

Extreme $\delta^{37}\text{Cl}$ depletion in pore fluids of compacting clay sediments of the fore front of the Nankai subduction zone

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This study focuses on the isotope of chlorine of porewater chlorides from two deep boreholes drilled in clays and volcanic ashes deposited over 19 million years. Porosity decreases from 0.8 down to 0.4 at 800 mbsf.

The chemical concentration profiles of majors cations (Ca^{2+} , K^+ , Na^+ , Mg^{2+}) and anions (Cl^- and SO_4^{2-}) confirm a sea water origin for the pore waters with a chemical evolution due to fluid-rock interaction and diagenesis in the sediments. Cl^- and Br^- concentrations [1] stay rather close to seawater's. $\delta^{18}\text{O}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ vary downwards between 0 ‰ to -5.1 ‰ and between 0.7085 to 0.7068, respectively, [2, 3] and $\delta^{37}\text{Cl}$ varies from ≈ 0 to -8 ‰. Mg and K are depleted while Ca increases due to the formation of Smectite from volcanic ashes, later the conversion of smectite to Illite and zeolite formation [4]. In addition, upwards advection of deep fluids released by diagenesis is invoked to explain similar chemistry and Cl-O-Sr isotope features in Nankai.

Although in sediment under compaction, ionic filtration was invoked to explain low $\delta^{37}\text{Cl}$, [5], It was rejected it for Nankai on questionable arguments [6]. By modeling the fluid flow induced by compaction, we explore what should the chlorine isotope fractionation factors of ion filtration for generating the ^{37}Cl depletion in the pore fluids. Two models are used i) a box model using the conservation of H_2O and Cl^- ; ii) a model of the transport equation of ions in porous media. They both require large chlorine isotope fractionation factors to reproduce the negative $\delta^{37}\text{Cl}$ values and for a small chloride concentration change at the bottom of the profile. For the box model, Chloride molal filtration efficiency at 0.18, and an isotope fractionation factor of 0.9876 (that is ^{35}Cl would be filtered more efficiently than ^{37}Cl) are computed. At the top of profile positive $\delta^{37}\text{Cl}$ are generated, it is believed that they are erased by the mixing with seawater chlorides.

[1] Saito, Proc. IODP 322, 2010 ; [2] Destrigneville, Proc. IODP 322, 2016; [3] Joseph., Proc. IODP 322, 2013; [4] Underwood, Proc. IODP 131, 1993; [5] Bonifacie, GCA 72, 2008 ; [6] Kastner, Proc. IODP 131, 1993