Ocean borehole broadband seismometer system deployed by ODP Leg191

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Abstract. The new borehole seismic observatory, called WP-2 was successfully installed at ODP Hole 1179E in the northwestern Pacific basin by ODP Leg 191. The WP-2 station is positioned at a unique point for study of the earth structure. Two broadband seismometers were fixed in a basaltic layer by cementing. ROV activated the system and checked the condition of the system. The ROV also recovered preliminary data. Seismic noise of WP-2 is enough low for earthquake observation.

1. Introduction

In August 2000, the new borehole seismological observatory, called WP-2, at ODP Site 1179 in the northwestern Pacific basin was installed successfully during the ODP Leg191 (Fig.1). This observatory can cover northwestern Pacific area where the global seismological observatories distribute sparsely. Data from the WP-2 are invaluable and will help revolutionize studies of the global earth structure and upper mantle dynamics by providing higher resolution of mantle and lithosphere structures beneath the area, which are poorly imaged.

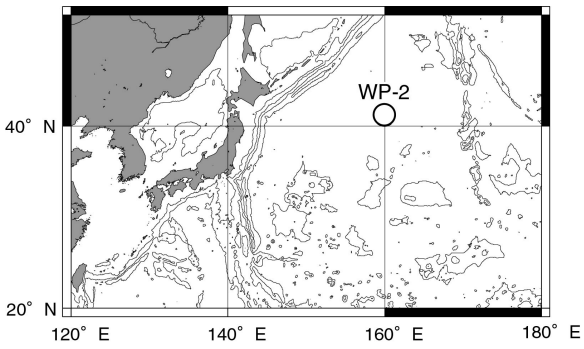

Fig.1. Position of borehole seismological observatory, call WP-2 at ODP Site 1179. There is no seismic station near WP-2 station.

2. System

The WP-2 seismic observatory is designed to work for many years as a stand-alone system. Different from other existing (JT-1 and JT-2) and planned (WP-1) oceanic borehole observatories, there is no nearby retired co-axial transoceanic telephone cable to utilize for data recovery and power. Therefore the WP-2 is designed as a stand-alone system with its own batteries and recorder. Two broadband seismometers (CMG-1T) are placed near the bottom of the hole in igneous basement (Fig.2).

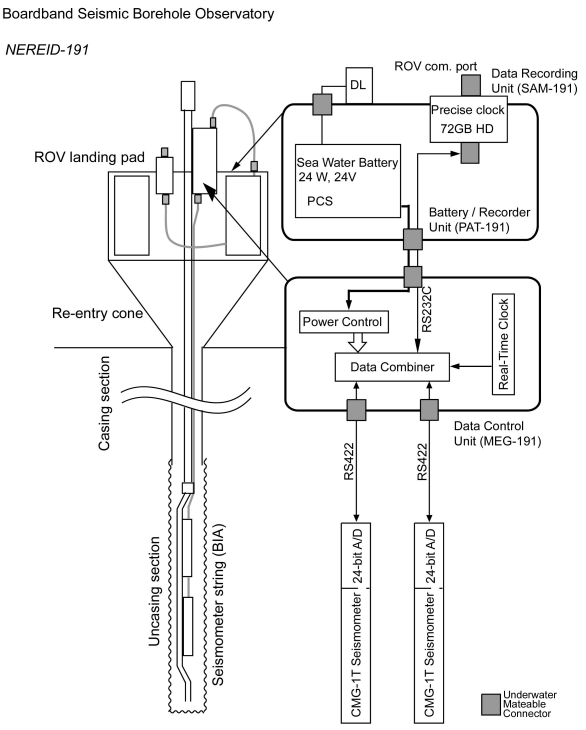

Fig.2. Schematic block diagram of the WP-2 observatory and configurations of the instrument packages. All the package on the sea floor is accessible to an ROV.

The signals are digitized in the sensor packages and sent in digital form to the sea floor packages. The seafloor package called MEG-191 serves to combine the digital data from the two seismometers to a single serial data stream. The data are stored in a digital format in a separate module, called SAM-191, via a RS232C link. The SAM-191 has four 18-Gbyte SCSI hard disks equivalent to more than 6 channels of one year-long continuous data of 24-bit dynamic range at 100 Hz sampling rate. The SAM-191 also provides a communication link to the borehole system. We can make a check of the status of the observatory via a "SAM-ROV interface" that enables RS-232C communication between the SAM-191 and the ROV at an ROV visit. Electric power is supplied from the battery system called Sea Water Battery (SWB). The SWB can supply up to about 24 W with more than 400 kWh capacities. Its energy comes from electrolytic dissolution of the magnesium anode. All the sea-floor instruments, the MEG-191, the SAM-191 and the magnesium anode of the SWB are designed to be replaceable by ROV or submersible.

3. Installation

Installation of the WP-2 seismometer system to Hole 1179E was performed from 22nd to 24th, Aug, 2000. Hole 1179E is 475 mbsf deep and has a basalt section below 377.2 mbsf. The seismometers are supported on 4.5" diameter casing pipe which hangs on the base of the reentry cone at the seafloor (Fig.3). The pipe provides a conduit for cement pumping for installation of the seismometers. After cementing, the drill pipe from the ship can be uncoupled and withdrawn leaving the casing pipe in the hole. The cables are protected by being strapped to the casing pipe and also are protected from wall contact by centralizers. The cable structure is such that it is almost neutrally buoyant in sea water, further minimizing the long term stress on the cables. In order to make a strong plug below the seismometers, a 3.2 m long extension tube, called a "stinger", is coupled to the bottom of the pipe supporting the seismometers. The cement was pumped through the casing pipe and the stinger, and then up around the seismometers and up into the 10.75" casing. The open hole was 86.9 m, the top end of the stinger was 11 m above the bottom of the hole, and cement was pumped up from the bottom of the stinger, filling about 198.9 m of the hole. The seismometers were grouted at a depth of about 460 mbsf in a basement layer. After the cementing, assembly of the battery

frame, called PAT-191, around the drill string over the moon pool.

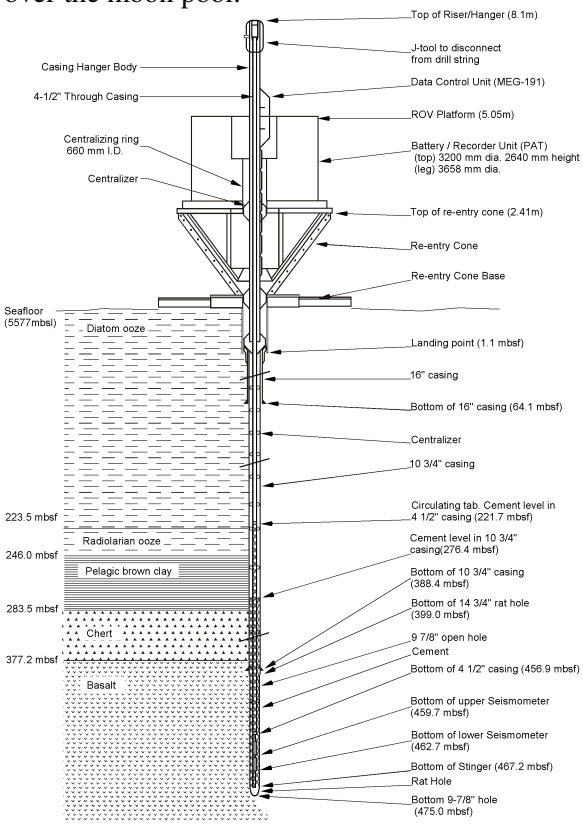

Fig.3. Schematic of the system assembly with lithologies.

The PAT-191 was lowered through the moon pool. After the PAT-191 was landed, an acoustic signal was sent to the release mechanism and it confirmed having released the PAT-191.

4. Activation of system

In October 2000, KAIKO, an ROV belonging to the Japan Marine Science and Technology Center, visited Site 1179 to activate the WP-2 observatory. Since performance of SWB is depended on the environment around deployed position, there was a possibility that SWB could not generate enough power for the whole system. Therefore we decided to operate the WP-2 using lithium batteries during the first observed period and developed the lithium battery system, which supplies power to the system. The lithium battery system consists of five lithium batteries with a capacity of 1300 AH and SAM-191. The components are put into titanium sphere with a diameter of 65 cm. Before a ROV dive, the titanium sphere was deployed near the WP-2 site by free-fall. KAIKO dive #175 was carried out on 29th, October. KAIKO brought the SAM-191 unit and deployed the SAM-191 on PAT-191. First, ROV connected the SWB to the system using the UMC for check of the whole system. After connecting the SWB to the system, ROV made a RS-232C link between the WP-2 system and a computer on the mother ship KAIREI using the SAM-ROV interface. We could confirm the WP-2 has no problem by this check. After checking the system, ROV switched power supply to the lithium battery system. The SWB has a data logger for recording voltages and currents of the system. ROV recovered the SAM-191 on PAT-191 and the data logger of the SWB. The SAM-191 has data from borehole seismometers with 1 hour long. Seismic noise of WP-2 station is enough low for earthquake observation (Fig.4). From the data of the SWB system, we could confirm that the SWB generates power.

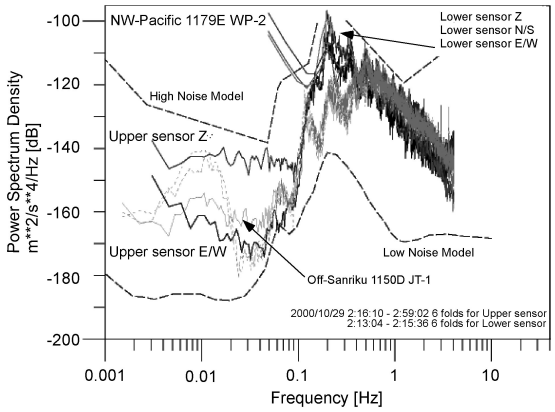

Fig.4. Seismic noise spectra from the borehole seismometers at WP-2. The noise level is positioned at a satisfactory level.

5. Reference

Kanazawa, T., M. Shinohara, M. Mochizuki, K. Hirata, E, Araki, and ODP Leg191 shipboard scientific Party, NEREID-191 -New Borehole Seismological Observatory in the Northwestern Pacific Basin-, *EOS*, **81**, 48, F838, 2000