EQUILIBRATION OF THE OXYGEN ISOTOPES IN THE EARTH – MOON SYSTEM.

Joseph A. Nuth III. Astrochemistry Laboratory, Code 691, Solar System Exploration Division, NASA's Goddard Space Flight Center, Greenbelt MD 20771 USA Joseph.A.Nuth@NASA.gov

Introduction: Oxygen isotopes can be used to distinguish material that comes from individual asteroids and planets. Each body appears to have a specific isotopic signature. Signatures from many meteorite parent bodies such as carbonaceous chondrites, ordinary chondrites, etc. cluster around common isotopic values, though none are identical. The Earth and Moon have identical oxygen isotopic compositions, a situation typically attributed to the breakup of a common parent body when looking at meteorites. If the Earth's moon formed from the fragments of a gigantic collision between two independently-accreted, planetary-scale bodies, how did the isotopic composition of the resultant system equilibrate to yield the same signature in both?

We have previously shown that the size of the feeding zones for the accretion of planetesimals depend on both size of the body and the total mass of the nebula. For reasonable values of nebular mass (up to 50 times the Hayashi Minimum Mass Nebula) and planetesimals that have grown to roughly one kilometer in diameter, all contain significant quantities of ice ranging from 5 to 35%.

Consequence of Wet Planetesimals: Most planetesimals that are accreted into planets growing via runaway accretion will bring substantial quantities of water into the proto-planet. The later stage of the accretion process will generate considerable thermal energy due to the accreting planetesimals that will melt the initially accreted ice and generate a large flux of hot, liquid water through the planet. If the planet is large enough to hold an atmosphere and hydrosphere, this will be thoroughly equilibrated with the oxygen of the planetary interior.

A second consequence of wet planetesimals will be that the proto-Earth must accrete considerably more initial mass (including the ice) in order to accrete sufficient rocky mass to account for the current mass of the planet.

Oxygen Isotopes in the Earth-Moon System: If both the proto-Earth and the "Mars-size impactor" were both equilibrated bodies containing significant reservoirs of liquid water prior to impact, the energy of the collision would vaporize any oceans on the surfaces of the bodies while simultaneously equilibrating the isotopic composition of both bodies in the debris cloud surrounding the Earth. Depending on the accretional loss of water during the initial accretion of both bodies, there could be several tenths of an Earth mass of water vapor in this cloud. Although most of this water would be lost from the system due to the high temperature of the debris disk, this same high temperature would ensure the equilibration of the silicates in the cloud. If the oceans of the larger proto-Earth dominate the contribution to this disk, then the cloud will be equilibrated with the Earth before it coalesces into the Moon.