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Calcium isotope compositions and fractionation in the mantle and oceanic crust

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Calcium isotope compositions in Earth's mantle and crust are determined by complex magmatic processes which depend on equilibrium isotope fractionation between different phases. To explore the compositions and fractionation of Ca isotopes in the mantle and oceanic crust, we investigate the mechanisms and magnitude of Ca isotope fractionation between major Ca-bearing minerals (clinopyroxene, orthopyroxene, garnet, plagioclase, and carbonate), and during magmatic processes in both silicate and carbonate systems. Based on our Ca isotope studies of a series of well-characterized natural rocks and their mineral constituents including mantle rocks (peridotites, pyroxenites, eclogites)[1,2], oceanic gabbros and MORBs[3], and silica-undersaturated carbonate-rich rocks, we show that Ca content, pressure, and temperature exert the major controls on equilibrium Ca isotope fractionation between minerals[2]. The indistinguishable $\delta^{44/40}$Ca values in mantle rocks indicates negligible Ca isotope fractionation during partial melting and melt-peridotite reaction due to the overwhelming control of the Ca budget by clinopyroxene. There is limited Ca isotope fractionation between plagioclase and clinopyroxene and therefore gabbros and MORBs display uniform$\delta^{44/40}$Ca values regardless of the degree of fractional crystallization or spreading rates[3]. These suggest no significant Ca isotope fractionation during magmatic processes in silicate systems and homogenous Ca isotope compositions for the mantle (0.94 ± 0.10‰) and global igneous oceanic crust (0.85 ± 0.09‰ (2sd))[1,3]. Partial melting of carbonated peridotite also does not significantly fractionate Ca isotopes due to the limited Ca isotope fractionation between carbonate and clinopyroxene. However, light Ca isotopes signals may be caused by preferential enrichment in the silicate portion during immiscible separation of silicate and carbonate liquids from carbonated silicate magma. In addition, we observed highly variable $\delta^{44/40}$Ca values in the peridotite xenoliths metasomatized by recycling of carbonated sediments[4]. This series of studies lay a solid foundation for understanding the evolution of mantle and crust using Ca isotopes.

[1] Chen *et al.*(2019) GCA **249**, 121-137. [2] Chen *et al.*(2020) GCA **290**, 257-270. [3] Chen *et al.*(2020) GCA **278,** 272-288. [4] Chen *et al.*(2018) GCA **238,** 55-67.