Collisional erosion of the Earth's primordial crust: consequences on the Bulk Silicate Earth composition

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Superchondritic Sm/Nd (Samarium/Neodymium) and Lu/Hf (Lutetium/Hafnium) ratios have been evidenced in Earth's mantle rocks. This observation is at odds with the canonical view of planetary accretion from chondritic building blocks leading notably to chondritic ratios of refractory and lithophile elements (RLE) in the Bulk Silicate Earth (BSE). During the last stage of planetary accretion, planets grow from collisions with other embryos and with a remnant planetesimals population. During this process, relative abundances of RLE may be affected by impact events. Especially, it has been suggested that the BSE superchondritic Sm/Nd ratio could be inherited from collisional stripping of the Earth's early crust (enriched in more incompatible elements). We quantify the influence of collisional erosion during accretion on the budget of RLE such as Sm-Nd, Lu-Hf, U-Th and Rb-Sr to evaluate the efficiency of this scenario using a combination of analytical modeling, N-body numerical simulations, and geochemical modelling. We explore a space of parameters that spans a large range of accretion and differentiation scenarios including notably the effect of a grand tack event and the effect of variable degree of mantle-crust chemical equilibration: (1) The mantle and crust fully reequilibrate after each impact; (2) The accreted material merges with the crust only and the mantle does not reequilibrate with the crust (3) Full equilibration between the crust and mantle only occurs with giant impacts. The model tracks the effects of collisional erosion and accretion for every single embryo. We show that the fractionation of Earth-like bodies is highly dependant on the existence of an atmosphere and on the size-frequency distribution of the population of planetesimal impactors.