The Calcium Isotope Composition of the Lower Mantle and bulk Earth

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The relevance of the Earth's Ca element and isotope inventory became increasingly evident with the emergence of global climate simulations linking the Ca cycle to the global CO_2 system [e.g. 1, 2]. The determination of the bulk Earth Ca isotope value is challenged by Ca isotope variations in igneous rocks and between different meteorite groups [3, 4]. Recent studies have constrained the bulk silicate Earth Ca isotope composition by empirical and/or theoretical approaches [e.g. 5, 6]. To date, a $\delta^{44/40}Ca_{(SRM915a)}$ of ~1.05‰ is estimated for the bulk silicate Earth based on model calculations considering inter-mineral fractionation between orthopyroxene and clinopyroxene as the predominant Ca-bearing phases in the mantle [5]. This value implies an enstatite/ordinary chondritic Earth for Ca isotopes while being significantly higher than carbonaceous (C-)chondrites [6]. However, if deducing the Ca isotope bulk silicate Earth value is based on equilibrium Ca isotope fractionation at high temperatures [7], then subsequently the Ca isotope composition of the lower mantle reservoir containing Ca-(silicate-)perovskite needs to be explored and/or a Ca isotope fractionation between upper and lower mantle precluded in order to extrapolate to bulk Earth.
Here, we discuss several scenarious for the Ca isotope bulk Earth composition including nominally lower values for the lower mantle and hence implying a C-chondritic Earth. We base our discussion on a compilation of recent and previous data for Ca isotopes in various terrestrial and extraterrestrial materials and on theoretical calculations for equilibrium Ca isotope fractionation. Ultimately, we attempt to further constrain the Ca isotope composition and evolution of the Earth and potentially also for other planetary bodies.

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