CHIPS OFF THE OLD BLOCK: ENSTATITE CHONDRITES AS SAMPLES OF THE PROTO-EARTH.

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Enstatite chondrites (EC) as well as the related enstatite acondrites (aubrites) are remarkable in terms of their isotopic similarity to Earth [1-8] but also because of their chemical dissimilarity to Earth as well as most material from the inner Solar System. Models of the Earth using an EC composition [9] have been criticized because of this disparate chemistry, i.e. low Fe/Si and high Mg/Si in silicates, and carbide minerals, consistent with equilibration with very low oxygen fugacity (high C/O) conditions [10]. Recently, significant differences in silicon [11,12], titanium [13] and oxygen isotopes [14] between EC and Earth have emerged. The first could be explained by mass-dependent fractionation between the silicate- and metal-associated moieties of Si and could arise in the primordial nebula [15]. But the latter, may be important clues to the relationship between EC and Earth.

Supposing that Earth and EC came from the same reservoir, the difference in chemistry could be explained in part by requilibration of the latter with a gas from which oxygen-rich solids of approximately carbonaceous chondrite were removed [16,17]. The enrichment of some EC in volatile elements such as Na can be explained by charging of nebular gas by elements lost during accretion of protoplanets [18]. Enrichment might explain the high S vapor pressure inferred from the glassy chondrule mesostasis of some EC [19] and potentially the sulfidation of silicates and loss of FeO [20].

Supposing an origin in a common reservoir, the fact that the (few) EC with established ages [21,22] precede the Moon-forming impact and that the post-impact Earth is isotopically very similar to EC means that Theia must also been similar as well [14]. It also follows that input of material from the outer Solar System following EC formation at ≤10 Myr [21,22] was negligible as well. A scenario that unifies these pieces of information is: (a) Protoplanets emerged from an isotopically uniform reservoir in the inner Solar System; (b) this reservoir was isolated from the outer Solar System by the formation of Jupiter and the mean properties of this reservoir did not evolve; (c) protoplanet variation in $\Delta^{17}O$ was produced by differential retention of ^{16}O-poor water in planetesimals as they were heated by ^{26}Al. Those bodies such as Mars that accreted quickly retained more water and have higher $\Delta^{17}O$, while the bulk silicate Earth reflects accretion of the remaining, more water-depleted and ^{16}O-rich material; (d) EC retained their Earth-like (but not Earth-identical) O-isotopic signatures because the residual gas was oxygen-depleted.

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