Long term and real time deep seafloor observation by using multidisciplinary sensors

Ryoichi Iwase, Hiroyasu Momma, Katsuyoshi Kawaguchi
Deep Sea Research Department
Japan Marine Science and Technology Center
2-15 Natsushiraa-cho Yokosuka Kanagawa 237, Japan

Abstract - The real-time and long-term deep-sea floor multisensor observation equipment which is equipped with a CTD sensor, a current meter, a transmissiometer, a seismometer, a geophones and a digital still camera has been developed for VENUS project to observe deepsea geophysical phenomena by multidisciplinary measurements. The equipment will be deployed in the landward slope of Nansei Syoto Trench about 90km southeast off Okinawa Island at the depth of 4,180m in March 1998 and connected to TPC-2, a commercially retired submarine co-axial telecommunication cable between Okinawa and Guam Islands. The deployment and connection to the TPC-2 will be carried out by deep tow and submersible using the underwater mating connector. The prototype of this multisensor observatory was deployed off Hatsushima Island in Sagami Bay at the depth of 1,174m in 1993 and continuous observation by the observatory has been carried out for more than three years.

I. INTRODUCTION

Integrated observatories which include various sensors, such as a broadband seismometer, a tsunami pressure gauge, a hydrophone array, geomagnetometer, geopotentiometer, etc. are planned to be deployed for the long term multidisciplinary geoscientific deep seafloor observation in real time in the VENUS (Versatile Eco-monitoring Network by Undersea-cable System) project by reusing TPC-2 (Transpac-2 Cable) which is a submarine co-axial telecommunication cable between Okinawa and Guam islands and was terminated its commercial use in 1994 [1]. The first observatory in the VENUS project will be deployed in the landward slope of Nansei Syoto Trench about 90km southeast off Okinawa Island at the depth of 4,180m in March 1998. The VENUS project is funded by the Science and Technology Agency (STA) of Japan, which started in 1995 as a five year project and is carried out by several research institutions and universities. JAMSTEC is in charge of the development of a multisensor observation equipment, underwater work system and a data center.

JAMSTEC has installed the multisensor observatory 6km southeast off Hatsushima Island in Sagami Bay at the depth of 1,174m in 1993 and continuous observation by the observatory has been carried out for more than three years [2],[3]. Based on this experiment, the multisensor observation equipment for the VENUS project has been developed.

II. OBSERVATORY OFF HATSUSHIMA ISLAND

In September 1993 the real-time long-term deep-sea floor observatory was deployed within the Calyptogena soyoae colony which is one of the cold seepage chemosynthetic biological communities and is located 6km southeast off Hatsushima Island at the depth of 1,174m in the west of Sagami Trough, the boundary of Philippine and North American plates in Sagami Bay. This area is characterized by seismic swarm
activities which occur several times (significant activities occur almost once a year) and in 1989 volcanic eruption was generated in this area.

The observatory is equipped with two video cameras, two probes of underground thermometers, a CID (conductivity, water temperature and water depth) sensor, an electromagnetic current meter, a hydrophone and a seismometer. It is installed at the end of an 8km long electro-optical cable, power (1500 Volts AC) is supplied by the land unit and the data of those sensors are sent to the land station at Hatsushima Island through the cable. The primary deployment of the observatory with the cable attached was carried out by the work ship. After that, it was moved by the JAMSTEC’s ROV “Dolphin 3K” to the place where a large clam colony is located in November 1993. The seismometer, the hydrophone and the probes of underground thermometers were installed directly on the seafloor at that time.

Since the installation, real-time observation has been carried out for more than three years. In April 1996 sudden increase of averaged current velocity was observed [Fig.1] and periodic variation of underground temperature which seems to be correlated with the tide has been observed since that time [Fig.2]. Long-term variations of salinity and water temperature are not as significant as the current velocity, although they show annual variations. The spawning of Calyptogena soyoae has been observed more than ten times since the deployment. The spawning seems to be accompanied by a slight increase (about 0.2 degrees C in less than one hour) of water temperature. Significant earthquake swarm activity occurred in September 1995 and October 1996.

Another cable-connected observatory is planned to be deployed south off Muroto Peninsula to observe the seismic activity and deep seafloor environment around Nankai Trough. At the end of the 120km long electro-optical cable multisensor observatory is attached, which is equipped with a seismometer, a tsunami pressure gauge, a video camera, two probes of underground thermometers, a CTD sensor, an electromagnetic current meter, a hydrophone and an ADCP (acoustic Doppler current meter) and will be deployed 100km south off Muroto at the depth of 3700m where small Calyptogena colonies were found. In the middle of the cable, 50km south off Muroto, another seismometer and tsunami pressure gauge are also attached.

Fig.1. 24 hour averaged current velocity profile off Hatsushima

Fig.2. Water temperature, underground temperatures and water depth profiles. Temperatures profiles shown above are the data which subtracted 24 hour averaged values from the 10 minute averaged values.
III. MULTISENSOR OBSERVATION EQUIPMENT FOR VENUS PROJECT

Unlike the observatories mentioned above, those for the VENUS project are designed so flexible as to be connected and disconnected in the water by submersible, using underwater matable connectors. However, there are several constraints in reusing TPC-2 cable. These are the limitations of power supply ability and transmission capacity, because the TPC-2 cable system was originally made for the analogue telephone lines.

Under those limitations, JAMSTEC has been developing multisensor observation equipment which is equipped with a digital still camera with a strobe light, a velocity type short period seismometer, a underground thermometer, a CTD sensor, a transmissiometer, an electromagnetic current meter, a hydrophone and a multiplexer [Fig.3]. In stead of video camera and lights, digital still camera with a strobe light is equipped to get the visual information of the seafloor. However, most power consuming sensor of those is the still camera with a strobe light.

In order to decrease the power consumption, a picture is taken every 6 hours. The data of those sensors are multiplexed by the multiplexer to 24kbit per second digital signal which is transmitted to the land unit through TPC-2 cable. The control commands from the land unit is transmitted to not only JAMTEC's multisensor equipment but also all of other underwater equipment simultaneously through 9.6kbits per second signal line. Time signal which has a unique header information is transmitted every minute through the same line in the same way. Each equipment has a different address respectively, and it recognize its own commands and time signal by comparing the address which is written in the header information to its own address.

In March 1998, the deployment of the multisensor equipment southeast off Okinawa Islands will be carried out in the following way: First by using deep tow it will be deployed near the junction box which is a connection unit of transmission system attached to the TPC-2 cable. Second, underwater matable connector of the equipment is connected to the junction box by using the submersible "Sinkai6500".

In September 1995 and in August 1996, JAMSTEC carried out site survey around the VENUS observatory installation point in the landward slope of Nansei Syoto Trench using deep tow camera and manned submersible "Sinkai 6500" respectively.

In both survey, the site is found to be almost flat and covered with mud, and there seems to be no geographical problem in installing observation equipments.

IV. SITE SURVEY

In September 1995 and in August 1996, JAMSTEC carried out site survey around the VENUS observatory installation point in the landward slope of Nansei Syoto Trench using deep tow camera and manned submersible "Sinkai 6500" respectively.

In both survey, the site is found to be almost flat and covered with mud, and there seems to be no geographical problem in installing observation equipments.

V. CONCLUDING REMARKS

The multisensor observation equipment which is equipped with a digital still camera with a strobe light, a velocity type short period seismometer, a
underground thermometer, a CTD sensor, a transmissiometer, an electromagnetic current meter and a hydrophone has been developed for the VENUS project and will be deployed in March 1998 in the landward slope of Nansei Syoto Trench. There is no real-time observatory around this area so far, by the installation of the multisensor observation equipment, the valuable information about the long-term variation of deep seafloor environment will be obtained with sufficient time resolution.

ACKNOWLEDGMENT

The Authors wish to thank all the crews of R/V "Kaiyo" and "Yokosuka" and the operation team of submersible "Sinkai 6500" for supporting our research.

VENUS project is performed through Special Coordination Funds of the Science and Technology Agency of the Japanese Government.

REFERENCES

