Chinese manned submersible JIAOLONG's scientific cruise in 2014-2015

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***Abstract*—From June 2014 to March 2015, the manned submersible JIAOLONG conducted its second scientific cruise, including one leg in cobalt-rich ferromanganese crust seamounts of Northwest Pacific and two legs in the hydrothermal vents of the Southwest Indian Ridge respectively. Here we present diving results, tools and equipments testing and pilots training. It is the first report of JIAOLONG working in these areas and the preliminary scientific results achieved.**

Keywords—JIAOLONG; Submersible; Hydrothermal Vents; Seamounts formatting

I. INTRODUCTION

Chinese submersible JIAOLONG had completed its sea trail in Mariana Trench in 2012 with the depth of 7062m after three terms of 1000m, 3000m, and 5000m sea trails [1-3]. In 2013, the first scientific cruise was conducted by JIAOLONG in South China Sea, COMRA (China Ocean Mineral Resources R&D Association)'s polymetallic nodule and cobalt-rich ferromanganese crust Contract Areas in Northeast and Northwest Pacific [4].

From the mid-2014 to March 2015, the submersible JIAOLONG carried out its second scientific cruise, which were separated into three legs，the first from June to August 2014 in the COMRA' s cobalt-rich ferromanganese crust Contract Areas, the second and third from November 2014 to March 2015 in the COMRA's ploymetallics sulphide Contract Areas of the southwest India ridge. Seamount biodiversity, hydrothermal ecosystem, in-situ tools testing, pilot training are the main targets of diving and some preliminary scientific results achieved.

II. DIVING RESULTS

In the first leg, ten dives were executed by JIAOLONG in the CAIWEI Seamount and its circumjacent area. The keystones were on the cobalt-rich ferromanganese crust coverage and the distribution characters of megafauna. All dives were arranged in the different direction sides of seamount in order to obtain the general information. The JIAOLONG's capacity of climbing was validated again from the depth difference at the dive beginning and the ending. The height of climbing is about 1000m. High definition videos and many samples as well as ferromanganese crusts, megafauns, etc, are achieved.

In the second and third legs, JIAOLONG dived in four areas along the ridge of southwest India, i.e. Dragon Flag Field (DFF), TianCheng Field, TianZuo Field, and ChangBaiShan carbonated area. The geological and chemical characters in different thermal vents were measured by several tools loaded in the sample basket of JIAOLONG. Comparing with the British Research Cruise JC67 [5,6], many new hydrothermal vents were found in the DFF, where 17 marks were deployed around the vents or chimneys during the cruise. The location and the coordinate of the marks are as shown in Figure 1 and Table1. Massive sulfide, chimneys, microbe, and fluid were sampled.

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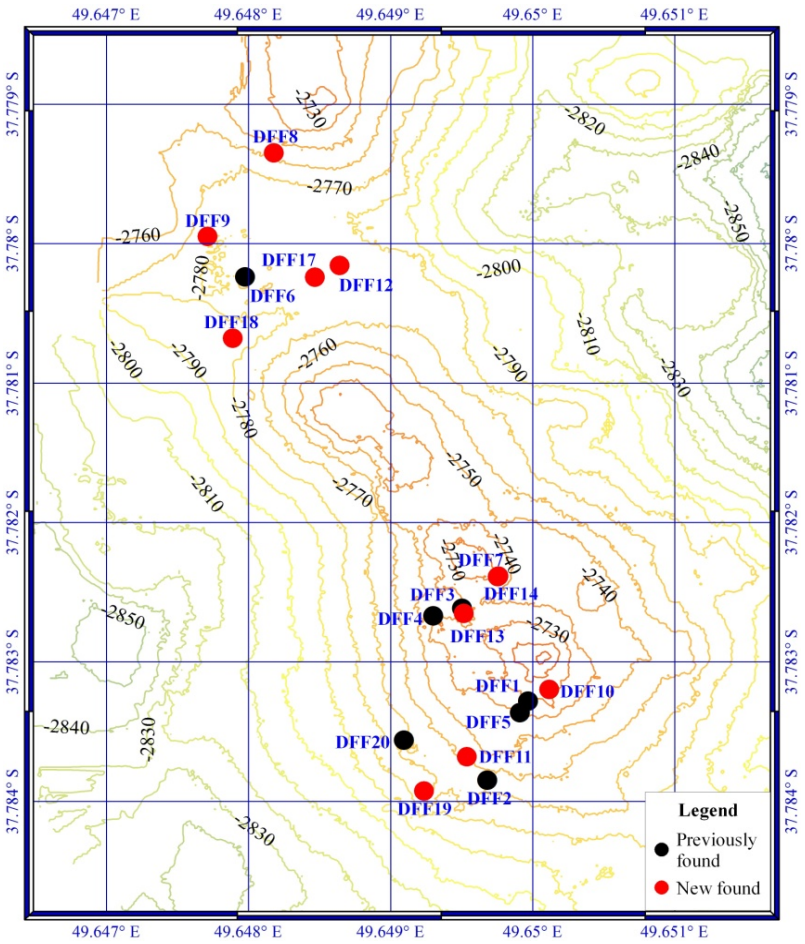


Fig. 1 The mark location in the DFF

Table 1. The coordinate of marks by ultra-short baseline

Name of Mark[1]	Longitude(°E)	Standard Deviation of Longitude	Latitude(°S)	Standard Deviation of Latitude	Standard Deviation of horizontal distance
DFF1(Jabberwocky)	49.649967	6.66E-05	37.783283	1.42E-04	16.9m
DFF2(JiaoLong Palace)	49.649681	1.48E-04	37.783851	2.20E-04	27.7m
DFF3	49.649503	1.62E-04	37.782617	1.15E-04	19.3m
DFF5(Ryugo-jo)	49.649910	3.44E-05	37.783365	8.21E-05	9.6m
DFF6	49.647975	2.86E-04	37.780239	9.85E-05	27.6m
DFF7	49.649754	9.64E-05	37.782389	5.06E-05	10.23m
DFF8	49.648179	2.48E-05	37.779350	2.59E-05	3.63m
DFF9	49.647712	3.31E-05	37.779949	5.06E-05	6.35m
DFF10	49.650117	4.66E-05	37.783198	4.80E-05	6.75m
DFF11	49.649537	4.01E-05	37.783681	1.75E-04	19.78m
DFF12	49.648642	4.00E-05	37.780157	6.34E-05	7.89m
DFF13	49.649516	2.76E-05	37.782654	5.24E-05	6.31m
DFF14	49.649759	1.94E-05	37.782386	1.44E-05	2.35m
DFF17	49.648467	3.92E-05	37.780241	9.64E-06	3.63m
DFF18	49.647890	2.07E-05	37.780680	1.42E-05	2.42m
DFF19	49.649235	2.12E-05	37.783928	1.83E-05	2.77m
DFF20(Fucanglong's Furnace)	49.649093	1.56E-04	37.783563	7.37E-05	16.1m

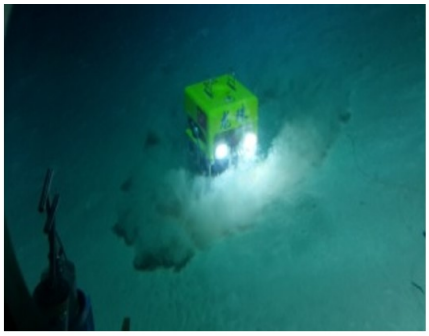
[1] Names in the brackets are cited from the report of JC67.

III. TOOLS AND EQUIPMENTS TESTING

In addition to pushcore, CTD, Bio-Box, water sampler as common tools in its sample basket, JIAOLONG was also equipped with Mini-ROV "LONGZHU" and In-situ dynamometer for soil mechanics in the first leg, which extended JIAOLONG's operation range in confined space, measured the variation in shear force and penetration resistance along depth in sediments, simultaneously were tested available.

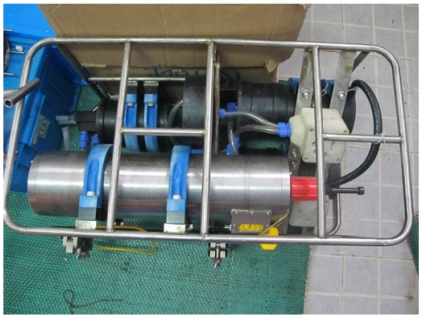
According to operation requirements of the second and third legs in hydrothermal fields, JIAOLONG was installed with MAPR, multi-parameter electrochemical sensors, NKE Low-temperature sensor, NKE high-temperature sensor, super HD video camera, subterranean heat probe, high-temperature probe, multi-level in-situ collector for marine microbes, the multi-parameter sensors, device for in-situ enrichment of hydrothermal microbes, and other in-situ sensors. All the sensors and apparatus loaded on the basket, which proved that JIAOLONG as a working platform were more effective and flexible. Some related equipments are as shown in Figure 2.

In-situ Dynamometer for Soil Mechanics

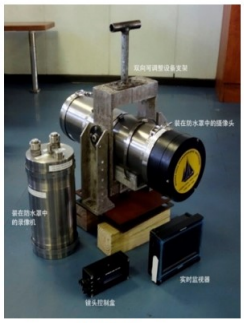


Mini-ROV "LONGZHU"

Multi-parameter Electrochemical Sensors



Multi-level In-situ Collector for Marine Microbes



Super HD Video Camera

NKE Low-temperature sensor

Fig. 2 Some equipments tested in the cruise

IV. PILOTS TRAINING

The Chinese second generation of pilots in training (PIT) includes six persons, 4 males and 2 females. The main tasks of training during the cruise contained three parts of physical, psychological, and technical training. Beside the daily physical exercise, the cruise paid more attentions to the psychological and technical training. The psychological training was mostly conducted by the questionnaire，by which the psychologist could be evaluated the mental state of the PITs. If necessary, some special psychological assists could be supplied to alleviate the anxiety of the PITs. Technical training basically focused on diving preparation, diving operation, daily maintenance, and even urgent repairing. The preparation including plan making and tools preloading were usually very important for a successful dive. Six PITs had finished not only all the preparation training, but also part of operation by 8 dives as the assistant of the Pilot. Additionally, all of them were involved in the data analysis, maintenance operation, and repairing in emergency.

V. PRELIMINARY SCIENTIFIC RESULTS

A. *CAIWEI Seamount*

Overall, for both northern and southern hillsides, the crusts grow well on the relatively flat slope area near the top of CAIWEI Seamount, while the deep-water area away from the top counts against to the development of crusts. Rather than by the depth, the distribution of megafauna is mainly influenced by bottom currents and topography in the range of 3500m~1500m depth, in which the megafauna appear with zonal distribution. Sponges and corals are often found at the cliffs and steep slopes forming in groups. Sponges are the most predominant group of megafauna in CAIWEI Seamount with a variety of species and a large number of individuals, and are the most abundant group on western, southern and northern CAIWEI Seamount. Corals are the second predominant group, and mainly distribute in northern and eastern hillsides of CAIWEI Seamount. The other groups with relatively high abundance include brittle stars, sea lilies and fishes.

B. *Ridge of Southwest India*

The scale of Dragon Flag vent system is one of the largest hydrothermal venting systems in the Mid-Ocean Ridges of Southwest India. Results of continuous temperature observation on DFF6 high-temperature vent and DFF11 low-temperature diffuse flow area show that there are semidiurnal tide cycles. Temperature variation range of diffuse flow area was greater than that of high-temperature vent. Paroxysmal of venting was also observed in diffuse flow area. Hydrothermal fluids from different vents vary in physical and geochemical characteristics. Fluid from vent site DFF6 with maximum temperature up to 379.7℃ has salinity of 40‰, pH 3.42 (measured at 26.5℃ on board) and DO 14.3mg/L. The fluid with low temperature yields salinity 32‰, pH 6.25 (measured at 21.9℃ on board). The fluid from vent site DFF3 with temperature measured 352℃, yields the highest salinity up to 45‰, pH 3.21 (measured at 21.9℃ on board) and DO 12.9mg/L.

As the characteristics of the hydrothermal fluids and seabed alter at various temperatures, the chemosynthetic ecosystems therein possess distinct energy sources, thus resulting in divergent community structures. The preliminary cultivation and functional gene analysis results have shown that there are low- and medium- temperature sulfur oxidizing microorganisms, sulfate reducing microorganisms, and iron reducing microorganisms in the low-temperature chimneys and scale samples of scaly foot gastropod; while in the medium- and high-temperature chimney samples, high-temperature sulfur oxidizing microorganisms and sulfate reducing microorganisms are identified. Total DNA of chimney samples collected from five different dives have been extracted for further Miseq analysis. The diversity of archaea and bacteria in both high- and low-temperature chimney will be compared with other hydrothermal vent systems.

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