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An abrupt seafloor water-temperature increase in the epicentral region of the 2011 Tohoku earthquake

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We report an abrupt seafloor water-temperature increase observed just after the 2011 Mw9 Tohoku earthquake. Ocean bottom pressure variations during the Tohoku earthquake were observed by a deployment of pressure gauges at eight stations in the epicentral region (Ito et al. 2013 Tectonophys.). The temperature sensors for pressure sensor compensation built into the pressure gauges recorded seawater temperature variations that are presented here.

The temperature data documented the following. Abrupt temperature increases were evident at two stations (TJT1 and GJT3: ocean depth of 3000-6000 m) where maximum slip occurred during the Tohoku earthquake. The temperature increases started less than 10 hours after the earthquake occurrence, reaching up to 0.1 ℃ above background temperature, and last for a few weeks. Comparable temperature increases were not evident at other stations farther landward, where the ocean depth is less than 2000 m. Prior to the Tohoku earthquake, there were no temperature changes related to other earthquakes at any of the stations. Thus the observed temperature increases are probably associated with the Tohoku earthquake, particularly in the region of maximum coseismic slip.

Geochemical analyses of the seawater sampled near the seafloor suggest that formation pore water was released in the region of maximum coseismic slip following the earthquake. The pore water was thought to originate at about 1 km below seafloor, based on analysis of methane (Kawagucci et al. 2012 Sci. Rep.), with a contribution from the mantle at deeper than 15 km below seafloor as suggested by helium isotope analysis (Sano et al. 2014 Nat. Comm.).

Here we suppose that the observed temperature anomaly is related to pore water release from greater than 1-km depth. In order to explain the timing of the temperature anomalies, required flow velocity of the released water is $>10^{-1}$ m/s. This is several orders of magnitude more than typical velocities of background fluid flow driven by dewatering of subduction zone sediments (10^{-9} m/s) (e.g., Screaton and Saffer 2005 EPSL). The high velocities ($>10^{-1}$ m/s) most likely reflect fluid flow due to enhanced permeability along fractures and fissures (Tsuji et al. 2013 EPSL) extending to depths of kilometers or more below seafloor, generated by the greatest slip of the Tohoku earthquake.

Keywords: Seafloor water temperature, 2011 Tohoku earthquake