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Oxygen isotope evolution in the early solar system

Rubie*, D.C., Young, E.D., Jacobson, S.A., Morbidelli, A., O'Brien, D.P. *Bayerisches Geoinstitut, Universität Bayreuth, D95490 Bayreuth, dave.rubie@uni-bayreuth.de.

The terrestrial planets formed at oxygen fugacities ~5 orders of magnitude higher than that of a solar gas. This was due to oxidation of Fe to form a FeO component in silicates, with the most likely oxidant being water. The oxygen isotopic composition of water was high in $^{18}O/^{16}O$ and $^{17}O/^{16}O$ which implies a link between the oxygen isotope ratios of planetary bodies and their oxidation state. We have investigated this link in the context of N-body accretion models for planet formation. We find that the composition of the cores and mantles of the terrestrial planets are best reproduced when Fe is significantly oxidized at heliocentric distances greater than 1 to 1.5 AU prior to accretion. The oxygen isotopic corollary is that the high $^{18}O/^{16}O$ and $^{17}O/^{16}O$ ratios of the planets relative to solar is also determined by the FeO component rather than by accretion of H_2O ices. Exchange between Fe-bearing dust and water vapor enriched in the heavy oxygen isotopes prior to planet formation explains both the chemical and oxygen isotopic compositions of the planets. This exchange can be understood as mixing between water produced by photochemical dissociation of CO and oxygen of solar composition.

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