Final report about the marine scientific research in Northern Mariana

U2015-034

Third Institute of Oceanography, SOA

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1. Marine scientific plan

The marine scientific research in the Northern Mariana under the national jurisdiction of the America was applied by the Third Institute of Oceanography, State Oceanic Administration, using R/V "Xiangyanghong 19". The application U2015-034 was approved by America. The deadline of application was from June 24, 2016 to August 25, 2016. In July 26, 2016, the marine scientific research in the application area was began to conduct by the Third Institute of Oceanography, State Oceanic Administration, using R/V "Xiangyanghong 19" , and finished the marine scientific research in August 12, 2016. After that the "Xiangyanghong 19" left the survey region in August 12, 2016. The marine scientific research continued for about 18 days.

2. Oceanographic settings

The Parece Vela Basin is located in the east of the Philippine Sea, and is one of the largest backarc basins in the world (Ren and Li, 2000). More specifically, it is a nearly closed marginal basin lying to the west of the Mariana Trough, south of the Shikoku Basin, east of the Palau Ridge and north of a complex system of island arc-trench-fault zones, with an average water depth of 4800 m. The main ocean current flowing through the Parece Vela Basin is the North Equatorial Current, and the bottom current is a branch of the Antarctic Intermediate Water that travels counterclockwise around the Parece Vela Basin and Shikoku (Lee and Ogawa, 1998). The North Equatorial Current is formed under northeast trade winds, and travels from east to west. After meeting the Philippine islands, the North Equatorial Current splits into two branches, with the Kuroshio towards the north and the Equatorial Counter Current turning eastward.

3. Scientific objectives

Western Mariana Submarine Ridge locates at the northern boundaryline of source region of Kuroshio Current. The marine sediments recorded the information of the Kuroshio Current evolution and palaeoenvironment variation. This project would be collect marine sediment sample and suspended matter at the west of Western Mariana Submarine Ridge. As an important component of marine sediment can be used to indicate the provenance of marine sediment; in addition, it shows a good response to the change of the East Asian monsoon and ocean current. The aim of the project is determine the sediment source of the marine sediment and palaeoenvironment evolution.

4. Investigation content

The sediment trap was not deployed in the Parece Vela Basin in this survey, because of there was not shipping schedule to recovery sediment trap for the Xiangyanghong 19 in 2017. In this survey, it was difficulty to collect the sediment sample due to a large variation of water depth. In addition, there were many typhoons formation in this area, which caused severe sea condition. We have collected 15 sites surface samples, a gravity core, 7 sites CTD and LISST survey. The detail information of the survey site is as follow Table1 and Figure 1.

Table 1. The detail information about the sample station.

Site	°E	°N	Depth（meter）	Survey type	Sediment type

2016PAC-1	141.3335	13.7008	4651	Surface sediment, LISST,CTD, Benthos	clay
2016PAC-2	141.7072	13.0984	3276	Surface sediment	foraminifera ooze
2016PAC-3	141.5285	14.3568	4534	Surface sediment, LISST,CTD, Benthos	clay
2016PAC-4	141.9419	14.2938	4394	Surface sediment	siliceous ooze
2016PAC-5	141.9304	13.7371	4309	Surface sediment, core, LISST, CTD, Benthos	clay
2016PAC-6	141.7928	14.7459	4478	Surface sediment	clay
2016PAC-7	142.0276	12.6204	2674	Surface sediment, LISST, CTD, Benthos	foraminifera ooze
2016PAC-8	142.2783	13.1342	2308	Surface sediment	foraminifera ooze
2016PAC-9	142.5737	14.7963	4022	Surface sediment, LISST, CTD, Benthos	siliceous ooze
2016PAC-10	142.4882	14.3550	3875	Surface sediment	siliceous ooze
2016PAC-11	142.4335	13.7273	3083	Surface sediment, LISST, CTD, Benthos	foraminifera ooze
2016PAC-12	142.7141	12.6117	3485	Surface sediment	foraminifera ooze
2016PAC-13	142.9506	14.4338	2450	Surface sediment	foraminifera ooze
2016PAC-14	142.9574	13.7942	4452	Surface sediment, LISST, CTD, Benthos	siliceous ooze
2016PAC-15	142.9489	13.1071	3247	Surface sediment	foraminifera ooze

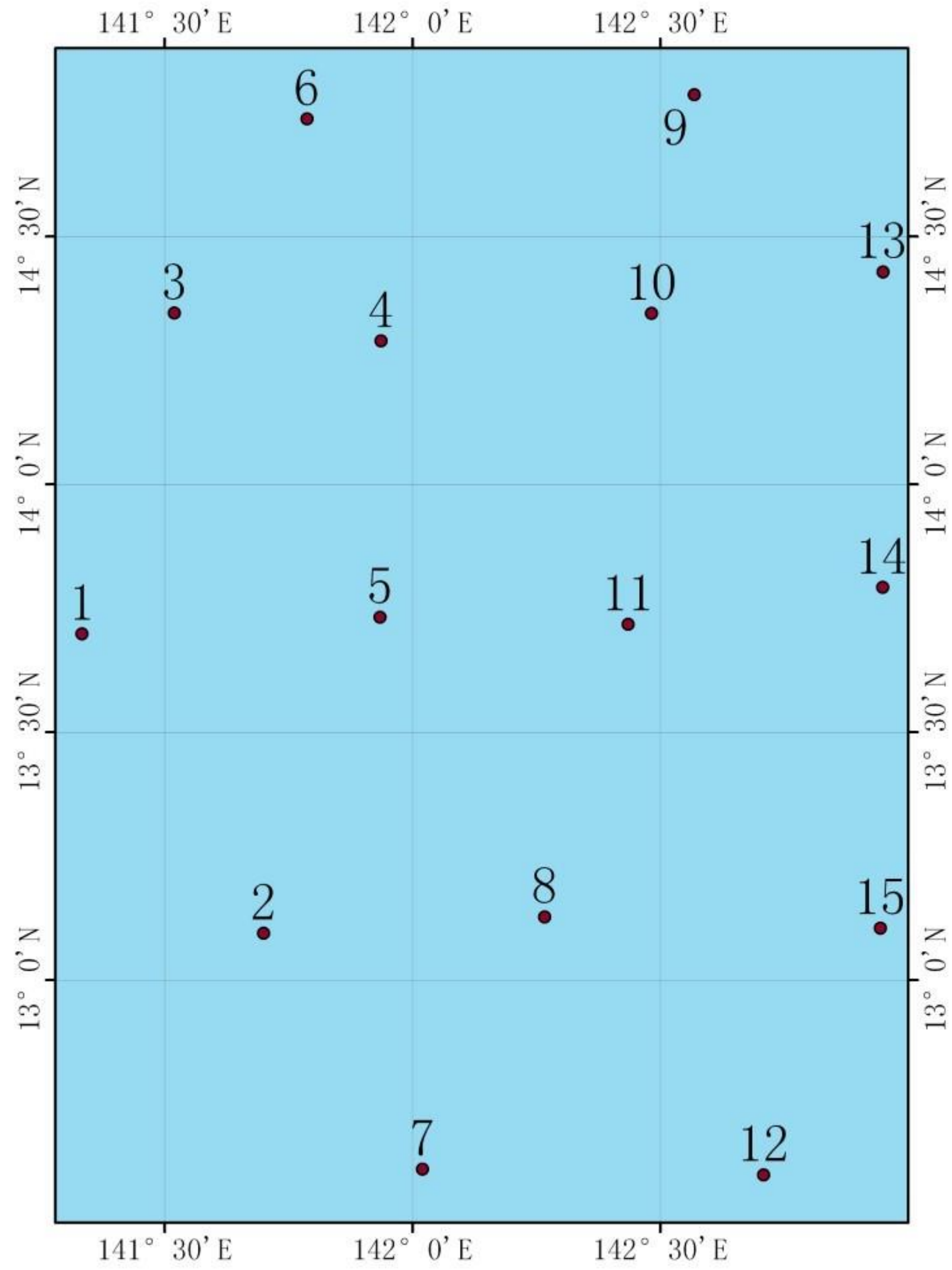

Fig 1. The areas of the sampling stations

5. Result

5.1 Characteristics of surface sediments

(1)Sediment type

There are three major sediment types in research region, such as, gray siliceous ooze, foraminifera ooze and dark clay. There are few black ferromanganese nodules in the surface sediments. Calcareous sediments are dominant in the shallow water areas of the east, while the western basins are mainly clays.

(2) Grain size

Silt is a major component of sediments, ranged from 19.60% to 80.61% with an average value of 65.64%. Sand content is a wide range from 5.15% to 76.25%, with an average of 31.65%. The distribution characteristics of sand and silt showed that their contents were obviously affected by the eastern part of seamount matter. The content of clay components in sediments is relatively low, between 4.15% and 25.76%, with an average of 13.71%. The distribution characteristics of clay components in sediments show that the content is obviously increased in the basin.

Table.2 The major elements of surface sediment from surrounding sea areas (%)

	This study	Parece Vela Basin[1]	Shallow sea sediment[2]	South China Sea[2]	Ocean Sediment[2]	Volcanic material of the Palau Ridge
SiO_2	40.14±20.28	49.16	62.51	47.40	47.72	49.81
CaO	16.34±17.33	9.36	4.43	3.93	5.83	13.33
Al_2O_3	9.70±4.86	15.64	11.09	9.54	12.29	14.43
Fe_2O_3	5.92±2.88	2.47	5.08	12.31	0.60	9.66
Na_2O	3.85±1.64	1.09	0.07	0.37	0.41	0.21
MgO	2.37±1.07	2.43	2.32	1.81	2.10	0.71
K_2O	1.29±1.07	3.58	1.82	2.04	2.18	6.23
MnO	0.59±0.35	4.24	2.00	-	1.10	3.13
TiO_2	0.47±0.24	0.78	0.58	0.53	0.59	1.18
P_2O_5	0.19±0.09	0.29	-	-	0.16	0.12

Source: 1.Xu et al. (2010); 2. Li et al.(2007)

(3)Major and trace elemental compositions

The average contents of major elements in the sediments are $SiO_2 > CaO > Al_2O_3 > TFe_2O_3 > Na_2O > MgO > K_2O > MnO > TiO_2 > P_2O_5$. The contents of SiO_2, CaO and Al_2O_3 vary significantly. The major elements in the survey area are significantly different from those in shallow sea sediments in China (Li et al., 2007). The contents of SiO_2 and Al_2O_3 were lower than those in the eastern of Philippines Sea (Xu et al., 2010). The content of Fe_2O_3 was significantly higher than that of east Philippines Sea, but less than that of South China Sea.

The rare earth element contents (ΣREE) range from 55.2 to 262.6 μg/g. The REE contents of clay are higher than those of calcareous ooze. The ratios of heavy rare earth to light rare earth (LREE/HREE) are between 4.6~7.4. The chondrite-normalized patterns of REE indicate enrichment in light REE, Ce negative anomaly (δCe=0.76), and weakly Eu negative anomaly (δEu=0.97).

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Fig.2 Chondrite-normalized patterns of REE for surface sediments

(4)Clay mineral

The clay mineral assemblages are mainly composed of illite (28.9%~55.4%, average 44.2%), smectite (16.3%~48.7%, average 34.4%), chlorite (1.2%~18.9%, average 15.8%), and kaolinite (4.9%~9.4%, average 5.6%) are less abundant. The smectite contents are higher in the ridges than those in the basin. In contrast, the illite contents were higher in the basin than those in the ridges.

5.2 Core characteristics

(1) Sedimentation rate

The average sedimentation rate of this core is 1.56 cm kyr^{-1}, which is higher than that of the Parece Vela Basin (Xu et al., 2008). It may be that the station is closer to the eastern seamounts and has more sources of seamount weathering materials.

Table 3. Radiocarbon analyses by AMS for sediments from the core 2016PAC-5

Sample	Depth(cm)	Conventional AMS ^{14}C age(yr BP)	Calendar age (2σ)(cal yr BP)	$\delta^{13}C$
2016PAC-5-6	11--12	13440±40	15583(15362-15803)	0.6
2016PAC-5-17	33-34	17500±60	20620 (20490-20750)	0.9
2016PAC-5-28	55-56	32200±220	35682 (35168-36196)	2

(2) Grain size

The results of grain size analysis show that the main components of sediments are silt, with an average content of 64.78%. The silt content from bottom to top decreases obviously; the clay average content is 18.91%, and the sand average content is 16.31%. From bottom to top, the sand content increases obviously.

(3) Major and trace elemental compositions

The results of geochemical analysis show that the two most abundant chemical components in sediments are SiO_2 and Al_2O_3, which are 40.73% and 12.17% respectively. The contents of major elements are $SiO_2 > Al_2O_3 > CaO > TFe_2O_3 > Na_2O > MgO > K_2O > MnO > TiO_2 > P_2O_5$, respectively. The change trends of SiO_2, Al_2O_3, TFe_2O_3, Na_2O, TiO_2 and MgO are similar. The content of CaO decreases obviously in 40-90 cm and 110-150 cm, while the content of CaO increases obviously in 40-90 cm and 110-150 cm. The content of ΣREE is also higher in the strata with high SiO_2 content. From below 85 cm, the content of ΣREE increases obviously. The value of δCe in the subsurface layer (5-45cm) was obviously high, approaching 1.0, while below 45cm, most of the delta Ce values were less than 0.7, indicating that Ce had a strong loss. The value of δEu decreases obviously from 5 to 120 cm, from 1.0 to 0.92, while below 120 cm, the value of δEu remains basically unchanged (0.92). The ratio of La_N/Yb_N increases obviously below 45 cm and fluctuates.

(4) Clay mineral

The clay mineral assemblages are mainly composed of illite with an average content of 55.0%, followed by smectite with an average content of 25.6%, chlorite with an average content of 13.1% and kaolinite with a minimum content of 46.3%. In general, illite increased slightly from bottom to top, while kaolinite decreased slightly from bottom to top.

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Fig3 Cross-sectional variations of grain size components and major elements in columnar samples

5.3 Benthos species

Seven sites were selected for benthic identification. Because of the deep of water depth in this survey, few benthic organisms have been identified. Only four species of benthic organisms were obtained, including 2 species of sponges, 1 species of mollusks and 1 species of polychaetes.

5.4 Water temperature, salinity, turbidity and fluorescence characteristics

The temperature of the sea water decreases gradually from the surface to 150 m in depth. The thermocline appears when the temperature range increases from about 150m. The vertical distribution of salinity shows that the upper bound of halocline appears at about 50m~100m, and the lower bound of halocline is about 150m. From the surface to 150m in depth, the turbidity unchanged. However, turbidity slightly decreased at 150 m below the water. From the surface to about 150m in depth, the chlorophyll -a concentration gradually increased, and the chlorophyll -a concentration reached the peak at about 150 m, and decreased gradually at 150 m below the water.

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Fig.4 The vertical distribution of the water temperature, salinity, turbidity and fluorescence

5.5 Particle size of suspended particulate matter (SPM)

The average particle size of SPM in surface is between 383 μm and 425 μm, with an average of 395 μm. The average particle size of SPM in 50 m deep is between 380 μm and 399 μm, with an average of 391 μm. The average particle size of SPM in 100 m deep is between 385 μm and 409 μm, with an average of 399 μm. The average particle size of SPM in 200 m deep is between 378 μm and 398 μm, with an average of 389 μm. The average particle size distribution of SPM shows a trend of high in the east and low in west.

Acknowledgments

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