# Multi-stage Cl-rich fluid activity and behavior of REE-bearing minerals in a Neoproterozoic granulite terrane

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Cl-rich fluid is a powerful solvent, and can coexist with $CO_2$-rich fluid under granulite facies conditions [1]. Despite such important roles, the scale and timing of its activity during high-grade metamorphism are still not clear. Field distribution of Cl-rich biotite, amphibole and apatite, which are evidence for the presence of Cl-rich fluid, is investigated in detail in the Sør Rondane Mountains (SRM), East Antarctica where granulites are widely exposed.

Cl-rich biotite preserved as inclusions in garnet shows linear distribution in the SRM. Among them, a pelitic gneiss from the east SRM (Balchenfjella) shows Cl-rich fluid infiltrated around near-peak metamorphism at ca. 800 ºC, 0.8 GPa [2]. In this sample, monazite is present in the garnet core, whereas zircon and xenotime are included in the garnet rim. This suggests that the Cl-rich fluid infiltration that took place at the garnet core/rim boundary lead to the change of REE-bearing mineral species. This implies that Cl-rich fluid carried LREE and Th away and brought HREE, Zr and Y in. U-Pb dating of zircon included in the garnet rim gave 603±14 Ma [2], representing the timing of Cl-rich fluid infiltration. Biotite in the matrix is Cl-poor, suggesting that the retrograde metamorphism occurred in a Cl-poor environment. The rim of zircon in the matrix might represent a timing of this fluid activity (564±17 Ma), which is consistent with the zircon ages obtained from metacarbonates (ca. 545 Ma) that represent the timing of fluid activity [3, 4].

In addition, the mafic gneisses from the central SRM (Brattnipane) host cm-thick veinlets composed of garnet and Cl-rich amphibole that discordantly cut the penetrative gneissosity. In our presentation we discuss the processes associated with multi-stage Cl-rich fluid infiltration in the SRM during the peak- to retrograde stages.

[1] Newton & Manning (2010) *Geofluids* **10**, 58-72. [2] Higashino *et al* (2013) *Precam. Res.* in press. [3] Higashino *et al* (2013) *JpGU abst.* [4] Otsuji *et al* (2013) *JpGU abst.*

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# Magnesium isotope evidence for a link between low-temperature clays, seawater Mg/Ca, and climate

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Cooling of Earth's climate over the Cenozoic has been accompanied by large changes in the magnesium and calcium content of seawater. The processes that control these changes affect the magnesium isotopic composition of seawater, rendering it a useful tool for elucidating the processes that control seawater chemistry. We use measurements of magnesium isotopes in both pore fluids and carbonate sediments together with a numerical model of sediment diagenesis and show that the magnesium content of seawater has increased by 10-15 mmol over the last 15-25 Myr with little change in its isotopic composition. These observations are best explained by a reduction in removal of Mg from seawater in marine clays formed at low temperatures. A temperature-dependent Mg sink in marine clay directly links the major element chemistry of seawater to global climate, providing an additional explanation for the co-variation of seawater Mg/Ca and climate on ~100 million year timescales over the Phanerozoic.

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