EGU22-4332
https://doi.org/10.5194/egusphere-egu22-4332
EGU General Assembly 2022

Tidal analysis of the NanTroSEIZE Long Term Borehole Monitoring System (LTBMS) pore pressure records at the Nankai margin, SW Japan.

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In southwestern Japan, the northwestward subduction of the Philippine Sea plate beneath the Eurasian plate results in large magnitude (>8) earthquakes and tsunamis (e.g. 1944 Tonankai and 1946 Nankaido earthquakes) and slow earthquakes at the Nankai margin. As part of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), Long Term Borehole Monitoring Systems (LTBMSs), a suite of high-sensitivity borehole sensors providing real-time observations of hydrologic processes and crustal deformation, were installed from 2010 at 3 boreholes of the International Ocean Discovery Program (IODP).

The pore pressure recorded by the LTBMSs, used as a proxy for volumetric strain, shows transient variations associated with slow slip events (Araki et al., 2017). Similar observations have been made at other subduction zones, like the north Hikurangi margin (e.g. Wallace et al., 2016), highlighting the key role of hydromechanical properties in fault mechanics and processes. The LTBMSs also capture the pore pressure oscillations arising from Earth tides forcing, with diurnal (~24 h) and semidiurnal (~12 h) periods. The phase and amplitude of the tidal signal can be decomposed from the observational data using tidal analysis programs, providing an opportunity to monitor changes related to the hydraulic and poroelastic responses to tectonic loading and transient loading arising from SSEs.

In this study, we use BAYTAP-08 (Tamura and Agnew, 2008), a modified version of the Bayesian Tidal Analysis Program - Grouping Model program of Tamura et al. (1991), to extract the tidal response from the pore pressure recorded at different depth intervals, at three sites: above the updip limit of the locked seismogenic zone at Site C0002 (first-time LTBMS deployment in 2010), at the megasplay fault zone and its footwall at Site C0010 (since 2016) and at the frontal thrust of the accretionary prism at Site C0006 (since 2018).

Tidal amplitudes and phases of semi-diurnal and diurnal tide components were carefully checked for any possible temporal variations, that may be related to subseafloor strain accumulation or coseismic release. We focused on the M2 and O1 canonical components.

Using a 1D poroelastic model, the analytic solution for tidal amplitude and phase was derived and compared with observations. The average amplitude ratio (relative to the seafloor) is 0.62-0.66,

which is lower than the theoretical loading efficiency value. The phase lag difference is <1° for all depth intervals, as predicted by the 1D poroelastic theory for the range of permeability values (10^{-15} to 10^{-19} m^2) determined from core samples (e.g. Reuschlé, 2011; Rowe et al., 2011; Tanikawa et al., 2012, 2014; Chen, 2015; Dutilleul, 2021) or drilling data (e.g. Pwavodi and Doan, 2021). This may be caused by the borehole casing or the LTBMS assembly itself. More careful inspection is on the way.

The removal of the tidal signal computed with BAYTAP-08 provides a clearer residual (i.e. non-tidal) pore pressure signal, which seems to have a long-term variation. It may either be the instrumental drift, but may be related to potential subseafloor strain modulations related to plate convergence and seismic activities.