Ion filtration in oceanic clay-rich sediments: evidence from chlorine stable isotopes of pore fluid chlorides

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Pore fluids from young clay-rich sedimentary piles (Nankai Though and Japan trench accretion prisms, Black Ridge and Juan de Fuca Ridge flanks; data from ref. 1-6) systematically show a regular decrease of $\delta^{37}Cl$ of chlorides with depth from about 0‰ (seawater value) at the seafloor down to -8.5 ‰ at the most, in very low permeability sedimentary levels. However, deviations towards higher $\delta^{37}Cl$ values are observed locally. They are resulting from injection of external fluids at higher permeability sedimentary levels.

Using conservation equations for chlorides and water, these $\delta^{37}Cl$ profiles can be modelled by the compaction of a growing clay–rich sedimentary pile. Isotope fractionations of chlorine isotopes, $\alpha^{37Cl/35Cl}_{expulsed/residual\ fluid}$, in the range of 1.006 to 1.001, explain the observed negative $\delta^{37}Cl$ chlorides at the bottom of the sedimentary piles. They are in agreement with the of ion filtration theory of [7] in which the mobility of chlorides through semi-permeable clay membranes is determined by ion repulsion. The complementary positive $\delta^{37}Cl$ chlorides must accumulate at the top, but are very likely masked by dilution with seawater chlorides accross the seafloor interface. As a result, young clay-rich sediments blanketing oceanic crusts are reservoirs of ^{37}Cl-depleted chloride. The fact that no such ^{37}Cl-depleted chlorine is documented in subduction zone products is therefore a strong argument to propose that most of the clay-rich sediments pore fluids are released back to the ocean rather than being subducted.

References: [1] Agrinier et al. 2019, Geochi. Cosmo. Acta, 245, 525 ; [2] Bonifacie et al., 2007 Earth Planet. Sci. Lett. 260, 10; [3] Deyhle et al., 2003 The Island Arc,13, 258; [4] Hesse et al.,, Geofluids, 6, 1 ; [5] Spivack et al., 2002, Geophysical Res Letters, 29, 1661; [6] Wei et al., 2008, Earth Planet. Sci. Lett, 266, 90. [7] Phillips and Bentley 1987, Geochi. Cosmo. Acta, 51, 683 ;