Exchangeable cation composition of the smectite-rich plate boundary fault at the Japan Trench

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The source fault of the 2011 Tohoku-oki earthquake (M_w9.0) and accompanying tsunami is extremely enriched in pelagic smectite. To better understand physico-chemical processes in such a smectite-rich fault zone, we examined exchangeable cation composition of core samples recovered by the Integrated Ocean Drilling Program (IODP) Expedition 343 The Japan Trench Fast Drilling Project (JFAST).

The exchangeable cation compositions (Na^+, Ca^{2+}, K^+ and Mg^{2+}) for the bulk samples were determined by two methods. Four samples including two slip zone samples were analyzed by extracting cations in ammonium acetate solution (Schollenberger method), and the concentrations of extracted cations in the solution were measured using an atomic absorption photometer (Z-2000; Hitachi). Other samples were analyzed by extracting cations with cobaltihexamine [Orsini and Remy, 1976], following standard NF X31-130 at the INRA (Institut National de Recherche Agronomique) soil analysis laboratory in Arras, France.

Our chemical analyses revealed that the fractional concentrations of exchangeable Ca^{2+} and Mg^{2+} are higher in the slip zone than in surrounding host rocks, while Na^+ is depleted in the slip zone. K^+ shows a complicated depth profile, and this is probably due to strong interaction of K^+ with smectite interlayer such as K-fixation. Based on pore fluid chemistry data, we estimated apparent selectivity coefficient of exchange reactions in ternary system of Ca^{2+}-Mg^{2+}-Na^+. Comparison of the coefficients suggests that Na^+ to Mg^{2+} exchange reaction on smectite might have progressed markedly in the slip zone. One explanation for this feature is local progress of the reaction triggered by a recent thermogenic event, that was probably related with frictional coseimic slip during the earthquake. Considering that frictional property of smectite gouge is dependent on the exchangeable cation composition, chemical processes as observed in this study are intimately linked to physical aspect of smectite-bearing faults.

Keywords: Tohoku-oki earthquake, cation exchange reaction, pelagic smectite

