts.fe.up.pt) that targets the development of robotic systems requiring navigation, sensing, and

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
Universidade do Porto		cooperative control to enable a effective presence in remote, hostile locations to support sustainable mining operations; ii) CIGAR (http://paginas.fe.up.pt/~cigar) with application of ore processing and hydrometallurgy to the recover metals from massif poly-metallic sulphides, cobalt crusts and nodules.
Instituto Português do Mar e da Atmosfera (IPMA)	Portugal	Develop studies on the distribution, origin and composition of metallic and nonmetallic mineral resources and environmental impact of their exploitation. IPMA can contribute with expertise for the: coordination of exploration surveys in the Legal Platform of Portugal (LPP); coordination of the marine database of raw materials resources in the LPP; study of the ferromanganese and sulphide deposits within the LPP.
Universidade de Aveiro	Portugal	Application of geophysical methods for massive sulphide exploration, and development of new/modified geophysical tools/technologies; geological site evaluation and characterization of the mineralizations structural control;habitat mapping with high resolution multibeam/backscatter, side-scan sonar, high resolution seismic methods and biological studies; studies for the use of the non-metalic component of the deposit for industrial use.
University of Evora/Hercules Laboratory	Portugal	Hercules 2014 updated research facility can offer high quality analytical data. The capabilities are focused in micro-analytical techniques and can deliver useful information on phase, major and trace chemical composition in small volumes. The distribution of phases and elements can be ascertained by mapping. This knowledge is essential to estimate the economic value of raw materials and marine resources and to create accurate exploration models.
Nautilus Minerals Inc.	Canada	The main activities of Nautilus Minerals will include exploration and extraction. Exploration will be aimed specifically at finding on any European tenements granted to the Nautilus. Nautilus currently has several such prospecting licences applications in the EEZ of Portugal, surrounding the Azores Islands. Nautilus Minerals currently procures significant engineering and fabrication services from within the European Union.
Harren & Partner Ship Management GmbH & Co. KG	Germany	Harren & Partner, well-established shipping company (55 vessels), fills the role as maritime logistics partner within the marine mining value chain. We have profound knowledge in ship-building, ship-conversions as well as marine offshore operations and overland transport projects. As partner of Nautilus Minerals we made significant contributions to the navel design of a Mining Support & Production Vessel (MSV). We are ready to design, construct, manage and operate a MSV.
Fugro EMU Limited	United Kingdom	Fugro Group is currently actively involved in R&D to provide environmental survey, monitoring and EIA for deep sea resource exploration as part of the MIDAS and other UK funded projects. Within the EIP, Fugro will build on this knowledge, further developing acoustic and optical sensors, increasing AUV capabilities, improving the efficacy of environmental survey and monitoring, and supporting

Innovative Mining of Marine Mineral Resources – A European Pilot Mining Test in the Atlantic on Tools, Facilities, Operations and Concepts,		
		the development of robust policy and legislation.
The consortium has strong links to the recent European FP7 R&D projects MIDAS and Blue Mining		
Period to implement the commitment:		
1 April, 2015 to 31 March, 2020		
Financing:		
Existing EU contribution: FP 7		
Expected Impacts:		
<p>Blue Atlantis will cement Europe's expertise for the whole deep-sea mining added value chain. With respect to the existing SMS-deposits in the EEZ of the Azores, the aim is to create marine mining test structures which are strongly linked to the proposed work packages. In addition to the mining test structure, the consortium proposes the preparation and implementation of a conceptual study for large scale facilities for deep-sea mining. In cooperation with industry, research and government communities, all relevant aspects of the value chain should be addressed in a pilot mining operation. Blue Atlantis will cover inter alia the following key areas:</p> <ul style="list-style-type: none"> • geophysical exploration using new or modified tools and technologies • Development of robotic tools for mineral exploration • geological, mineralogical and geochemical evaluation, site selection and resource definition by drilling • environmental and biological characterisation, baseline collection and monitoring • development and testing of seafloor mining tools, lift and riser system • development and testing of robotic tools to support monitoring, infrastructure maintenance and sustainable mining operations • design studies of MSV • „at sea“ pretreatment of ore, transportation issues, port facilities • financing, economic models, and market impact • preparation of UNCLOS implementation under national legislation • legal requirements and fiscal impact • public outreach and public awareness/ acceptance. 		
Sources:		
https://ec.europa.eu/eip/raw-materials/en/content/innovative-mining-marine-mineral-resources-%E2%80%93-european-pilot-mining-test-atlantic-tools .		

Breakthrough Solutions for Seafloor Mineral Extraction and Processing in deep water environment, SeaFlores

Objectives of the commitment:

Scientific explorations from the past decades have identified several types of seafloor mineral deposits including seafloor massive sulphides. In Europe, Azores and Wallis and Futuna are shown to have the potential to contain seafloor massive sulphides ores. To enable commercial deep sea mining socially and environmentally acceptable, technologically achievable and economically viable methods need to be developed. The key innovation in this project is the generic design and in-situ demonstration activities of a cost-efficient and environmentally-acceptable deep-sea mining pilot system. This project is complementary with ALBATROSS deep-sea exploration project led by Eramet. Technology developed in this project will also reinforce Europe's ambitions to be active in exploration areas outside Europe, thus increasing access to Raw Materials via new mining solutions and decreasing EU dependency on resource imports.

Description of the activities:

SeaFlores activities will consist of three different phases: • Phase 1: Definition of mineral processing route and Feasibility study (FS) of the deep sea mining pilot, • Phase 2: Pilot Plant detailed design, manufacturing and deployment on the basis of the FS results, • Phase 3: Offshore demonstration activities in-situ. It must be pointed out that Phase 1 can be covered by upcoming Horizon 2020 topic "SC5-11-2014/2015: New solutions for sustainable production of Raw Materials, item c) Deep mining on continent and in sea-bed" where the emphasis is on developing new highly-automated technological sustainable solutions for deep mining in the sea bed in-situ and proving the concept and feasibility at the level of TRL 5-6. Activities described hereafter corresponds to this first phase (only). The process designed to pre-concentrate the Copper / Zinc sulphides shall consider the variability of the ore. Depending on the mineral composition, the process shall be robust enough to remain stable through the changes or be stabilized up front by premixing ore feed. The initial data required in process design can be most reliably obtained from a pilot study. GTK's pilot plant includes a versatile selection of equipment for all unit processes. As each aspect of beneficiation is optimized, it is incorporated into an efficient overall process. Campaign results at pilot scale are typically sufficient to give an accurate idea of the concentration process yield and economic performance at full scale. Complex sulphide ores contain more than one single valuable metal sulphide mineral each to be separated into its own individual concentrate. Generally, the ore is ground in two stages after which the ground pulp is subjected to conditioning followed by individual flotation stages to produce different concentrates that are then dewatered to optimum transport moisture. Outotec will provide the consortium with complete mineral processing solutions as Outotec has the expertise and capability for designing, supplying, and constructing mineral processing plant. In order to achieve a viable, environmentally sound and cost-efficient technological solution, a FS will be performed to better define and optimize the mining pilot layout, topsides and associated subsea systems and methods including but not limited to: • Vertical mining method, • Free-flying mining method, • Seabed based crushing and regulation unit, • Riser and lifting method, • Equipment launch and recovery method on surface, • Ore Transhipment method from the mining ship to the ore carrier, • The environmental impact assessment using "swarm" of AUVs for the real-time collection and synthesis of all data recovered during mining at sea. The objective is to compare various design options, evaluate each of them against a number of technical, ecological and economic criteria and, finally, select the most feasible pilot layout. Environmental management plan that includes preliminary EIA and risk management strategy will be delivered by Heriot-Watt. The aim will be to propose guidelines for the realization of the environmental baseline and the Environmental Impact Assessment and to compare them to the existing international regulations including the UNCLOS, and relevant institutions such as the ISA.

Consortia members

Breakthrough Solutions for Seafloor Mineral Extraction and Processing in deep water environment, SeaFlores		
Name	Country	Task
Technip	France	Consortium leading entity will be Technip France. Technip will perform the complete multidiscipline interfaces management and coordination. After determination of the key technical parameters, Technip will also design the Riser and Lifting System. The objectives of these studies are to confirm the technical feasibility of a riser and lifting method and define the most proper seafloor massive sulphides pumping system for the generic field development.
ERAMET SA	France	ERAMET SA is involved in seafloor massive sulphides Exploration project in Wallis and Futuna as leader of the EIP project proposed as "ALBATROSS". ERAMET will ensure that all information useful for SeaFlores can be collected during exploration campaigns and is effectively communicated. ERAMET intends to participate to the specification phase, to build the business plan and to validate the industrial solution as final operator of the pilot.
IFREMER	France	Ifremer will bring here its scientific knowledge of the processes for assessing: i) the characteristics of the potential sites; ii) the engineering properties; iii) the protocols for environmental assessment of potential exploitation. Ifremer propose to study new developments in autonomous sensing with fix and mobile autonomous or supervised platforms for environmental survey and monitoring, during drilling and production phases.
OUTOTEC	Finland	Partner, technology provider for mineral processing. Outotec will provide its industrial expertise in mineral processing (crushing and grinding, flotation, thickening and clarifying, filtering), process control and automation. Outotec's analytical and mineral processing laboratories are utilized as well as GTK's (Geological Survey of Finland) pilot facilities.
DCNS	France	DCNS will design, qualify and operate a long-term monitoring system. The system features a swarm of several AUV with high endurance. The number of AUVs to be deployed at sea will be adapted to the area to be monitored. The system will eventually mix DCNS' designed AUVs and any other-designed AUVs. The operation of the swarm will be performed from a dedicated command & control system for the synthesis of all the data collected.
Geological Survey of Finland (GTK)	Finland	GTK will concentrate on the development of beneficiation technologies for deep sea ores in cooperation with Outotec. GTK Mintec's research includes everything from mineralogical research and laboratory-scale beneficiation tests to continuous test runs at the pilot-scale.
Seatools B.V.	The Netherlands	Design and manufacturing of Subsea Equipment.
Kenz Figeo Group	The Netherlands	Design and manufacturing of Launch and Recovery System.
C Spencer Ltd	United Kingdom	Design and manufacturing services related to the installed sub sea mined material recovery equipment, particularly those areas

Breakthrough Solutions for Seafloor Mineral Extraction and Processing in deep water environment, SeaFlores		
		governing fluid management, valuing design and wear predictions.
BAUER Maschinen GmbH / Industrial	Germany	The role of BAUER Maschinen in this project is to design a cutting head able to penetrate and break the deposit that will operate under deep-sea conditions. Because of the very high pressure, a more ductile behaviour of the rock is expected and will influence the cutting head design. Bauer's task also involves the design of a pressure appliance system, a frame able to work under deep-sea conditions that maintains the breaking conditions and the progression speed into the deposit and that support all subparts of the mining system.
MMD Mineral Sizing (Europe) Ltd.	United Kingdom	MMD Mineral Sizing (Europe) Ltd. is part of the UK-based MMD Group of Companies which is specialized in the design and manufacture of mineral sizing (crushing) equipment. MMD has been involved with the subsea mining project in partnership with Technip as well as other entities for the last few years during which research and development work has been carried out to evaluate sizer crushing performance in conditions similar to those found in deep sea.
Heriot-Watt University	United Kingdom	The role will be to evaluate the potential environmental impact generated by the Pilot. Minimizing this impact is a critical component of this project and the evaluation of the impact will follow the different development steps of the Feasibility Study. For each component of the mining activity, environmental impact criteria will be investigated in order to qualify and quantify the potential responses of biotic structures and functions.
Period to implement the commitment: No known		
Financing: No existing EU contribution		
Expected Impacts: Significantly improve Europe's and also global marine resource base by unlocking deeper deposits in the EU, global sea-bed deposits using tested and evaluated innovative technologies. One of the pillars of the EU raw materials policy is to increase the attention to raw materials sources in Europe. A marine mining pilot-project would be a substantial contribution to ensuring a coherent approach to Horizon 2020 Blue Growth. Create numerous new jobs in mining and equipment manufacturing industries in many regions of the EU, including remote and coastal areas. Many countries do not have economic deposits of base and precious metals on land. Mining and processing seafloor massive sulphides deposits would provide these countries with a degree of self-sufficiency, lessening the need to import supplies of metals. Push Europe to the forefront in the areas of extraction concepts, technologies and related services. Participation of major European mining players and several European technology providers ensures the efficient use of the project results. Therefore a sharing of issues will enable to elaborate a common solution that automatically will be less expensive and time saving for all. Reduce both the environmental impact of the mine operation and the risks to the population and natural life caused by potential failures. Environmental and social impacts still need to be properly assessed. For some environmental aspects, subsea mining will clearly be less harmful than corresponding land mining (less area disturbed, no overburden, less residues...). Reduce energy and water consumption by the reduction of the volume of materials to be extracted from the mine. New opportunities will arise to incorporate energy efficient processes in the FS and minimise waste and emission to reduce the risk of polluting incidents.		
Sources:		

**Breakthrough Solutions for Seafloor Mineral Extraction and Processing in deep water environment,
SeaFlores**

<https://ec.europa.eu/eip/raw-materials/en/content/breakthrough-solutions-seafloor-mineral-extraction-and-processing-deep-water-environment>.

Objectives of the commitment:

The 3DS European Mineral Asset Definition and Valuation System (EUROASSET) will be developed to overcome the barriers that currently constrain the European Mineral Sector and which the SIP developed by the EIP is designed to break down. In general terms these are: Lack of Unified Data Model Diversity of evaluation and analysis techniques, lack of centralised system to evaluate existing datasets through the EU Dependence on specialist skills, lack of integration with downstream activities in the minerals sector (e.g mineral processing, manufacturing, recycling, etc.), the inability to alleviate non-technical perceptions and opinions and no reliable mechanism for economic and risk evaluations.

Through its unique material life-cycle simulation approach, 3DS is well placed to provide a platform that will address these issues on any scale. At present, 3DS already provides modelling and analysis tools to individual clients on an industry-based portfolio of products and the objective of drawing on EU support will be to provide a platform that harmonizes the data sets and technology that is already synonymous with best practice for the delimitation and evaluation of raw material resources.

Description of the activities:

GEOVIA EUROASSET proposes to facilitate the formation of a globally accepted unified data model for the storage and sharing of all spatial data related to raw materials. This would underpin a system we also propose to develop, of rapid deposit modelling and economic analysis tools, coupled with a rich visualisation client for visually engaging and effective communication of the results. This unified system of geological resource evaluation and visualisation will be developed on three key initiatives; 1. Data Model, Data Storage, Connectivity and Presentation At the heart of any software solution is the data model. GEOVIA proposes to facilitate the creation and global acceptance of a unified data model for spatial data relating to Raw Materials. We will create a centralised system (or 3DGeodatabase) to store data and provide connections to external data sources and locations. This 3DGeodatabase will understand the multitude of file formats across any external sources of different spatial configurations. This can be done by offering both a centralised repository to store this data, or by offering a connection to an external data source from the central repository. The connection could be live or it could be an as-requested pull of information. Once the data has been drawn from the connection it would be converted on the fly as it was delivered to and utilised by the user. The data from the centralised 3D Geodatabase would be accessed by a rich data viewer capable of multi-scale 3D interactive viewing of the information from the highest aerial view down to first person. The viewer would have a sophisticated graphics edge over existing technologies, offering realistic animation, textures and lighting. Controls and interaction with the viewer would be secure and confidentiality ensured by means of password and login credentials for secure data. 2. Rapid Exploratory Modelling of Raw Material Deposits. GEOVIA will deliver an implicit modelling solution that is applicable to a broad range of Raw Material deposit types, including massive type deposits, stratigraphic and also vein hosted deposits. The time savings gained when using these automated methods would allow more widespread and rapid understanding of all new exploration information. This system would be delivered in a manner which provided flexibility in its delivery platform. It could be made available as a traditional installable software package, which would take advantage of the processing power of dedicated machines. This would enable larger companies who frequently engage in exploration work to buy more powerful machines and make best use of those resources. Alternatively the modelling system could also be deployed online, enabling those with smaller budgets access to the same leading edge tools as others, but in a pay-as-you-go model. This could also provide the opportunity to have centrally hosted data storage, and could potentially open up a market for data sharing and re-sale. 3. Rapid Economic Analysis of Raw Material Deposits Once rapid exploratory modelling has been completed, the resulting geological model can be analysed using an economic analysis tool, which would calculate the NPV of the deposit to provide an indication of the feasibility of extracting it. This system would also be available in the same delivery models as the rapid modelling system – both as an installable product or an online model with the same benefits as previously described.

3DS European Mineral Asset Definition and Valuation System, EUROASSET		
Consortia members		
Name	Country	Task
Dassault Systemes GEOVIA Ltd	United Kingdom	Coordination.
Dassault Systemes SA	France	Dassault Systèmes S.A. is a French company that specializes in the production of 3D design software, 3D digital mock-up and product lifecycle management solutions. The role of Dassault Systemes SA will be to leverage facilities and technologies from its global infrastructure to support the GEOVIA brand develop the proposed solution. This will involve making available additional development personnel and assisting in international collaboration and non-technology activities.
BRGM, The French Geological Survey	France	Provision of access to public, existing, digital geoscientific metadata/ data sets for the French territory we are owning; - 2D – 3D geoscientific (i.e. geological, geophysical, geochemical, geostatistical) data modelling, including integrated data modelling; - Geoscientific data quality control; - Development of geoscientific metadata/ data interoperability schemes, of data models; - Development of geoscientific thesauri and of multilingual access to data/ metadata - Development of methods and tools for creating 3D models.
Delft University of Technology	The Netherlands	TU Delft will provide selected research and testing support for the project as well as international collaboration to ensure that leading edge technology and processes are built into the project solution.
British Gypsum PLC UK	United Kingdom	British Gypsum will make available its facilities and sites to demonstrate the outputs of the project and assist with international collaboration.
EDMA Innova, S.L.	Spain	EDMA will leverage its experience of administering and managing EU R&D projects as well as helping to develop complementary technology aimed at making the project platforms accessible to the wider community in Europe.
Period to implement the commitment: 1 January, 2015 to 31 December, 2018		
Financing: No existing EU contribution		
Expected Impacts: The expected impacts are 1. To enable rapid early stage assessments of mining assets of all depositional environments. 2. Provide a consistent tool and approach too deposit evaluation and economic assessment which will allow for the comparative analysis between deposits to be more meaningful. 3. Allow for an iterative modelling process which currently does not exist. 4. Supply a system with live data connections providing instantaneous updates. 5. Deliver an online marketplace for the sharing and re-use of exploration data; 6. Create a solution which is accessible to all levels of budgets.		
Sources: https://ec.europa.eu/eip/raw-materials/en/content/3ds-european-mineral-asset-definition-and-valuation-system .		

References

Literature

Actu-environment (2012) : Vers une exploitation minière des grands fonds marins, <http://www.actu-environnement.com/ae/news/exploitation-miniére-fonds-marins-ifremer-permis-16321.php4>.

Atmanand, Director National Institute of Ocean Technology (2011): Presentation on Status of India's Polymetallic Nodule Mining Programme, ISOPE-2011 Maui Conference, <http://www.deepoceanmining.org/docs/atmanand.pdf>.

Diamond Fields (2010): Joint Venture Company Granted Mining License over World Class Zinc, Copper, Silver and Gold Project. *DFI News Release*, http://www.diamondfields.com/s/NewsReleases.asp?ReportID=403052&_Type=News-Releases&_Title=Diamond-Fields-Joint-Venture-Company-Granted-Mining-License-over-World-Clas.

Diamond Fields (2011): D.F.I.'s Red Sea Silver/Zinc/Copper Polymetallic Deposit Becomes First Marine Sedex in History to have Third Party National Instrument 43-101 Resource Report Completed. *DFI News Release*,, http://www.diamondfields.com/s/NewsReleases.asp?ReportID=468610&_Type=News-Releases&_Title=D.F.Is-Red-Sea-SilverZincCopper-Polymetallic-Deposit-Becomes-First-Marine-S.

Diamond Fiels (2011): Survey Ship Begins Work on Diamond Fields' Atlantis II JV Mining License. *DFI News Release*, http://www.diamondfields.com/s/NewsReleases.asp?ReportID=442386&_Type=News-Releases&_Title=Survey-Ship-Begins-Work-on-Diamond-Fields-Atlantis-II-JV-Mining-License.

Diamond Fields (2011): Updated NI 43-101 Resource Estimate for Atlantis II Deposit to Include Manganese Values. *DFI News Release*, http://www.diamondfields.com/s/NewsReleases.asp?ReportID=488267&_Type=News-Releases&_Title=Updated-NI-43-101-Resource-Estimate-for-Atlantis-II-Deposit-to-Include-Mang.

Diamond Fields (2014): Diamond Fields in Dispute with Red Sea Joint Venture Partner. *DFI News Release*, http://www.diamondfields.com/s/NewsReleases.asp?ReportID=621783&_Type=News-Releases&_Title=Diamond-Fields-in-Dispute-with-Red-Sea-Joint-Venture-Partner.

Egorov L., Elostá H., Kudla N. L. , Shan S, Yang K.K. . (2012): Sustainable Seabed Mining: Guidelines and a new concept for Atlantis II Deep, The LRET Collegium 2012 Series, Volume 4.

Eugenio, H.V. (2014): Sitting on a gold mine, CNMI may have gold, silver, oil deposits waiting to be explored, <http://www.saipantribune.com/index.php/sitting-gold-mine/>.

Hegedus N., D'Elia, P., Sloan M., (2010): Seafloor Mining of Massive Sulfide Deposits.

Herzig, P.M, Plüger W. L. (1988): Exploration for hydrothermal activity near the Rodriguez triple junction, Indian Ocean, *Canadian Mineralogist*, Vol.26, pp. 721-736.

ISA (n.d.): G-TEC Sea Mineral Resources NV (GSR) of Belgium signs exploration contract, <http://www.isa.org.jm/en/node/801>.

ISA (2010): A Geological Model of Polymetallic Nodule Deposits in the Clarion-Clipperton Fracture Zone, <http://www.isa.org.jm/files/documents/EN/Pubs/GeoMod-web.pdf>.

ISA (2010): Proposal to seek an advisory opinion from the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea on matters regarding sponsoring State responsibility and liability, <http://www.isa.org.jm/files/documents/EN/16Sess/Council/ISBA-16C-6.pdf>.

ISA (2011a). Report and recommendations to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the China Ocean Mineral Resources Research and Development Association. 17th Council

Session Kingston, Jamaica 11th – 22nd July 2011:

<http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-11.pdf>.

ISA (2011b). Report and recommendations to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the Government of the Russian Federation. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011: <http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-12.pdf>.

ISA (2011c). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by Tonga Offshore Mining Limited. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011: <http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-10.pdf>.

ISA (2011d). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration by Nauru Ocean Resources Inc. 17th Council Session Kingston, Jamaica 11th – 22nd July 2011: <http://www.isa.org.jm/files/documents/EN/17Sess/Council/ISBA-17C-9.pdf>

ISA (2012a). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by Marawa Research and Exploration Ltd. 18th Council Session Kingston, Jamaica 9th-27th July 2012:

<http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-18.pdf>.

ISA (2012b). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by UK Seabed Resources Ltd. 18th Council Session Kingston, Jamaica 9th-27th July 2012: <http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-17.pdf>.

ISA (2012c). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by G TEC Sea Mineral Resources NV. 18th Council Session Kingston, Jamaica 9th-27th July 2012:

<http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-19.pdf>.

ISA (2012d). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for approval of a plan of work for exploration for polymetallic sulphides by the Institut français de recherche pour l'exploitation de la mer. 18th Council Session Kingston, Jamaica 9th-27th July 2012:

<http://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-16.pdf>.

ISA (2014a). International Seabed Authority website

<http://www.isa.org.jm/en/scientific/exploration/contractors>. [accessed 1/5/2014].

ISA (2014b). Report and recommendations to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration by Ocean Mineral Singapore Pte Ltd. 20th Council Session Kingston, Jamaica 7-25 July 2014:

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-7.pdf>.

ISA (2014c). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by UK Seabed Resources Ltd. 20th Council Session Kingston, Jamaica 7-25 July 2014: <http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-7.pdf>.

ISA (2014d). Application for approval of a plan of work for exploration for cobalt-rich ferromanganese crusts by the Companhia de Pesquisa de Recursos Minerais S.A. 20th Council Session Kingston, Jamaica 7-25 July 2014:

<http://www.isa.org.jm/files/documents/EN/20Sess/LTC/ISBA-20LTC-2.pdf>.

ISA (2014e). Report and recommendations of the Legal and Technical Commission to the Council of the International Seabed Authority relating to an application for the approval of a plan of work for exploration for polymetallic nodules by the Cook Islands Investment Corporation. 20th Council Session Kingston, Jamaica 7-25 July 2014:

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-18.pdf>.

ISA (2014f): Application for approval of a plan of work for exploration for polymetallic nodules by the Cook Islands Investment Corporation, Executive summary, <http://www.isa.org.jm/files/documents/EN/20Sess/LTC/ISBA-20LTC-3.pdf>;

.

=

Kamiya, N. (2014): Japan's Work of Cobalt Rich Crusts Exploration and Technology Development, <http://www.isa.org.jm/files/documents/EN/Seminars/2014/NatsumiNYC.pdf>.

Kotlinski, R. et al. (2003): Relationships between nodule genesis and topography in the Eastern area of the C-C region, http://www.iom.gov.pl/uploads/iom_attachment-95635.pdf.

Lipton, I (Golder Associates). (2012): Mineral Resource Estimate. Solwara Project, Bismarck Sea, Papua New Guinea. Technical Report compiled under NI43-101. 23 March 2012.

Lockheed Martin (2013): Lockheed Martin seabed mining venture set to explore Pacific, The Engineer, <http://www.theengineer.co.uk/channels/policy-and-business/lockheed-martin-seabed-mining-venture-set-to-explore-pacific/1015815.article>.

Lockheed Martin (2013): UK Government sponsors Lockheed Martin UK subsidiary for licence to harvest Polymetallic Nodules, Press release, <http://www.lockheedmartin.co.uk/uk/news/press-releases/2013-press-releases/uk-government-sponsors-lockheed-martin-uk-subsiary-for-licence.html>.

Lowe, J. (2013): Nautilus Minerals, Global Vision, http://www.economistasmadeira.org/files/Apresentacoes%20CAT/Apresentacoes%20CAT%20VII/3-NautilusMinerals_Madeira__Lowe_20130503.pptx.

Ministry for the Environment, New Zealand (2007): Improving Regulation of Environmental Effects in New Zealand's Exclusive Economic Zone: Discussion Paper, www.mfe.govt.nz/publications/oceans/nz-exclusive-economic-zone-discussion-paper-aug07/html/page4.html

Nautilus Minerals Inc. (2007): "Prospecting License Applications Lodged in Tonga and Fiji, Nautilus Press Release No. 2007-02. 8 January 2007.

Nautilus Minerals Inc. (2007): Nautilus Launches World's Largest Commercial Exploration Program For High Grade Seafloor Massive Sulphide Systems, Nautilus News Release Number 2007-10, 21 March 2007. http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=177849&_Type=News-Releases&_Title=Nautilus-Launches-Worlds-Largest-Commercial-Exploration-Program-For-High-Gr.

Nautilus Minerals Inc. (2007):, Programme Update, Nautilus News Release Number 2007-14, http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=186621&_Type=News-Releases&_Title=Programme-Update.

Nautilus Minerals Inc. (2008): Mineral Resource Estimate Solwara 1 Project Bismarck Sea Papua New Guinea for Nautilus Minerals Inc, Ian Lipton, BSc (Hons), FAusIMM, Principal Geologist, Golder Associates Pty Ltd, http://www.nautilusminerals.com/i/pdf/2008-02-01_Solwara1_43-101.pdf.

Nautilus Minerals Inc. (2009): Drilling discovers new high-grade zones near solwara 1 resource, Nautilus News Release, 13 May 2009. <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=347637>.

Nautilus Minerals Inc. (2012): Nautilus Minerals Defines 410 million tonne Inferred Mineral Resource*, Nautilus Minerals Press release, 18 September 2012, <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=548462>.

Nautilus Minerals Inc. (2012):.Nautilus Minerals discovers more high grade systems in Tonga. Nautilus Press Release No. 2012-27, 1 November 2012.

Nautilus Minerals Inc. (2014): Annual information form for the fiscal year ended december 31, 2013, <http://www.nautilusminerals.com/i/pdf/Q4-2013-AIF.pdf>.

Nautilus Minerals Inc (2014): Nautilus Confirms Grade and Extent of CCZ Nodule Deposit, Nautilus Minerals Press release (19 March 2014), <http://www.nautilusminerals.com/s/Media-NewsReleases.asp?ReportID=643004>.

Neptune Minerals (2007): Preliminary results for year ended 30 June 2007, <http://www.mineweb.net/mineweb/content/en/mineweb-company-releases?oid=37118&sn=Detail>.

Norwegian University of Science and technology (n.d.) Seabed massive sulphide (SMS) resource assessment within the Norwegian Economic Exclusive Zone (NEEZ), <http://www.nordicmining.com/getfile.php/Bilder/Operations/NORA/Reports%20NORA/Seabed%20massive%20sulphide%20%28SMS%29%20resource%20assessment%20within%20the%20Norwegian%20Economic%20Exclusive%20Zone%20%28NEEZ%29..pdf>.

Oancea, D. (2011): Mining in Brazil, <http://www.infomine.com/countries/SOIR/brazil/welcome.asp?i=brazil-soir-2>.

Okazaki, Masatsugu and Tsune, Akira (2013). "Exploration of Polymetallic Nodule Using AUV in the Central Equatorial Pacific (2013): Proceedings of the Tenth ISOPE Ocean Mining and Gas Hydrates Symposium (September 22-26, 2013), http://www.isopec.org/publications/proceedings/ISOPE_OMS/OMS%202013/data/papers/M13-42Okasaki.pdf.

Phys Org (2011): Japan deep-sea robots to seek minerals: report, <http://phys.org/news/2011-01-japan-deep-sea-robots-minerals.html>.

Southern Fried Science (2013): One-fifth of all known hydrothermal vents are threatened by deep-sea mining, <http://www.southernfriedscience.com/?p=15951>.

SRK Consulting (2012): NI 43-101 Technical Report 2011 PNG, Tonga, Fiji, Solomon Islands, New Zealand, Vanuatu and the ISA, http://www.nautilusminerals.com/i/pdf/NAT008_Nautilus_NI_43-101_Technical_Report_2011.pdf.

The Hindu (2013): Soon nodules to be mined from seabed, <http://www.thehindu.com/sci-tech/science/soon-nodules-to-be-mined-from-seabed/article4577372.ece>.

Tsering, D. (n.d.): China's Deep Sea Exploration: Research and Capacity Building, http://www.academia.edu/2482772/Chinas_deep_sea_exploration#.

Yonhap News Agency (2014): S. Korea gains right to explore deep-sea mines in Indian Ocean. 25 June 2014, <http://www.globalpost.com/dispatch/news/yonhap-news-agency/140625/s-korea-gains-right-explore-deep-sea-mines-indian-ocean>.

Websites

<http://www2.camara.leg.br/atividade-legislativa/comissoes/comissoes-temporarias/especiais/54a-legislatura/pl-0037-11-mineracao/audiencias-publicas/apresentacao-cprm>.

<http://www.deepseaminingoutofourdepth.org/green-light-given-to-explore-for-minerals-in-fijis-seabeds/>;

<http://data.nzpam.govt.nz/permitwebmaps?commodity=minerals>.
<http://www.dord.co.jp/english/corporate/index.html>.

<https://ec.europa.eu/eip/raw-materials/en/content/3ds-european-mineral-asset-definition-and-valuation-system>.

<https://ec.europa.eu/eip/raw-materials/en/content/breakthrough-solutions-seafloor-mineral-extraction-and-processing-deep-water-environment>.

<https://ec.europa.eu/eip/raw-materials/en/content/environmentally-responsible-deep-sea-mining>.

<https://ec.europa.eu/eip/raw-materials/en/content/securing-supply-primary-resources>.

<https://ec.europa.eu/eip/raw-materials/en/content/%E2%80%9Calternative-blue-advanced-technologies-research-seafloor-sulfides%E2%80%9D-securing-long-term-raw>.

<https://ec.europa.eu/eip/raw-materials/en/content/innovative-mining-marine-mineral-resources-%E2%80%93-european-pilot-mining-test-atlantic-tools>.

http://www.economistasmadeira.org/files/Apresentacoes%20CAT/Apresentacoes%20CAT%20VII/3-NautilusMinerals_Madeira__Lowe_20130503.pptx.

http://en.ymg.ru/w/Programs_and_projects.

<http://en.ymg.ru/pdf/ymg.pdf>.

http://eng.kiost.ac/kordi_eng/main.jsp?sub_num=354&state=view&idx=201&ord=0.

<http://www.fbc.com.fj/fiji/10492/deep-sea-mining-tests-planned>.

<http://www.ft.com/cms/s/0/52cdac0e-8cbe-11e2-8ee0-00144feabdc0.html#axzz31VIMVQh6>.

<http://www.g-tec.eu/innovation.html>.

http://wwz.ifremer.fr/institut_eng/content/download/57277/797335/file/12_03_23_CP_BIONOD.pdf.

<http://www.investigate.co.uk/article.aspx?id=200510100700043912S>.

http://www.iom.gov.pl/files/IOM_Claim_Area_and_Bathymetry_Poster.pdf.

<http://www.iom.gov.pl/welcome.htm>.

<http://www.isa.org.jm/en/scientific/exploration/contractors>.

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-5.pdf>.

<http://www.isa.org.jm/files/documents/EN/20Sess/Council/ISBA-20C-6.pdf>.

<http://www.isa.org.jm/files/images/maps/CCZ-Sep2012-Official.jpg>.

<http://www.isa.org.jm/files/images/maps/IndianOcean.jpg>.

http://www.jogmec.go.jp/english/metal/finacial_015.html.

http://www.jogmec.go.jp/english/metal/technology_018.html?recommend=1.

<http://magazines.marinelink.com/Magazines/MarineTechnology/201106/flash/?page=12#>.

<http://marawaresearch.com/index.html>.

http://www.mining-journal.com/reports/marine-mining-rising-tide?SQ_DESIGN_NAME=print_friendly.

<http://www.mining-technology.com/projects/kermadec-neptune>.

<http://www.mining-technology.com/projects/solwara-project/>.

<http://www.nauruoceanresources.com/>.

<http://www.nautilusminerals.com/i/misc/Table2Tonga.pdf>.

<http://www.nautilusminerals.com/i/pdf/FijiTenementsAug11.pdf>.

<http://www.nautilusminerals.com/s/Projects-Solwara.asp>.

<http://www.nautilusminerals.com/s/2007Programs.asp>.

<http://www.neptuneminerals.com/tenements/>.

<http://ramumine.wordpress.com/tag/bluewater-metals/>.

<http://www.sopac.org/dsm/public/files/countries/Kordi%20Presentation%2001%20Feb%202012.pdf>.

<http://www.streetinsider.com/Corporate+News/Odyssey+Marine+%28OMEX%29+Acquires+Minority+Stake+in+SMM+Project+LLC/5131092.html>

<http://www.theengineer.co.uk/channels/policy-and-business/lockheed-martin-seabed-mining-venture-set-to-explore-pacific/1015815.article>.



P.O. Box 4175
3006 AD Rotterdam
The Netherlands

Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com

W www.ecorys.com

Sound analysis, inspiring ideas