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Off Hatsushima Island observatory in Sagami Bay : Multidisciplinary long term observation at cold seepage site with underwater mateable connectors for future use

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ABSTRACT

On the seafloor at a depth of 1175m off Hatsushima Island in Sagami Bay, Central Japan, a cable-connected multi-disciplinary observatory was installed in 1993. Since then long term real time observation has been carried out, experiencing replacement for upgrades in 2000, recovery and re-deployment for repair in 2002. This site is known as one of the most significant cold seepage sites with large chemo-synthetic biological communities consisted mainly of Vesicomyid clams (*Calyptogena*). The upgraded second observatory is equipped with underwater mateable connectors (optical / electrical). The observatory revealed geophysical and biological events occurred on the seafloor, such as the mudflows and sedimentation generated by swarm earthquakes, spawning of clams triggered by water temperature change. However, several kinds of phenomena and technological problems yet to be identified nor solved still remain. As a next step, the observatory is planned to be utilized as a test bed, by using the underwater mateable connectors.

1. INTRODUCTION

In order to understand the phenomena occurring on deep seafloor in various time scales, long-term continuous observation is necessary. Besides, multi-disciplinary observation by various kinds of sensors is very effective. JAMSTEC (Japan Marine Science and Technology Center)'s cable-connected observatories that enabled these observations have been deployed off Hatsushima Island in Sagami Bay, Central Japan, on the slope of Nankai Trough off Cape Muroto in Kochi Prefecture, Southwest Japan, and on the slope of Japan Trench off Kushiro in Hokkaido, Northeast Japan (Momma, 2000)[1)]. In VENUS project (Kasahara, et al., 2000)[2)], an observatory was installed at a depth of 2,150m on the landward slope of Nansei Shoto (Ryukyu) Trench off Okinawa Island. Off Hatsushima Island observatory was a primarily developed cable-connected multi-disciplinary observatory and was later replaced for upgrade with feedbacks of technologies developed through the other observatories.

In this paper, the configuration, associated works, results and problems of the off Hatsushima Island Observatory will be reported.

2. Off Hatsushima Island in Sagami Bay - Background and deployment of the primary observatory

Off Ito city on east coast of Izu Peninsula, which faces Sagami Bay, the crustal movement is very active and swarm earthquakes have occurred almost every year until recently. 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 (*Calyptogena*), exits on the seafloor southeast off Hatsushima Island. In order to observe environmental changes on the seafloor, 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)[3)].

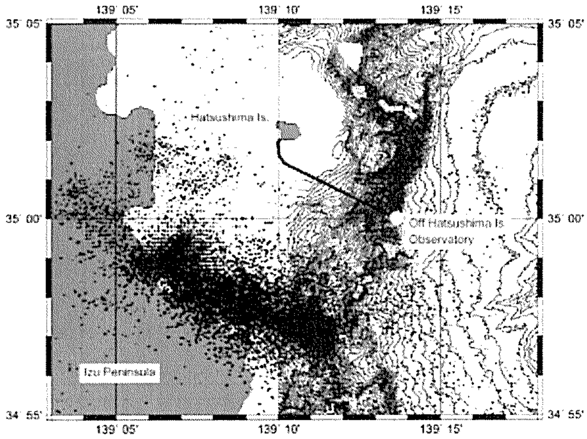

Fig.1 Location of "off Hatsushima Island observatory". Small dots are the epicenters of swarm earthquakes occurred in 1989-1999 (after JMA).

The primary observatory was equipped with a CTD sensor, an electro-magnetic current meter, two video cameras, a sub-bottom thermometer with two probes, a seismometer (three component servo velocimeter) and a hydrophone. Data transmission and AC power supply from land was made through an electro-optical cable between observatory and a land station on Hatsushima Island. The probes of 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 (Remotely operated vehicle) "Dolphine 3K" in October, 1993. At the same time, the observatory was moved at the side of a colony in which more clams existed (Fig.2).

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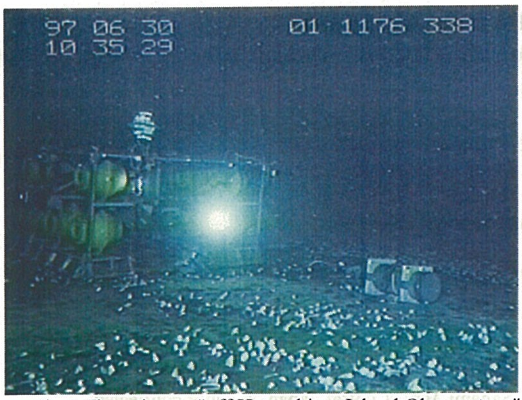

Fig.2 The primary "off Hatsushima Island Observatory"

3. Replacement of the observatory – Configuration of the present observatory

After the installation of the primary observatory, continuous observation has been carried out for about six years. In July, 1999, overcurrent of the AC power supply caused by the short circuit of submarine cable was detected at the shore station and the observatory stopped working. The cause of the breakdown was considered to be the water immersion through pin hole in the submarine cable, since the severe damage was not found along the cable nor on the underwater unit of the observatory.

Fortunately, just before the breakdown, replacement of the observatory was planned and designing of a new observatory for upgrade was started comprehending new technologies such as underwater mateable connectors developed after the deployment of the primary observatory for the purpose of carrying out more multi-disciplinary observation. The primary observatory and the submarine cable was recovered in March 2000. At the same time the new observatory was deployed with a new submarine cable.

It is equipped with a transmissometer, an ADCP (Acoustic Doppler Current Profiler), a tsunami pressure gauge (a precise pressure gauge) and a gamma ray spectrometer as well as the same kind of sensors of the primary observatory. Performances of some of those sensors were improved. A/D sampling of seismometer is 24bits/200Hz (former one was 16bits/100Hz). One of two video cameras is a Super HARP (High-gain Avalanche Rushing Photoconductor) camera, which is far more sensitive than a CCD camera. An acoustic type was adopted for the current meter instead of electro-magnetic type to avoid electro-magnetic interference caused by other sensors or equipments. Pressure cases and frames are made of titanium to prevent corrosion. Underwater wet mateable connectors, five electrical and four optical, are also equipped (Fig.3).

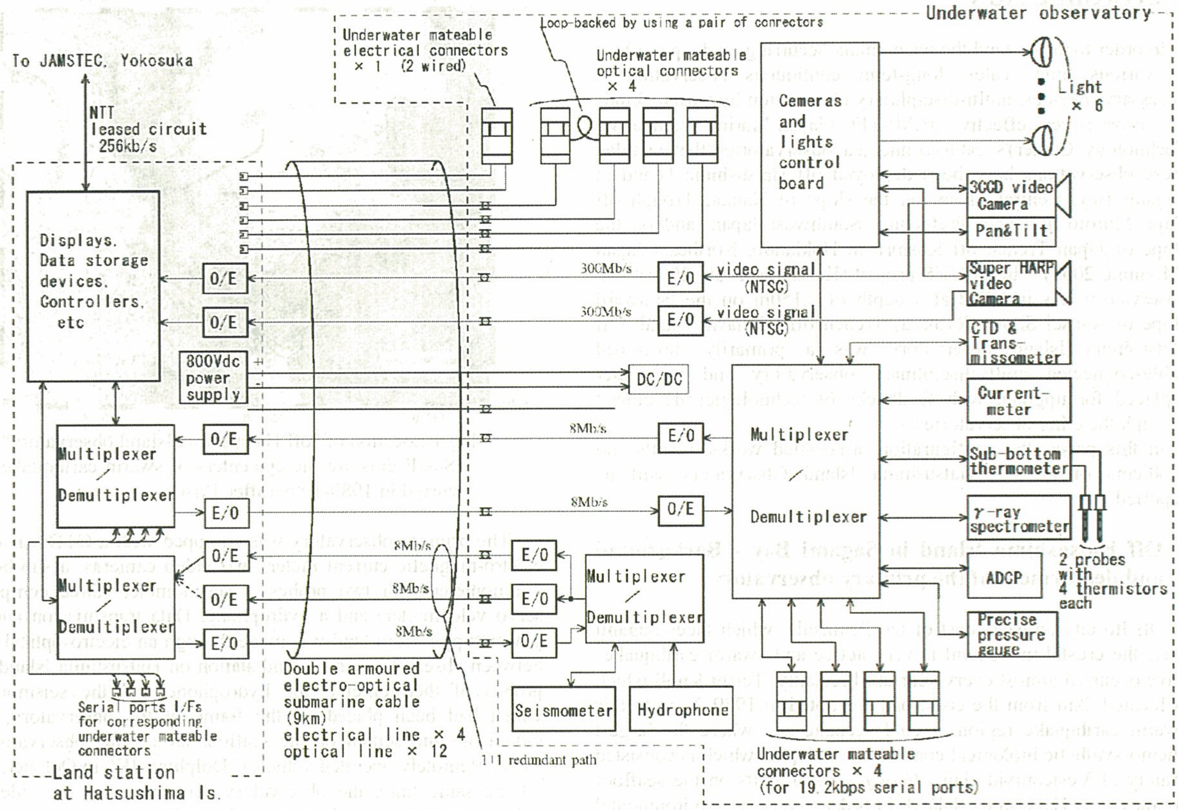

Fig.3 Schematic diagram of the new "off Hatsushima Island observatory"

Installation of the new observatory was carried out on March 18 and 19, 2000. The method of installation was same as that of the former one. After the cable-end observatory was lowered and deployed on the seafloor by a work boat (Fig.4), the submarine cable was laid to the shore of Hatsushima Island and was connected to the land unit. Probes of sub-bottom thermometer, seismometer, hydrophone and gamma ray spectrometer were settled on the seafloor around the observatory by an ROV (Fig.5). The observation started at the end of March. The location where the new observatory was deployed was another clam colony about 40 m north of the previous observatory where the cold seepage seemed to be less active.

Fig.4 The new "off Hatsushima Island Observatory" just being lowered by a work boat

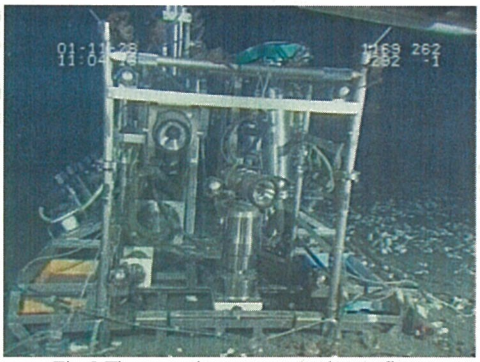

Fig.5 The new observatory on the seafloor

Unfortunately, however, the current meter broke down just after the deployment.

In order to repair the current meter and to make some adjustment on the other sensors, the observatory was recovered in March, 2002. It was redeployed in November, 2002 at almost the same position where the primary observatory had been located. Higher heat flow than that of the previous location has been observed and gray bacteria mats were recognized at the present site.

Four of five underwater mateable electrical connectors are assigned for serial ports with DC power supply (three ports for RS232C and one port for RS422. 19.2kbps baud rate and DC15V/1A power supply are available for each one.). They are retained for additional sensors to be used on the seafloor whose interface matches those specifications. The other electrical connector and all optical connectors are directly connected to the submarine cable. They can be used as a pair of auxiliary power supplying line and four auxiliary fiber optic lines. By utilizing them, additional optical telemetry units can be attached. Experiments of optical fiber sensors, such as optical fiber seismometers, are also possible. Before the 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 shore station on Hatsushima Island (Fig.2, top). Fig.6 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, de-mating and mating test was carried out by ROV "Hyper-dolphin". After this test optical loss was almost the same, rather decreased.

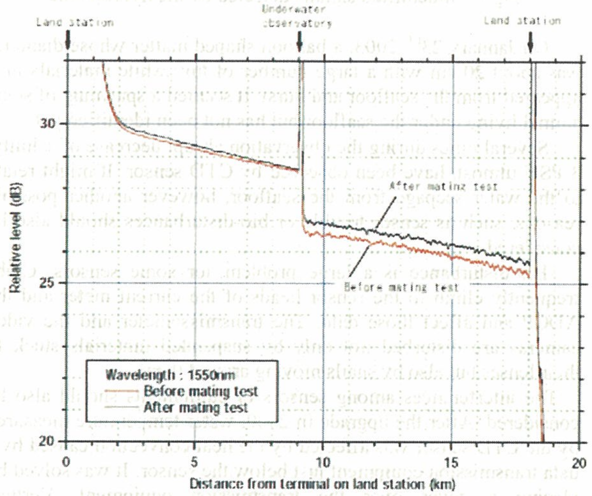

Fig.6 Optical loss profile of electro-optical cable between land station on Hatsushima Island and underwater unit through roop-backed underwater mateable connectors, measured by an OTDR. Lower line shows a profile before mating test. Upper line shows that of after mating test.

4. Observational results

By the continuous observation, seasonal variations of sub-bottom 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 sub-bottom temperatures were detected. Mudflows that were generated by the swarm earthquake in March 1997 and in April and May 1998, and increase of sub-bottom 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 sub-bottom temperatures, spawning of clams were triggered by rapid increase of water temperature. The semidiurnal variations of sub-bottom temperatures which correlated with the variation of hydraulic pressure i.e. ocean tide were also observed by the primary observatory. These are considered to have some relation with the behavior of cold seepage. However, seasonal and semidiurnal changes in sub-bottom temperatures independent of water temperature change were less distinct at the new observatory. These results are considered to show the locality or heterogeneity of water seepage.

There are several kinds of phenomena and technological problems yet to be identified nor solved.

Through the hydrophone, rhythmical click sounds have sometimes been heard. It is probable that they are related to some biological activities like clams, but are not identified yet. Besides, the hydrophone sometimes detects pressure signal whose sources are not identified yet as shown in Fig.7, though seismometer does not detect these signals.

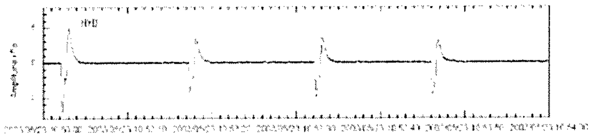

Fig.7 Unidentified signals detected by the hydrophone

On January 23rd, 2003, a balloon shaped matter whose diameter was about 20 cm with a large number of tiny white materials in it appeared from the seafloor and burst. It seemed a spawning of some animal living under the seafloor but has not been identified yet.

Several times during the observation abrupt decrease of salinity, 3 PSU utmost, have been observed by CTD sensor. It might relate to the water seepage from the seafloor, however another possible reasons, such as sensor trouble or bio-disturbances should also be considered.

Bio-disturbance is a large problem for some sensors. Crabs frequently climb to the sensor heads of the current meter and the ADCP and affect those data. The transmissometer and the video cameras are disturbed not only by suspended materials stuck to their lenses but also by snails moving around them.

The interferences among sensors or equipments should also be considered. After the upgrade in 2000, water temperature measured by the CTD sensor was affected by the heat convection caused by a data transmission equipment just below the sensor. It was solved by placing a cover over the transmission equipment. Vertical component of the current meter data seems to be affected by the heat convection of lights. It was found after the repair in 2002 and could not be fixed so far.

5. Conclusions

During the observation since the installment in 1993, experiencing replacement for upgrades in 2000, recovery and re-deployment for repair in 2002, the "Off Hatsushima Island Observatory" revealed geophysical and biological events occurred on the seafloor. It also gave us various kinds of phenomena and technological problems yet to be identified nor solved. As a next step, the observatory is planned to be utilized as a test bed, such as the field tests of newly developed magnetometer and gravity meter by connecting them to the underwater mateable connectors, with feedbacks of the results that have been obtained during the observation.

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REFFERENCES

1) Momma, H. (2000): Deep Ocean Technology at JAMSTEC, MTS Journal, 33-4, 49-63
2) Kasahara, J., Y.Shirasaki, and H.Momma (2000) : Multi-disciplinary measurements on the ocean floor using decommissioned submarine cables: VENUS project, IEEE Journal of Ocean Engineering, 25, 111-210
3) Momma,H., R.Iwase, K.Mitsuzawa, Y.Kaiho and Y.Fujiwara (1998): Preliminary results of a three-year continuous observation by a deep seafloor observatory in Sagami Bay, central Japan, Physics of the Earth and Planetary Interiors, 108, 263-274