Deep-seated mud volcanoes and their impact on seismicity at Nankai (landward of the NanTroSEIZE drilling transect)

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Sediments in subduction zone forearcs experience major and progressive compositional changes as a function of depth and distance to the trench when they are buried through accretion or underthrusting. Fluids primarily exit the system along fault pathways, thereby reducing the stress state along the plate boundary and allowing aseismic slippage. However, little is known about the abundance or role of water within the region of the seismogenic zone itself, and whether such waters leave the system via landward-dipping reverse faults in the frontal or distal portion of the forearc wedge.

In this study, we sampled the sub-seafloor of the Kumano forearc basin of the Nankai accretionary complex, Japan, along the landward extension of the IODP NanTroSEIZE drilling transect. During R/V SONNE cruise SO222 in June 2012 we collected 450 pore fluid samples from 6 sea floor drill rig cores (up to 35 m depth) and 26 gravity cores (up to 8 m depth) at 13 mud volcanoes and additional background sites, all located some 120 km behind the deformation front (and about 50 km landward of the end of the IODP drillings). The data set was complemented by further sampling during R/V SONNE cruise SO251 in october 2016. The material was analysed for major and minor elements and isotopes of H, O, B, Li and Sr. Mud volcano fluids were strongly freshened, with Cl^{-} as low as 20% of the sea water value, Mg is completely depleted in the most altered samples, and B and Li^{+} are enriched to values rarely seen in this environment. B peaks at 16 mM in the most altered samples with B/Cl reaching 200x the seawater value, possibly the highest ever recorded in seafloor pore fluids. Similarly Li/Cl peaks at 50x the seawater value.

The most likely source of pore fluid freshening is mineral dehydration, with complete depletion of Mg and very low Li isotope ratios being typical of hydrothermal systems in igneous rocks. We hence provide the first evidence for water sourced within the subducting ocean crust directly beneath the decollement in the seismogenic zone, which migrates upward through the upper plate wedge and exits through mud volcanoes ca. 15 km above. The presence of water in sufficient quantity to drive mud volcanism in this region coincides with fewer earthquakes in this region of the fault zone.

Keywords: earthquake, mud volcano, Nankai

