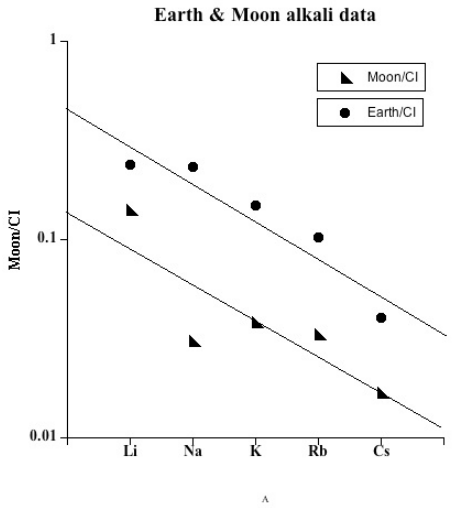
LUNAR VOLATILES: AN EARTH-MOON PERSPECTIVE. J.H. Jones, KR, NASA/JSC, Houston, TX 77058. john.h.jones@nasa.gov

Introduction: It has generally been accepted that the Moon is depleted in volatile elements [e.g., 1]. However, the recent discovery of measurable water in lunar glasses and apatites [2, 3] suggests that volatiles are not as depleted as was once thought. And, in fact, some authors have claimed that water contents of the lunar and terrestrial mantles are similar [e.g., 2, 4].

Moderately volatile alkali elements may have a bearing on this issue. In general, bulk Moon alkalis are depleted relative to the bulk silicate Earth [1]. Although the bulk lunar chemical composition is difficult to reconstruct, good correlations of alkali elements with refractory lithophile incompatible trace elements make this conclusion robust. These observations have been taken to mean that the Moon overall is depleted in volatiles relative to the Earth (Fig 1). Since water is more volatile than any of the alkali elements, presumably this conclusion is true for water, or even more so.

Figure 1



Given this conclusion, it is then of interest to explore how much water exists in the terrestrial mantle and investigate the origin of that water.

What is the water content of the terrestrial mantle? In general, the water content of the Earth's mantle is unknown. But based on (i) bulk analyses of mantle peridotite xenoliths, (ii) analyses of MORB glasses, and (iii) FTIR measurements of water in nominally anhydrous minerals, a value of a few hundred ppm water seems reasonable [5].

Origin of water in the terrestrial mantle: There are two endmember possibilities for the origin of water in the Earth's mantle: (i) it is primordial (i.e., "juvenile") or (ii) it has been emplaced over geologic time by subduction of hydrated oceanic lithosphere.

The isotopic composition of mantle water is presumably of importance in addressing that water's origin. Since oxygen in mantle water is presumably buffered by exchange with mantle silicates and oxides, we turn to H isotopes as a guide.

As a generality, "juvenile" waters have ∂D values of ~ -50-80 ‰. Perhaps coincidentally, this value is approximately that of a vertically integrated column of oceanic crust [6].

Hydrothermal cells at oceanic spreading ridges circulate deep (several kilometers) into the oceanic crust, partially altering the primary igneous minerals into hydrous phases. The nature of these hydrous phases changes with (P,T) conditions, as does the D/H fractionation between the alteration assemblage and the altering fluid. As a consequence, the ∂D of the oceanic crust is variable with depth, but its integrated value is about that of "juvenile" water.

As a consequence of this observation, it is now believed that "juvenile" water does not exist [6]. Or if it does, there is no evidence for it. Water in the Earth's mantle is most probably a secondary phenomenon, the result of subduction plate tectonics. By geochemical standards, the Earth's primordial mantle was probably dry.

Recapitulation: The water content of the terrestrial mantle is to some degree artificial. Our mantle has been highly modified by several eons of subducting hydrated slabs. Of course, this process is not very efficient. A large portion of a slab's water budget tends to be lost early in the subduction process, producing arc volcanics. That said, it is not inconceivable that an ocean of water could have been subducted over geologic time. A corollary of this view is that the water of the Earth's oceans were probably not formed *via* mantle outgassing, but by the late accretion of hydrous materials.

It is not possible to specify with certainty the primordial water content of the terrestrial mantle. Because the Earth has a metallic core, the water content of the Hadean mantle was presumably dictated by water-metal reactions. Regardless, the prediction based on alkali metals is that the Moon has less water than the early Earth.

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