LITHIUM, MAGNESIUM AND IRON ISOTOPIC COMPOSITION OF THE MOON. F.-Z. Teng, Isotope Laboratory, Department of Geosciences and Arkansas Center for Space and Planetary Sciences, University of Arkansas, 113 Ozark Hall, Fayetteville, Arkansas 72701. (fteng@uark.edu).

Introduction: Bulk chemical and isotopic compositions of the Moon can place strong constraints on its formation, differentiation and evolution. For example, the identical oxygen isotopic compositions of the Moon and Earth [1] have been used to estimate the scale and grade of mixing and equilibrium processes during lunar-forming giant impact [2]. Isotopic studies of lunar samples on other elements with different volatility may further shed light on this event. Here I review the application of lithium, magnesium and iron isotopic systems on the formation and evolution of the Moon.

Lithium Isotopic Composition of the Moon: Lithium isotopic compositions of lunar samples show a small variation [3-5] and on average are similar to those of the terrestrial basalts and mantle peridotites [3-7]. Thus the Moon has the same lithium isotopic composition as the Earth (Figure 1).

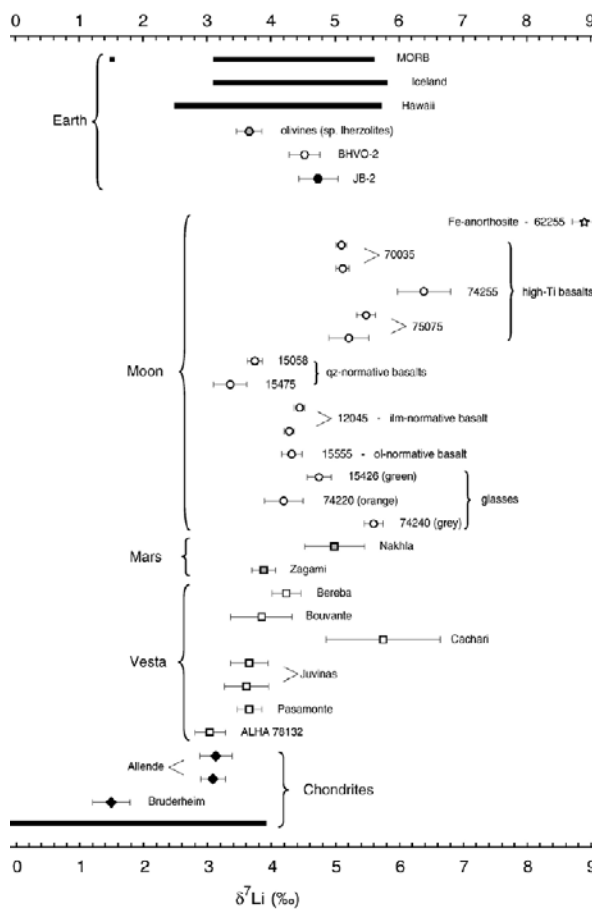

Figure 1. Lithium isotopic composition of terrestrial and extraterrestrial materials. From Magna et al. [3].

Magnesium Isotopic Composition of the Moon: Due to limitations in the mass spectrometry, many previous magnesium isotopic studies have concentrated on either non-mass dependant isotope anomalies to look for the radiogenic ^{26}Mg produced by the decay of short-lived ^{26}Al [8,9] or large kinetic mass-dependant isotope fractionation during evaporation [10, 11]. The recent advent of multi-collector inductively coupled plasma mass spectrometry (MC-ICPMS) has made it possible to measure Mg isotopes with unprecedented high-precision [12, 13].

Thus far, there have been only two studies on magnesium isotopic compositions of the lunar samples. Norman et al. [14] studied olivines from different planetary bodies (Earth, Mars, Moon and pallasite parent body) by laser-ablation MC-ICPMS and found very limited variations in the magnesium isotopic compositions of these samples. In contrast, Wiechert and Halliday [15] improved the analytical precision by using solution MC-ICPMS and found magnesium isotopic variations in both lunar and terrestrial basalts, which has been interpreted as a result of isotope fractionation during lunar magmatic differentiation. On average, the Moon has a magnesium isotopic composition slightly different from the Earth while both of them are different from chondrites. The non-chondritic magnesium isotopic compositions of the Earth and Moon are considered as a result of sorting of chondrules and CAIs in the proto-planetary disk. However, a more recent study on basalts from Kilauea Iki lava lake found the absence of magnesium isotope fractionation during basalt differentiation; consequently, the Earth, based on basalts, have a chondritic Mg isotopic composition [16].

Iron Isotopic Composition of the Moon: Similar to magnesium isotopes, iron isotopic studies on lunar samples have yielded exiting yet debated results. Poitrasson et al. [17] found Fe isotopic compositions of lunar and terrestrial basalts are slightly heavier than those of chondrites, Mars, and Vesta and interpreted this as a result of evaporation-induced kinetic fractionation of Fe isotopes during the giant impact that formed the Moon (Figure 2). In contrast, Weyer et al. [18] confirmed the fact that lunar and terrestrial basalts are heavier than those of chondrites but interpreted this as a result of iron isotope fractionation during planetary differentiation. Our recent studies [19, 20] show that iron isotopes fractionate during fractional crystallization during basalt differentiation in the Kilauea Iki lava lake. This suggests that, at least for Earth, its iron isotopic composition is chondritic, similar to the conclusion derived from studies of mantle peridotites [21].

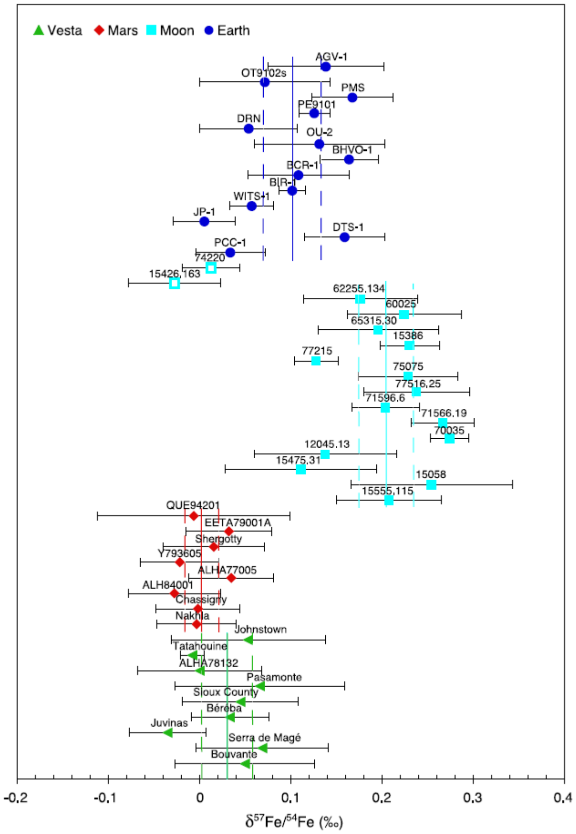

Figure 2. Iron isotopic compositions of terrestrial and extraterrestrial materials. From Poitrasson et al. [17].

Future Studies: Comparative studies of Li, Mg, Fe and other isotopes on lunar samples can potentially provide important constraints on the nature of the source regions of mare and highland basalts, on their fractionation histories and on the bulk isotopic compositions of the Moon. In addition, comparisons of isotopic compositions of elements with different volatility between the Moon and Earth may help to evaluate the effects of lunar-forming giant impact on the compositional evolution of the Moon and Earth. However, the database on lunar samples, especially Fe and Mg isotopic data, are still very limited. More comparative, multiple isotopic studies on well-characterized lunar samples are therefore needed. For example, the effects of fractional crystallization on lithium, magnesium and iron isotopes have been investigated in the Kilauea Iki lava lake (Figure 3) while such studies for a set of lunar samples are highly needed in order to better explain the isotopic variations in the Moon.

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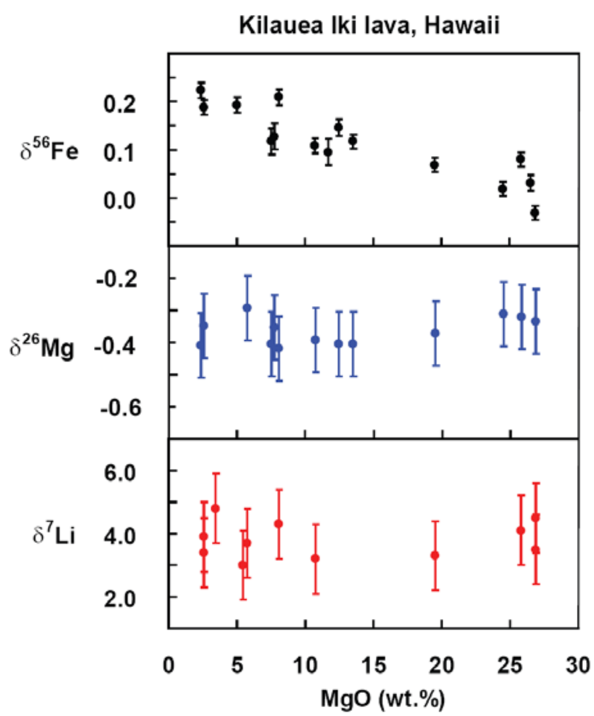

Figure 3. Plot of iron [19, 20], magnesium [16] and lithium [22] isotopic compositions of samples from the Kilauea Iki lava lake, Hawaii, as a function of the weight percent MgO. A change in isotopic composition with wt% MgO would indicate a crystal-melt isotopic fractionation. From Richter et al. [23].