



## Legal and Technical Commission

Distr.: General  
23 July 2014

Original: English

---

**Twentieth session**  
Kingston, Jamaica  
14-25 July 2014

### **Evaluation of the annual reports submitted by contractors**

#### **Report and recommendations of the Legal and Technical Commission**

#### **I. Introduction**

1. The Legal and Technical Commission has reviewed the 2013 annual reports received from the contractors, pursuant to section 10 of annex 4 to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and section 10 of annex 4 to the Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area. All contractors are under the obligation to submit their annual activity reports by the end of March each year.
2. The contractors for polymetallic nodules are: Yuzhmorgeologiya (Russian Federation); Interoceanmetal Joint Organization (Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia); the Government of the Republic of Korea; China Ocean Mineral Resources Research and Development Association (China); Deep Ocean Resources Development Co. Ltd. (Japan); Institut français de recherche pour l'exploitation de la mer (France); the Government of India; the Federal Institute for Geosciences and Natural Resources of Germany; Tonga Offshore Mining Ltd.; Nauru Ocean Resources Inc.; UK Seabed Resources Ltd.; and G-TEC Sea Mineral Resources NV.
3. The contractors for polymetallic sulphides are: Ministry of Natural Resources and Environment of the Russian Federation, China Ocean Mineral Resources Research and Development Association (China) and the Government of the Republic of Korea.
4. As at 30 April 2014, all annual reports that were due had been received (see annex I to the present report). The Commission noted that G-TEC Sea Minerals Resources did not submit an annual report in 2014 in accordance with an understanding made with the secretariat owing to the fact that the sponsoring State had not authorized the contractor to commence its activities until domestic legislation was in place.



5. The Government of the Republic of Korea signed its contract recently, on 24 June 2014, therefore its first annual report for polymetallic sulphides should be submitted in 2015.

6. Section II of the present report contains the analysis of and comments on the annual reports by the Legal and Technical Commission. The analysis has been prepared in accordance with the suggested template for the Commission's report and recommendations to the Secretary-General, as set out in document [ISBA/15/LTC/2](#), annex, as well as the Commission's recommended format for the presentation of statements of actual and direct exploration expenditure, as contained in document [ISBA/15/LTC/7](#).

### **General comments**

7. The majority of reports largely followed the general format prescribed by the Commission and generally focused on work carried out during the reporting year under consideration, in accordance with the suggestions made by the Commission after previous evaluations. A few reports reviewed work from earlier years.

8. Six of the eight pioneer contractors have entered the final five-year phase of their respective contracts. By the end of that time it is to be expected that they will have identified a first-generation mine site, obtained good baseline environmental data, and developed a mining system prototype and arrangements for processing. Five of those contractors have reported different stages of mining tests and siting in their respective areas.

### **Exploration work**

9. Most contractors fulfilled the activities mentioned in their working plan. All the activities reported are directly related to field work carried out during the previous year.

10. The Commission noted that high-resolution maps (2 x 2 m) are being generated using multibeam acoustic measurements by most of the contractors. It was also noted that first-generation mining sites have been defined by some contractors.

11. Few contractors have made considerable progress in developing and testing tools for both nodules and sulphides exploration.

12. Geo-acoustic survey linked to natural electric potential measurements proved to be a reliable approach to map the polymetallic sulphide deposits.

13. The Commission recognizes the efforts made by contractors to deliver exploration data to the Authority in accordance with the standard formats.

14. The Commission also recognizes the need for a better template for standardized reporting to the Authority regarding exploration data. The reporting of nodules and sulphides chemical data based on statistics remains valid, but tables with the full chemical analyses should be provided in the digital format.

15. A big effort on assessment and reporting of resource and reserve estimates should be pursued.

**Mining tests, mining technology and metallurgical processes**

16. Metallurgical processing has been reported by some contractors using different processes (leaching) with high recoveries for selected elements such as Cu, Ni, Co, Zn, Au and Ag as well as for rare earth elements through ion exchange resin techniques.

17. Progress still remains to be made on technology-related issues, particularly with respect to the mining and metallurgical processing of nodules. A few contractors have yet to begin to develop their technological capacity and it may therefore be beneficial if such contractors made a concerted effort by pooling their resources.

**Environmental monitoring and assessment**

18. The environmental work reported by contractors in 2014 is generally of better quality than that reported in previous years. However, there is still a lack of raw tabular data as well as detailed taxonomic information (preferably at species level) being provided by contractors. In few cases there are no geographic reference data reported for the environmental data. Raw tabular data are essential for evaluating potential cumulative and regional impacts on the marine environment. They are also required for the development of the Authority's data management strategy for developing the environmental management plans.

19. The Commission recommends that contractors provide a summary table for the environmental baseline data in the future annual reports. The table should be formulated to itemize environmental baseline data that have been collected in the reporting year and through the contracting periods in separate columns, in reference to the environmental variables that are listed in the recommendations for the guidance of contractors for the environmental baseline study ([ISBA/18/LTC/6](#)). It facilitates the evaluation of the progress in contractor's environmental monitoring programme and would help contractors to find gaps in their environmental baseline study. The template for the table was developed in the consultation meeting between contractors and secretariat in January 2012.

20. Before commencing operations, contractors are required in some cases to provide to the Authority and agree with it on an environmental impact assessment for certain types of equipment. This applies particularly for operations relating to polymetallic sulphides on ocean ridges and cobalt-rich ferromanganese crusts on seamounts. The commission welcomed with appreciation the submission of the first environmental impact assessment prior to dredging operations by one contractor.

21. Several contractors have expressed their appreciation for the Authority's taxonomic and standardization workshops. It is evident that there is considerable variability in the reporting of environmental data by contractors. The workshops are essential to improving data quality and all contractors should attend them.

22. Some contractors have generated high-quality molecular data on seabed fauna which indicate the degree of change in species across the Clarion-Clipperton Zone. The data support the transregional planning of areas of particular environmental interest, but also indicate that for some taxa additional spatial planning may be required.

23. Contractors undertake to verify that field activities during exploration are not causing serious environmental harm. Consideration needs to be given by each contractor, especially those working on polymetallic nodules and cobalt crusts, to how this can be achieved and reported following each cruise.

#### **Financial statements**

24. Most contractors have provided a breakdown of expenditure, as recommended in the document [ISBA/15/LTC/7](#). The majority of contractors submitted their financial statements for the 2013 period in a timely and itemized manner (see annex II to the present document). The amount spent by contractors totals US\$ 80.4 million. This is an improvement that was noted by the Commission. It was also noted that half of the contractors have spent more than anticipated in their projected five-year working plan schedule. In this regard, the Commission encourages all contractors to inform and provide further details in the future, whenever there are significant variations in their expenditures vis-à-vis the amounts set forth in their plans of work.

#### **Training programme**

25. Most of the contractors report “no training activity”, as they are in the final five-year period of their contracts, and report their designated training as having been completed, in some instances, nearly a decade ago. The Commission would like contractors to consider additional training activities in order to increase the capacity-building carried out in line with regulation 27 of the Nodules Regulations, which provides for revision and development of training programmes from time to time by mutual agreement. It would also like contractors to take into consideration the suggestions set forth in the “Recommendations for the guidance of contractors and sponsoring States relating to training programmes under plans of work for exploration” ([ISBA/19/LTC/14](#)), in order to provide for the training equivalent of at least 10 trainees as a minimum, by mutual agreement, during each five-year period of the contract.

#### **Other matters**

26. Few of the contractors have provided a list of research published in peer-reviewed journals during the reporting year.

27. Few examples currently exist of any collaborative work between contractors. Although several of the contractors mentioned the usefulness of the standardization workshop organized by the Authority in Germany in 2013, an effort should be made to encourage greater levels of collaboration by sharing manpower and resources among contractors.

28. A positive trend observed during the reporting period is that some of the contractors have started analysing data on the economic feasibility of nodule mining, and that some of them are providing limited information on mineral resource classification.

## II. Evaluation of annual reports and recommendations

### A. Polymetallic nodules

#### 1. Deep Ocean Resources Development Co. Ltd.

##### General

29. The contractor submitted its annual report for 2013 in English on 25 March 2014. The report includes details of exploration work, environmental studies, mining test and applicable mining techniques metallurgical processing system, training programme, financial statement and survey plan of 2014. Each section is supported with figures, tables and references. The report is structured in line with the headings and content list recommended by the Commission in the annex to document [ISBA/8/LTC/2](#).

##### Exploration work

30. For exploration work and environment studies during 2013, the contractor carried out a research cruise from 3 to 22 November of total 12 working days, on board the research vessel RV *Kilo Moana* in the high-abundance area having > 2.5% grade in the west area (SA 24), and related laboratory work. The annual report of 2013 includes results and analysis of the autonomous underwater vehicle cruise done in 2012 and a summary of the cruise carried out in 2013.

31. Based on multibeam exploration data collected in 2012, 2x2 m grid maps were prepared for the whole east and west areas and six categories of gradients were marked from 1 degree to 10 degrees. The west part of the area (90 per cent) has less than a 3 degree gradient, while the east part is steeper and has gradient above 5 degrees. Sonar Wiz 5 software was used for processing the sidescan sonar data and three-dimensional topographical maps were prepared.

32. Morphology and chemical composition for Ni, Co, Cu, Mn, Fe for 27 samples and rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) were analysed for 14 samples. The 2012 analyses showed results very similar to those of 1975-1996.

33. Based on size (2 to >8 cm), nodules were classified into five categories. The distribution pattern of nodules is controlled by size, composition and number.

34. Some 998 photographs from 2012 autonomous underwater vehicle surveys were used for image analysis, using the Image-Pro Plus of Median Cybernetics Co. In comparison with deep-sea camera, the frequency of photo by autonomous underwater vehicle is very high.

35. Using the free fall grab data obtained before 1997, which were formatted into ArcGIS, a resource evaluation was made for the west and east J license areas. The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (2004) was used for nodule resource classification in the area. It has been emphasized that the resource evaluation cannot simply be done by comparing with on-land resources. Unlike land-based three-dimensional evaluation, nodules show simple distribution mode with good continuity of distribution in horizontal extension and two-dimensional evaluation is sufficient.

36. A comparison of the past data shows that the abundance in the west area is higher than 17.5 kg/m<sup>2</sup>, but the 2012 results show abundance from 12.5 to 15 kg/m<sup>2</sup>. Similarly, the east area showed abundance varying from 10.0 to 15 kg/m<sup>2</sup>, and the 2012 results show only around 10 kg/m<sup>2</sup> abundance. The metal amounts of the west and east part calculated from 2012 data are also 75 to 80 per cent of the results of 2011.

37. An autonomous underwater vehicle survey conducted in two small areas on the west and east part of the centre of high-abundance areas for obtaining micro-topography and photographs were used as the reference data for estimating resources of all high-abundance areas.

### **Environmental monitoring and assessment**

38. Detailed analyses of the autonomous underwater vehicle survey in the 2012 cruise are provided, as well as a summary of a sampling cruise in 2013. The use of autonomous underwater vehicles in generating environmental data is an excellent initiative.

39. In general there are good oceanographic measurements and analyses, that include conductivity, temperature and depth, acoustic Doppler current profiler, water and sediments analyses. There is long-term oceanographic monitoring, but it is recommended oceanographic monitoring is conducted in both the Japan Deep-Sea Impact Experiment (JET) and high-abundance areas (see below) to meet objectives of the plan work. Turbidity analyses are missing.

40. Data analyses of sediment and water samples were obtained from two areas: the JET area, where seafloor processes are being monitored following a planned disturbance of the seabed made in 1994; and an area with high (nodule) abundance. The two areas were about 300 km apart.

41. Post-disturbance data were obtained previously at the JET area in 1994, 1995 and 1996. In 2011-12, the contractor conducted further surveys at the JET area (17 to 18 years after the seabed was disturbed). Statistical analyses showed that there was no significant difference in sediment properties between the pre- and post-disturbance periods. However, sampling intensity was low. Precision sampling relative to actual disturbance tracks on the seafloor using the sophisticated technologies now available to the contractor, including autonomous underwater vehicles and remotely operated vehicles, would provide much better and more convincing data.

42. Baseline studies of sediments included physical property (water content and sediment bulk density), chemical properties (calcium carbonate, total silica, biogenic silicate, total organic carbon and total nitrogen of sediments). Additionally, water qualities (dissolved oxygen, alkalinity, phosphate, ammonium, nitrite, nitrate, total organic carbon and heavy metals were measured.

43. Sediment samples from the JET and high-abundance areas were compared to investigate differences between the two areas (300 km apart). Only one box corer was successful and so was not used for comparison. In 2012, 9 cores from only 2 successful multi-corer deployments for the JET area and only 2 cores from 1 deployment in the high-abundance area were available (no samples were obtained from 10 other deployments of the multi-corer). Statistical comparisons were therefore not possible and the conclusions drawn can only be regarded as indicative.

It is evident there were difficulties in sampling (owing to sea state?) and this may have contributed to the variability evident. The contractor may need to consider how greater sampling success might be achieved (for instance, by remotely operated vehicle?).

44. Surface sediment bacteria abundance was higher at the JET area than the high-abundance area. Abundances of nanofauna on surface sediments (top 1 cm) showed a similar pattern. Meiofauna included five groups (foraminiferans, nematodes, tardigrades, copepods and polychaetes) and showed greater abundances at the JET area compared with the high-abundance area.

45. For standardization purposes, 32-250 micrometres and >250 micrometres are recommended as size criteria for meio- and macro-fauna analyses, respectively ([ISBA/18/LTC/6](#)).

46. No significant differences in megafaunal abundance were evident between the JET and high-abundance areas based on photographic data. Sampling of specimens (by remotely operated vehicle?) will be required to generate better taxonomic resolution of the images.

#### **Mining tests, mining technologies and metallurgic processes**

47. Based on the results of the research and development project “Investigation of polymetallic nodule mining systems” in 2012-2013, another project, “Technical considerations in polymetallic nodule mining systems”. was launched in 2013 to be completed by March 2014. The results of the former and outline of the latter are given.

48. A review of mining technology from the 1960s to the present was conducted in 2011 with the goal of selecting and economically evaluating the optimum polymetallic nodule mining system. Possible solutions were advanced and the multiple collector fluid dredge system and mechanical lift system were proposed as more realistic.

49. The technical problems in the single collector fluid dredge system and the possibility of their solution are considered. Three candidate systems for mining polymetallic nodules — the single collector fluid dredge system, multiple collector fluid dredge system and mechanical lift system — are outlined, and the system configurations and rough specifications of each are given. Based on assumptions about system and operating requirements for each system, capital expenses and operating expenses are estimated. Influence of topography on mining is considered in the last section using a recent detailed seafloor topographic map made by using the data obtained from an autonomous underwater vehicle survey in the future mining area.

50. Technical data released by Technip for flexible risers show that a flexible pipe 3,000 m long with a 7 to 9 inch inner diameter can be put into practical use. Recently, it has been found that if a flexible riser using carbon fibre reinforced plastic cord or high-carbon steel cord were developed in the future, 1,500,000 tons per year of polymetallic nodules could be mined in 5,000 m of water; it is still uncertain, though, whether some technical problems will be solved in the near future.

51. Past consideration of polymetallic nodule mining systems was examined and a comparative statement between the main features was tabulated. It is suggested that a combination of multiple collector system and mechanical lift system is a better candidate for mining polymetallic nodules than the single collector system with a large collector and riser pipe.

52. The 2013 research and development project titled “Technical considerations in polymetallic nodule mining systems” will be completed in March 2014. An outline of the project is given. For research and development of a metallurgical system, capital expenses and operating expenses were roughly estimated for the smelting and chlorine leaching method for copper, nickel, cobalt and manganese in early 2014.

53. A research and development project “Leaching extraction of rare earth elements from polymetallic nodules” was started in 2012 and completed in March 2013. The outline was reported in the 2012 annual report, and detailed results are reported in this 2013 annual report. Methods of extracting rare earth elements from leaching solution are studied and a preliminary economic evaluation of rare earth elements extraction systems is carried out. Rare earth elements extraction methods, such as precipitation, ion exchange resin and solvent extraction, were also examined for their applicability. Equipment, facility and operating costs for this system were estimated based on present information and present market conditions.

54. This research and development project was aimed at understanding the occurrence and distribution of rare earth elements in polymetallic nodules and finding the optimum method for selective leaching and extraction of rare earth elements from polymetallic nodules.

#### **Financial statements**

55. The contractor’s total expenditure in 2013 amounted to US\$ 3,663,371 (366,337,065 yen), consisting of expenditure under five subheads: resource evaluation, environmental studies, research and development of mining system, research and development of metallurgical system and other activities.

#### **Training programme**

56. The contractor in January 2014 expressed regret at not having provided any training, as the current contract is coming to an end.

#### **Comments**

57. The same United States Navy research vessel, RV *Kilo Moana*, was used by Japan and Germany in 2013.

58. A total of 12 working days were spent in the field, of which 3 were devoted to the exploration work and rest for the environmental work, including the non-biological environmental aspects.

59. Metallurgical studies are confined to the research and development projects. The focus now is on rare earth elements extraction methods.

60. A technical overview of the problems in polymetallic nodule mining systems is given.



## 2. China Ocean Mineral Resources Research and Development Association

### General

61. The contractor submitted its annual report for 2013 in English and Chinese on 28 March 2014.

62. The report contained information on exploration and studies of polymetallic nodules for the contractor's contract area No. 1, environmental survey and studies, mining technology, research and development of metallurgical processing technology, analysis of the prospects for commercial exploitation of polymetallic nodules, training, working plan of 2014, financial statement, a list of publications and references and a reply to the specific advice and suggestions of the Legal and Technical Commission.

### Exploration work

63. In 2012 the contractor delineated nine ore bodies in its contract area using krigging, three in the west and 6 in the east section. Out of these ore blocks in the west section, an area of 1800 km<sup>2</sup> (named as SC-1) was selected for detailed exploration in 2013. Another area with flat terrain in SC-1 was chosen as a test mining area (217 km<sup>2</sup>). Two field survey cruises were carried out, the first being a short field survey cruise of six days, from 6 to 12 August on board the RV *Xiangyanghong Jiu hao*, the mother ship of the submersible *Jiaolong*, for the experimental application of the submersible, megafauna survey and conductivity, temperature and depth measurements in the west section of the contract area.

64. The second field survey cruise, consisting of two legs (environmental survey leg and polymetallic nodule resource exploration leg), was conducted on board the RV *Haiyang Liu hao* from 18 August to 12 October 2013. The first leg of the environmental baseline survey was conducted in both the east and west sections of the contract area during from 18 August to 13 September 13 for conductivity, temperature and depth measurements, and sampling by box corer, multi-corer and plankton net. The second leg was conducted for resource exploration in the detailed exploration area (SC-1) in the west section from 28 September to 12 October 2013.

65. During the resource exploration cruise in the test mining area, 18 box corer sampling stations and autonomous underwater vehicle acoustic measurements (bathymetry, side scan, sub-bottom profile and photography) with 93 km length were completed. The bathymetric data of autonomous underwater vehicle measurements in the test mining area were processed and the bathymetry map plotted. The polymetallic nodule samples collected from the test mining area were classified and described on board the ship, and the abundance and coverage of the nodules were calculated. The calculated abundance of nodules ranges from 3.24 kg per square metre to 14.6 kg per square metre with a mean value of 10.2 kg per square metre. The sediments characteristics were described and geotechnical properties of sediments were tested. The relation between the nodule abundance calculated from 160 stations and the slope in the detailed exploration area indicates that the nodule abundance has an increasing trend and the nodule grade a decreasing trend with the increase in the slope.

66. This variation of the nodule abundance is in conformity with that calculated from the seafloor photographs from this area. In the test mining area, the terrain shows a high relief in the west and lower relief in the east and the nodule abundance

shows the same trend as the terrain. In the south of the autonomous underwater vehicle survey area, higher abundance occurs on the hill and lower abundance occurs in the depression. The distribution of the nodules in the detailed exploration area and in the test mining area is consistent with the distribution of the nodules in the west section of the contract area. The mean nodule abundance decreases with the decrease of the sampling intervals in both the detailed exploration area and test mining area.

67. Based on three conceptual conditions, the nodules in the contract area have been classified as measured and indicated resources.

68. The surface sediments characteristics collected from 6 box corer sampling stations were measured on board. Physical mechanics parameters of the sediments, such as particle size distribution, specific surface area, density and mineral elements, were also tested. The microstructures of the undisturbed samples were also studied.

69. A comparison of the bathymetry measured by autonomous underwater vehicle and the bathymetry measured by the multibeam revealed a similar terrain, though the bathymetry measured by autonomous underwater vehicle is shallower than that measured by the multibeam. Moreover, the bathymetry measured by autonomous underwater vehicle shows fine seafloor topography more clearly, with broad and gentle depression in the west and broad and gentle mounds in the east of the surveyed area.

#### **Environmental monitoring and assessment**

70. Environmental baseline surveys in 2013 included physical, chemical and biological baseline data collection and analyses. Analytical methods that include statistical processing are missing. The physical data included the meteorological parameters (wind speed, wind direction, air temperature, air pressure and relative humidity), as well as the hydrological parameters (temperature, salinity and sea current). Chemical parameters studies included the pH value, dissolved oxygen, phosphate, silicate, nitrate and nitrite. A digital meteorological equipment XZC2-2D, a Sea-Bird 911*plus* conductivity, temperature and depth profiler, a multi-corer test video and a box corer were also used. Conductivity, temperature and depth measurements and water sampling of the entire water column were taken at 12 stations and at 200 m at one station. However, in addition to the sample collection methods the annual report should also include a summary of the analytical methods used for the acquisition of environmental data.

71. From 1997 to 2013 a total of 11 cruises were carried out to generate environmental baseline data. Using these data, inter-annual variations of phosphate, silicate and nitrate in the surface water were studied to determine spatial and temporal variations. However, the salinity sections would appear to show considerable mesoscale variation and it is not clear how much of the temporal change represents mesoscale variation rather than real change over time. Long-term mooring observations are required rather than comparisons between cruises, which may be undertaken at different times in the year and which have not taken mesoscale variation into account. The same would apply to the temporal data for chlorophyll-a.

72. The additional sampling conducted in the areas of particular environmental interest is welcome, although greater sampling intensity will be required to determine whether conditions in the areas of particular environmental interest are significantly different from those of the licence area.

73. The mobilization of the submersible *Jiaolong* is particularly impressive. Three dives provided qualitative information on the main taxa of the deep-sea megafaunal community. There is a comparison of fauna observed on the Weiluan seamount in the licence area. Ultimately it may be possible to compare these data from rocky substrates on the seamount with fauna attached to nodules. The biological baseline study considers chlorophyll-a (inter-annual variation), zooplankton and meiofaunal findings. The maximum chlorophyll-a depth in the eastern part of the study area appears to be influenced by La Niña events.

74. Zooplankton was quantified at four stations. However, no data are presented on the depths over which the mean values were calculated. No data are presented on time of sampling and day and night variations owing to diurnal vertical migration. The observed species richness at the four stations ranged from 117 to 177 zooplankton species. However, no species list was provided.

75. The meiofauna abundance in the western part of the contract area averaged 89 ind./10 cm<sup>2</sup> of sediment and was dominated by Nematoda (94.6 per cent) followed by Harpacticoidae (2.6 per cent) and Allogromiidae (1.2 per cent).

76. The biological data presented are all at a low taxonomic resolution. It is suggested that biological data are reported to genus and species level wherever possible. The Authority's taxonomic and standardization workshops will provide useful guidelines for all contractors to follow.

#### **Mining tests, mining technologies and metallurgic processes**

77. An in-situ instrument measuring the seafloor sediments' geotechnical mechanics parameters (the traction characteristics and carrying capacity of the seafloor sediments) was developed. It has undergone a number of the integrated tests and the test on the seabed. It is planned to carry out the measurement with the instrument by the manipulator arm of the submersible *Jiaolong* in 2014.

78. The collection and disturbance experiment plan was improved and adjusted to the supporting situation and the features of the experiments at sea, and the new design plan was made.

79. The reduction smelting process for mixture of the polymetallic nodules and the cobalt-rich crusts was tested in 2012, taking into account that the polymetallic nodules are characteristic of high manganese, low phosphorus and low alkalinity, while the cobalt-rich crusts are characteristic of low manganese, high phosphorus and high alkalinity.

80. In 2013, further studies on the reduction smelting process for the mixture of the polymetallic nodules and the cobalt-rich crusts were carried out with the emphasis on the studies of the effects of the major factors on the recovery of manganese, nickel, cobalt and copper from the mixture, and on the variations of the phosphorus in the manganese-rich slag. Major factors including the reduction temperature, coke proportion in the mixture, amount of added silicon and its effect were studied. It was observed that satisfactory results could be obtained from the

reduction smelting process of the mixture of the two minerals under certain controlled conditions.

#### **Other activities**

81. Based on the market analysis on production and consumption of Cu, Ni, Co, Mn and Mo as well as analyses of the land based resources of these metals and a techno-economic assessment model, a prospective analysis of commercial exploitation of the polymetallic nodules was carried out in 2013.

82. The ocean data management standards and system of the China Ocean Mineral Resources Research and Development Association established the ocean data centre in 2013. In addition, development and system upgrading were done for the sample repository.

#### **Financial statements**

83. The expenditure incurred in 2013 is approximately US\$ 11,740,600. A breakdown of the expenditure under five categories is given. A list of seven published papers (five on biology, one on metallurgy and one on waste water treatment) and a list of five references are given.

#### **Training programme**

84. No formal training programme was planned and carried out in 2013.

#### **Comment**

85. The contractor gave a reply to the specific advice and suggestions of the Legal and Technical Commission.

86. The contractor resubmitted the environmental data mentioned in its 2011 and 2012 annual report.

87. Figure 2.9 (rarefaction curve) in the annual report 2012 was explained.

88. Details on macrofaunal studies are given.

89. It is noted that three stations studied for environmental assessment coincided geographically with three areas of particular environmental interest. Water column conductivity, temperature and depth as well as nutrients profiles were sampled at these locations and reported by the contractor. This is the first time that a contractor stated objectives for environmental monitoring of areas of particular environmental interest.

90. The activities of 2013 pursued the objectives reported in the programme of activities for the period 2011-2015. Chemical analyses of recovered nodules are lacking. Only mean grades of Cu+Co+Ni are provided.

91. The Commission welcomed and took note of the creation of the ocean data centre.

### 3. Government of the Republic of Korea

#### General

92. The contractor submitted its annual report for 2013 in English on 25 March 2014. The report contained information on exploration works, environmental studies, mining technology, processing technology, training programme, financial statement, other activities and outcomes from 2013 activities.

#### Exploration work

93. In 2013, two deep-sea exploration voyages were carried out using the RV *Onnuri*. The first cruise was devoted to the geophysical survey for 27 days (22 June-18 July 2013) and the second to the environmental study for 27 days (20 July-15 August 2013). The geophysical survey was carried out in the primary mining area within KR5 block, located in the southern part of the contract area. Newly computed bathymetry identified that approximately 70 per cent of the total survey area had slope gradients of  $< 5^\circ$ , whereas the central-western part showed slope gradients  $< 3^\circ$ .

94. A box corer was used for sample collection to investigate nodule abundance, sediment characteristics, and meiobenthos. A multiple corer was used to obtain undisturbed sediment cores for the interstitial water studies, physical properties and detailed geochemical studies.

#### Environmental monitoring and assessment

95. The report provides good data on a variety of oceanographic measurements with details of collection methods and analytical procedures. All the acquired data were presented in an appropriate digital format (as Excel files). Characteristics of seawater, currents, numerical simulation for currents direction and speed were studied.

96. Inter-annual variations of temperature, dissolved oxygen and inorganic nutrients such as nitrogen (nitrite and nitrate) from 1995 to 2013 were studied in relation to El Niño-Southern Oscillation variability (El Niño and La Niña).

97. The geochemical characteristics of sediments were studied using 11 multiple corer samples at the potential benthic impact experiment site and nearby possible preservation site (KOMO1). They were analysed by X-ray fluorescence for 10 major elements and inductively coupled plasma-optical emission spectrometry for trace elements. Mass flux to deep sea was studied by the sediment traps, moored at the depth of 500 m and 50 m above the seabed at approximately 5,005 m water depth and at a depth of 500 m above bottom at BIE station.

98. Meiobenthos studies were based on 11 multicorer samples collected in July and August 2013 at the Bie and Komo sites. Meiobenthos densities varied from 4 ind./10 cm<sup>2</sup> to 80 ind./10 cm<sup>2</sup> (Nematoda: 3-57 ind./10 cm<sup>2</sup>) and meiobenthos biomass ranged from 5.4 to 101.4 µg ash-free dry weight/10 cm<sup>2</sup> with most animals in the top 10 mm of sediment and about 0.063 mm in size. This is probably greater variation than would be expected. The contractor should compare the data with other meiobenthos data from oligotrophic areas to assess whether the differences are real or may be indicative of problems with sample processing. How was the biomass

evaluated for meiofauna? Information is not available in the text. The text mentions 9 different types of meiobenthos, but the list includes 11 taxa and 11 stations.

99. Ten box-core samples were used to study macrobenthos. The text conclusions on the dominant groups in the macrobenthos is different from the figure provided. Labelling on other figures is incorrect. Data are inconsistent between figures. The mean macrofauna density amounted to 514 ind./m<sup>2</sup> (max. = 740 ind./m<sup>2</sup>). The contractor has taken an important step in allowing its data to be assessed independently. Very useful comparisons with other sampling in the Clarion-Clipperton Zone were made. This has shown that there may be some problems in sample processing, also evident in the variability of the proportions of major macrofauna taxa between cores, which is larger than expected. Sampling procedures and sample processing methods need further review. The polychaete species were compared with the Polychaete Intercalibration Project. Overall, more than 80 per cent of the 22 species from the Kaplan C site were not recorded in the claim area (about 500 km apart from Kaplan C), indicating rather small species ranges in the Clarion-Clipperton Zone and high geographic variability. Alternatively, polychaete communities may still be significantly undersampled in the Clarion-Clipperton Zone. Table III-3-4 provides information on 12 box cores but only 10 box cores are cited in the text.

100. A deep-sea camera was towed for 2.3 hours 4 to 10 metres above the sediment, covering 9,900 m<sup>2</sup>. A total of 226 megabenthic organisms were identified. The scale is missing for the megafaunal photos on page 59. Figure III-3-3 needs to be labelled correctly. Are biomass values in wet weight or in carbon units? Good advice on standard methods for video surveys has been made available (for example at the international workshop held in April 2014 at the National Oceanography Centre, Southampton, United Kingdom). Reporting of the seabed photographic surveys could be improved considerably.

#### **Mining tests, mining technologies and metallurgic processes**

101. No mining test work was carried out in the contract area.

102. However, research on mining technology continued in 2013 under the projects “Second pre-pilot mining test at a water depth of 1,370 m of the East Sea”, “Design and manufacture of pilot lifting system” and “Development of core design technology for pilot mining system”. A second test of the mining robot MineRo using artificial nodules was conducted successfully near Hupo Harbor at water depth of 130 metres.

103. For the design and manufacture of a pilot lifting system, a lifting pump with shroud was manufactured, a flexible pipe for the pilot mining test was designed and a buffer system to store manganese nodules collected by MineRo and feed them into the lifting pipe was manufactured.

#### **Processing technology (metallurgy)**

104. Important results were achieved concerning the capacity of nodules treatment and content of recovered metals.

105. Using a dredge and beam trawl, a total about 6 tons of nodules were collected at five stations for study of processing technology during the cruise in 2013.

106. Cooperation work with Dong-Bu Metal Co. on reduction smelting tests with a submerged arc furnace was continued. A 2 tons/day manganese nodules treatment capacity showed recovery of Cu, Ni, Co as 91.3 per cent, 95.9 per cent and 92.7 per cent, respectively. Continuous combination processes of solvent extraction and electrowinning with capacity 200 kg/ton of nodules, over a two-week test period, produced Co and Ni purity > 99.9 per cent. Recovery of rare earth metals from leaching solution using solvent extraction process (60 times). Cooperative work with the LS-Nikko copper smelting company on the development of technologies for continuous autoclave leaching of matter was initiated.

#### **Financial statement**

107. Expenditure of US\$ 12,440,191 was reported for the activities during the fiscal year of 2013.

#### **Training programme**

108. The contractor has completed the proposed training programme, hence no training work was carried out in 2013.

#### **Other activities**

109. Seven research papers were published and 21 patents obtained in 2013. Abstracts of research papers are attached to the contractor's report.

#### **Comments**

110. The contractor has fulfilled the work programme as planned and reported all relevant data to the Authority. However, the contractor states that the analytical work for the collected samples, data and information from the 2013 field survey is still in progress. The Commission requires that the latter be duly provided in the 2014 annual report.

111. In 2013, three international cooperation programmes were carried out between the Korea Institute of Ocean Science and Technology and the University of Hawaii with funding provided by the Institute. The contractor obtained 21 patents in 2013.

### **4. Interoceanmetal Joint Organization**

#### **General**

112. The contractor submitted its annual report for 2013 in English on 9 of April 2014. The report contains information on contract activities, expenditure incurred while implementing contract activities in 2013 and amendments to the programme of contract activities and a list of publications by the contractor. The report contains two annexes.

#### **Exploration work**

113. The report provides information on field campaigns planned for 2014 and a description of the geological and exploration work carried out in 2013. Results of the 2014 cruise scheduled for March-May 2014 on board the RV *Yuzhmorgeologiya* in the exploration block H22, as well as the original data, will be provided in next year's report. The new block H22 of 3,875 km<sup>2</sup> is situated in the north of the block

H11 studied earlier, and is a part of the ore deposit area B2-01 identified during the nodule resource assessment in 2011. A diagram of the exploration block H22 with indication of the work already accomplished and the research planned for the contractor's 2014 cruise is given as an annex to the contractor's report.

114. Results of the research conducted jointly by the contractor and VNIIOkeanologiya (St. Petersburg, Russian Federation) in 2011-2013 are reported, including the zonation of the exploration block H11. Based on geo-acoustic data and results of photo and video surveys the geotechnical characteristics of H11 block such as seafloor relief and geological set-up were analysed. For this analysis of the contractor's archived materials, three-dimensional computer modelling of the seafloor surface, and the chart of seafloor surface slope angles were used. An area H11-G within H11 was selected for detailed geotechnical studies. A 1:50,000 chart illustrating the sequence of specialized geotechnical research was prepared and used for further recommendations and actions on geotechnical research in H11-G, to be carried out in two stages.

115. Data from 105 stations were analysed for nodule size distribution, which is helpful in the design of a nodule miner. The results showed nodules of 4 to 6 centimetres as dominant in H11. However, there were seven stations with three dominant nodule sizes, a heterogeneity which can substantially affect the construction of the nodule collector. The distribution of nodule sizes in H11 is shown in the 1:200,000 charts in the report.

#### **Mining tests, mining technology and metallurgical processes**

116. Studies on the development of a nodule collector (miner) were carried out under the project "Selection of configuration and development of parameters of a nodule mining system adapted for conditions in the IOM exploration area". Preferred and optimal versions of engineering solutions with respect to the basic modes of the nodule collector were analysed. In addition, analysis was carried out on the products available in the market.

117. Major technical indicators and characteristics of the miner were computed. A layout for a deployment-lift system was proposed with respect to simultaneous use of three miners and an alternative version of a nodule collector allowing to fulfil a demand for increased production. The research conducted was based on theoretical computations and analyses. The study resulted in a proposal of deployment-lift operations for the simultaneous use of three nodule collectors. Two new, alternative versions of a nodule collector are proposed and described in detail: (a) a contact-type sediment collector and (b) a floating miner.

118. Appropriate methods such as the radiotracer method, particle image velocimetry and laser Doppler anemometry for the measurement of continuous sedimentation were analysed during the reporting period. The sedimentation velocity of certain modelled particles of nine sizes, consistent with sizes of particles with the slide velocity measurements, was measured in a specially constructed three-metre-long transparent organic glass cylinder sedimentation column.

119. Research was continued on improvement of metallurgical technology and effective utilization of nodule processing waste under the study "Application of leaching nodule processing waste as adsorbents". Different adsorption tests and the research were conducted. It is recommended to continue the ongoing research on



possibilities of applying nanostructured sorbents obtained to the removal of heavy metals.

### **Financial statements**

120. Expenditures incurred by the contractor while implementing contract activities described in the report amount to US\$ 912,297.48. Financial statements for different activities are given along with the statements on experimental mining, nodule extraction and training.

### **Training programme**

121. The contractor has completed the proposed training programme, hence no training work was carried out in 2013.

### **Other activities**

122. A list of five publications is given.

### **Comments**

123. No field work was conducted during 2013. However, a cruise was held in March-May 2014 and the obtained data will be provided in the next annual report.

124. New designs have been developed for a nodule collector (miner) that incorporate, in addition to the classical seabed-contact system, a floating miner hat that is expected to significantly minimize the environmental footprint.

125. A simulation of the operation of the mining system was carried out with a concept design of closed-circuit slurry test equipment.

126. Basic studies on the polymetallic nodules characterization were conducted, and new results in nodule processing technology are reported.

127. Despite a minor delay with respect to the cruise scheduled for 2013, the contractor has fulfilled the work programme as planned and reported all relevant data to the Authority.

## **5. Institut français de recherche pour l'exploitation de la mer**

### **General**

128. The contractor submitted its annual report for 2013 in French on 2 April 2014. A translation was obtained by the Authority. The report is divided into seven subsections: exploration activities, mining tests and proposed extraction techniques, environmental monitoring and evaluation, training, other activities, financial statement and references.

### **Exploration work**

129. From existing hard copy of maps, the bathymetry points were digitized by manually plotting the data, obtained without the use of GPS. These data will be used for the slope calculation necessary for resource estimation.

130. On the basis of pixel, extracted from the *Bionod* imagery analysis in the NIXO45 area, four categories are drawn and used for nodule facies determination —

from no nodules to facies B and C. These categories are applied to the *Bionod* imagery as a whole (75x85 km).

131. The contractor is in possession of chemical analyses and nodule powders obtained from its own exploration campaigns and from other consortiums. Some 800 nodule powders were re-analysed by X-ray fluorescence. Half of them came from the NIXO project (Association française pour l'étude et la recherche des nodules), the other half from the Ocean Mining Associates (OMA) and Ocean Minerals Company (OMCO) consortiums. The old and the new NIXO analyses are not very different but the relative variations between the old and new OMA and OMCO analyses are of the order of 10 per cent. (No mention of the elements analysed).

132. The results were compared to verify homogeneity by the Mann-Whitney test (coupled with the Kolmogorov-Smirnov test and the median test). In spite of an identical X-ray fluorescence analysis, the NIXO, OMA and OMCO metal contents are not homogeneous; the bias will be corrected by anamorphosis.

133. Work is in progress to determine the best krigging parameters to model metal concentrations and nodule density on the seabed.

134. Under the heading of scientific activities related to exploration work, the contractor summarizes the work done for two theses, one thesis defended in 2013 related to Fe-Mn crusts; the other, a Master's thesis carried out in the first half of 2013, dealt with the impact of mineralization processes on the metal and rare-earth content of polymetallic nodules, hydrogenetic crusts and hydrothermal mineralization.

#### **Environmental monitoring and assessment**

135. The report presents analyses of data collected in during the *Bionod* cruise in 2012. The major giant protists, cumaceans and tanaidaceans analysed from the Macrofauna collected using a United States Navy Electronics Laboratory space corer and an epibenthic sledge.

136. Geographical reference data to the sites sampled are not included in the report. There are no data on species composition, abundances or biomass. In collaboration with Germany, a total of 75 operational taxonomic units of Polychaeta and 62 units of Isopoda were identified using DNA bar-coding in the German and the French claim area. Of 39 non-singletons, 27 Polychaeta operational taxonomic units were identified (69 per cent) and of 16 non-singletons, only two Isopoda units (13 per cent) have been extensively reported in the German report. This corroborates morphological taxonomic data that the geographical distribution of polychaetes is broader than that of the isopods in the Clarion-Clipperton Zone. The contractor relates it to different strategies of reproduction. The data are far more comprehensively reported in the annual report of the Federal Institute for Geosciences and Natural Resources of Germany.

137. In collaboration with scientists, 27 morphotypes were identified, including 17 species of Komokiacea; a list of morpho-species as well as a collection of 17 images is provided. The preliminary results report 34 species of Cumacea, including at least two new genera and three new species, and a new genus and a new species of Tanaidacea.

138. The results provided are preliminary; they are being submitted to the Biocean database for validation and will be available to the Authority in the future.

#### **Mining tests, mining technology and metallurgical processes**

139. Historical description is given on mining tests.

140. Metallurgical processing studied in the past and economic studies carried out between 1975 and 1977 and updated in 1979 and 1982 are described.

#### **Financial statements**

141. A financial statement certified by the Senior Expenditure Accounts Officer is attached to the contractor's report. The total sum of all activities is 137,047.9 euros, including the cost of personnel under each subsection.

#### **Training programme**

142. No training activity carried out during the period.

#### **Other activities**

143. During the period, the contractor engaged in European initiatives devoted to deep-sea mineral resources, particularly polymetallic nodules.

144. The European Union MIDAS (managing impacts of deep-sea resource exploitation) project began on 1 November 2013 for a three-year period for studying environmental impacts linked to deep-sea mineral resources exploitation. The contribution of the contractor to the project focuses on the biogeography and connectivity of species and populations in the Clarion-Clipperton Zone and on the definition of strategies and indicators for the environmental impact assessment.

145. In the framework of the German initiative "Ecological aspects of deep-sea mining" it is proposed to study the DISCOL site in the Peru basin 26 years after an experimental disturbance simulating exploitation of the polymetallic nodules. The contractor will be responsible for the assessment of residual impact of the pilot tests undertaken by the OMCO consortium in 1978 in the area of the current French exploration licence. Further, in the Clarion-Clipperton Zone, the distribution and diversity patterns of the main fauna groups at various sites would be studied, including the special environmental interest areas defined by the Authority, and also to study various sites where experimental disturbances or pilot exploitation projects have taken place.

146. At the initiative of the Federal Institute for Geosciences and Natural Resources of Germany, an informal meeting of European contractors of nodule exploration licence areas was held in Hanover on 19 November 2013. The contractor participated in the meeting, aimed at the exchange of information on progress made by the various contractors as regards exploration, development of extraction techniques and environmental monitoring. After that first contact, a new meeting will be organized by the contractor in mid-2014 in Brest.

#### **Comment**

147. The report is very short and reflects the low level of exploration activities in 2013, which is in agreement with the plan of work. These activities seem to have

been restricted to digitizing old contour maps and the re-analysis of 800 old powder samples in order to construct a new model for metal distribution based on krigging. We assume that the re-analysis of 800 powder samples by X-ray fluorescence and comparison with old chemistry results was done in 2013 by the contractor. The Commission requested a copy of these analyses in digital format as specified in [ISBA/18/C/20](#), as well as copies of the two Master's theses referred to.

148. Detailed information on biological sampling (geographic sampling sites) as well as detailed water column sediment column data will be reported accordingly with biological data to the secretariat independent of Biocean validation.

## **6. Government of India**

### **General**

149. The contractor submitted its annual report for 2013 in English on 22 April 2014. The report contained information on survey and exploration, environmental impact assessment study, technology development (mining), technology development (metallurgy) and expenditure.

### **Exploration work**

150. Extensive field investigations related with Survey and Exploration and Environmental Impact analyses were carried out in the Central Indian Ocean Basin between 1981 and 2012 along with supporting laboratory work, bathymetric data processing and resource estimation studies. Accordingly, no further field investigations were planned for the third five-year period, except for some specific detailed surveys relating to the planning of test mining. The 2012 annual report had covered partial activities as for 2012, hence a full presentation of the work is given in the following section.

151. The first-generation mine site with an area of 7863.61 km<sup>2</sup> was identified after detailed sampling at 12.5 km grid of the retained area. The first-generation mine area is also sampled at a close spacing of 6.25 km in some places. Located almost in the centre of the retained area, there are 42 blocks of 0.125° x 0.125° size. The block-wise krigged estimates of abundances and grades (per cent Cu+Ni+Co) are presented in maps.

152. Based on slow-scan bathymetry data collected, the bathymetry map of the first-generation mine area was generated and the digital terrain model was produced. The topographic structure and slope angle maps of various blocks of the first-generation mine area are reported in figures and in an appendix. The slope angle for all blocks of the first-generation mine area was derived and krigged estimates of nodule abundance, total metal and bathymetry parameters were used for ranking and identifying the best block. Block 112C was identified as the best block in terms of bathymetry, nodule abundance and mineral grade and thus designated as a test mining site. This block of 12.5 km x 12.5 km within the first-generation mine area forms the focus for subsequent related studies such as detailed exploration/bathymetric mapping, data generation, environmental impact assessment baseline studies and planning for test mining.

153. Nine peer reviewed research publications published in international journals and two dissertation reports for doctorate degree are listed as scientific output.

**Environmental monitoring and assessment**

154. A number of major and trace elements have been analysed in surficial sediments at 26 locations collected using box cores at a regular spacing of 10 x 10 in the Central Indian Ocean Basin. The objective is to provide input to predict the pathway of the plume from nodule mining. A study was carried out to identify diagnostic elements that can be used for tracking sediment plumes generated from nodule mining. The Rb/Sr systematic was identified as a sensitive indicator of sedimentary processes, in addition to some trace elements such as Ti, Pb, Cr, Zr, Rb, Sr, Nb and rare earth elements, identified as indicators of geological processes, provenance and tectonic settings of sedimentary basins. An attempt is made to quantify the relative contribution of sources using mixing calculations of rare earth element data. The studies relating to validation of the hydrodynamic model for transport of sediment plume will be completed by the end of the third five-year period.

155. The results from baseline, pre-disturbance and post-disturbance studies have shown (a) vertical mixing of sediment on the seafloor, (b) lateral migration of sediment plume, (c) changes in physical, geochemical and biochemical characteristics of the sediment, and (d) an overall reduction in benthic biomass after disturbance.

156. It is surprising that the Government of India does not plan any further environmental field work during the third five-year period of its contract, particularly as there has been considerable investment and development of new sophisticated technologies that would allow the contractor to achieve a much higher standard than has been evident to date. In particular, precision sampling by remotely operated vehicle in and around the benthic impact experiment area would provide very useful information. Studies on long-term natural change in benthic communities should continue.

157. Greater taxonomic resolution of samples will be required for any future environmental impact assessment of test mining. Sample analysis methods would be enhanced by participation at the Authority's next taxonomic and standardization workshop, to be held in the Republic of Korea. The contractor may have particularly valuable data for comparing Indian and Pacific Ocean communities likely to lead to important publications.

158. The contractor refers to environmental data concerning the environmental impact assessment programme submitted to the secretariat following the submission and review of the annual report.

159. The results of an experiment carried out at a deep-sea experimental disturbance site since June 1997 are reported. The effect of disturbance at the site was evaluated in 1997 and 2005. A reference non-disturbed area was also sampled and the observations reported. Parameters (clay percentage, water content, shear strength, organic carbon percentage) were significantly modified upon the disturbance. Macrofauna, meiofauna and microfauna decreased in density after eight years of the disturbance. Similar declines were observed in the non-disturbed area with only 30 per cent of macrofauna, 14 per cent of meiofauna (43 per cent of meiofauna "groups") and 1 per cent of microbes found.

**Mining tests, mining technology and metallurgical processes**

160. The highlight of the activities and achievements during 2013 is the design of the electro-optic umbilical cable for transmitting electrical power from the ship to the underwater mining machine capable of handling the entire weight of this machine during launching and retrieval operations. Aramid fibre-armoured cables are preferred in lieu of steel cables with the intention of reducing overall weight and to avoid the possibility of twisting underwater during launching and retrieval operations ease of handling. Detailed analysis is being carried out for the flexible riser configuration proposed to be used in the mining system to transport the slurry from 5000-6000 metres depth to the mother ship. Preliminary work towards achieving this has been done.

161. Interactions are in progress with well-regarded industry partners to carry out the configuration and handling studies of the flexible riser. In-house studies on electrical power, pumps and hydraulic systems were made. The specifications of the major sub-systems are being formulated as a result of the in-house research. Interaction with the potential suppliers and industry partners has been initiated to realize these systems for mining polymetallic nodules. Five research publications resulting from this study have been listed.

162. Laboratory scale optimization of the ammonia and sulphuric acid production process using ion exchange membranes continued during 2013. Further, development of integrated flow-sheet and material balance for the process (liquid effluent), electro-washing process for residues, optimization studies on reduction roasting, and melting study of reduced nodule and matte formation were carried out in house laboratories.

163. The cation exchange membrane and anion exchange membrane were found to respond differently over a range of pH of catholyte and anolyte, respectively. A process based on the ammonia-ammonium sulphate-SO<sub>2</sub> route followed by solvent extraction and electrowinning to recover Cu, Ni and Co has been developed.

**Financial statements**

164. Total direct expenditure incurred by India as a contractor in 2013 US\$ 4.788 million (a detailed certified breakdown is given). This expenditure does not include non-technical and administrative manpower.

**Training programme**

165. The contractor has completed the proposed training programme, hence no training work was carried out in 2013.

**Comments**

166. At several places in the report, mention has been made of the supplementary report submitted by the Ministry of Earth Sciences of India to the Authority in October 2013, containing an extensive presentation on the environmental impact assessment data generation/collection during the entire period of the programme (from 1981 to 2012), and of the fact that the information contained in the supplementary report is not repeated in the annual report.

167. India has identified a test mining site (block 112C) in its retained area.

168. For the secretariat to properly evaluate the final results of the experiment at the experimental disturbance site by, it is suggested that the environmental information and biological data be requested in a more detailed form (for example, water column parameter profiles, sediment characteristic profiles (tabular data), number of samples, type of samplers for biota).

## 7. Yuzhmorgeologiya

### General

169. The contractor submitted its annual report for 2013 in English on 30 April 2014. The report contains information on exploration studies, environmental studies, mining technology development, metallurgical process development, research activities, personnel training programme, financial statements, the quantity of recovered nodules, proposed corrections of the programme of activities and programme of activities for the next year 2014.

### Exploration work

170. The report contains information about the activities carried out in 2013 at three sites (B4, B5 and B6) in the eastern polygon of the Russian exploration area of Yuzhmorgeologiya. The main activities carried out were (a) data collection within sites B5 (4,240 km<sup>2</sup>) and B6 (5,600 km<sup>2</sup>) and (b) the processing of field data collected during 2011-2012 at the B4 site. Research vessel *Gelendzhik* was used for 133 days at the B5 site and 122 days at the B6 site including transit time.

171. At the B4 site, the work involved geo-acoustic profiling along 13 lines (470 km), photo/video profiling along 32 lines (1,032 km), 44,280 photographic shots and geological sampling at 83 stations. The technique of the offshore activities was described in details in the 2011 and 2012 annual reports therefore, they are not presented in this section.

172. The laboratory studies included some studies on board the vessel such as morphometric study of nodules; density and water saturation, nodules internal structure; processing and study of the sediment samples, structural/textural characteristics; physical-chemical parameters and dry soil bulk density, porosity, void index and specific weight.

173. A number of methods and instrumentation were used for chemical analyses, such as atomic emission with inductively coupled plasma for Na<sub>2</sub>O, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, K<sub>2</sub>O, CaO, TiO<sub>2</sub>, V, Cr<sub>2</sub>O<sub>3</sub>, Mn and Fe) using the Optima-4300 spectrometer (manufactured by Perkin-Elmer, United States of America); atomic absorption for estimation of non-ferrous metals (Co, Ni, Cu) content using the AAnalyst-100 spectrometer (Perkin-Elmer.); photometric estimation of P<sub>2</sub>O<sub>5</sub> content; gravimetric estimation of total S, SO<sub>3</sub>, H<sub>2</sub>O+ and H<sub>2</sub>O, loss during thermolysis); titrimetric estimation of FeO; ionometric estimation of F, Cl content; mass spectrometry with inductively coupled plasma for estimation of 49 trace elements chemical estimates using the Elan-6100 mass spectrometer (Perkin-Elmer).

174. Field data acquired during 2011-2012 within the B4 site was processed and main geological maps at 1:200,000 scale were prepared including the bathymetric map, physiographic map, scheme of geological setting and patterns of the nodule bodies.

175. The sedimentary cover studied up to 120 m depth by the MAK-1M deep-water geoaoustic system data processing revealed that the sedimentary cover is divided into four typical seismic successions.

176. Within the upper part of the section, on the seabed surface, a thin (1-10 cm) geochemical active layer occurs with nodules on it.

177. Physical properties of rocks were determined, petrographical, petrochemical and micro-analytical investigations were carried out, the absolute age of basalts was dated by the K-Ar method (mid-Miocene to late Eocene — late Oligocene).

178. The geological setting of the nodule fields zonation within the site revealed that the site as a whole has a complicated geological setting. Adjacent nodule fields, as a rule, are bathymetrically separated, with the depth difference from a few tens to 200 meters. The site was sub-divided into (i) favourable nodule fields (zones of simple mining setting), (ii) non-favourable zones and (iii) dangerous for the nodule collector (zones with difficult and moderate geological setting). It is revealed that within the site more than 90 per cent of the nodule-rich fields occur within the zone of favourable geological setting.

179. At 21 of 78 stations sampled by the box corer, buried nodules (3 to 10 cm) at 5 to 30 cm sediment depth were discovered. The nodules size vary from 1 cm to 14 cm (for their long axis) within the B4 site, however 4-12 cm nodules predominate (92.3 per cent). Nodule morphology has been studied and shape classification done. More than 80 per cent of the nodules have nodule density ranging from 1.92 to 2.01 g/cm<sup>3</sup> and water saturation (porosity) from 29.8 per cent to 32.2 per cent whereas the buried nodules have density from 1.80 to 1.88 g/cm<sup>3</sup>. Based on the morphological and geochemical features, two main types of nodules C and A, and intermediate type B, were classified. Up to 90 per cent of the nodules in the area are type C. Abundance of nodules within the site varies from 0.1 kg/m<sup>2</sup> to 24.8 kg/m<sup>2</sup>, with the majority being 10 to 20 kg/m<sup>2</sup>. The highest abundance of nodules occurs in the northern part of the site.

180. An analysis of the statistical parameters of chemical composition of the nodules has been carried out. The results of multicomponent investigation of samples demonstrate that a first group of elements (tantalum, rhenium, mercury, precious metals) in nodules have concentrations less than 1 g/t. The second group of elements (beryllium, caesium, tin, uranium, tellurium, hafnium, selenium, bismuth) is characterized by content from 1 to 10 g/t; the third group of elements (chromium, scandium, cadmium, thorium, rubidium, gallium, niobium, antimony, tungsten) is characterized by contents from 10 to 100 g/t; the fourth group of elements (vanadium, lithium, thallium, lead, zircon, strontium, molybdenum) is characterized by contents from 100 to 1,000 g/t; and some elements like barium, zinc, titanium concentrations are higher than 1,000 g/t.

181. Three groups may be distinguished among rare-earth elements for their concentration in nodules. The first group is constituted of lutetium, thulium, holmium, terbium and europium (concentration is less than 10 g/t); the second group consists of erbium, ytterbium, dysprosium, gadolinium, praseodymium and samarium (from 10 to 100 g/t); and the third group consists of yttrium, neodymium, cerium and lanthanum (from 100 to 1000 g/t).

182. Within the 4,240-km<sup>2</sup> site, there were contoured 62 ore bodies of total area 1,830 km<sup>2</sup>. The majority of the ore bodies are to 30 km long, some up to 64 km long



and a few km wide. The most frequent width ranges from 2 to 4 km and maximum width is 6.5 km. Areas of the separated ore bodies vary from a few square kilometres to 172 km<sup>2</sup>. Non-productive small and isolated ore bodies of maximum 7 km<sup>2</sup> totally occupy about 70 km<sup>2</sup>, that is less than 4 per cent of the total ore area (1,830 km<sup>2</sup>). Ore bodies are mostly located within the northern part of the site (to the north of 13° N). Of the 62 contoured ore bodies, 42 were selected and recognized as prospective deposits for future mining. The total area of the ore deposits is 1,731 km<sup>2</sup>, i.e. 41 per cent of the entire Site (4,240 km<sup>2</sup>) and it is 94.6 per cent of the picked up ore area (1,830 km<sup>2</sup>).

183. At the B5 site, photo/video profiling was done of 24 lines (837 km), 35,256 photographic shots were taken and the geological sampling was done at 124 stations in 2013. The laboratory studies of collected samples and field data processing commenced and should be completed in 2014. The deep-sea photo/video system Neptune; box-corer with photo unit; gravity-corer and cylinder rock dredge installed on board the research vessel *Gelendzhik* were used for data collection. A SIMRAD EM12 S-120 multibeam echo-sounder was used for bathymetry and charts were prepared at Mercator projection (main parallel 13°N, main meridian 0°E).

184. Vertical hydro-physical profiles of the water column were obtained and a photo/video survey was carried out in the central and southern parts of the B5 site, with infilling of the survey line grid (considering the previously surveyed lines) for more detailed delineation of the polymetallic nodule deposits and their structural elements to study the nodules distribution and their areal variability within deposits.

185. Continuous photo/video survey of the seabed (photo/video profiling) was carried out with use of the underwater deep-towed photo/video system Neptune. The average spacing between the photo/video lines surveyed through the site was 3 km considering the earlier surveyed lines.

186. A total of 124 stations were sampled, including 115 stations by the box corer with photo unit, 4 by the gravity corer and 5 by the rock dredge. The samples were used for determination of nodules abundance, types, chemical and physical properties, studying of sediments underlying nodules and also for environmental studies. The samples recovered were processed on board.

187. The polymetallic nodules were recovered in all 115 geological stations sampled by box corer. In total, 474.4 kg of wet nodules were recovered, including 7.8 kg of buried ones at four geological stations. The gravity cores (82-237 cm long) recovered were photographed, described and tested at various horizons. The grain size and morphometric analysis, determination of physical/mechanical properties (density and water content (porosity)), Eh and pH tests were done in the laboratory on board the RV *Gelendzhik*.

188. Final processing and geological interpretation of the original data acquired at the B5 site should be completed in 2014 and will be presented in the next annual report.

189. At the B6 site, all field activities are planned to be completed in 2014, with the original data processing to be completed in 2015. Activities completed in 2013 at this site include geo-acoustic profiling of 20 lines (894 km), photo/video profiling of 14 lines (625 km) and 27,472 photographic shots.

190. The research vessel *Gelendzhik* was used, carrying the same equipment as for the B5 site with the exception of some specialized equipment like the deep-water geo-acoustic system MAK-1M and deep-water photo/video system Neptune. Sound velocity measurement and physical characteristics of the water column (vertical hydro-physical profiles) data were obtained. A geo-acoustic survey (near-bottom geo-acoustic profiling) was performed by the MAK-1M acoustic system. A total of 20 lines (894 km) in north-east orientation were completed in 2013 at the B6 site. Sonograms with the a 1000 m swathe on each side and cross-sections with penetration up to 120 m were obtained.

191. Continuous photo/video survey was done using underwater deep-towed photo/video system Neptune in the northern part of the B6 site for distribution and areal variability of nodule accumulations within deposits, and assessment of baseline parameters of megafauna. 14 photo/video lines (625 km) were surveyed and 27,472 digital seabed images photographic shots were taken. The survey is planned to be continued in 2014 and to be completed in 2015. The results should be presented in the subsequent reports.

### **Environmental monitoring and assessment**

192. The results of the seabed sediments studies of the B4 site and their detailed description (physical and physical-chemical properties, carbonate content, granulometric and aggregate composition, age) are provided.

193. This report recounts the results of extensive, in-depth studies of megafauna, macrofauna, meiofauna, epifauna, and endofauna at the B4 site (an area of 4,240 km<sup>2</sup>). To study the macrofauna, 108 sediment samples were collected from 36 stations (resulting in 2147 organisms) and for meiofauna 84 sediment samples were collected from 12 stations (8,208 organisms). For nodule endofauna ten nodules were crushed carefully to retrieve meiofauna organisms living inside.

194. A collection of 44,280 photographs requiring scale resulted in 22,043 records of megafaunal animals. The most common were Anthozoa (23.8 per cent; of which Actiniaria 17.3 per cent), Xenophyophorida (22.3 per cent), Ophiuroidea (20.2 per cent), and Echinoidea (15.1 per cent). Taxonomic determination was usually to class or order level and only rarely to family level. The report provides density maps for seven taxa within the B4 area. These maps show high variability in density and biodiversity over small geographical scales.

195. The 36 macrofauna sampling stations in B4 resulted in 133 Polychaeta/m<sup>2</sup> on average as well as 89 Malacostraca/m<sup>2</sup> (including 46 Tanaidacea/m<sup>2</sup> and 39 Isopoda/m<sup>2</sup>) as main macrofauna components. Again, they were only identified to class and order level. The 12 meiofauna sampling stations in B4 resulted in an average density of 9478 individuals/0.25 m<sup>2</sup>. (83.5 per cent Nematoda and 10.3 per cent Harpacticoida as main meiofauna components) identified to between class and family level. Greater taxonomic resolution as decided at the ISA Taxonomic and Standardization workshops is required for all biological groups.

196. The endofauna sampling provided only 4 Nematoda and 9 Foraminifera in ten samples (one stained sample photograph). The epifauna was studied at 46 stations resulting in 236 epifauna specimens mostly identified to class and order level with twelve sample photographs.

### **Mining tests, mining technology and metallurgical processes**

197. No field mining tests were planned and carried out in 2013, in accordance with the Program of Activities for the third five-year period (2011-2015).

198. The research and development activities were carried out in 2013 to construct deep-water hardware and instrumentation necessary for mining activities. The development of a conceptual design of the vessel for testing deep-water experimental equipment and different technological models for pilot mining of nodules were carried out simultaneously. Initial technological requirements for the multi-purpose vessel and shipboard instrumentation package providing emergency recovery of the sunken equipment were formulated.

### **Other activities**

199. Research and development activities were carried out in 2013 to construct deep-water hardware and instrumentation necessary for exploration activities.

### **Financial statements**

200. The sum of costs with the main activity in 2013 is US\$ 11,532,903 and has been reported against the five subheads.

### **Training programme**

201. The contractor has completed the proposed training programme, hence no training work was carried out in 2013.

### **Comments**

202. In the processing of data collected during 2011-2012 at the B4 site (4,240 km<sup>2</sup>), 62 ore bodies of total area 1,830 km<sup>2</sup> were identified. Of the 62 contoured ore bodies, 42 are recognized to be prospective deposits for the future mining. The total area of the ore deposits is 1,731 km<sup>2</sup>, i.e. 41 per cent of the entire site (4,240 km<sup>2</sup>).

203. The report shows a very intense sampling of biota at least for the B4 and B5 sites. A coarse taxonomic classification was used that should be increased to family levels. The contractor has good material to work on during the standardization workshops.

## **8. Federal Institute for Geosciences and Natural Resources of Germany**

### **General**

204. The contractor submitted its annual report for 2013 in English on 26 March 2014. The report contains information on exploration work, environmental studies, mining tests and proposed mining technologies, training programme, exploration expenditure in 2013 and publications.

### **Exploration work**

205. The work was carried out during a 42-day cruise from 1 April to 13 May on board the RV *Kilo Moana*. The main aim of the voyage was to determine the nodule abundance and metal contents within the eastern license areas of approximately

2,000 km<sup>2</sup> of predominantly flat seafloor, in order to determine its suitability for potential future mining. Three working areas were selected — working areas 1 and 2, for nodule abundance and metal concentration and environmental parameters, and working area 3 as a “preservation reference area”, which in mining terms would represent an “impact reference area”.

206. During the cruise, 27,500 seafloor images were taken along seven video transects covering 68 km. 51 Box cores, 13 multi-corers and 2 chain bag dredges were deployed for sample collection. A side-scan sonar was towed for three days to map the backscatter and topography in high resolution over a total distance of 150 km. A total of 120 nodule samples from box cores have been analysed for their metal contents and added to the contractor’s chemical data base. The analytical work focused on the determination of Mn, Fe, Cu, Ni, Co, Ti, Mo, Li and the rare earth elements, including yttrium. Some high field strength elements such as Hf, Nb, Ta and potentially redox-sensitive elements such as Ce, Pt, V and W have also been analysed. Statistical analyses, such as the coefficient of variation, reflected an overall low variability in the metal contents in the nodules of the eastern German license area. In contrast, nodule abundance reflected a higher coefficient of variation, implying that the nodule abundance remains the most critical exploration criteria.

207. Based on multi-beam backscatter mapping, the contractor has developed a method to distinguish between areas that are predominantly covered by large nodules >4 cm from those covered by smaller nodules. The contractor was able to distinguish between areas with >10 kg/m<sup>2</sup> nodule abundance, areas with < 10 kg/m<sup>2</sup> abundance and areas devoid of nodules. During the 2013 *Mangan* cruise, the contractor took samples mainly in areas with predicted nodule sizes and was able to omit unattractive areas right from the beginning due to its selective approach. The contractor compared its results with the regular sampling pattern of the Interoceanmetal Joint Organization license area, where nodules >10 kg/m<sup>2</sup> showed only 45 per cent abundance, whereas the contractor’s showed 92 per cent abundance.

208. The key prospecting area (PA1) has been divided into two parts, PA1-West and PA1-East. Based on a variogram model, the nodule abundance per block is calculated. About 27 per cent of PA1 is not suitable for mining due to slope angles >3°, leaving about 1,500 km<sup>2</sup> of potentially mineable area within PA1.

209. The contractor classified the resources in this entire areas as “indicative mineral resources”, according to the Canadian Institute of Mining, Metallurgy and Petroleum definitions for mineral resources and mineral reserves (2010). The estimates are of sufficient quantity to support a future preliminary feasibility study.

210. The contractor is a partner in a recently approved European project called “Blue mining” that started on 1 February 2014 and will last until 31 January 2018. The main aim of the project is to advance sea-mining technology beyond the current technology readiness level. Target minerals are seafloor massive sulphides and seafloor manganese nodules.

### **Environmental studies**

211. The contractor rescheduled its original plan of work to year 2015 and no activities requiring environmental impact assessment were carried out in 2013.

212. A study of megafaunal abundance and species diversity led to a catalogue containing 162 morpho-species from 16 different taxa by means of photographic transects. For macrofaunal and meiofaunal abundance, diversity and geographic distribution, a total of 1,955 organisms (mostly polychaetes and isopods) were analysed morphologically and genetically in two areas (a prospective exploitation area and a potential preservation reference area).

213. For a detailed biodiversity analysis, the contractor is comparing available data from the French and the German licence areas, areas with high species diversity. Among the over 800 registered species are about 70 per cent with only a single specimen recorded, thus indicating the general difficulty of recording the complete biodiversity. Of those species found repeatedly, only 28 per cent of polychaetes, 10 per cent of isopods and 9 per cent of meiobenthic copepods were recorded in both licence areas (about 1,000 km apart).

214. For species identification in complex samples, the use of DNA signatures (barcodes) was considered a potential solution, even though molecular methods are acknowledged to typically underestimate the number of species and overestimate species ranges in marine habitats. This topic should be included for discussion at the Authority's taxonomic and standardization workshops to reach a consistent approach to reporting and showing molecular data.

215. Within the meiofauna, the nematode assemblages were studied in 26-year-old mining tracks (experimental nodule mining that occurred in the French *Nodinaut* licenced area in 1978) compared to other areas (e.g., inhabiting the nodule fields). Samples were obtained by submersible during the French *Nodinaut* cruise (2004). Different nematode genera appeared to inhabit different microhabitats and have responded differently to the mining impact. In total, nematode diversity representing 37 families and 129 genera were distinguished among 4,027 examined individuals. About 500 nematode species were estimated to be present, of which 90 per cent remain could not be attributed to a known species.

216. For DNA analyses, 1955 macro- and meiofaunal organisms were selected and photographed before analysis, including 1,068 polychaetes and 715 isopods. Of 38 molecular operational taxonomic units represented by more than one individual, only 29 per cent occurred in both the prospective exploitation area and in the preservation reference area (about 30 km apart). A comparison between the French and the German licenced areas was also made (1,000 km apart). Of 3,620 macrofaunal specimens, 557 polychaetes and 495 isopods were sequenced. Of 9 polychaete molecular operational taxonomic units that occurred more than once, only 28 per cent were found in both the French and German areas. For isopods, out of 53 molecular operational taxonomic units found more than once, only 5 (10 per cent) were found in both the German and French areas. Distribution patterns in the Clarion-Clipperton Zone appear to be taxon-specific. The genetic data also suggest the existence of cryptic species, that are morphologically indistinguishable but genetically distinct. All the environmental data need to be submitted in a standardized digital format that is available from the secretariat of the Authority.

217. Molecular analyses of meiofaunal copepods in the French and the German licence areas showed that, of 28 molecular operational taxonomic units that occurred more than once, only 3 (about 10 per cent) were present in both the French and German areas.

218. The molecular data will be very useful in future environmental planning. This is an excellent initiative.

219. The contractor deployed three ocean bottom acoustic Doppler current profiler moorings that will be recovered in May 2014. These tasks were not included in the original plan, but carried out in accordance with the recommendation of the Authority.

220. Using a Sea-Bird SBE conductivity, temperature and depth profiler, seven vertical conductivity, temperature and depth profiles of the entire water column in two working areas were measured. The profiles of temperature and salinity reflect the vertical distribution of water masses.

221. In its future strategy for environmental studies, the contractor proposes to carry out environmental studies that comprise analyses of (a) basic physical oceanographic data, (b) sediment properties and soil mechanics and (c) biological communities focusing on fauna.

222. The contractor is a partner in the European Union's MIDAS project, which started on 1 November 2013 and will run for three years, and in another project, the European Joint Programming Initiative "Mining impact", which will run for three years from 1 January 2015.

#### **Mining tests, mining technology and metallurgical processes**

223. In accordance with the programme of work, the contractor did not carry out a mining test during 2013.

224. The contractor has contracted with the Institute for Metallurgy and Metal Recycling and the Institute for Mineral Processing of the RWTH Aachen University in order to provide more insight into potential metallurgical nodule processing techniques. One starting point for research is the separation of solid, pre-reduced manganese nodules using mechanical processes rather than pyro-metallurgical methods. Another possible extraction method proposed by the Aachen University is the leaching of nodules by microbial means (bioleaching). The experiments have started in 2013.

#### **Financial statements**

225. The contractor stated a total expenditure of €5,554,848 euros reported against five categories (resource evaluation, environmental work, mining technology development, metallurgical process development and other activities).

#### **Training programme**

226. No training programme was carried out in 2013.

#### **Other activities**

227. In 2013 two articles relating to the German programme were published. Additionally, a master thesis and a bachelor thesis were carried out.

## Comments

228. The United States Navy research vessel, the RV *Kilo Moana*, was used by Japan and Germany in 2013.

229. Detailed responses have been given to 15 comments of the Legal and Technical Commission on the 2012 annual report (see [ISBA/19/LTC/15](#)). As concerns the request of the Commission to submit data to the Authority independently of previous publication, the Commission insists that this principle should be accepted. All data will remain closed and subject to the confidentiality terms. The contractor has rescheduled its original plan of work to 2015 and has not done any activity for environmental impact assessment in 2013.

230. The contractor has fulfilled the work programme as planned and reported all relevant data that are so far processed to the Authority.

231. The contractor has outsourced the work to different institutes and universities within and outside Germany and is partnered with several projects that have a direct relation with the polymetallic nodule project.

232. Chemical analyses are treated on the basis of average values. However, the contractor states in the report the existence of a chemical database with 434 analysed nodule samples. These data should be delivered to the Authority.

233. Appendix 1 to the contractor's report contains statistics on the elemental composition of nodules (41) elements recovered from the eastern German license area.

234. Appendix 2 to the contractor's report contains a summary of environment baseline data collected in 2013 and in total since 2008.

## 9. Tonga Offshore Mining Ltd.

### General

235. The contractor submitted its annual report for 2013 in English on 27 March 2014. The report contains information on exploration work, future strategies, environmental studies, mining tests and engineering studies, metallurgical studies, conceptual cost and economic modelling, training programme, quantity of nodules recovered, exploration expenditure and proposed adjustments to the future programme. Overall the report is very well presented.

236. The report summarizes the progress made by the contractor in 2013 around three primary goals: gaining a much better understanding of the resource, developing a viable technical and economic case for production and developing a platform to conduct baseline environmental studies. The contractor has completed a 55-day mapping and sampling cruise in its contract areas B, C, D, E and F aboard the RV *Mt Mitchell*, between August and September 2013. This cruise was the first of a two-phase programme with the ultimate goal of increasing the contractor's level of confidence in the resource from inferred to indicated. Data collected during this cruise will be used to design and plan more detailed environmental baseline studies.

### Exploration work

237. An extract from the 2013 RV *Mt Mitchell* cruise report is given. This 55-day cruise (total 22 working days and 32.5 days transit) to contract areas B to F

accomplished in its main objective (multibeam echo-sounder survey) and two secondary objectives (sampling and at-sea training). The 2013 cruise has enabled selection of priority areas over which a second precision sampling (box coring) and video/sonar (autonomous underwater vehicle) cruise will be focused.

238. Five of the six contract areas in the Clarion-Clipperton Zone were surveyed, generally from east to west. A 12 kHz Kongsberg EM120 system was used. Area F was surveyed in a north-south orientation and all other contract areas were surveyed from east to west. Line spacing was about 12 km with minor adjustments. All five areas were 100 per cent covered by the multibeam echo-sounding system. The survey data are generally of very good quality and considerable useful geological detail can be interpreted from these data. This should enable effective selection of priority areas for sampling work in 2014. A Sea-Bird SBE 19*plus* V2 was used for measuring conductivity, temperature and depth at four survey areas for calibration of the multibeam echo-sounding system. Apart from quality control of the sound speed profile data, no other analysis of the conductivity, temperature and depth data was performed at sea. The key data collected by the conductivity, temperature and depth at each of the survey locations are represented by multi-plots.

239. A fundamental key assumption behind the interpretation is that the backscatter intensity relates to nodule size or coverage and thus nodule abundance. These multibeam data and interpretations compared well with the Gebco (Smith and Sandwell sea gravity) bathymetry and the historical contractor sampling for nodule abundance-coverage. Interpretation of the multibeam data would be useful to identify areas of greater prospectivity suitable for sampling to reach an indicated mineral resource, besides understanding on the seabed morphology for any future mining operation. A more detailed interpretation is planned, and this should be possible at 1:250,000 scale.

240. Fourteen samples were collected using a specially constructed epibenthic sled attached to synthetic line.

241. Four samples taken in area F, nine in area D and one in area B collecting a total of slightly over 2.1 wet tons of nodules. About 350 smaller sub-samples were taken from across all of the sled samples for grade range analysis and analysis of free and crystallization water content. Logging of the different samples provided valuable information per different nodule morphologies as well as the frequency of crust in some areas.

242. Area A was not surveyed as it was too remote and unlikely to have the indicated mineral resource given the endurance of the vessel.

243. An epibenthic sled sampling was carried out for metallurgical test work, including whole rock chemical analysis and mineralogy, as well as bench top processing tests. Results of the 14 sled deployments completed are summarized for its coordinates, weight collected and a nice pictorial description of nodules at each station is given. Examples of each mapped or identified unit are shown.

#### **Environmental monitoring and assessment**

244. A few baseline environmental data were collected during the RV *Mt Mitchell* cruise. However, the contractor has not as yet conducted any of its own field work on seafloor sampling within the contracted Areas. Only four conductivity, temperature and depth casts were made, one in each of four different licence blocks.



In reviewing its future environmental baseline programme greater effort in water column studies (currents, physical and chemical properties) may be required. conductivity, temperature and depth data should be plotted with depth as the y axis.

245. The biological data presented of samples taken by epibenthic sledge highlight how necessary it will be to use sophisticated technologies, such as remotely operated vehicles, to generate real results, as well as standard equipment such as box corers.

246. A comprehensive environmental impact assessment is provided in an appendix to the annual report. The environmental impact assessment for individual sampling gears would be a good model for other contractors, especially those now working on polymetallic sulphides and cobalt crusts. All the environmental data need to be submitted in a standardized digital format that is available from the secretariat of the Authority.

### **Mining tests, mining technology and metallurgical processes**

247. Advances in this area during the reporting period included more detailed investigation of current and historical technologies applicable to collecting, concentrating, lifting, transporting and processing of polymetallic nodules. The contractor is at an advanced stage of a concept study looking at the most efficient and effective means to concentrate nodules on the seafloor. A patent application for a “seafloor nodule concentrating system and method” has been filed.

248. The contractor has employed third-party designers to develop the nodule concentrating system, and this concept design is expected to be completed during the first quarter of 2014. The contractor continues to develop its vertical hoisting system concept, as well as other aspects of the nodule mining system. This concept is part of a series of concept studies planned to investigate solutions for the key components of an integrated mining system and processing, which include the reclaimer and pump system, hoist system, transport system and metallurgy.

249. The contractor is planning to progress to the pre-feasibility stage using the work completed during 2012 and 2013. The contractor favours a de-coupled mining system. Work undertaken during 2013 focused more specifically on optimizing the critical mining system components. The contractor is still on the path to test the go-forward selections and move from demonstrator scale through to full-size scale and to production scale.

250. About 350 smaller sub-samples were taken from across all the sled samples for grade range analysis.

251. Average grade for each of the 14 epibenthic sled samples for five metals (Ni, Cu, Co, Mn, Fe), rare earth elements and Mo have been analysed using X-ray fluorescence and the inductively coupled plasma-atomic emission spectrometer and results are tabulated.

252. A multi-element analysis method has now been developed, which will be used for future nodule sampling programmes and to support any future updates of mineral resource data. The test work planned for 2014 will continue to build on the metallurgical review completed in 2012.

**Other activities**

253. Two possible timelines representing a possible time range to production are included in an appendix to the contractor's report.

254. However, both timelines are subject to some constraints and uncertainties.

255. The contractor is currently considering, as a more cost-effective alternative that should also mitigate development risks, a series of scaled engineering field trials for the key mining system components. Firm decisions will be made in this regard after fully and properly engaging with the Authority.

256. The contractor is also working closely with Golder Associates to develop and apply the essential sampling and statistical criteria necessary to increase the confidence level in the contract area resource to an indicated level under NI 43-101.

257. To date, the contractor's estimates of cost and revenue are still only at a conceptual level of confidence. On the basis of earnings before interest, tax, depreciation and amortization, the conceptual mining operation is attractive even if only nickel and copper are considered marketable products.

258. Approximately 2.1 tons of nodules were recovered over 14 epibenthic sled deployments during the RV *Mt Mitchell* cruise of 2013.

**Financial statements**

259. No information is given in the report. It has been provided to the Authority separately. Total exploration expenditure for 2013 is US\$ 2,860,991 including wages and salaries, general administration, boat charter and engineering services.

**Training programme**

260. At-sea training was provided to two students selected by the Authority and one Tongan observer.

**Comments**

261. The contractor requests the Authority to consider changes to the trainee selection and approval process for applicants and companies. The availability of offshore assets such as vessels and equipment may not necessarily align with the Authority's timetable to approve or vet trainees, therefore, the contractor would very much appreciate the Authority considering an approval process for trainees that is flexible enough for it to be able to vet and approve suitably qualified trainees at any time of the year.

262. The box corer was newly constructed and enlarged in terms of size. It proved to fail at the first deployment and was entirely lost.

263. The geological results were displayed in a corresponding map but the legend of the complicated pattern is too difficult to understand. It is suggested to improve the legend.

264. The table summarizing the chemical constituents displays 16 samples but in the text only 14 samples are mentioned. The units in the tables are not completely indicated.

265. The Contractor has fulfilled the work programme and reported all relevant data that are so far processed to the Authority.

## 10. Nauru Ocean Resources Inc.

### General

266. The contractor submitted its annual report for 2013 in English on 27 March 2014. The report contains information on exploration work, environmental monitoring and assessment, mining tests, engineering and metallurgy, training programme, financial statement and appendices.

### Exploration work

267. The contractor's exploration license consists of four separate areas (areas A to D). A multibeam echo-sounder survey was carried out on board the RV *Mt Mitchell* in 2013 and polymetallic nodule sampling work was done in area As and B between 22 August and 15 October, including transit and bunkering. The activities carried out during the 2013 cruise varied slightly from what was originally proposed for that cruise. A comparative statement of planned and completed activities in 2013 is presented.

268. The exploration work was aimed at collecting data to identify a potential first-generation mine site. The geophysical mapping and sampling work is done in all four of the contract areas. A Kongsberg Simrad EM120 12 kHz multibeam system with a data-collection processing unit was used to carry out the acoustic surveying. Approximately 8,924 km<sup>2</sup> was surveyed in area A and approximately 2,911 km<sup>2</sup> in area B. The Caris, D-Magic and Fledermous programme software were used to clean and carry out three-dimensional processing of the beam data.

269. A summary of the geophysical interpretation of backscatter data obtained in 2012 across area C and area D is provided. Global Mapper (v.11) software for three-dimensional analysis was used for data processing to make imagery comparable. The back scatter imagery has been used to generate boundaries around potential areas of nodule abundance in the contract area.

270. The dredging was carried out using an epibenthic sled model. Approximately 190 kg of nodules were recovered from area A and approximately 85 kg from area B. A 2 kg sub-sample was taken for laboratory analysis. The results for Co, Cu, Fe, Mn, Mo and Ni are reported on weight loss basis, after drying at 120 degrees for 12 hours.

271. Areas A to D have sufficient samples of adequate quality and authenticity to define an inferred mineral resource of nickel, copper, manganese and cobalt. It is stated that the estimate of abundance at sample stations within the contract area may be low due to sampling by the free-fall grab samplers.

272. Estimation of tonnage and grade was undertaken using sample data within the area and modelling was done using the Datamine Studio mining software version 3.20.6140.0. The modelling methodology used for estimating the mineral resource considers the scale of deposit, geological mechanism and controls behind nodule formation and nature of the sampling method. The approach involved estimating nodule abundance and grades into a two-dimensional block model (931 blocks covering 74,840 km<sup>2</sup>) with abundance in wet kg/m<sup>2</sup> used for calculating tonnage.

Grades were estimated using ordinary krigging and inverse distance weighting was used for validation.

273. The interpretation of the multibeam data shows areas C and D to have small isolated seamounts. Essentially, the entire contract area falls within the abyssal hill domain.

274. Declustering was used to remove potential biases in statistics that can arise from variable sample spacing. A modified cell declustering algorithm was used that weights the cells to the block model volume within each cell. The process provides a declustering weight which is used to weight the univariate statistics.

275. The model was validated by (a) visual inspection of the grade estimates, (b) Global mean and variance comparisons and (c) swath plots (in universal transverse mercator coordinates). The swath plots include comparison of block model and declustered composite grade averages for north-south slices. The swath plots show good agreement between the average estimated grades compared with the sample average grades by slice.

276. A comparison of the global mean and variance between the declustered composites and the volume weighted block model estimates for each combined domain is provided for nickel, cobalt, copper, manganese and Abundance. The comparison of the ordinary krigging and inverse distance weighting estimates are globally identical while individual cells show minor variance.

277. The global inferred mineral resource estimate, based on 20 km sampling at an abundance cut-off of 6 wet kg/m<sup>2</sup> (on wet basis), is the selected base case scenario, considering a non-selective bulk mining operation and is based on historic data (mostly free-fall grab samples). Assaying of 20 samples taken from the bulk sample indicate mean grades that are consistent with the mean grades derived from the historic grab samples. The Mineral Resource estimates were prepared in accordance with the “Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines” of the Canadian Institute of Mining, Metallurgy and Petroleum and the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code, 2012). More work will be required to define any high-confidence (indicated or measured) mineral resource estimate, and will be required for detailed mine planning.

278. Grades for elements of interest other than manganese, nickel, copper and cobalt from 20 samples of nodules taken by the contractor within the area are grouped into three categories: alloy metals, rare earth and their transition metals and other elements.

279. Quantile-quantile plots comparing the assay distributions of the samples within the contract area with all other available data from the reserved areas are presented through figures. These plots show that nickel, copper, manganese and nodule abundance is conditionally higher for the area compared with the overall distributions for the Clarion-Clipperton Zone, while cobalt is conditionally lower.

280. Comparison of nodule samples from within the contract area between the pioneer explorers is shown in log probability plots. These plots show that within the area of Nauru Ocean Resources Inc. the distributions for nodule abundance, manganese and cobalt are similar between contractors, with the German data being higher in nodule abundance and manganese and significantly lower in cobalt.

281. From the contractor's area C approximately 280 kg of nodules were recovered (5 dredge deployments) and from area D approximately 4,500 kg (28 dredge deployments).

#### **Environmental monitoring and assessment**

282. The 2013 report of Nauru Ocean Resources Inc. assesses and interprets environmental data obtained in a 2012 exploration cruise. Some information is reported in an appendix entitled "Biological specimens report".

283. Initial work has focused on megafauna collected in passing by sledges and dredges with primary tasks other than megafauna sample collection. The data presented included a number of pelagic taxa. The work highlights the need to use appropriate equipment for the task. This is likely to be achieved when work starts on the primary mining site. The taxonomy workshop highlighted the need to collect actual specimens in good condition — photographic evidence of the odd specimen is not adequate. Quantification of megafauna using seabed camera transects by remotely operated vehicle or autonomous underwater vehicle will be required.

284. A box corer was lost on a cruise immediately prior to the contractor's cruise, so no data on macrofauna were collected. Despite this, the contractor should participate in the Authority's macrofauna taxonomic and standardization workshop in the Republic of Korea in 2014.

285. All the environmental data need to be submitted in a standardized digital format that is available from the secretariat of the Authority.

#### **Mining tests, mining technology and metallurgical processes**

286. Meetings were held in 2013 with leading international engineering firms including Hatch, Jacobs Engineering and Aker Solutions regarding the offshore and onshore components of the polymetallic nodule mining project.

287. A general description of the offshore elements of a mining system that the contractor plans to continue to consider in 2014 is given. The potential mining system involves electric to hydraulic remote controlled harvesters that would feed a pump and riser pipe system transporting the nodules to a mining services platform where they would be separated from slurry and then conveyed to ore carriers that would transport the nodules to a land based processing plant.

288. Sediment properties, such as clay percentage, liquid limit, plastic limit, plasticity index, activity, specific gravity solids and clay mineralogical composition were studied.

289. In 2013 process test work was carried out at bench scale on nodules obtained from the licence area. This work concentrated on a hydrometallurgical approach leaching the nodules.

290. The preferred process being tested operates at 1 atmosphere and relatively low temperature compared to high pressure acid leach nickel laterite processing.

**Other activities**

291. The contractor reports that its collaboration with Tonga Offshore Mining Ltd. reduced its costs about US\$ 1 million. Therefore, the anticipated exploration budget for the third-year plan of work will be reduced to reflect these changes.

292. The contractor acknowledged the Authority's comments regarding the seafloor images from its first cruise and will be working to provide improved seafloor images in the future.

293. In response to the recommendation from the Legal and Technical Commission (see [ISBA/19/LTC/15](#)), nodule sampling data with the location coordinates and weight of five samples from location C and 23 samples from location D, collected during the contractor's 2012 cruise, have been provided.

**Financial statements**

294. A financial statement providing a breakdown of expenditure in 2013, certified by a firm of chartered accountants, shows a total of US\$ 1,258,414 to have been spent by the contractor in 2013.

**Training programme**

295. In 2013 the contractor continued to fund scholarships to undergraduate courses in environmental science and engineering for Nauruan students at the University of the South Pacific in Suva, Fiji.

296. At-sea training for a trainee from Indonesia was given during the 2013 cruise.

**Comments**

297. The contractor has fulfilled the work programme as planned and reported all relevant data that are so far processed to the Authority.

298. Inferred mineral resource estimated for the contractor's area is 823 million tons (wet, cut-off abundance 8 kg/m<sup>2</sup>).

299. Commodity market/price studies carried out by Nauru Ocean Resources Inc., including for nickel, copper, manganese, cobalt and molybdenum markets, reveal that the metal prices for the key pay metals of nodule extraction have fallen significantly (by 30 to 50 per cent) over the last three years. To compensate for this fall and to maintain the project economics, the contractor looked at the four major options to obtain potential increased efficiencies: mine higher grades; higher density; mine greater quantity; and/or improve metal recovery. The contractor observed that, the potential to improve metal recovery from a processing plant would make a significant positive impact on the project economics. Additional metals like molybdenum, iron, cerium and rare earth metals were considered.

300. The environmental data reported here are not sufficient to be used for any kind of environmental assessment. There is no geographically referenced material. This information must be requested as well as all the water column and sediment column information gathered by the contractor.

## 11. UK Seabed Resources Ltd.

### General

301. The contractor submitted its first annual report for 2013 in English on 3 April 2014. The report contained information on the intended programme and its completion, 2013 cruise resource survey accomplishments, 2013 cruise environmental baseline accomplishments, mining tests, training programme and financial statement.

### Exploration work

302. The first environmental baseline cruise, "AB01", took place from 3 October 2013 to 27 October 2013 on the RV *Melville* in a 30 km x 30 km area of the contractor's exploration licence area. The equipment was deployed at 13 stations (12 in the contractor's licence area labelled A to L and one approximately 140 nautical miles to the east labelled M) and consisted of 56 deployments of major sampling systems, and four remotely operated vehicle dives. It will require more than a year to process and analyse the data collected.

303. Resource survey data acquired on the cruise included multi-beam bathymetric and backscatter coverage over the entire 30 km x 30 km study area, nodule abundance ( $\text{kg/m}^2$ ) and sediment shear strength for each of the 12 box core samples and high definition video and still images from the remotely operated vehicle deployments. The four remotely operated vehicle dives explored 10.9 km of seabed and recorded video and still images.

304. A semi-quantitative resource measurement was obtained via the high resolution photography and video from the remotely operated vehicle transects.

305. The total net weight of nodules samples acquired on the 2013 cruise was approximately 100 kg. Seabed mechanical strength measurements were obtained by use of a shear strength measurement tool applied to the mud of each box core as it arrived on deck.

306. The contractor has incorporated all of the data gathered on the 2013 cruise into its comprehensive Geographical Information Systems database. This database already included all the proprietary manganese nodule data from the Lockheed Martin efforts from the 1970s and 1980s.

### Environmental monitoring and assessment

307. The environmental objective of the 2013 AB01 cruise was to conduct the first in a series of cruises to evaluate biological and environmental baseline conditions in the contractor's UK1 lease block.

308. At each station, some or all of the following instrumentation was deployed: box corer, mega corer (an upgraded version of a multiple core), respirometer lander, baited trap, baited camera with attached current meter, plankton net, Brenke epibenthic sled, conductivity, temperature and depth and remotely operated vehicle. Ship-based multibeam surveys were conducted by the EM 122 multibeam echosounder from Kongsberg, providing bathymetric coverage for essentially the entire study area.

309. Other sampling device included the push corer by the manipulator of the remotely operated vehicle, where it is pushed into the seafloor to collect quantitative sediment and overlying water samples, with minimal disturbance.

310. A deep-sea mooring with time-series sediment traps at altitudes of 11 m and approximately 146 m above the seafloor was deployed in October 2013. The traps were set to sample at 17-day intervals for determination of the sinking fluxes of particulate organic carbon (food for the deep-sea benthos), inorganic particles (the materials constituting deep-sea sediments) and sinking larvae of benthos over the full annual cycle. These traps will be recovered and redeployed annually over the four-year duration of the field programme to allow examination of variation in particle and larval flux (key ecosystem parameters) over seasonal to multi-year time scales in UK1.

311. A respirometer lander experiment to study ecosystem function was used which will allow the contractor to gain the first insights into the response rate of bacteria and macrofauna to phytodetritus deposition, and C-cycling rates in Clarion-Clipperton Zone abyssal seafloor sediments.

312. The contractor's report is interesting and promising, although it does not provide many results at this point. The chapter on cruise environmental sampling and procedures outlines the sampling infrastructure available which include all usual equipment as well as a baited camera system (imploded on the third use) and a baited trap (very successful) at one end of the size spectrum as well as molecular analyses (DNA and stable isotopes) at the other end. Furthermore, the contractor appears to have enlisted excellent taxonomical support from the University of Hawaii, the Natural History Museum (London), the University of Bergen (Norway) and the Senckenberg am Meer (Wilhelmshaven). Intended studies are outlined in detail.

313. There may be scope for enlarging taxonomic expertise of the fauna in the region working with scientists engaged in polymetallic nodule research in the adjoining exclusive economic zone of Mexico.

314. Remotely operated vehicle data are limited at the moment. A greater library of images would be useful for the Authority in outreach activities on deep-sea mining.

315. Quantification of megafauna and nodule abundance using autonomous underwater vehicle surveys may be useful.

316. The chapter on preliminary scientific results describes only few, very preliminary research results. Preliminary taxa lists are provided for the baited camera as well as for the baited trap (>1000 amphipods and 14 fish). Similar rows of taxa names are provided for epifauna and Foraminifera (including six photographs). The meiofauna samples are dominated by Nematoda and Copepoda followed by Ostracoda. The macrofaunal samples also included Cumacea, Amphipoda, and Tanaidacea as well. Some Copepoda families are being named for both size classes. Finally, microbial activity is studied with a respirometer. For all analyses, including microbial diversity and functionality, very interesting results can be expected for the coming years.



**Mining tests, mining technology and metallurgical processes**

317. In keeping with the provisions of the contractor's license, no tests of mining hardware were conducted.

**Other activities**

318. The contractor had first workshop which took place in March 2013, in London, focusing on the methods to be used for collection and processing of data related to benthic fauna. The outcome of the workshop was agreement on an integrated study plan. A follow-on workshop was necessary to ensure coordination of all the scientific gear, scheduling and remotely operated vehicle operations. This workshop was subsequently held at the Friday Harbor laboratories of the University of Washington later in 2013.

**Financial statements**

319. No financial statement is provided in the report; however, the contractor submitted the appropriate financial report to the secretariat on 15 July 2014, itemized for a total of US\$ 5,629,529.

**Training programme**

320. The contractor is supporting two students at Plymouth University for doctoral programmes of study that are expected to start in autumn 2014. One programme of study will have to do with analysis and modelling of the deep sea ecosystem while the other will have to do with the mineralogy/metallurgical processing of manganese nodules.

**Comments**

321. The contractor reports that its respirometer lander experiment to study ecosystem function, conducted during its first cruise under the recently acquired license was the first experiment of its kind ever conducted in the Clarion-Clipperton Zone and the second conducted in the Pacific Ocean. The technique allows the first insights to be gained into the response rate of bacteria and macrofauna to phytodetritus deposition, and C-cycling rates in Clarion-Clipperton Zone abyssal seafloor sediments. It is noted that the training programme of the contractor is not within the official Authority procedure system. In that regard it does not fulfil the formal requirements.

**B. Polymetallic sulphides****1. Ministry of Natural Resources and Environment of the Russian Federation****General**

322. The contract was signed in October 2012. Therefore following advice of the Secretary-General of the Authority through his letter of 19 December 2012, the Russian Federation presented its first combined annual report for period of 2012-2013 in March 2014. The report contains information on prospecting/exploration works, environmental studies, development of mining technologies, metallurgical

process and research work carried out in order to identify priority areas for more detailed work.

### **Exploration work**

323. The main activity in 2012-2013 was exploration work in the two clusters of application blocks (A and B), in 15 blocks numbered 1-12 and 15-17. In 2012 a total of 161 days and in 2013 78 days were spent. The main activities and their purposes were: hydrophysical sensing, geo-acoustic profiling, measurement of the natural electric field, TV profiling, geological testing of the seabottom, on-board analytical studies and geological sampling.

324. A new ore field “Yubileynoye”, consisting of two ore bodies, and another ore occurrence “Surprise”, were discovered. TV grab samples were selected from these two fields. The ordinary and grab samples were used for the geochemical, mineralogical, technological, and petrographic studies.

325. In the 15 blocks of the Russian exploration area, 32 hydrophysical stations were made, over the ore fields “Puy des Folles”, “Zenith-Victoria” and “Yubileynoye”. In the bottom water column no anomalies in the distribution of potential temperature, salinity and density anomalies were discovered. In the “Yubileynoye” (block 10) area, six hydrophysical stations showed no signs of modern venting.

326. Fifteen natural electric field anomalies were recorded by intensity and divided into three groups: (a) intensive local negative or positive anomalies with a distinct single extreme; (b) intensive local alternating anomalies with two or more extremes; and (c) low-intensity local negative anomalies. All the selected anomalies are shown in the first annex to the report. The basic amount of the natural field anomalies was recorded in the areas of known vents “Zenith-Victoria” and “Puy des Folles”. Based on the results, the complex “MAC-1M”, for geo-acoustic profiling was considered as a highly efficient method of searching for deep-sea polymetallic sulphides and very cost-effective use of the ship time. Sampling was concentrated in the block 10 in “Yubileynoye” field except two stations in the block three. The area of the “Yubileynoye” field reaches 1.4 km<sup>2</sup>. The ore body 1 lies in the depth interval 2350-2450 m. By the TV observation, its dimensions are 420 x 260 m. The ore body 2 is located 400 m to the northeast of the body 1 in the depth interval 2500-2550 m; its dimensions are 200x100 m.

327. Within the ore field “Yubileynoye” metalliferous sediments, sulphide ore, mineralized rocks, crust of iron hydroxides and other hydrothermal formations have been sampled. The ore body 1 was sampled by seven television-guided gripper stations. The ore body 2 was sampled by one television-guided gripper station and one dredge. Large boulders, debris and detrital material of various sizes of massive sulphide ores were recovered at all the stations. The ore body 1 is represented mainly by the sulfur-pyrite (approximately 90 per cent of the recovered ore material) and zinc-pyrite types. The massive ore of the ore body 2 belongs to the sulfur type (100 per cent of the uplifted ore material). The most common mineral varieties are marcasite-pyrite (approximately 40 per cent) and sphalerite-marcasite-pyrite (approximately 60 per cent). They are similar to the described above ores from the ore body 1.

328. Four types and 12 varieties of mineral ores are encountered in the ore field “Yubileynoye”. The most common variety is mineral marcasite-pyrite ore of the sulfur-pyrite type. The dimensions, shape and mineral composition point to the “young” age of the sulphide ores. Only 2 to 3 per cent of the ore material recovered came from the formation zone of copper and copper-pyrite ores. The studied textural features and relations of metallic and non-metallic minerals show that the deposition of sulphides was taking place repeatedly by the ore overlaying the previously formed complex ores.

329. A potential evaluation of inferred resources of the ore field “Yubileynoye” has been made on the basis of the achieved degree of knowledge; in this context the inferred resources are classified as belonging to the category P2. The inferred ore resources of the “Surprise” were not evaluated, as at present the contours of this object are unknown. Total resources of the wet sulphide ore in the newly discovered hydrothermal ore field “Yubileynoye” are about 2.88 million tons. The resources of the dry ore mass are about 2.73 million tons.

330. Block 4 (ore occurrence “Surprise”), block 8 (hydrothermal field “Puy des Folles”), block 10 (hydrothermal field “Yubileynoye”) and block 12 (hydrothermal field “Zenith-Victoria”) were found promising for further research and detailed prospection. The prospects for block 3 remain unclear.

331. In the hydrothermal ore field “Yubileynoye” and ore occurrence “Surprise”, the physical and mechanical properties of the sea bottom formations represented by sulphide ores, mainly of pyrite mineralization, hydrothermal crusts and bottom sediments were studied.

#### **Environmental monitoring and assessment**

332. In the reporting period, special field studies of environmental monitoring were not carried out.

333. However, hydro-physical parameters of the water column may be indirectly used for modelling the impact of mining activities on the environment. Hence, these parameters of bottom water above the ore field “Peterburgskoye”, where no modern venting was registered, was included.

334. During the work a database (to 90 per cent) on the hydrothermal fauna of the Mid-Atlantic Ridge was created. The database (in the Excel format) includes information about 200 species of animals and for 9 hydrothermal regions of the northern Mid-Atlantic Ridge (north to south); namely Menez Gwen, Lucky Strike, Rainbow, Lost City, Broken Spur, TAG, Snake Pit, Logatchev and Ashadze. The contractor feels that after completion the database will become the most comprehensive in the world. The database is shown in the annex to the report).

335. An environmental impact assessment, including cumulative impacts in localized areas, is required for dredging activities. Data presented indicate that significant near-bottom sediment plumes are created by dredging activities. Environmental impact assessments are required to be submitted to the Authority and agreed before activities commence. A good example of an environmental impact assessment template might be obtained from Tonga Offshore Mining Ltd.

336. The conductivity, temperature and depth presented are good, but the values of turbidity need to be checked to discard active hydrothermal vent events by

calculating vent temperature anomaly. Also it will be necessary to carry out in the future acoustic Doppler current profiler or bottom current measurements to check water mass erosion flow hypothesis indicated.

337. The contractor needs to work closely with its environmental advisers to ensure and verify that no significant environmental harm is occurring from its exploration activities. A specific statement of how the contractor has determined that no significant environmental harm has been created during each field programme is required.

#### **Mining tests, mining technology and metallurgical processes**

338. To create a prototype of the technological drilling complex TC-15 and its commissioning, the specialists of “Sevmorgeo” together with the specialists of “Polar Marine Geosurvey Expedition” checked and confirmed the workability of an experimental sample of the drilling complex EOTK-15 in the shallow water. Further, the ability of coring under water by a drilling tool 76 mm diameter using removable core receivers was also checked.

339. A number of parts and components were manufactured to provide the tightness of the enclosures and expansion joints, sealing systems and television monitoring by the remote control from aboard.

340. Two samples of polymetallic sulphides samples were analysed in 2012: sample 311345, collected in 2008 in the ore field “Puy des Folles”, ore body 1, weighing 75 kg., and sample 321277, collected in 2009 in the ore field “Semyonov-2”, ore body 1, bulk weighing 105 kg. The main mineral components are copper (6.13 per cent) and zinc (3.03 per cent); the associated metals are gold 0.34 ppm and silver 35 ppm.

341. The hydrometallurgical processing technology has been worked out; it includes oxidative roasting of the ore and leaching by sulfuric acid to produce the solution and cake. The precious metals are extracted from the cake by sorption cyanidation. This process produced: copper — 96.73 per cent, zinc — 95.65 per cent, gold — 86.45 per cent, silver — 45.69 per cent.

#### **Other activities**

342. During the research work a detailed study of major and minor mineral components in deep-sea polymetallic sulphides was carried out. The sulphide ores are divided into Cu-pyrite, sulphide and sulfur pyrite. The potential and practical significance of rare earth elements was analysed on all-ocean data. It was noted that the content of rare earth in the deep-sea polymetallic sulphides is extremely low. The elements traditionally associated with continental pyrite ores — Se, Te, Ge, As, Co, Ni, etc., are also present in the deep-sea polymetallic sulphides.

343. In 2012, at the field “Yubileynoye” two dredges and seven grabs recovered 1183 kg of seafloor massive sulphides. From the field “Surprise” two dredges and a grab recovered 23 kg of ore. In 2013, at the field “Yubileynoye” two dredges lifted 25 kg of ore. In total in 2012-2013, 1231 kg of sulphides were recovered.

**Financial statements**

344. A total of US\$ 9,737,425 was spent and an itemized work statement is provided.

**Training programme**

345. No training programme was planned for part of the reporting period and none was implemented.

346. Coordinates of hydrological stations, geological stations (TV-grab, rectangular-core) and dredging stations are provided in the annex. Method of analysis and detection range of hydrothermal formations as well as the results of analysis are shown.

347. A summary of databases on the composition and distribution of hydrothermal fauna at the Mid-Atlantic Ridge is given.

**Comments**

348. The Contractor has fulfilled the work programme as planned and reported all relevant data that are so far processed to the Authority. Of particular interest are the results of the testing and subsequent full implementation of the MAC-1M system which combines bottom sonar surveying and continuous measurement of the natural electric field potential. One extinct new ore field “Yubileynoye”, and one ore occurrence “Surprise” were discovered based on distinct natural electric field anomalies recorded by this MAC-1M system. This should be regarded as very promising tool for the exploration of inactive ore fields.

349. The overview of activities scheduled for 2014 should have been more detailed.

350. During the work a database (to 90 per cent) on the hydrothermal fauna of the Mid-Atlantic Ridge was created. The contractor feels that after the completion the database will become the most comprehensive in the world.

351. Based on these results, the complex “MAC-1M” was considered as a highly efficient method of searching for deep-sea polymetallic sulphides and a very cost-effective use of the ship time.

352. Two ore samples had a very high copper content (44.08 per cent), with low concentrations of zinc (0.41 per cent), low iron content (13.48 per cent) and low sulfur content (27.32 per cent). There were high concentrations of gold (7.45 ppm) and silver (63.8 ppm).

**2. China Ocean Mineral Resources Research and Development Association****General**

353. The contractor submitted its annual report for 2013 in English on 28 March 2014. The report was submitted both in hard-copy and electronic format.

**Exploration work**

354. The contractor had to reschedule its cruise due to the failure of the equipment RV *Dayang Yihao* in December 2013 and extremely bad weather, after completion of only nine conductivity, temperature and depth stations for comprehensive baseline

surveys and integrated water sampling; the contractor has rescheduled the survey plans to a year later (specified in table 1.1-2 of the report).

### **Environmental monitoring and assessment**

355. A Sea-Bird conductivity, temperature and depth system was used at five stations, at 2 to 200-metre water column at the first four stations and one full-depth investigation was conducted. Greater full ocean depth conductivity, temperature and depths are required. The main survey items included the water chemical baseline studies: vertical profiles of nutrients silicate, phosphate, nitrate and nitrite concentrations in seawater were measured by AA3 flow injection analyser (Bran-Luebbe). Methane concentrations measured on seawater by pulsed discharge helium ionization detector were not high. Environmental baseline monitoring included physical parameters such as conductivity (i.e. salinity), temperature and depth of the seawater, and biological parameters such as zooplankton, phytoplankton and photoautotrophic picoplankton biomass and concentration profiles of Chlorophyll a.

356. Phytoplankton and Bioness plankton towing nets, and Trilogy fluorescence analyser were used for biological surveys.

357. Sediments containing macro-benthos were collected using a TV grab from surface sediments at 10 cm depth. Samples from two stations were collected. It is highly unlikely that samples of sediment using TV grabs will provide useful analyses. The contractor's application for a licence highlighted that sophisticated technologies would be used, such as autonomous underwater vehicles and remotely operated vehicles. No details or plans to use these systems have been presented.

358. Environmental impact assessments are required for other sorts of seabed sampling, such as dredging. These must be submitted to the Authority before any activities commence.

### **Mining tests, mining technology and metallurgical processes**

359. With reference to such large seabed equipment as large work-type remotely operated vehicles, deep seabed core drillers, HYBIS, deep-sea sampling and remote control grabs, mobile docker for underwater sciences, NEXANS spider, the shifting principle of the seabed mining equipment based on hydraulic thruster was studied and a preliminary technical design was done. Studies were also carried out for the technology of mining, sampling and in-situ testing of the mining system. The equipment will be tested in late 2014 in the polymetallic sulphides exploration area of the contract area.

360. Mineralogy of the samples was studied using the energy dispersive spectroscopy analysis in conjunction with scanning electron microscopy with a view to developing a best processing technology.

### **Other activities**

361. The contractor established its data management standards and system; and a sample repository, the China Ocean Sample Repository, for archiving of sulphide samples.

362. Thirteen research articles published in 2013 and their abstracts are given in appendix II to the report.

363. Appendix I is the reply to the overview on the contractor's annual report for 2012 made by the Legal and Technical Commission of the International Seabed Authority.

364. In the past, between 2007 and 2010, the contractor had discovered seven hydrothermal fields in the Southwest Indian Ridge; five were at 49-53° E which is currently the highest-degree-investigated area for hydrothermal activity on the Southwest Indian Ridge.

**Financial statement**

365. The actual and direct expenditure occurred in 2013 amounts to approximately US\$ 5,879,100. A breakdown of the expenditure is given.

**Training programme**

366. No training was provided. The contractor has planned to implement the training programme in 2014.

**Comments**

367. No cruises were conducted in 2013.

## Annex I

## Contractor annual reports received by the secretariat

<i>Contractor</i>	<i>Date of receipt of report by the secretariat</i>	<i>Polymetallic nodules</i>	<i>Polymetallic sulphides</i>
Deep Ocean Resources Development Co. Ltd.	25 March 2014	x	
China Ocean Mineral Resources Research and Development Association	28 March 2014	x	x
Government of the Republic of Korea	25 March 2014	x	
Interoceanmetal Joint Organization	9 April 2014	x	
Institut français de recherche pour l'exploitation de la mer	2 April 2014	x	
Government of India	22 April 2014	x	
Yuzhmoregeologiya	30 April 2014	x	
Ministry of Natural Resources and Environment of the Russian Federation			x
Federal Institute for Geosciences and Natural Resources of Germany	26 March 2014	x	x
Tonga Offshore Mining Limited	27 March 2014	x	
Nauru Ocean Resources Inc.	27 March 2014	x	
UK Seabed Resources Ltd.	3 April 2014	x	



## Annex II

## Summary of contractors' reported costs for 2013

(United States dollars)

<i>Contractor</i>	<i>Resource evaluation</i>	<i>Environmental monitoring</i>	<i>Mining technology development</i>	<i>Metallurgical process development</i>	<i>Other activities</i>	<i>Total spent 2013</i>
<b>Polymetallic nodules</b>						
Federal Institute for Geosciences and Natural Resources of Germany <sup>a</sup>	5 054 738.27	2 387 593.25	–	113 644.30	–	7 555 853.62
China Ocean Mineral Resources Research and Development Association	51 561 000	54 790 000	696 000	3 130 000	7 229 000	117 406 000
Deep Ocean Resources Development Co. Ltd.	339 519	2 236 665	40 231	40 427	1 006 530	3 663 371
Institut français de recherche pour l'exploitation de la mer	85 529.15	39 299.45	5 700.16	5 700.16	818.98	137 047.9
Government of India <sup>b</sup>	504 000	588 000	2 604 000	1 092 000	–	4 788 000
Interoceanmetal Joint Organization <sup>c</sup>	366 221 69	196 962 22	192 390 32	156 723 25	–	912 297.48
Government of the Republic of Korea	2 336 993	1 857 944	6 226 624	1 657 085	361 545	12 440 191
Nauru Ocean Resources Inc.	Not known	Not known	Not known	324 778	8 944	4 744 779
Tonga Offshore Mining Limited	2 860 991	5 261				
Yuzhmorgeologiya	11 409 591	21 477	59 396	–	42 439	11 532 903
<b>Polymetallic sulphides</b>						
Ministry of Natural Resources and Environment of the Russian Federation	1 202 369 <sup>d</sup>	–	1 134 985	47 312	374 750	9 737 425
China Ocean Mineral Resources Research and Development Association	5 406 500	274 500	43 100	44 100	110 900	5 879 100
Federal Institute for Geosciences and Natural Resources of Germany	5 655 267.07	2 859 139.43	–	–	–	8 514 422.01

<sup>a</sup> Converted from euros to United States dollars using [www.xe.com/currencyconverter/](http://www.xe.com/currencyconverter/) on 23 June 2014.

<sup>b</sup> Cost of the personnel not included.

<sup>c</sup> Stated as expenses prior to the beginning of commercial mining.

<sup>d</sup> The Russian Federation has one additional expenditure of \$5,800,927 quoted as “industrial transportation”.