Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

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During the International Ocean Discovery Program (IODP) Expedition 370 "Temperature Limit of the Deep Biosphere off Muroto" (T-Limit) in 2016, the drilling was conducted at the protothrust zone in the Nankai Trough off Cape Muroto by using the D/V *Chikyu*, which penetrated the plate boundary fault (dé collement) between 758.2 and 796.4 meters below seafloor (mbsf) and recovered the accretionary deposits down to the basement. Expedition 370 aimed to explore the limits of subseafloor life and the biosphere where temperature exceeds the known temperature maximum of microbial life (~120ºC) at the sediment/basement interface at ~1.2 km below seafloor. Within the protothrust zone, it is thought that deep sourced water and energy, which are necessary for maintaining microbial activities, are supplied by fluid flow through faults. In order to clarify the origin and migration paths of the fluid, we analyzed the stable hydrogen and oxygen isotopic composition of water (δD and δ^{18}O), the isotopic compositions of ^{87}Sr/^{86}Sr and ^{7}Li/^{6}Li ratios of the porewaters, and compared those isotopic compositions to the chemical compositions of porewater analyzed on-board. The previous study of the in-situ strength of sediments using drilling parameters shows that there are mechanically strong (potential impermeable layers) and weak (potential fluid pathway) zones at 602–648 mbsf and 800–1050 mbsf, respectively. The especially weak zone is observed between 836 and 870 mbsf. The concentration of chloride ion (Cl^-) suddenly decreases from 530 mM at ~600 mbsf to 480 mM at ~660 mbsf, below which it slightly decreases with depth and shows the minimum value of 450 mM at around ~950 mbsf. The concentration again increases from ~460 mM at ~1000 mbsf to ~550 mM, which is similar to the seawater value, at 1126 mbsf (just above the basement rock). The decrease of Cl^-concentration suggests that the dilution of the original porewater by the addition of fresh water. The depth profiles of δD and δ^{18}O show the trends corresponding to that of Cl^-. The δD value scatters in the range from −12 to −8‰ between 600 and 940 mbsf, and shows the minimum value of −12‰ around ~940 mbsf, below which it increases to −4‰ at 1126 mbsf. The δ^{18}O value increases from −4‰ at ~600 mbsf to −1.5‰ at ~800 mbsf with depth. Then the value increases to −0.6‰ at ~960 mbsf. Below the depth, it decreases to −1.2‰ at 1126 mbsf. The decrease of δD and increase of δ^{18}O accompanied with the depletion of Cl^-between ~600 and ~1000 mbsf suggest the addition of freshwater derived from in-situ clay mineral dehydration and the lateral fluid flow. The sharp decrease of the Cl^-concentration between ~600 and ~650 mbsf suggests that the sediments at this interval is a boundary of low permeability, corresponding to the mechanically strong zone estimated by the drilling parameters. Around décollement (758.2–796.4 mbsf), no remarkable changes were observed in chemical compositions in porewater. Instead, the vicinity of ~900 to ~1000 mbsf, where the lowest Cl^-concentration was observed, is probably associated with the main fluid pathway at present. On the other hand, the depth profiles of the isotopic compositions of Sr and Li as well as their concentrations were not corresponding to that of the Cl^-concentration. The maximum concentrations of Sr and Li, ~620 μM and ~790 μM, respectively, were observed at ~1080 mbsf, together with the high ^{87}Sr/^{86}Sr and the lowest ^{7}Li/^{6}Li ratio. The high concentration of Li and low δ^{7}Li around ~1080 mbsf indicate that the fluid was experienced by relatively high temperature conditions; i.e., presumably the deep sourced fluid. The discrepancy between the depth profile of $Cl^-$and those of Li and Sr suggests that there is (or was) another fluid pathway at the vicinity around ~1080 mbsf.

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