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Detecting time-dependent fluid discharge at the toe of the Nankai Trough accretionary prism

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To detect time-dependent fluid discharge from the toe of the Nankai Trough accretionary prism, the Omine Ridge, we have deployed heat-flow probes since 2010. Observing fluid discharge is a first step to understand seismic activity of subduction zones, because fluid discharge is not only related to fluid drainage from accretionary prisms but also to building-up mechanism of pore fluid pressure at the seismogenic zone of accretionary prisms.

We have deployed two stand-alone heat-flow meters (SAHF) on one of the bacterial mats where fluid discharge is expected and on a normal seafloor near the bacterial mat where no fluid discharge is expected. The 60 cm long heat probe contains five preciously calibrated thermistors at an interval of 11 cm. We have also deployed a temperature meter near one of the SAHFs, which records the temperature slightly above the seafloor. The deployment periods are during Mar 15 and Aug 6 2010, Aug 6 2010 and Sep 11 2012, and Sep 11 2012 and the present. A remotely controlled vehicle, Hyper-dolphin (controlled by R/V Natsushima) and a submersible, Shinkai-6500 (R/V Yokosuka) were used during the deployments and the recovery of the instruments (NT10-05Leg1, YK10-09, NT12-18).

Because the location of deployment is as shallow as 2500 m and is suffered from temperature fluctuations of bottom water due to tides as well as the Kuroshio Current, we deliberately use these fluctuations to obtain fluid flow velocity (Goto et al., 2006). The temperature time series is analyzed using the short-time Fourier transform (STFT) with a given time window (typically, 4 to 5 months). The amplitude ratio (of the deep sensor to the shallow sensor) and phase difference between two thermistors of different depth as functions of frequency simultaneously give Darcy velocity and thermal diffusivity. The phase difference is mainly related to thermal diffusivity; it is small for large diffusivities. Given the phase difference, the amplitude ratio is related to Darcy velocity. For example, the ratio is small for upward flows and large for downward flows with reference to the zero velocity.

We have obtained meaningful difference between the temperature records taken from the two sites: a bacterial mat and a normal seafloor around the bacterial mat. On a normal seafloor, almost zero velocity is obtained with a typical thermal diffusivity observed at this area, 3x10?7 m^2/s. In contrast, on a bacterial mat, upward Darcy velocity of 2?3x10?7 m/s is detected. Preliminary analysis shows that the estimated Darcy velocity is $1x10^{?7}$ m/s in early 2011, smaller than that before and after this period. Anomalous high thermal diffusivity up to twice as a typical value (e.g., $5x10^{?7}$ m^2/s) is obtained at the shallowest 20 cm below the seafloor, although a typical value is obtained at deeper locations than that. This large diffusivity is probably resulted from the formation of the bacterial mat.

Keywords: fluid seepage, accretionary prism, heat flow, subduction zone, long-term monitoring