Continental scientific drilling at Shingu, Kii Peninsula and implications for studying a Nankai subduction earthquake

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In-situ measurements for crustal stress and physical properties using a deep borehole on land are essential for investigating a plate subduction earthquakes such as the Nankai earthquake. A 550 m borehole was drilled at Shingu city in the Kii Peninsula, and in-situ crustal stress measurement by hydraulic fracturing, as well as geophysical logging and heat flow measurement have been conducted.

The site is located around the 'hinge line', which is the zero line of crustal movement, and where is expected to be affected strongly by the stress change before and after the interplate thrust earthquake.

The borehole was drilled into Middle Miocene age sedimentary rocks (Miyai group). The lithology contains alterations of mudstone and sandstone with a few gravel and fractured zones. Kumano acid igneous rocks are distributed widely in the north-western ares neighboring the drilling site.

Geophysical well loggings show the in-situ variation in the physical properties. The average value of the formation density was about 2.5 g/cm^3, and that of the P-wave velocity was 3.5 km/sec. The electric resistivity was relatively very low around 10 - 100 ohm m.

In-situ stress measurement by the hydraulic fracturing method was conducted in points selected according to results of geophysical logs and a borehole televiewer survey. The break-down pressure (P_b) and the instantaneous shut-in pressure (P_s) was detected accurately. The magnitude of minimum horizontal compressive stress, S_{hmin}, was equal to P_s. The magnitude of the maximum horizontal compressive stress, S_{Hmax}, was detrmined from the P_b, P_s and tansile strength of core, T: S_{Hmax} = 3P_s-(P_b-T)-P_p, where P_p was hydrostatic pore water pressure. The vertical stress, S_v, was equal to overburden pressure using the formation density of 2.5 g/cm^3. Both the S_{Hmax} and S_{hmin} increase linearly with depth, and the S_{hmin} is almost the same value as that of the vertical stress. The ratio of the maximum shear stress value to mean stress value, (S_{Hmax}+S_{hmin})/(S_{Hmax}-S_{hmin}), was about 0.2. The azimuth of S_{Hmax}, provided by the borehole televiewer log and impression packer test indicateded the north-south to northwest-southeast deirection. This N-S to NW-SE direction is considerably different from the E-W compressive stress direction found at the shallower part of the Kii Peninsula estimated from focal mechanisms of earthquakes in the crust. This is a point of great interest in considering the state of stress relating to the 'hinge line'.

The temperature profile in the borehole down to the depth of 511m was measured about one year after the drilling processes. It is suggested that the enough time has passed so that the temperature becomes to be in equilibrium with the geotherm. The gradient of temperature changed a little at the depth of 400m, where the lithology also changed. Thermal conductivities of 15 core samples were measured by transient line source method. The temperature gradient and the avaraged value of thermal conductivity data of the same lithology indicated the value of 55-65 (10^{-3} W/m^2). This magnitude of heat flow was consisent to heat flow data determined using borehole data distributing in the kinki distinct.