Mars: A major ingredient to the Earth's recipe

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The Earth formed in a swarm of Moon to Mars-sized objects that collided together to build our planet. A large body of work has been dedicated to make the Earth out of single groups of chondrites, however, these models could not account for the isotopic and elemental characteristics of the Earth. A model based on CI chondrites cannot account for the Cr or O isotopes systematics of the Earth or Mars while CV chondrites have a similar refractory lithophile element contents but show large isotope differences with the Earth. Enstatite chondrites have similarities in various isotope systems but recent work show small but resolvable differences between Earth and this meteorite group [1,2]. In addition, Si isotopes argue against a large component of enstatite chondrites [3].

In this study, we have considered that the Earth could be made of a mixture of planetary materials as sampled in the meteorite collections, notably including achondrites as possible building blocks. There are two basis for this approach: (i) the solids found in the terrestrial region must have formed by radial mixing of solids initially condensed at different distances from the Sun [4] (ii) astronomical models show that the asteroid belt collected materials from both the inner and outer solar system [5]. Our Monte-Carlo inversion yielded a new model where Earth and Mars almost entirely came from the same source material. This finding is in striking agreement with recent planetary formation models in which Earth and Mars formed in a common narrow zone of the protoplanetary disk [5]. In addition, our model matches all isotope compositions for both planets, reproduces volatile element budgets in Mars, and accounts for the enrichment in refractory elements of the Earth compared to chondrites. The difference in core size between Earth and Mars can be explained by different partitioning of O in the core of the two planets as argued in [6]. Based on the Rb-Sr system, the difference in volatile contents between Earth and its building blocks can be rationalized by a late volatile element loss during large impacts.

[1] Burkhardt *et al* (2012) *EPSL* **312**, 390-400. [2] Zhang *et al* (2012) *Nature Geosci*. **5**, 251-255. [3] Fitoussi & Bourdon (2012) *Science* **335**, 1477-1480. [4] Walsh *et al* (2011) *Nature* **475**, 206-209. [5] Ciesla (2008) MAPS 43, 639-655. [6] Rubie *et al* (2004) *Nature* **429**, 58-61.