Ocean Bottom Borehole Geophysical Installations: current and future developments

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Many tectonically important sites are below the sea so there is a clear need for a reliable installation technique and suitable instrumentation. Araki et al have already shown that longer period seismic noise, particularly for horizontal components, is very much lower in cemented, borehole installations. Many of the great thrust earthquakes that occur in subduction zones are seaward of the land area. Since stress redistribution and concentration is a slow process in many areas, it is necessary to monitor these strain changes to have any chance of assessing the earthquake potential.

The installation system used initially at ODP sites 1150 and 1151 off North-East Japan (leg 186), and later on leg 191, seems a satisfactory solution. The instruments are pre-assembled and hung on tubing, which is supported at the re-entry cone. All electric cables are strapped to this tube and protected from abrasion damage during installation by clamped on centralizers. The cables terminate in underwater-mateable connectors that are accessible to an ROV at a working platform on the cone. Batteries, data handling and data recording packages reside at this level. The ship's drill pipe remains coupled after the tube lands on the hanger in the re-entry cone, and is used to pump grout from below the instrument package to a level sufficient to couple the instruments firmly to the rock. Strainmeters have to be strong enough to withstand very high operating pressures but be resilient enough to deform measureably due to small stress changes in the rock. High, greater than 100,000, noise-free hydraulic amplification makes this possible.

Future ocean bottom borehole sites in tectonically active areas are expected to be both deeper and to have high temperatures at depth. Since such sites can be in critically important locations, it is necessary to have instruments capable of operating indefinitely under conditions of high pressure and high temperature. We have designed a borehole strainmeter that meets those requirements. The instrument is a modification of the Sacks-Evertson design and uses a liquid filled sensing unit. In the original instrument, the liquid filled sensors and the transducers are all installed down-hole. In the modified design, we separate the transducer section from the strain sensing section. The strain sensor at the bottom of the hole is connected hydraulically through small diameter tubes to the transducer at the well head. The transducer is identical to those used in the standard instrument. It is comprised of a dual bellows-DT-valve unit hydraulically connected in series. The physical characteristics of the design are such that baseline is always preserved, even during valve operations to re-zero the sensing volumes and that even the largest strain excursions due to earthquakes are within the operating range of the instrument. Because we have no electronic components down-hole, there are no components which might fail at high temperature. Since the interior of the strain sensing units are under the pressure of the liquid column to the surface (ocean bottom), we are able approximately to balance the interior and exterior pressures. Thus there is no requirement for the sensing body to be strong enough to support the high down-hole pressure. The first instrument of this modified design will be installed (on land) at a depth of about 2.2km in the Long Valley caldera, California. Instruments of this design will allow high sensitivity monitoring at conditions in even the deepest ocean bottom boreholes, such as will be drilled by the new ship now being built in Japan.