Isotope fingerprints for the formation and the composition of the Earth

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Building blocks

Most models for the formation and composition of the Earth usually focus on specific characteristics of its chemical or isotope composition. For example, since the formation of the Earth leads to substantial heating of planetary materials, volatile depletion and metal-silicate separation, it is sensible to consider only the refractory lithophile elements (RLE) to assess the potential building blocks of the Earth. In this context, the carbonaceous chondrites, notably the CI chondrites give the best match for RLE in the Earth's mantle and are often used as a starting material, although the processes mentioned above can affect the siderophile and volatile element concentrations in this starting material.

In contrast, when considering isotope observations, it appears that enstatite chondrites show an almost perfect match with many isotope systems, including oxygen, chromium, nickel and titanium. Then, if one considers the ^{146}Sm-^{142}Nd system, it appears that the terrestrial composition does not match with carbonaceous chondrites but could be better explained by ordinary or enstatite chondrites. However, the ^{146}Sm-^{142}Nd observations can also be explained by a non-chondritic Earth. Last, in the case of silicon isotopes, there is a clear offset between the terrestrial composition and that of chondrites. In summary, there seems to major issues in building the Earth from a single class of chondrites or from unprocessed chondritic material.

Processing of planetary materials

There are several processes that can modify the composition of the planetary materials that have formed the Earth, including thermal processing leading to volatile depletion (partial condensation or evaporation), grain sorting, impact-driven processes or metal segregation. In this presentation, I will examine the possible role of these processes in light of our recent isotope observations with a focus on Nd, Si, Mg, Mo and Sr isotopes and show how mixtures of various chondritic materials together with significant later processing is required to explain the composition of the Earth.

Molecular-scale basis of the ion exchange selectivity of clay minerals

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Ion exchange reactions on clay mineral surfaces play important roles in the aquatic geochemistry and mechanical properties of argillaceous media (soils, sediments, clayshales, engineered clay barriers). Despite more than a hundred years of investigation, fundamental aspects of the ion exchange selectivity of clay minerals, such as the activity coefficients of adsorbed species, the molecular-scale basis of ion exchange selectivity coefficients, and the structure of the electrical double layer (EDL), are poorly understood [1]. We report new molecular dynamics (MD) simulations elucidating the structure of the EDL on smectite surfaces contacting mixed NaCl-$CaCl_2$ electrolyte solutions at dilute concentrations ($\leq$ 0.1 mol_c dm^{-3}). Our simulations used methodologies known to correctly describe the structure and diffusion coefficients of water and solutes in smectite interlayer nanopores [2]. They complement our previous simulations of concentrated electrolyte solutions (0.34 to 1.83 mol_c dm^{-3}) on smectite surfaces [3]. Our results confirm the molecular-scale view of EDL stucture on phyllosilicate basal surfaces derived from X-ray reflectivity measurements of adsorption on mica surfaces [4]. They also provide insights into several fundamental aspects of the ion exchange selectivity of clays, such as the adequacy of the Gaines-Thomas or Vanselow conventions and the affinity of clay surfaces for $CaCl^+$ ion pairs [1].

[1] Bourg & Sposito (2011) *Ion-Exchange Phenomena*, In: *Handbook of Soil Science*, 2nd ed., Chapter 16. [2] Bourg & Sposito (2010) *Environ. Sci. Technol.* **44**, 2085. [3] Bourg & Sposito (2011) *J. Colloid Interface Sci.* **360**, 701. [4] Lee, Fenter, Park *et al.* (2010) *Langmuir* **26**, 16647.