Multidisciplinary and extensive real-time deep seafloor observatory off Hatsushima Island in Sagami Bay

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Abstract. A real-time long-term multidisciplinary observatory was developed and installed at a cold seepage site on deep seafloor off Hatsushima Island in Sagami Bay at a depth of 1170 m in 1993. Many observational results such as subbottom temperature variation and its relation with other environmental parameters or earthquake swarm activities have been obtained, and technologies that had been developed through the project was applied to other observatories such as off Muroto Cape in Nankai Trough observatory and VENUS in Nansei Shoto (Ryukyu) Trench observatory. And then the results of these observatories were fed back to the new off Hatsushima Island observatory that was deployed in March 2000. The new observatory is equipped with spare optical fiber lines and auxiliary serial ports to which underwater instruments can be connected on the seafloor with underwater wet mateable connectors. Far more advance in revealing phenomena occurring on the deep seafloor is expected not only by the continuous observation by the observatory but also by the development of new instruments by utilizing the facilities and the environment of the observatory for field tests.

1 Introduction

In order to understand fluctuation phenomena occurring on deep seafloor in various time scales, long-term continuous observation is necessary. In addition to that, multi-disciplinary observation by various kinds of sensors is very effective. JAMSTEC's cable-connected observatories that enabled these observations have been deployed off Hatsushima Island in Sagami Bay, off Cape Muroto in Kochi Prefecture and off Kushiro and Tokachi in Hokkaido, and continuous observations by those observatories have been carried out (Momma, 2000). In VENUS project (Kasahara, et al., 2000), which was supported by the special coordination funds for promoting science and technology of Science and Technology Agency, an observatory was installed at a depth of 2,150m off Okinawa Island on the landward slope of Nansei Shoto (Ryukyu) Trench. The off Hatsushima Island observatory was the primarily developed cable-connected multi-disciplinary observatory, and later became the newest and the most extensive observatory by the feedback of technologies developed through the other observatories.

2 Off Hatsushima Island in Sagami Bay – Background and deployment of primary observatory

Off Ito on east coast of Izu Peninsula, which faces Sagami Bay, the crustal movement is very active and swarm earthquakes have been occurred almost every year. Teishi Knoll which is located 2km from the coast of Ito erupted in 1989. Next to this swarm earthquake region, a cold seepage site where the largest chemo-synthetic biological community in Japan, which is consisted mainly of Vesicomyid clams, exits on the seafloor southeast off Hatsushima Island. In order to observe environmental changes that are generated by crustal movement, a long-time real-time deep seafloor observatory was developed and deployed in this colony at a depth of 1175m in September 1993 (Fig.1) (Momma et al., 1998).

This observatory was equipped with a CTD sensor, an electro-magnetic current meter, two video cameras, a geo-thermometer with tow probes, a seismometer (three component servo velocimeter) and a hydrophone. Data transmission and power supply from land was made through an electro-optical cable between observatory and a land station on Hatsushima Island. The probes of geo-thermometer, the hydrophone and the seismometer, which had been placed on the frame of the observatory, were pulled out and settled on the seafloor around the observatory by ROV "Dolphine 3K". At the same time, the observatory was moved to the colony in which more clams existed.

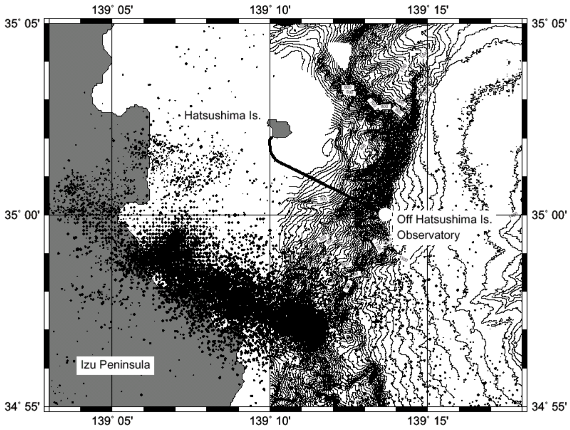

Fig.1 Location of "off Hatsushima Island observatory" and epicenters of swarm earthquakes east off Izu Peninsula (1989-1999, by JMA)

3 Observational results

After the installation of the observatory, continuous observation has been carried out .for about six years.

By the continuous observation, seasonal variations of subbottom temperatures that increased in spring, the increase of the amount of suspended particles also in spring, and diurnal or semidiurnal change of current, water temperature and subbottom temperatures were detected. Mudflows that were generated by the swarm earthquake in March 1997 and in April and May 1998, and increase of subbbottom temperatures accompanied by the mudflows were observed. Biological activities such as spawning of clams were also observed. Furthermore, relations between these phenomena were revealed. For example, the sedimentation of suspended particles and by mudflows affected the subbottom temperatures, spawning of clams were triggered by rapid increase of water temperature. The semidiurnal variations of subbottom temperatures which correlated with the variation of hydraulic pressure i.e. ocean tide were also observed. These are considered to have some relation with the behavior of cold seepage.

4 Deployment of the new observatory

In order to feedback newly developed technologies and to carry out more multi-disciplinary observation, the observation by off Hatsushima primary observatory stopped in July 1999, and was recovered in March 2000 and at the same time a new observatory was deployed (Photo.1).

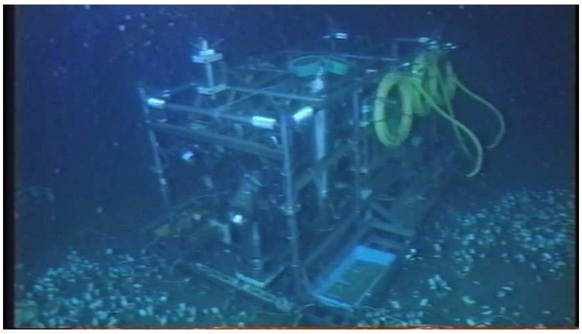

Photo.1 New "off Hatsushima Island Observatory"

The location of the new observatory is in a clam colony 40m north of the former location. The new station is equipped with a transmissometer, an ADCP (Acoustic Doppler Current Profiler), a tsunami pressure gauge (a precise pressure gauge) and a gamma ray spectrometer in addition to the same sensors as those of the former station. Performances of some of those sensors are also improved. A/D sampling of seismometer is 24bits/200Hz (former one was 16bits/100Hz). One of two video cameras is a Super HARP camera, which is far more sensitive than a CCD camera. Pressure cases and frames are made of titanium to prevent from corrosion. Underwater wet mateable connectors, five electrical connectors and four optical connectors, are also equipped (Photo.2).

Photo.2 Underwater mateable connectors attached to the observatory

Four of five electrical connectors are for additional serial ports (three ports for RS232C and one port for RS422. 19.2kbps baud rate and DC15V/1A power supply are available for each one.). Sensors whose interface matches those specifications can be attached to the observatory on the seafloor. The other electrical connector and all optical connectors are directly connected to the main electro-optical cable. By using those connectors, additional optical telemetry units can be attached. By utilizing these optical connectors, developments of optical fiber sensors, such as optical fiber seismometers, are also possible. Before deployment, a cable with a underwater mateable optical connector on both ends were attached to the observatory in order to measure optical loss of the connectors at land station on Hatsushima Island. Fig.2 shows the result of OTDR (Optical time domain reflectometer) measurement. As optical loss at the underwater unit was about 2dB, loss for one connector was about 1dB including splice losses of the fiber inside the underwater telemetry unit. Although the splice losses were not known and precise loss of the connector alone cannot be obtained, the loss of the underwater mateable connector is same as those of connectors commonly used on land. In November 2000, connection and disconnection test was carried out by ROV "Hyper-dolphin". After this test optical loss was almost the same.

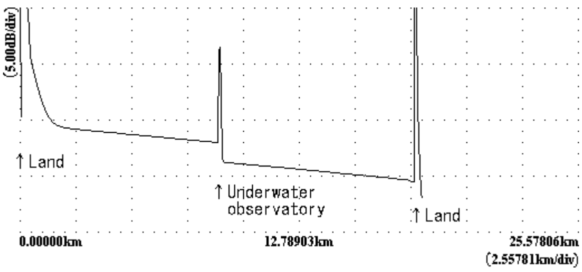

Fig.2 Optical loss profile of electro-optical cable between land station on Hatsushima Island and underwater unit with underwater mateable connectors, measured by an OTDR on July 7, 2000. (Wavelength: 1550nm)

Installation of the new station on the seafloor was carried out on March 18 and 19, 2000. The method of installation was same as that of the former observatory. After deploying the observatory by a work ship, probes of subbottom thermometer, seismometer, hydrophone and gamma ray spectrometer were settled on the seafloor around the observatory by a ROV. After the installation of the underwater unit, a main cable was connected to the land unit and observation started at the end of March. Continuous observation has been carried out so far.

Two probes of subbottom thermometer were placed inside and outside of the clam colony separately in the same way as the former station. At the former station, the temperature gradient inside the colony was larger than inside the colony just after the deployment, but at the new station temperature gradients do not differ so much as at the former one. Semidiurnal changes of subbottom temperatures correlated to ocean tide that have been observed by the former observatory have not been observed. These differences may show that at the new observatory, which is located about 40m north of the former one, environment caused by cold seepage is different from that at the former one, such that cold seepage may not be so active.

Fig.3 shows an example of current at bottom layer (12m above seafloor) of ADCP, light transmission, pressure and water temperature profiles. Water temperature was averaged for 1 minute.

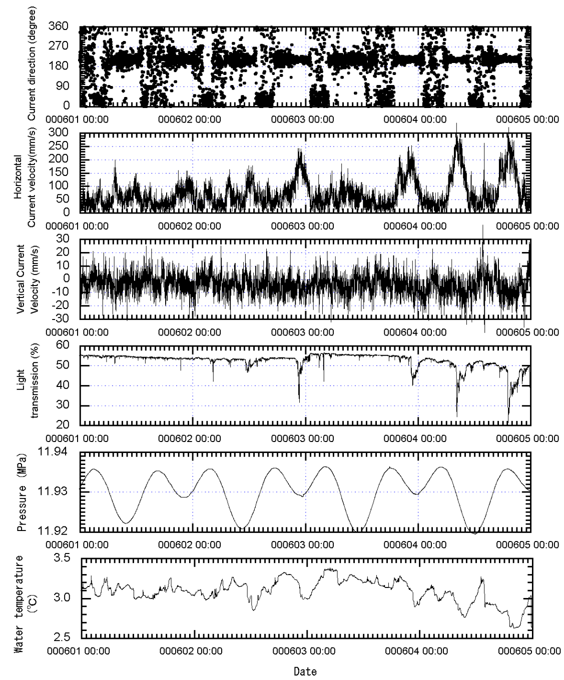

Fig.3 Example of current velocity (Bottom layer of ADCP, 12m above seafloor), light transmission, pressure and water temperature of CTD (profiles

Fig.3 shows the profile between June 2 and June 4, 2000 when relatively large amount of suspended materials were observed by video cameras. There was a semidiurnal change in current direction. SSW direction and a little downward current are dominant. Increase of current velocity correlated well to decrease of light transmission, i.e. increase of suspended matters. There is a problem in observing by the transmissometer and the video cameras that those has been affected by suspended matters or snails stuck to those sensors. There is also a problem in observing by the ADCP and the current meter that sometimes crabs stays on those sensors and obstruct current measurements.

As there are several problems in the new observatory, adjustments through checking data including recovery and re-deployment are planned in near future. At that time, it is also planned to improve coupling between the seismometer and seafloor by burying it.

. In order to reveal much more phenomena occurring on the deep seafloor, it is necessary not only to continue observation by the new observatory, but also to develop new instruments which can measure physical or chemical factors that have not been able to be quantified. By utilizing the facilities supplied by the observatory and by taking advantage of the environment such as cold seepage, active earthquake swarms and crustal movements, several plans of developing new instruments are in progress.

5 Conclusion

Real-time long-term multidisciplinary observation system was developed and installed at deep seafloor of Hatsushima Island in Sagami Bay in 1993. Technology developed through the project was applied to other observatories. And then results of other projects were fed back to the new off Hatsushima observatory deployed in March 2000. Expandability that sensors can be added on seafloor enabled the observatory to be used as test bed for developing observation instruments. Far more advance in revealing phenomena occurring on the deep seafloor is expected by long-term observation and development based on off Hatsushima observatory.

Acknowledgement. Off Hatsushima Island observatory and other observatories were developed by the members of Deep Sea Research Department in JAMSTEC. I thank Riyo Ohtsuka and Naotaka Togashi of Marine Works Japan Ltd. and Mr. Namba of YSI/Nanotech Ltd. for their help in carrying out observation and experiment by the observatory. I also thank Mutsumi Shimoda and his colleagues in Oki Electronics Ltd. for the construction of the new off Hatsushima Island Observatory.

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