Hydrothermal activity and long-term monitoring at Southern East Pacific Rise -Preliminary results of the Ridge Flux SEPR'97 Leg 2 cruise-

Kantaro FUJIOKA*1 Kyohiko MITSUZAWA*1 Masataka KINOSHITA*2
shipboard scientific party*3

During tthe Ridge Flux SEPR'97 Leg 2 cruise 9 dives were successfully accomplished by the "*Shinkai 6500.*" The surface ship "*Yokosuka*" was also used to launch and recover instruments and to make geophysical measurements at the super-fast spreading ridge on the East Pacific Rise during a 34 day cruise from Valparaiso, Chile (depart 25 October, 1994) to Papeete, Tahiti (arrive 19 September, 1997). Preliminary results of this cruise are briefly summarized in this paper.

* 1 Deep Sea Research Department, JAMSTEC
* 2 School of Marine Science and Technology, Tokai University
* 3 Tsugio SHIBATA, Faculty of Science, Okayama University, Jun-ichiro ISHIBASHI, University of Tokyo, Masato JOSHIMA, Geological Survey of Japan, Kiminori SHITASHIMA, Central Research Institute of Electric Power Industry (CRIEPI), Akihiko MARUYAMA, Department of Applied Microbiology National Institute of Bioscience and Human-Technology, James COWEN, University of Hawaii, Kevin ROE..NOAA/PMEL, Izumi SAKAMOTO, JAMSTEC, Kei OKAMURA, ORI, Univ. of Tokyo, Nozomi YTOW, Institute of Biological Sciences University of Tsukuba, and Toru KODERA, Nippon Marine Enterprizes Ltd.

1. Introduction

The present cruise of submersible "*Shinkai 6500*" and R/V "*Yokosuka*" is the second Leg of South East Pacific Rise Ridge Flux '97 Expedition which is a part of the 6 year program "Ridge Flux Project" funded by the Science and Technology Agency of Japan, in collaboration with the NOAA/VENTS program to evaluate the heat and material fluxes emanating from the fastest spreading ridge at the Southern East Pacific Rise. As a pre-cursor to this cruise, an extensive CTDT tow-yo survey was conducted during the R/V "Melville" cruise in December, 1993 where massive plumes were mapped along much of the fast spreading ridge axis. During the MODE '94 Leg 3 and Leg 4 cruises "*Yokosuka*" and "*Shinkai 6500*" had 30 dives at the sites RM04(14°S), 11 (14°50'S), 24 (17°30'S), 23 (17°35'S), 28 (18°26'S) , 29 (18°10–11'S), and OSC1822 (18°22'S), obtaining chemical, petrological, and biological samples as well as bathymetric, gravimetric and magnetic data. R/V "Gyre" cruise in 1995 TAMU square obtained side scan sonar image along the ridge. Extensive studies on the geology, geophysics, geochemistry and biology of the southern East Pacific Rise have been published on our study areas (See references). In 1997, "*Yokosuka*" and "*Shinkai 6500*" revisited SEPR sites during the first leg, 15 dives were dedicated on the deployment of long-term monitoring systems prepared for one-year measurements (current, depth, distance from ridge axis, and so on). 25 long-term monitoring instruments were deployed either from the surface ship or by the Shinkai manipulator at three sites (RM24, RM23, and RM28) in the Southern East Pacific Rise. The first cruise demonstrated a new style in the use of manned-submersibles. The "*Shinkai 6500*" has proven to be capaible and powerful enough to do such complex tasks.

Although the various devices are still recording data and will be recovered in fall 1998, we intend to present a short summary of the 1997 SEPR Leg 2 cruise in this report. In addition, all the devices were successfully recovered by "Atlantis" and "Alvin", in 1998 September

2. Objectives

The second leg focused more on sampling and observations of the hydrothermal systems and their environs. The main objectives of this cruise were five fold;

The first objective is the evaluation of heat and material fluxes. It includes 1) Chemical and biological budget at two different hydrothermal areas through the chemical analyses of hydrothermal fluids from diffuse and high temperature black and white smokers, collected with water samplers, pump/filter sampler and in-situ Mn, pH, CTDT sensors , 2) Dispersion process of hydrothermal fluids, plume, particle and microbiota with time and distance from the chimney, using the CTD–RMS and Niskin samplers.

The second target is the long-term monitoring of hydrothermal systems. We plan to carry out 1) Heat flow measurement using Moored heat flow arrays, 2)In-situ observation of the hydrothermal field by CTD, current, temperature, pressure, nephelicity, and 3) Monitoring particle flux using sediment traps surrounding site RM24.

The third target is geological and biological mapping of hydrothermal fields and the regional distribution of lavas and tectonic features along and across ridge.

The fourth objective is geophysical characterization of the ridge crest. It is based on the analyses of magnetic propeties and intensity using a proton, and a three component magnetometers, and an in-situ three component magnetometer carried by the submersible to estimate the magnetic structure under the ridge crest, and gravimetry data.

The fifth objective is modeling of the evolution of the fast spreading ridge by elucidating the relationships and order of various kinds of events.

To attain the above objectives we used an ORI Pump water sampler, SMAP, Niskin water sampler, In-situ pump particle sampler, titanium piston gas-tight samplers and eight cylinder pump sampling system to collect endmember samples of focused and diffusively flowing vent fluids and fixed volume water bottles closed by silastic springs to capture plume samples. We used CTD, CTDRMS, Laser Raman, Nephelometer, Plankton trap and net, pH sensor, and GAMOS II, III (in-situ Mn analyzer). Geophysical measurements were made using the Zabuton, a moored long-term heat flow monitoring

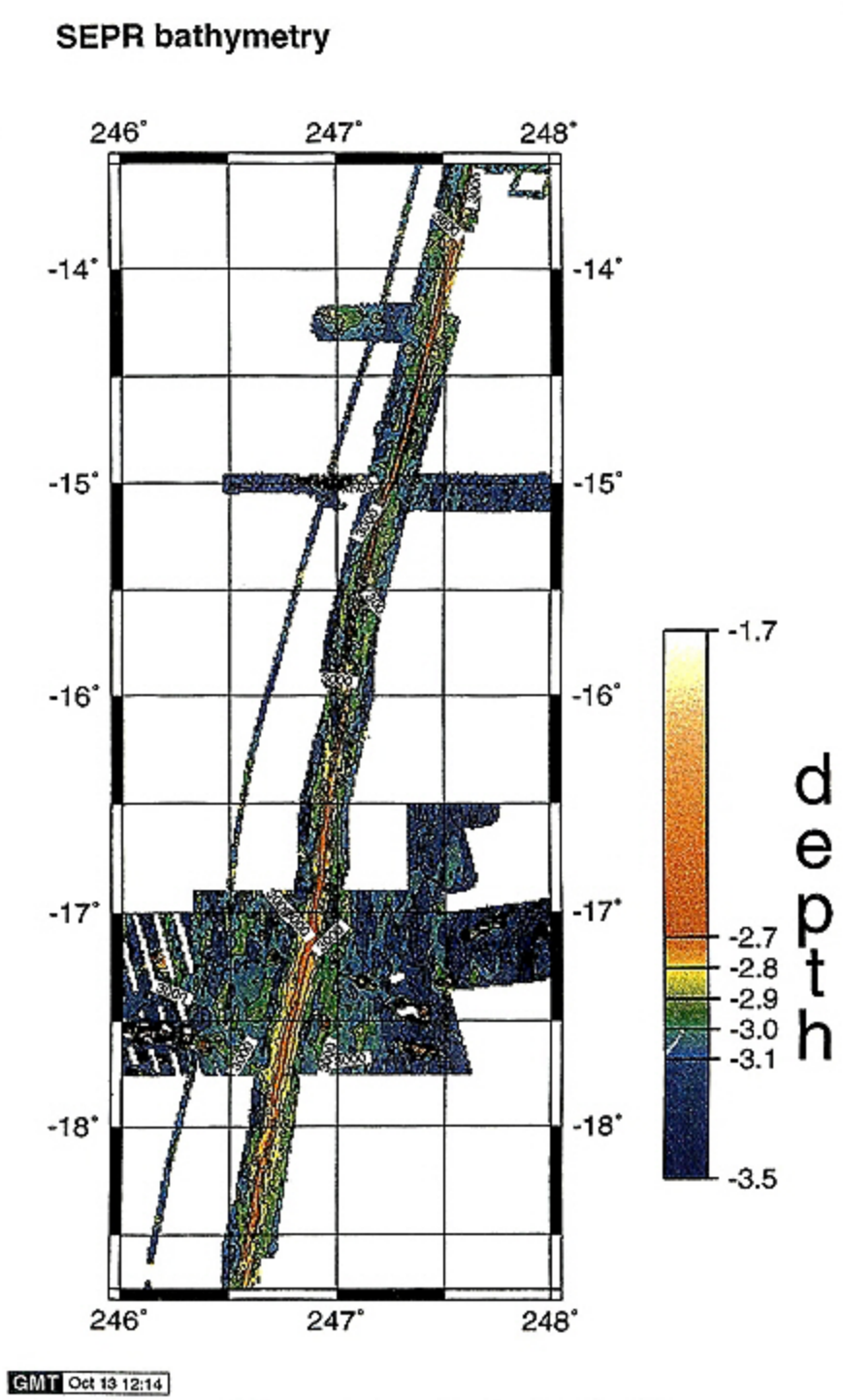


Fig. 1 Index map of the survey area (13°S to 20°S East Pacific Rise).

system and Manatee, a long-term in-situ environmental monitoring system to investigate the physical and chemical structure of the plume at RM28 and RM24. We also deployed 4 Sediment Trap moorings surrounding the hydrothermal sites at RM24 to measure the flux of particle related the hydrothermal input. We obtained a set of complete video record from along the seafloor track lines and collected numerous rock, sulfide and biological samples by submersible.

3. Preliminary results

3-1. Topography and geology

A topographic survey conducted around RM24, 23 and 28, between (17°20' and 18°30'S), using the HS-10 Multi-

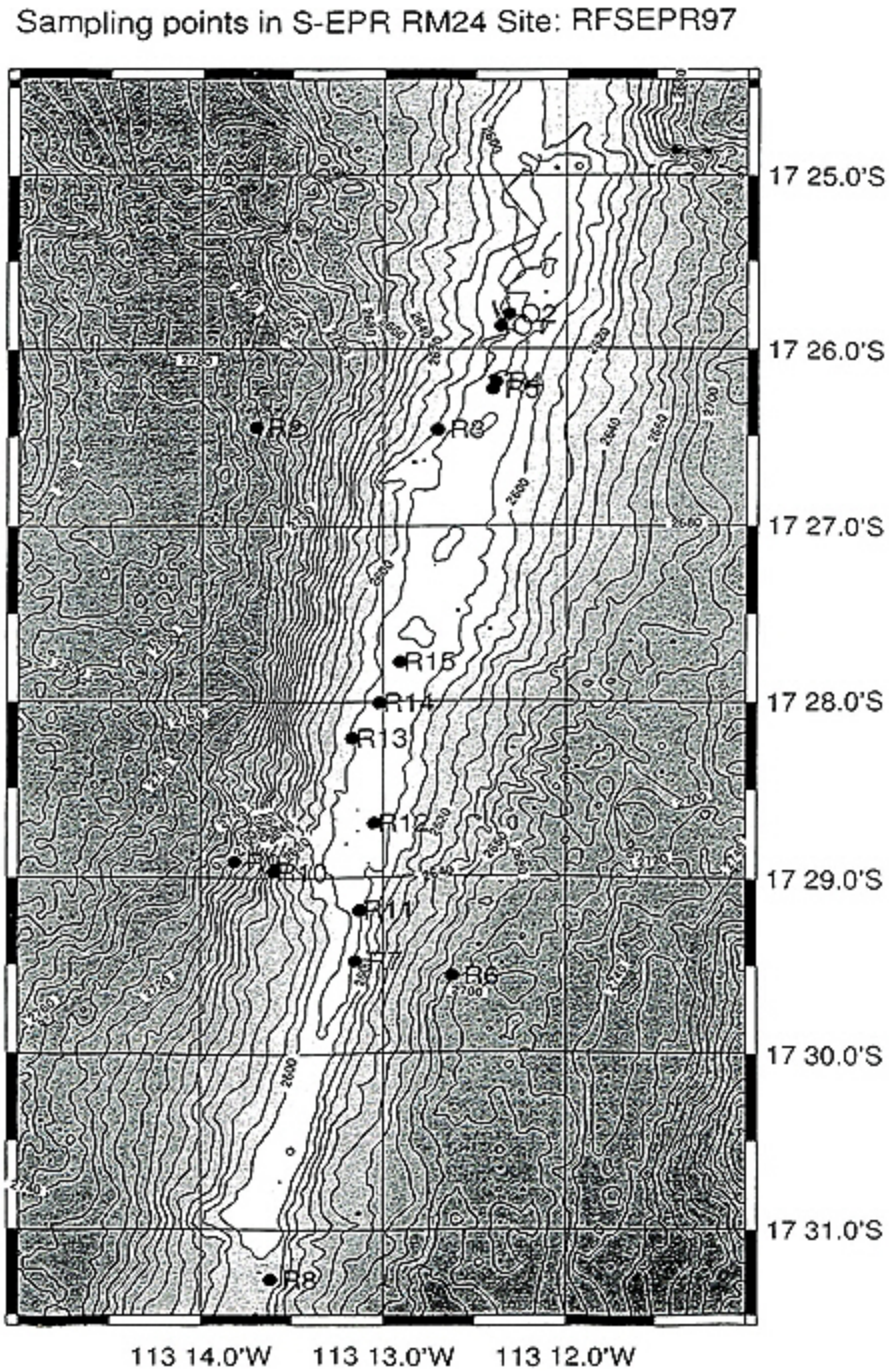


Fig. 2 Bathymetry and sampling points of the RM 24.

narrow Beam system, obtained a bathymetric map from 2300 survey miles of this ridge crest. Precise topographic maps were drawn for the survey areas, from north to south, RM24, 23, 29, OSC–1822, RM28, and OSC–1837. Three traverses across and along ridge were made using the submersible "*Shinkai 6500*" at RM24 and RM28 and 10 basement hard rock samples and one push core were obtained.

Re-examination of the topographic maps made from the Melville and Yokosuka cruises identified seven different segments, A to G from the Garett Fracture Zone south to the OSC–1903 at 19°03'S, based on the discontinuities of both depth and tectonic elements. However, based on the axial depth profile this portion of the ridge is basically three segments, I, II, III.

The stratigraphic relationships of the basalt lavas, both

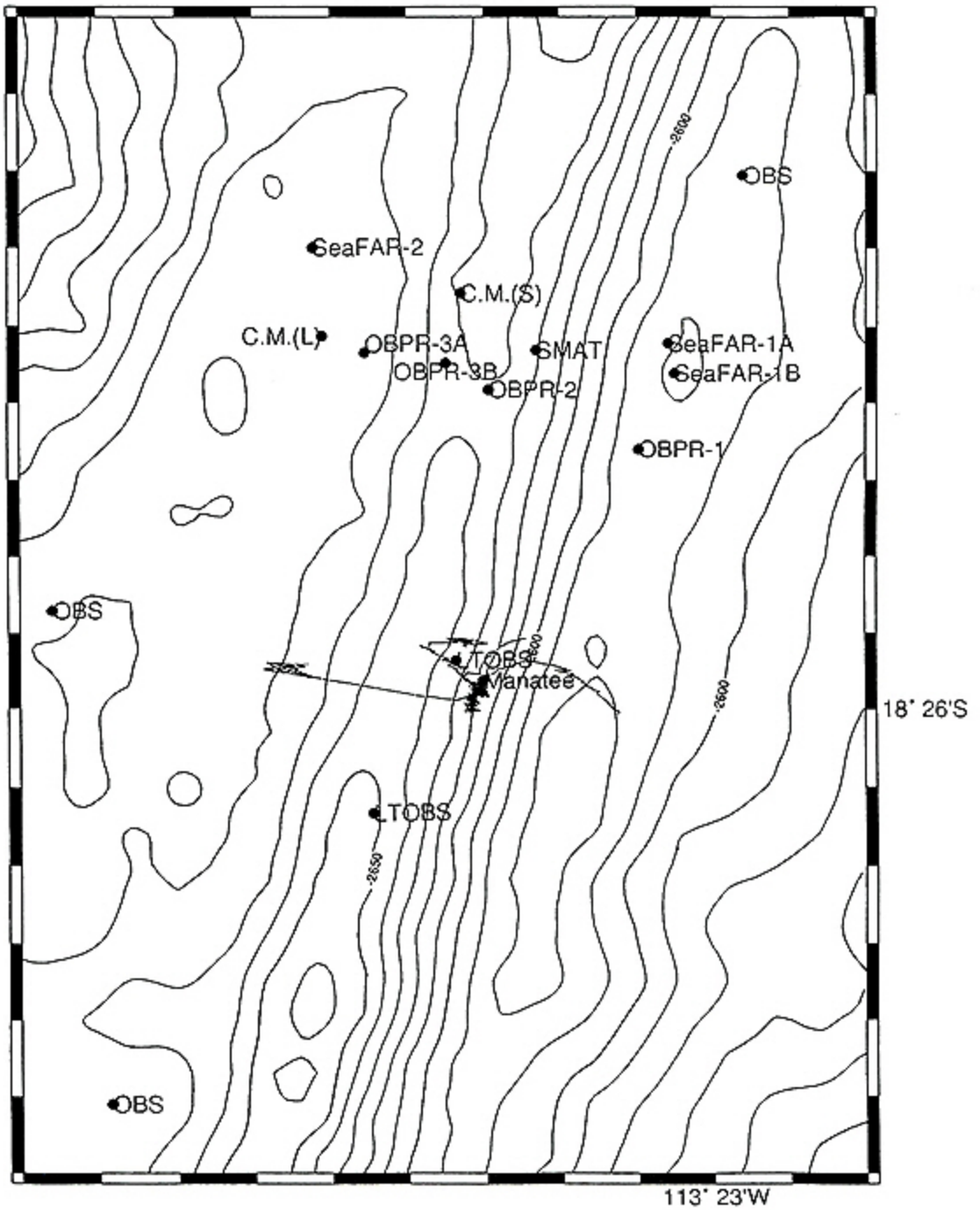


Fig. 3 Bathymetry and ship's track map of the RM 23 and 24.

pillow and sheet flows, consist of three different units reflecting their different age and sediment cover: sediment-free (L0), slightly sediment-covered (L1), and sedimented (L2). The distribution of the young lava flows were mapped for the notation position of site RM24. The hydrothermal field at RM 24 occupies the older lava field at the Oasis site. Sedimented and slightly sedimented lavas are distributed on the flank areas of the ridge.

The side scan sonnar data of the TAMU2 survey using R/V "Gyre" were compared with both dive observations and a topographic map. The RM28 site axial graben was well correlated with the black, narrow band and the western crest well correlated with the white, narrow straight liniaments. At site RM24, axial black, and narrow lineaments are well correlated with the young lava flow which was traced to the north during dive #391, south

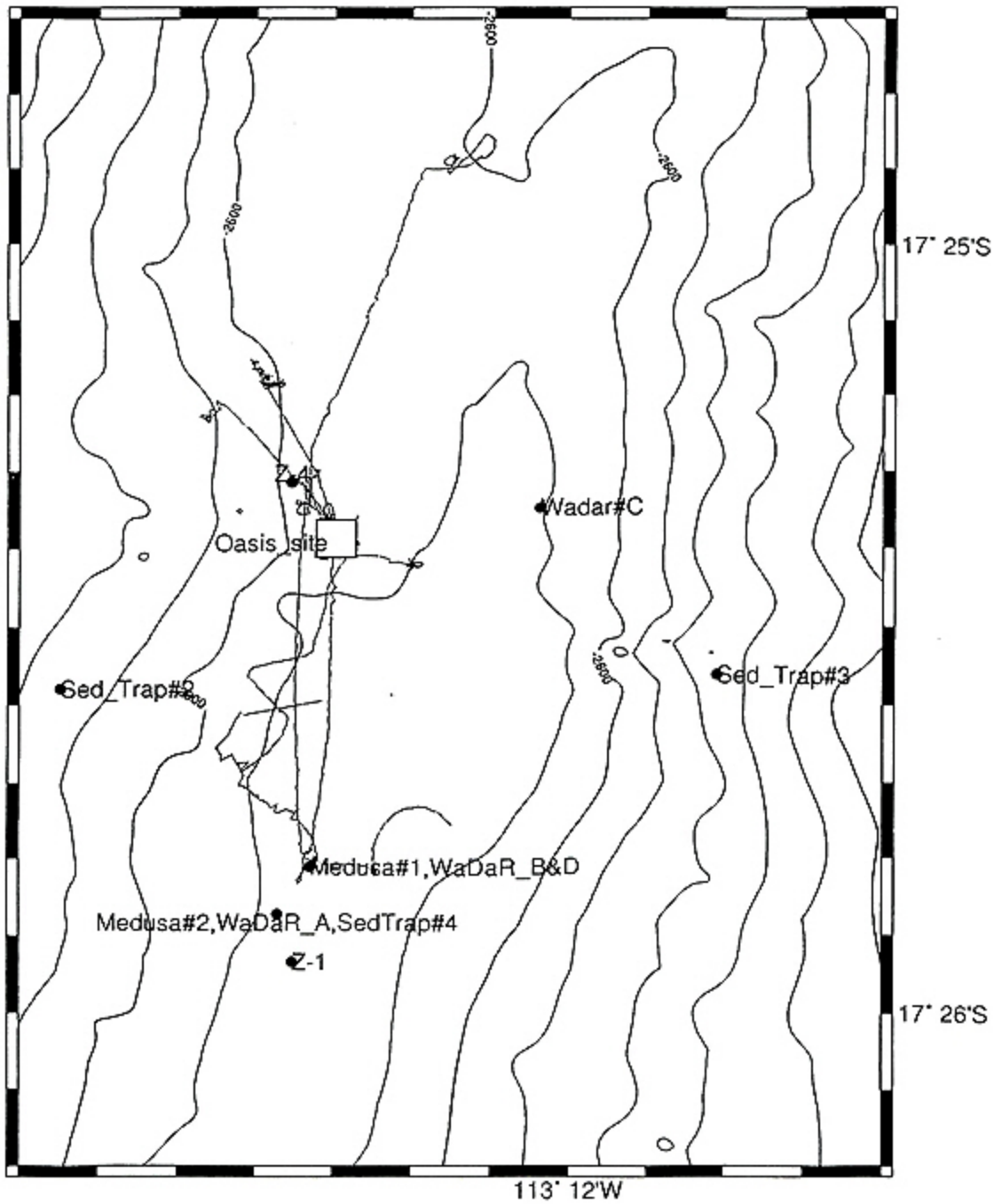


Fig. 4 Dive tracks and the location of the long-term monitoring systems at the RM 24.

during dive #390. Careful work of this kind will reveal existing correlations.

High resolution mapping of the distribution of hydrothermal focused vents, diffuse flow, large organisms, types of basalt and instrument deployments were carried out at site RM24, near the Oasis, Kaminari, Matsu, and Kohei hydrothermal sites based on the precise observations of several dives (dives #380, #386, #389, #3393, #394, #397, and #398).

3-2. Geophysics

A geophysical survey was carried out along combined track lines of 2,300 miles as to gravity, and magnetics. Of these, the magnetometer results show the sharp bundary between Brhunnes /Matuyama, corresponding to about 0.78 Ma. The average spreading rate was estimated and the

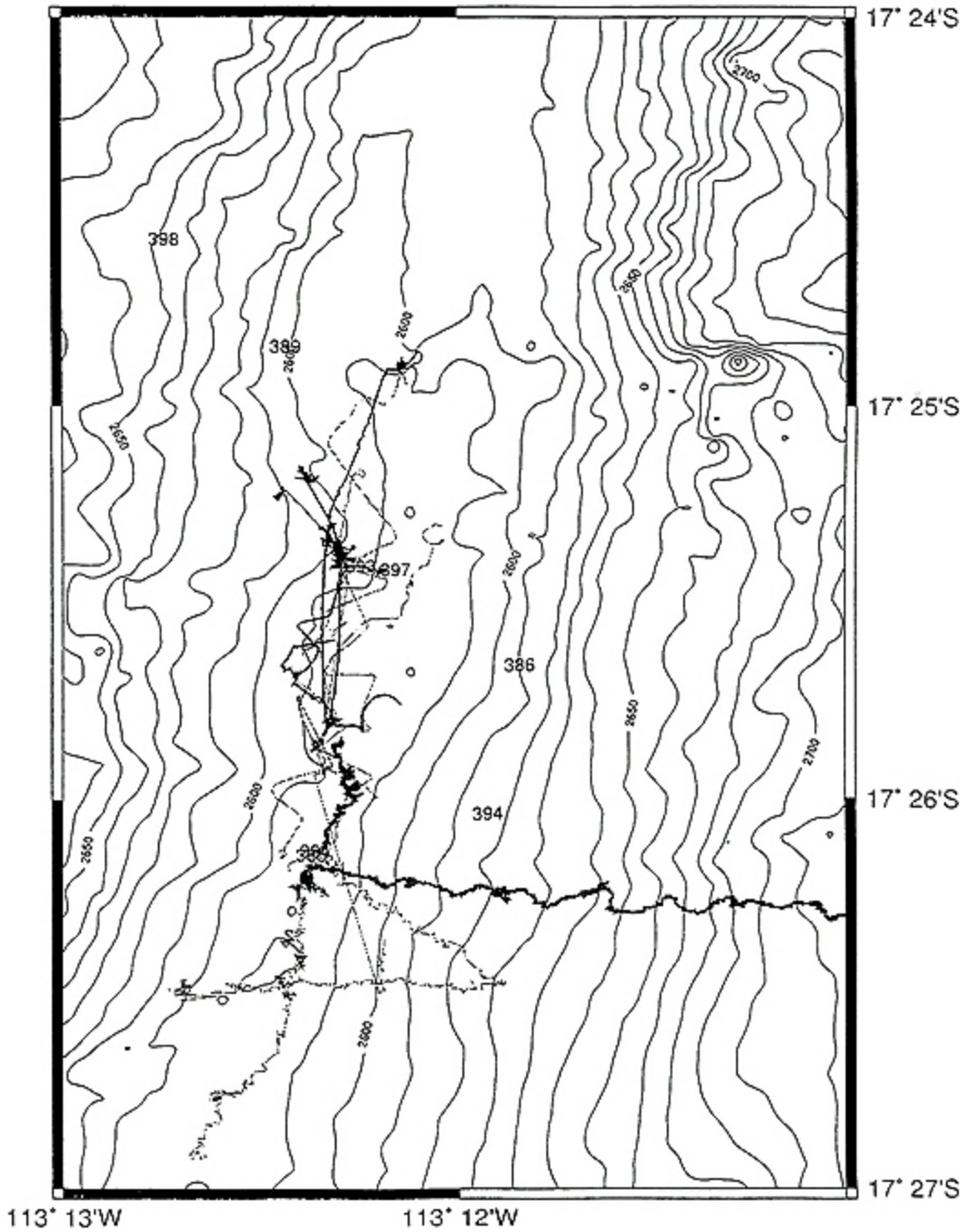


Fig. 5 Bathymetry and dive track map of the RM 28

results show that the spreading rate of the easten side of the ridge was much faster than that of the western side (at RM23, 17°30'S, 7.23cm/y in western half and 7.00 cm/y in the eastern half; at RM29, 18°10'S, 8.26cm/y W, 5.85 cm/y E; at RM28, 18°30'S, 8.17 cm/y W and 6.15 cm/y E).

3-3. Geochemistry

Hydrothermal fluid and particles were collected from two ridge segments of the Southern East Pacific Rise to reveal various geochemical processes associated with hydrothermal activity. Diffuse hydrothermal effluents (temperatures of 6.5℃ and 10.5℃) were sampled from two locations in the Oasis hydrothermal field of RM24 (17°20'S). Particles in the hydrothermal effluent were also collected by in-situ filtration for microbiological and biogeochemical studies. Vent fluid (measured temp. was

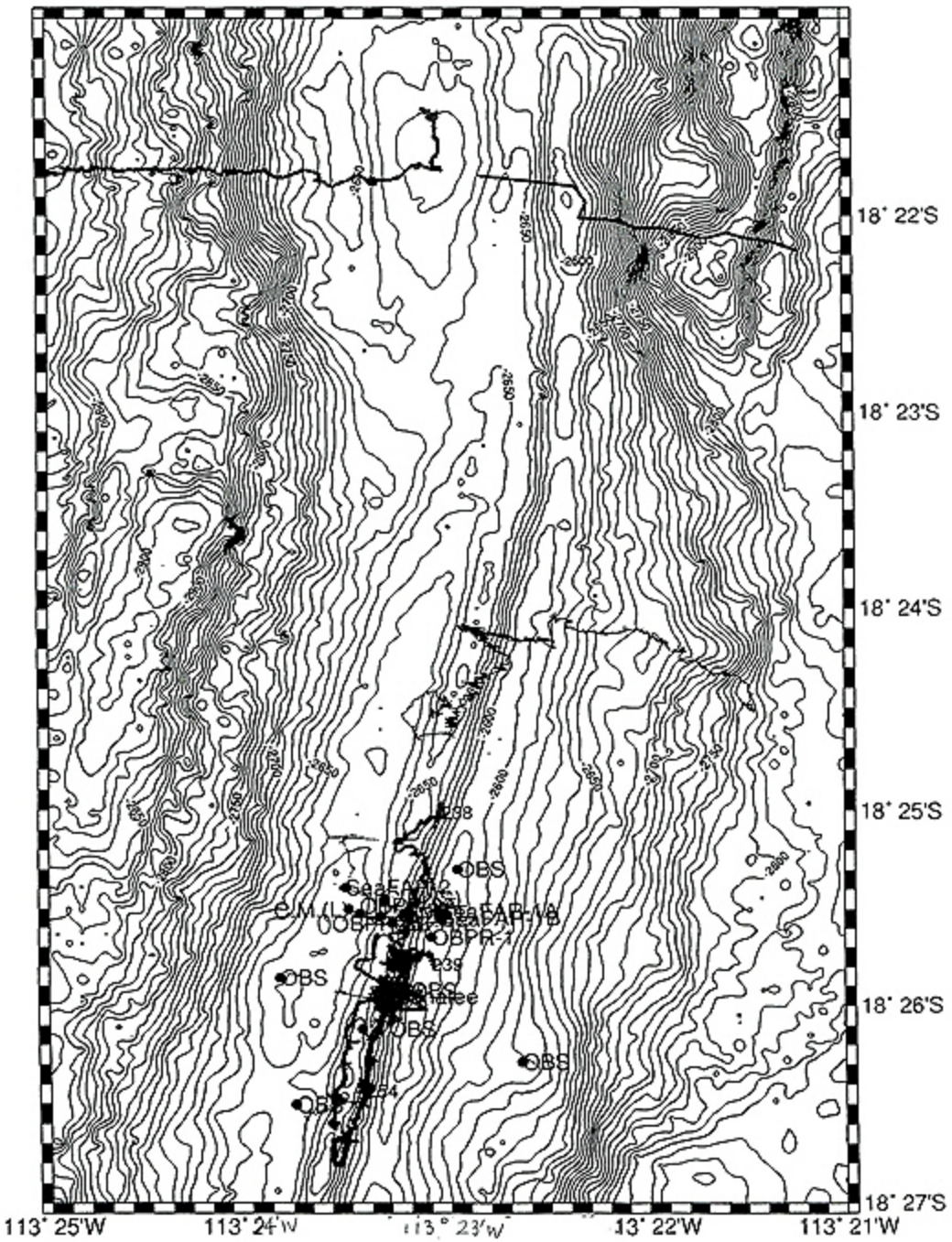


Fig. 6 Bathymetry, dive track map and the location of the long-term monitoring systems at the RM 28

268℃ and 306℃, respectively) and particles were sampled from two black smokers at RM28 (18°26'S). Buoyant plume water from a smoker was also collected at RM28 using Niskin bottles.

Resampling of vent fluids from RM28 and combining the results from the 1993 Nautile and 1994 Shinkai studies allowed us to investigate time series changes in the chemistry of hydrothermal discharges. Onboard analysis of H_2S, Cl, Si, CO_2 revealed large changes in the fluid chemistry from vapor-like to brine-like. Analysis of various additional chemical species is proposed in order to study geochemical characteristics during the evolution of hydrothermal systems.

An pH sensor and a manganese analyzer (named GAMOS) were developed for the in-situ measurement of the chemical properties of seawater in the vicinity of the

hydrothermally active regions. Both instruments were attached to the submersible during many dives and successfully collected data from the water column and the deepwater above the seafloor. The GAMOS study revealed variations in the ratio of manganese concentration to temperature anomaly, of up to over an order of magnitude depending on the style of venting in the hydrothermal fields at RM24.

The in-situ pH sensor and Eh sensors were deployed near the seafloor for a year-long time-series monitoring experiment. Together with the results of particle flux trap experiments and other geophysical and visual monitoring instruments, their results will provide key information for the estimation of the geochemical flux from hydrothermal activities.

3-4.Biology and Microbiology

Observation of the benthopelagic animal communities. The relative predominance of filter-feeders and detritus-feeders in the hydrothermal ecosystem of the Oasis at RM24 site indicated that the chemosynthetic primary production should be larger than other sites. Furthermore, it suggests that free-living microbes and microbial mats may be more productive in this environment than that at other sites. Distribution of these benthopelagic animals were actually plotted on a map of the Oasis site from dive observations and dive produced with observations video tapes for the first time.

In-situ measurement by Raman and Nephelometer

In-situ measurement by Raman and Nephelometer was successfully done at the Oasis site, showing that some signals are attributable to microbial activities.

Sampling of microorganisms and zooplankton

Many microbial samples for direct counting, cultivation and biomass estimation were successfully collected from both diffused and focussed vent waters. Large amounts of microbial particle samples were also obtained from hydrothermal fluids and plumes by Pump-Filter sampler. We also successfully collected zooplankton samples using a plankton net and trap samplers.

3-5. Deployment of the instruments

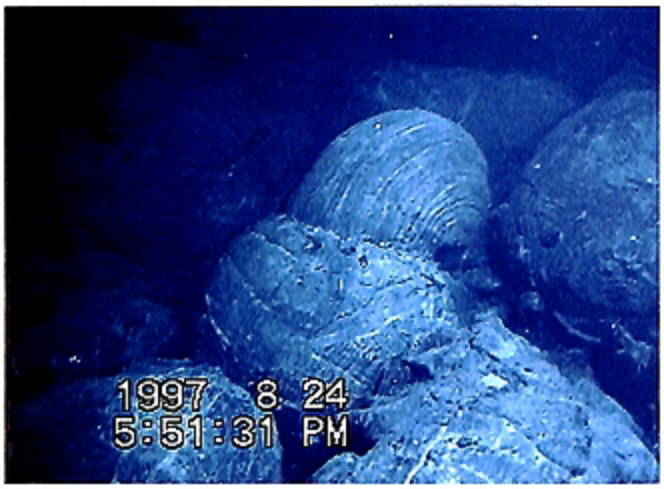
During this cruise, several instruments were deployed at RM24 and RM28. The Medusa #4 was deployed at the shimmering water site on a small terrace, 2～3 m south of SF6' s black smoker at RM28, during dive #392. During this dive, Manatee #01 was re-directed toward the black smokers. It was re-located about 5m southeast of the northern black smokers.

Two heat flow instruments were deployed on one of the diffuse flow sites ("Oasis site" at RM24; 17°25.6'S, 113° 12.3'W, 2,600m). ZABUTON, a thermal-blanket type long-term heat flow meter is designed to determine heat flow in sediment-free environments. After short-term measurements at three sites, it was finally deployed near the Oasis site during dive #398 on a thinly-sedimented basalt. The other instrument, a moored heat flow array, was deployed near the center of Oasis site. It consists of 5 temperature sensors and a current meter, and they are moored up to 50 m above sea floor.

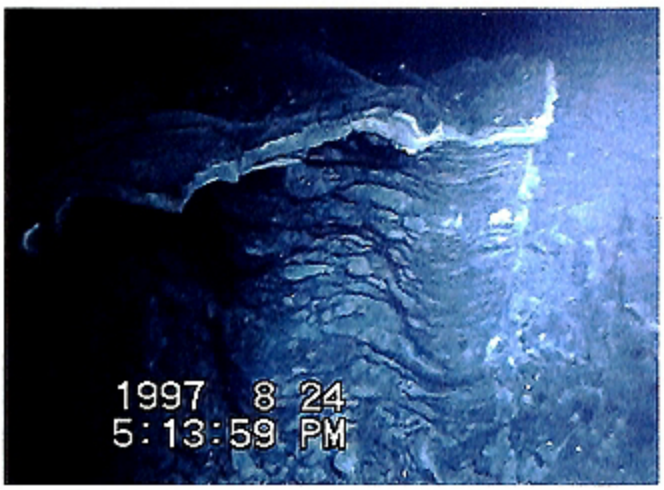
In addition, four particle flux trap arrays were moored at RM24. Trap mooring #1 is deployed near the Oasis site, however its precise position is unknown due to a transponder problem. Trap mooring #2 is positioned at the western slope on the axial dome; and Trap mooring #3 is on the eastern slope on the axial dome; and Trap mooring #4 is deployed adjacent to Matsu site.

4. Summary and future study

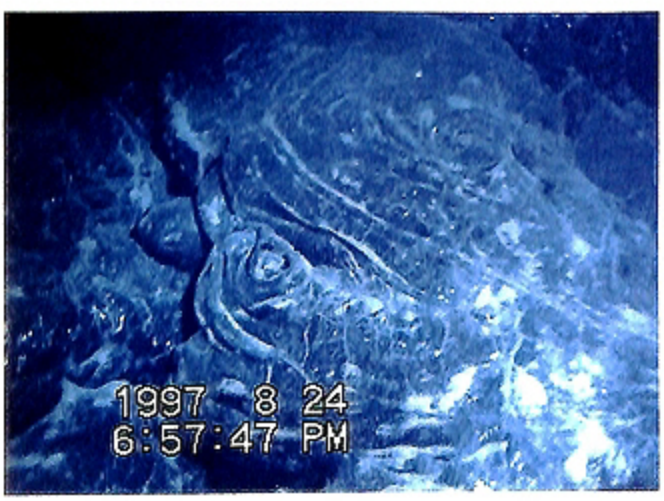
We deployed various kind of long-term monitoring systems at the RM24 and RM28 in the Southern East Pacific Rise to have a year monitoring of the current direction and current velocity, flow rate of the hydrothermal activity, observation of the variation of the chimneys, heat flow values, deep sea measurement, hydrophone, chemical changes, and so on. We will try to recover all the system during R/V Atlantis and Alvin cruise in 1998 fall and will analyze the data which will be successfully obtained during a year-long mneasurement and evaluate the heat and material fluxes from the fastest ridge and the deepwater above the seafloor. The GAMOS study revealed variations in the ratio of manganese concentration to temperature anomaly, of up to over an order of magnitude depending on the style of venting in the hydrothermal fields at RM24.



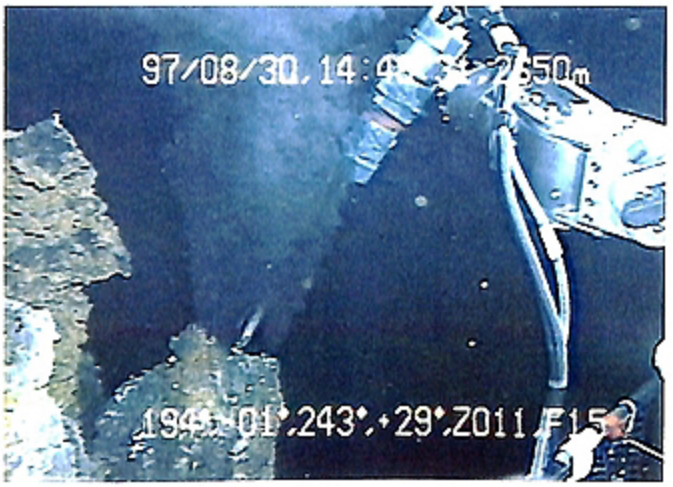
1. Submarine pillow lava



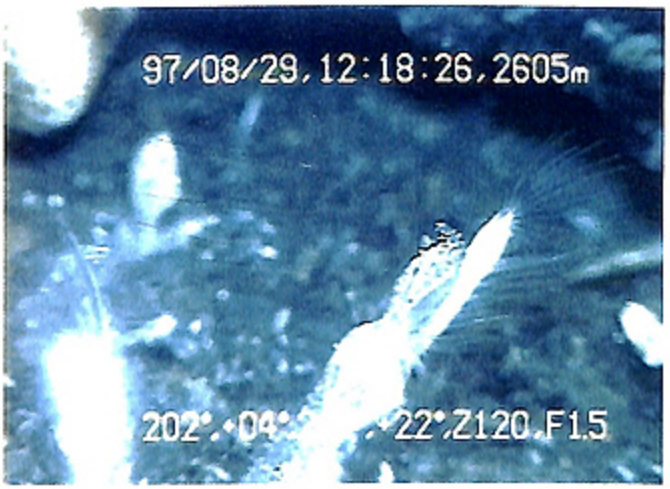
2. Pillar



3. Sheet flow



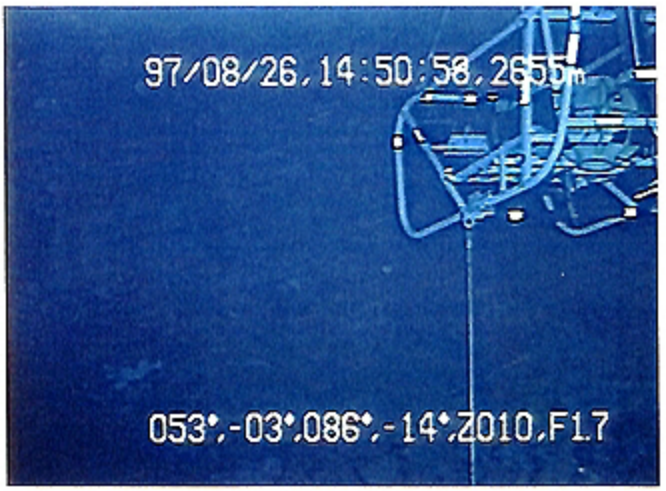
4. Pump Sampling



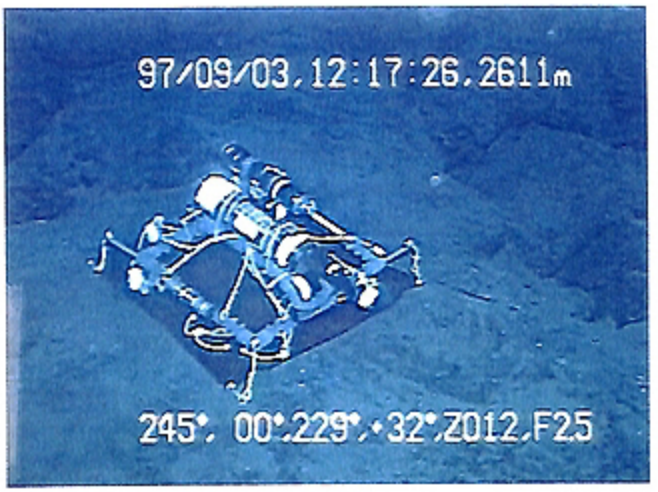
5. Microbiota

6. Laser Raman

Fig. 7 Photographs of the survey area



7.Manatee



8. Zabuton

The in-situ pH sensor and Eh sensors were deployed near the seafloor for a year-long time-series monitoring experiment. Together with the results of particle flux trap experiments and other geophysical and visual monitoring instruments, their results will provide key information for the estimation of the geochemical flux from hydrothermal activities.

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