Li isotopes fractionation during lower crustal magmatic segragation.

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Introduction

Kerguelen basalts contain abundant mantle xenoliths, including mantle peridotites and deep magmatic segregates equilibrated in the granulite facies [1]. Lithium chemical and isotopic distribution were measured in two-pyroxene granulites in using the Cameca IMS 1270 Ion probe at CRPG, in order to define their signature and describe the Li behavior during the lower crust formation process.

Samples description

The studied xenoliths display close mineralogical compositions, bearing Mg81-92 Al-diopside, Mg-78-93 enstatite and labradorite or bytownite. Spinel and garnet are observed in 2 of them, and they all are type II xenoliths [1,2]. The xenoliths range along a regular magmatic cristallisation trend, with decreasing Mg content.

Li and δ^7Li distribution

On the whole rock scale the Li contents increase from 1,5 up to 9 ppm, following the cristallisation trend with the Li content increasing during the cristallisation. At the sample scale Li contents is higher in Cpx compared to Opx and to plag, with a ratio Opx/Cpx of 0.8-0.9 and a ratio Plag/Cpx of 0.2-1. At the grain scale, Li displays an homogeneous distribution in most minerals, at the exception of few depleted or enriched Cpx rims.

The δ^7Li values measured on Cpx and Opx range in between -9 and +20, normalized to lsvec . The Cpx Li depleted rims display enriched δ^7Li values, associated to Li diffusion isotopic fractionation. Most xenoliths display relatively homogenous δ^7Li distibution, with only few per mil scatters, and only one Li poor xenolith display δ^7Li values scattered on a large range, from -9 to +14. A general observation is that Cpx display higher δ^7Li values than Opx (+2 to +3 ‰), and that the values are more scattered in Opx than in Cpx. There is positive correlation between the Li contents and the δ^7Li values, both at the mineral and whole rock scales, pointing out a melt-mineral isotopic fractionation for Li, with the melt being enriched in ^{7}Li compared to the residue.

Conclusions

The bulk value for these granulite samples is in agreement with a direct derivation from the mantle (5-8 ppm, d^7Li≈+5), but at the sample scale, Li content and Li isotopic composition is strongly dependent on the melt-solid fractionation during crystallization in the granulite facies. The large scatter observed on the Li poor sample could result from the partial re-equilibration of this early formed granulite with late enriched fluid.

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Understanding Archean weathering using silicon isotopes and Ge/Si ratios

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Weathering conditions in the Mesoarchean are poorly constrained. Recent studies have shown that neoformation of secondary clay minerals are associated with large Si isotope and Ge/Si fractionation in response to desilication processes and the weathering degree [1, 2, 3, 4]. Here, we present the first application of these weathering proxies on a 2.95 Ga paleosol profile and coeval shales. The paleosol is developed on andesite and shows a well defined mineralogical and chemical differentiation. δ^{30}Si values are lighter (down to -0.44‰) and Ge/Si values higher (up to 3.2µmol/mol) than parental andesite values (-0.14‰ and 2.1µmol/mol, respectively). Such trends support the formation of secondary minerals that preferentially incorporate light Si isotopes and Ge relative to Si, as observed during modern weathering [1, 2, 3, 4, 5]. However, less pronounced fractionation relative to modern soils with neoformation of kaolinite can be potentially explained by mineralogical control on δ^{30}Si with the formation of Fe-rich smectite, reported with heavier Si isotope composition than kaolinite [6]. In contrast, the top of the paleoprofile shows a return to heavier δ^{30}Si values (up to -0.11‰) and lower Ge/Si ratios (down to 1.1µmol/mol). This may be explained by a preferential release of light Si isotopes and Ge during partial dissolution of Fe-rich smectite to form kaolinite. This transformation is thought to have been governed by drainage conditions with fast drainage favoring kaolinite, implying moderate rainfall and/or poor-drainage conditions during weathering. In addition, we demonstrate that the combination of δ^{30}Si and Ge/Si tracers in 2.95 Ga Archean shales can reflect the relative proportions of primary rocks and secondary minerals. Moreover, a kaolin-rich or -poor nature of secondary clays can be evaluated. Therefore, combining δ^{30}Si and Ge/Si ratio as paleoweathering tracers opens new perspectives in quantifying Archean superficial weathering dynamics with potentially important paleoclimatic implications.

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