Deep-sea Mineral Potential in the South Pacific Region

— Review of the Japan/SOPAC Deep-sea Mineral Resources Study Programme—

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Abstract

The Government of Japan and South Pacific Applied Geoscience Commission (SOPAC) have been conducting joint surveys of deep-sea mineral resources in the Exclusive Economy Zones (EEZs) of SOPAC member countries, since 1985. The various research and government institutions that have been closely involved in this long-standing programme include: the Japan International Co-operation Agency (JICA) and Japan Oil, Gas and Metals National Corporation (JOGMEC) which is the former Metal Mining Agency of Japan (MMAJ) and relevant ministries of the participating Pacific Island government.

The survey programme is on-going using research vessel Hakurei-Maru No.2 which belongs to JOGMEC.

This twenty year long, joint project initiative has been extremely successful in confirming the resource potential of the Pacific region through discovering valuable deep-sea mineral deposits such as manganese nodules in the Cook Islands waters, cobalt-rich manganese crusts in the Marshall Islands, Kiribati and Federated States of Micronesia, and polymetalic massive sulfides in the Fiji waters.

Key words: cobalt-rich manganese crust, deep-sea mineral resources, manganese nodule, hydrothermal deposit

Introduction

Pacific Island countries consist of many small islands scattered over vast areas of ocean space (Fig.1). Therefore the ocean resources that occur within their exclusive economic zones (EEZs) are and will continue to be critical importance for the sustainable development of these countries' economies, due to the paucity of available land and related resources.

Aside from the richness of the living resources base, such as the oceanic and coastal fisheries, of the Pacific Islands Ocean Region, it is believed that non-living resources, such as the deep-sea mineral resources of manganese nodules, cobalt-rich manganese crusts and hydrothermal

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deposits (polymetalic massive sulfides), will become importance to the economies of these large ocean islands countries when deep-sea mining of sites for possible marine mining among the so-called “Seven Seas”. The results of current investigation on deep-sea mineral resources indicate that a significant proportion of the world’s known deep-sea mineral resources occuring in the Pacific Ocean.

Although the numerous marine scientific researches were/are conducted by the Japan, France, Germany, Korea and Australia in the South Pacific Region, continuous survey programme to assess the marine mineral potential in the South Pacific Region is only the Japan/SOPAC Co-operative Deep-sea Mineral Resources Study Programme.

The mineral potential in the South Pacific Region will be summarized through the results of the survey cruises as well as the outline of the Programme.

Fig.1 South Pacific Region Maritime Limits

Japan/SOPAC Deep-sea Mineral Resources Study Programme

The Government of Japan and South Pacific Applied Geoscience Commission (SOPAC) have been conducting joint surveys of deep-sea mineral resources in the EEZs of SOPAC member countries since 1985 (Table 1). The various research and government institutions that have been closely involved in this long-standing programme include: the Japan International Co-operation Agency (JICA), the Japan Oil, Gas and Metals National Corporation (JOGMEC) which is the former Metal Mining Agency of Japan (MMAJ), and relevant ministries of the participating Pacific Island government.

The first stage of this programme comprised three five-year phases, with surveys conducted

within the EEZs of the following eleven SOPAC member countries; Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. The primary objective of the first stage was to conduct a preliminary assessment of the deep-sea mineral potential of these eleven countries.

The second stage of the programme commenced in the year 2000 with the phase 1 completed in 2002 fiscal year. The focus of the second stage has been to conduct surveys within the EEZs of Cook Islands, Fiji and Marshall Islands to further evaluate the resource potential of marine mineral in the more prospective areas identified during the first stage. Also, since 2000, the programme has started to acquire environment baseline data for use in environmental assessments when marine mining activities commence. The phase 2 of the second stage of the programme started in 2003. The phase will concentrate its survey efforts in the EEZs of Kiribati, Niue, Fiji and FSM.

Table 1 Areas and mineral resources surveyed within the selected SOPAC Member Countries

Stage	Phase	Year	SOPAC Country	Area Surveyed	Mineral Resource
I	1	1985	Cook Islands	North Penrhyn Basin	Manganese Nodules
		1986	Cook Islands	South Penrhyn Basin	Manganese Nodules
		1987	Kiribati	Phoenix Islands Group	Nodules and Crusts
		1988	Tuvalu	Ellice Islands and Ellice Basin	Nodules and Crusts
		1989	Kiribati	Southern Line Islands	Nodules and Crusts
	2	1990	Cook Islands	Southern Cook Islands	Manganese Nodules
			Samoa	Samoan Islands	Nodules and Crusts
		1991	Kiribati	Gilbert Islands Group	Nodules and Crusts
		1992	Papua New Guinea	Manus Basin	Hydrothermal Deposits
		1993	Solomon Islands	Woodlark Basin	Hydrothermal Deposits
		1994	Vanuatu	Coriolis Trough	Hydrothermal Deposits
	3	1995	Tonga	Tonga Rides	Hydrothermal Deposits
				East Lau Basin	
		1996	Marshall Islands	Northern part	Cobalt-rich Crusts
		1997	FSM	Whole area	Cobalt-rich Crusts
		1998	Marshall Islands	Southern part	Cobalt-rich Crusts
			FSM	Whole area	
		1999	Fiji	North Fiji Basin	Hydrothermal Deposits
II	1	2000	Cook Islands	South Penrhyn Basin	Manganese Nodules
		2001	Fiji	North Fiji Basin	Hydrothermal Deposits
		2002	Marshall Islands	Northern and southern part	Cobalt-rich Crusts
	2	2003	Kiribati	Gilbert Islands Group	Cobalt-rich Crusts
			Niue	Whole area	Manganese Nodules
		2004	Fiji	North Fiji Basin	Hydrothermal Deposits
		2005	FSM	Whole area	Cobalt-rich Crusts

Survey and Sampling Platform Tools

The programme has been conducting using research vessel Hakurei-Maru No.2 (Fig.2). It is owned and operated by JOGMEC and is designed specifically for deep-sea mineral resources prospecting. The vessel is equipped with a full range of specialized survey devices (Fig.3) and uses the Benthic Multi-coring System (BMS), a state-of-the-art drilling machine, to recover up to 20m long cores (Fig.4).

Fig.2 Research Vessel *Hakurei-Maru No.2*

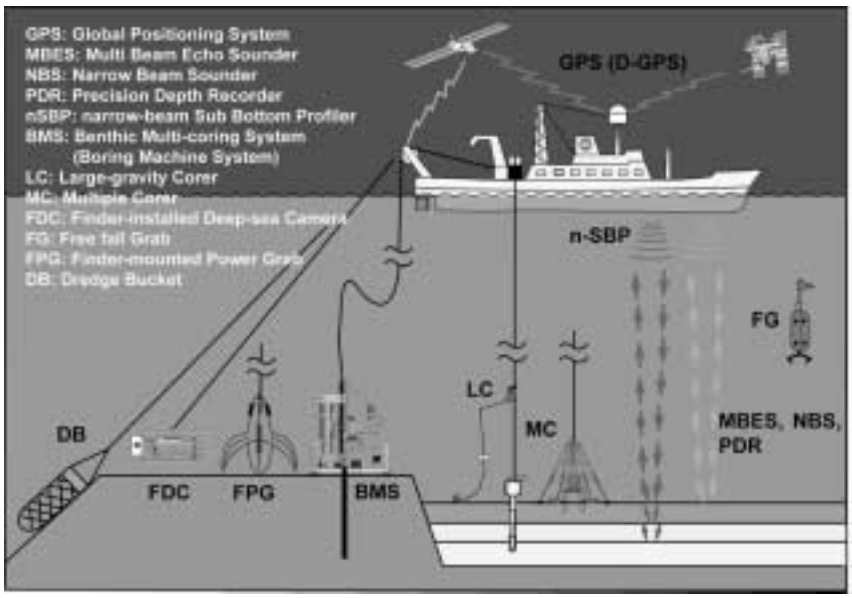

Fig.3 Survey and Sampling Platform Tools of the *Hakurei-Maru No.2*

Fig.4 Benthic Multi-coring System

Deep-sea Mineral Potential in the SOPAC Region confirmed by the Programme

Manganese Nodules

Nodules are small, very dark, "potato-like" balls of metals (Nickel, Copper, Cobalt, Manganese and Iron) and other minerals that have accreted around a central core, over millions of years. They vary in size and generally have a diameter of between 2 and 15cm. Nodules are most abundant on area of the seafloor with low sedimentation rate. Therefore they tend to occur far from major continental landmasses such as in the mid-Pacific Ocean. The nodule fields that have been discovered areas of the seafloor, in water depths of between 4,000 and 6,000m.

During the programme, the survey to assess the potential of manganese nodules of the programme were conducted in the EEZs of the four SOPAC member countries; Cook Islands, Kiribati, Tuvalu and Samoa.

Sampling using free-fall grab, spade corer and/or the large diameter gravity corer were conducted to confirm the distribution of manganese nodules in the EEZs of the selected four SOPAC member countries.

Based on these survey results, promising area was selected at the central area within the EEZ of the Cook Islands (Fig.5).

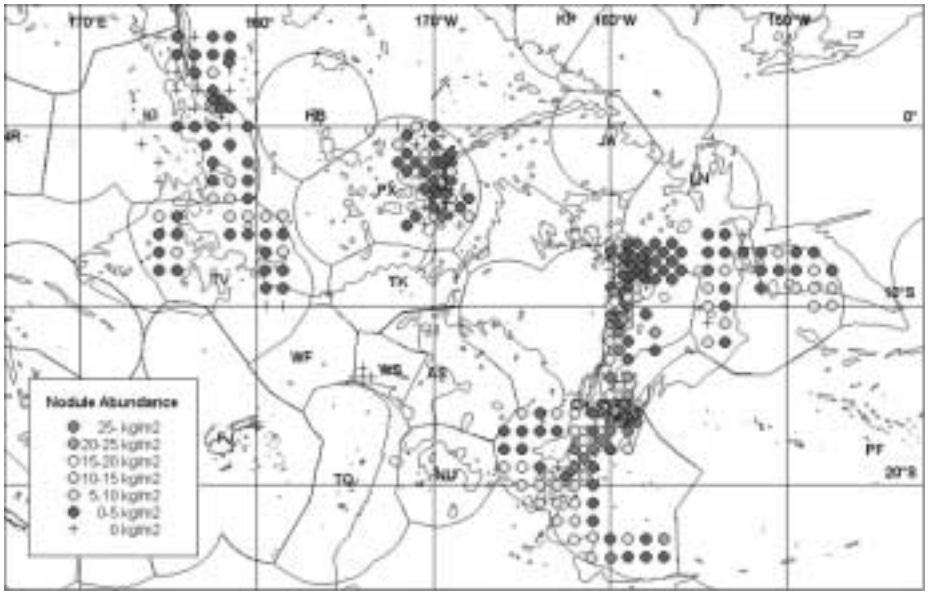

Fig.5 Manganese nodule abundance in the four SOPAC member countries

The survey revealed that the central area of the EEZ of the Cook Islands has the highest concentration of manganese nodules, with an abundance of over 25kg/m^2 covering approximately 7,000km^2 of the area (Fig.6). Seafloor photo is shown in Fig7.

Using the method of polygons developed by Kohpina and Usui (1996), the resource in the selected area is estimated to be about 55,000 metric tones of manganese nodules and 288,000 metric tones of cobalt (Table2).

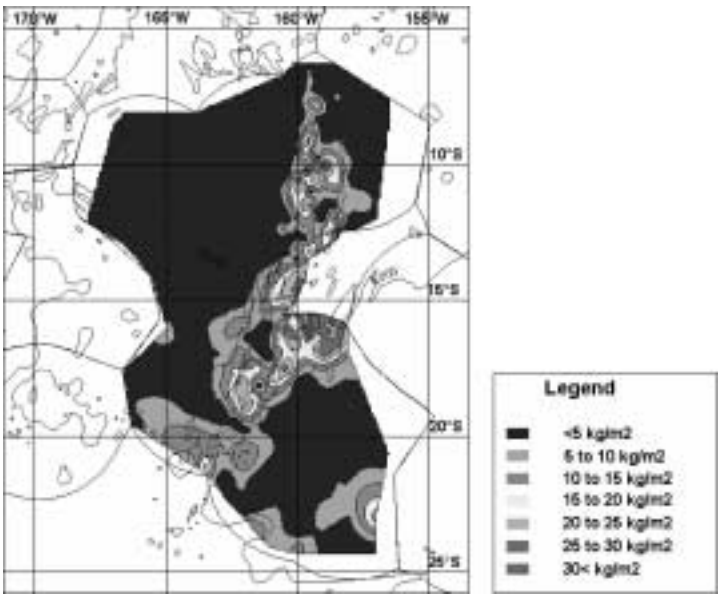

Fig.6 Distribution of Manganese Nodules in the Cook Waters

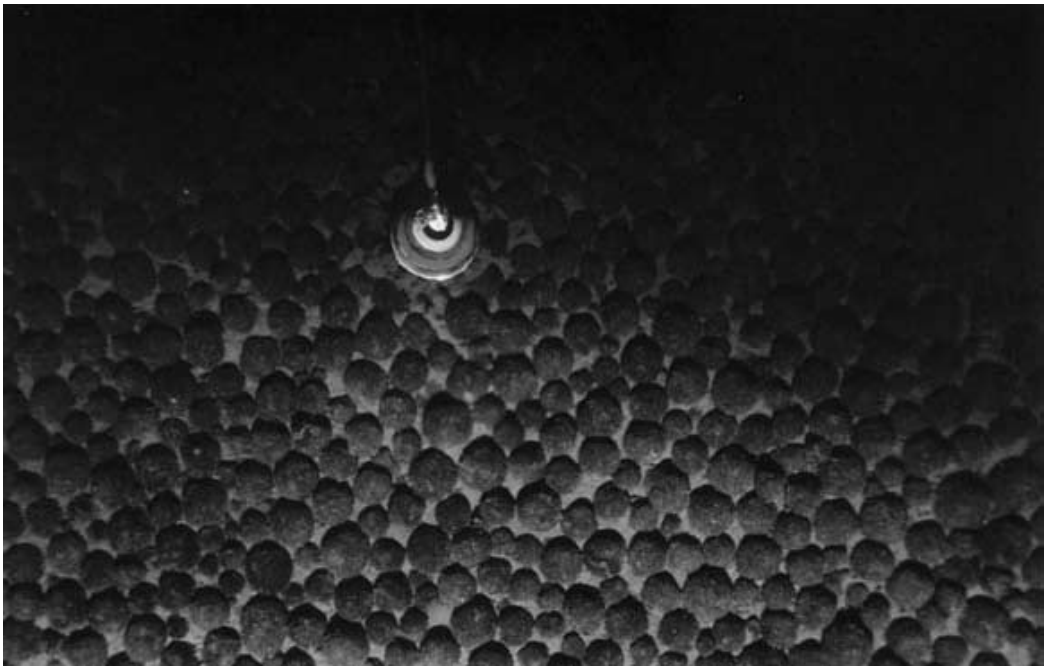

Fig.7 Seafloor Photo taken at around Central Area of the EEZ of the Cook Islands

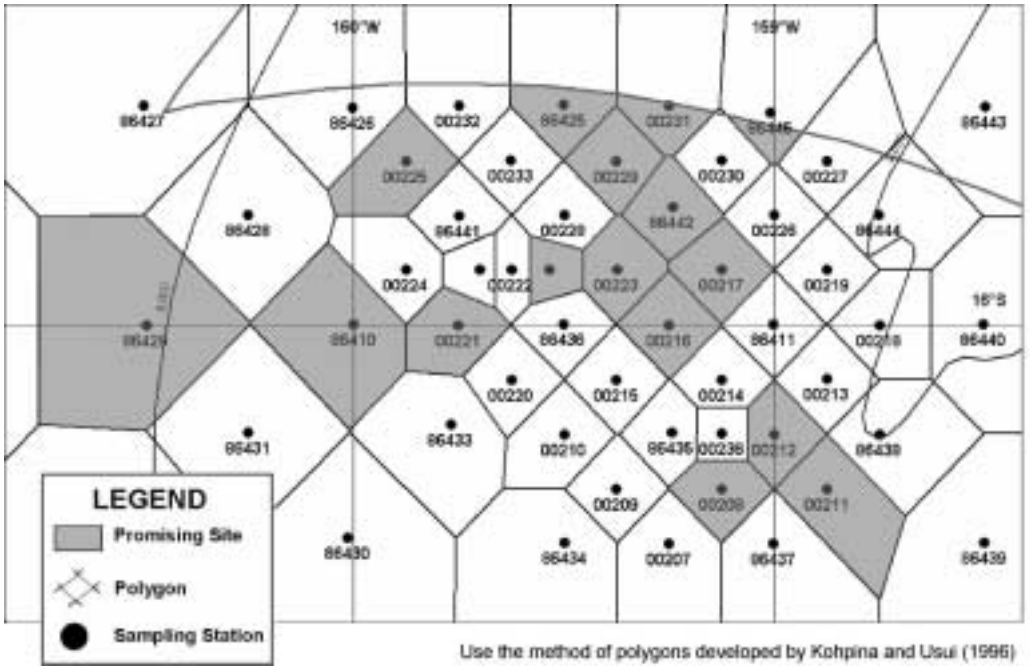

Fig.8 Resource Estimates of Manganese Nodules within the Central Area of the EEZ of the Cook Islands, using the Method of Polygons Developed by Kohpina and Usui in 1996.

Table 2 Nodule and cobalt resources in Area 1 located within the EEZ of the Cook Islands.

Station No.	Abundance (kg/m^2)	Water Content (%)	Co Grade (%)	Area (km^2)	Nodule Resources (thousand metric ton)	Cobalt Resources (metric ton)
86410	33.09	31.10	0.49	1,031	23,506	115,178
86425	34.57	28.60	0.48	304	7,504	36,017
86429	31.00	31.50	0.56	2,177	46,229	258,880
86442	31.54	30.50	0.55	369	8,089	44,487
86445	32.93	26.40	0.51	99	2,399	12,237
00208	31.18	22.20	0.50	325	7,884	39,419
00211	32.39	27.93	0.54	651	15,197	82,062
00212	31.14	23.73	0.55	325	7,719	42,454
00216	34.81	29.96	0.53	373	9,094	48,199
00217	32.16	25.99	0.46	378	8,997	41,386
00221	36.66	23.37	0.46	403	11,321	52,078
00223	33.08	30.33	0.58	368	8,481	49,191
00225	30.44	22.94	0.46	522	12,245	56,325
00229	32.96	27.52	0.52	369	8,815	45,839
00231	32.93	24.91	0.51	205	5,069	25,852
00234	30.63	33.63	0.44	185	3,761	16,548
Total				8,084	186,309	966,153

Cobalt-rich Manganese Crusts

Cobalt-rich manganese crusts occur largely on the flanks of volcanic islands, on submerged seamounts and on ridges and are recognized as a potential mineral resource reservoir for cobalt, in the future. The richest cobalt deposits of up to one percent cobalt generally lie in water depths of between 800 and 2,500m. Assessments suggest that crusts range from 2 to 15cm in thickness, however, crusts as thick as 20cm have also been found.

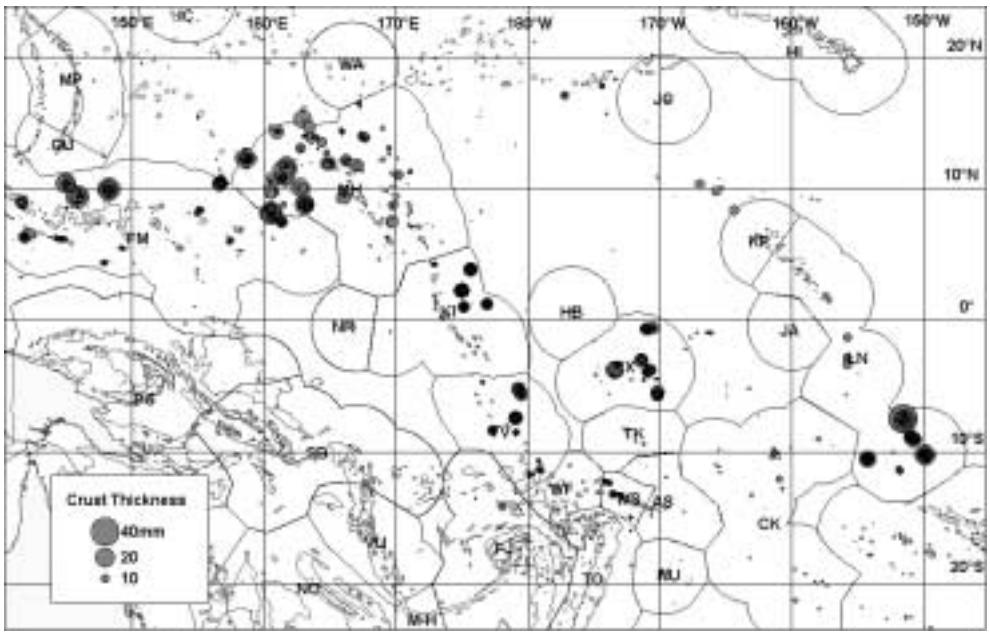

Fig.8 Cobalt-rich crust thickness in SOPAC region studied by the present Programme

The surveys to assess the potential of cobalt-rich manganese crusts were conducted in the EEZs of the five SOPAC member countries; Kiribati, Tuvalu, Samoa, Marshall Islands and Federated States of Micronesia (Fig.8)

The surveys found thick crusts that were well developed in the western part of the EEZ of the Marshall Islands and at some seamounts within the EEZs of the Federated States of Micronesia and the Line Islands of Kiribati. Several seamounts in the Marshall Islands warrant further investigation, based on their metal contents and the areas of manganese crust coverage.

Hydrothermal Deposits (Polymetalic massive sulfides)

The surveys to assess the potential of hydrothermal deposits were conducted in the EEZs of the five SOPAC member countries; Fiji, Papua New Guinea, Solomon Islands, Tonga and Vanuatu.

The 2001 cruise of the programme was conducted around the triple junction in the North Fiji Basin. The area had showed significant hydrothermal activities such as chimneys and mounds during the 1999 cruise of the programme.

Of the twenty-two sampling stations drilled using the Benthic Multi-coring System (BMS), polymetalic massive sulfides were recovered from eight of the twenty-two cores. This is the first time that the third dimension of a polymetalic massive sulfide deposits have been established in the North Fiji Basin, as well as in the Pacific region.

Polymetalic massive sulfides of up to 7m thick were confirmed from one of the cores drilled (Fig.9). Assay results of fragments of chimney and sulfides ore formed on the surface of the mound showed samples to be Zn-Au-Ag rich, with Cu4.04%, Zn3.17%, Au1.83g/t and Ag71.20g/t. Cu-rich massive sulfides formed in the core of the mound showed Cu6.93%,

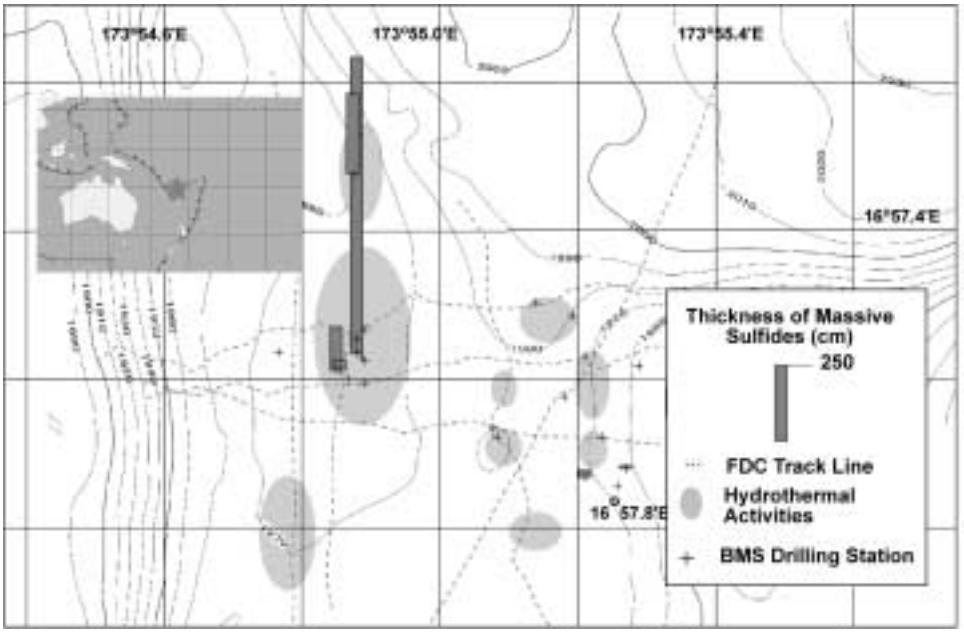

Fig.9 Distribution of the vertical dimension of massive sulfides around the Triple Junction in the Fiji EEZ

Zn0.61%, Au0.85% and Ag24.39%. Consequently, the inferred resource of a mound with lateral dimensions of 100m by 30m and vertical thickness of 7m was estimated to be 73,500t at the grade of Cu6.93%, Zn0.61%, Au0.85% and Ag24.39%. Although the scale of the mound (ore body) may be small in comparison to its on-land analogues, the Cu grade is considerably higher. The observation using deep-sea towed TV camera suggests that there are at least seven mounds within the vicinity of the mound that was sampled. It is proffered that through more detailed surveying within the area, further massive sulfide occurrences may be elucidated.

In addition to sampling using the BMS, an environmental baseline survey was also conducted within the survey site area. It is envisaged that this will be used in future environmental assessments in the event of marine mining. The environmental baseline surveys collected samples of water and sediments.

Conclusion

The survey cruises during the programme have identified numerous sites with potential marine mineral resources such as manganese nodules in the Cook waters, cobalt-rich manganese nodules in the Marshall Islands, FSM and Kiribati waters, and hydrothermal deposits in the Fiji waters. South Pacific countries consist of many small islands. These countries have limited land resources but have huge and rich EEZ (Exclusive Economic Zone) waters. Their EEZ are rich in not only living resources but also deep-sea mineral resources. The deep-sea mineral resources have a large economic potential. It is very important for the South Pacific nations to study their offshore mineral resources.

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