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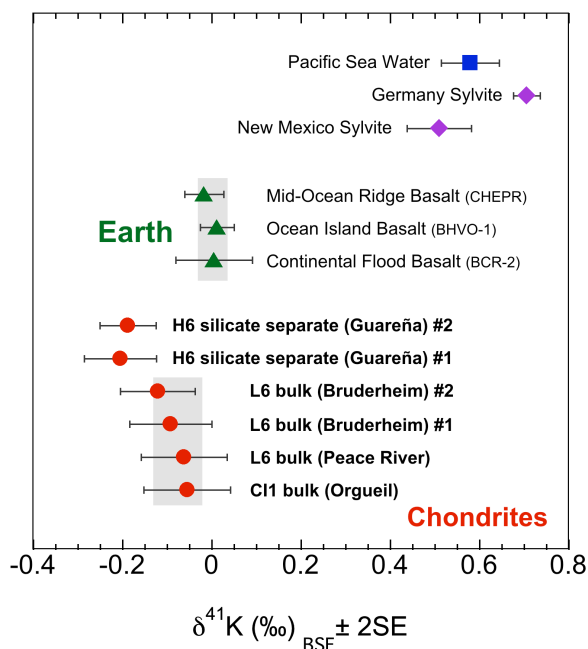
**Introduction:** The inner Solar System bodies, such as the Earth, Moon, Mars and asteroid 4 Vesta, are significantly depleted in volatile elements relative to the bulk solar and CI carbonaceous chondrite composition. The K/U ratio is an important indicator of such depletion because K is a moderately volatile element while U is a refractory element. The K/U ratio of CI chondrites is 69,900 [1], and the bulk silicate Earth is estimated as 13,800 [2], showing a factor of five depletion of K in the Earth relative to CI chondrites. The K/U ratio of the Moon is even five times smaller than the Earth (2,515; [3]). This depletion of K and other volatile elements is one of the fundamental characteristics of the bulk chemistry of the Earth, Moon and other inner Solar System bodies. The mechanism that caused the volatile depletion in the inner Solar System is still not entirely understood. It has been proposed that potassium isotopes could be used to distinguish different processes that may account for this depletion [4]. Here we report new high-precision K isotope data for chondrites and discuss their implications for understanding the volatile element depletion of inner Solar System bodies. This data is the first step to use K isotopes to test the Giant Impact origin of the Moon.

**Samples and Method:** Four chondritic meteorites were analyzed. One CI1 carbonaceous chondrite, Orgueil, is an 1864 fall in France. Three ordinary chondrites including one equilibrated H6, Guareña, an 1892 fall in Spain; two equilibrated L6, Bruderheim, a 1960 fall in Canada, and Peace River, a 1963 fall in Canada. All but Guareña are bulk samples. Guareña is from the silicate separate after removing metals from the bulk for a previous study.

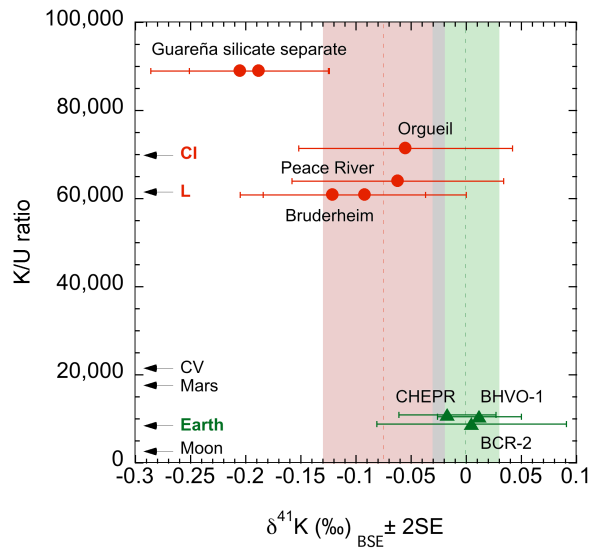
All samples (~100 mg each) were digested through a CEM microwave digestion system with a two-step protocol (first in concentrated HF/HNO<sub>3</sub>/HCl mixture and then in diluted aqua regia). A dry ashing procedure in a Thermolyne muffle furnace (800°C; 3 hours) was applied to the CI1 Orgueil before microwave digestion because of the high abundance of organic materials in carbonaceous chondrites.

Fully digested samples were dried and then loaded on to chromatography columns (ID=1cm; filled with 13 mL Bio-Rad AG50W-X8 100-200 mesh cation exchange resin). Potassium was eluted with 0.5 N HNO<sub>3</sub> and collected in the 180 to 340 mL cut. This K purification procedure was established and used by [4, 5].

Samples were analyzed with a GV Instruments IsoProbe P Multiple-Collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS). The IsoProbe is equipped with a hexapole collision cell to remove Ar<sup>+</sup> and ArH<sup>+</sup> interferences. The method used here has been described and evaluated in detail in a recent paper [6], and makes it possible to precisely measure K isotopes at the level of 0.05‰. The isotopic ratios of <sup>41</sup>K/<sup>39</sup>K are measured with the standard-sample bracketing technique. The K isotopic compositions are reported in the delta notation, where  $\delta^{41}\text{K} = ((^{41}\text{K}/^{39}\text{K})_{\text{sample}} / (^{41}\text{K}/^{39}\text{K})_{\text{standard}} - 1) \times 1000$ . The laboratory standard is Merck Suprapur<sup>®</sup> 99.995% purity potassium nitrate. The final data ( $\delta^{41}\text{K}_{\text{BSE}}$ ) are normalized relative to the Bulk Silicate Earth value, which is defined by the average of the terrestrial basalts [6].



**Fig. 1.** The K isotopic compositions ( $\delta^{41}\text{K}_{\text{BSE}}$ ) of carbonaceous and ordinary chondrites compared to terrestrial basalts, seawater and sylvites (KCl). For each sample, the error bars represent 2 standard errors (2SE) of ~10 repeat measurements. The shaded areas are the averages ( $\pm 2$  standard deviation; 2SD) for the three bulk chondrites ( $-0.075 \pm 0.056\text{‰}$ ) and three basalts from the Earth ( $0.000 \pm 0.030\text{‰}$ ). There is no resolved difference between the K isotopic compositions of bulk chondrites and terrestrial igneous rocks.



**Fig. 2.** The K isotopic compositions ( $\delta^{41}\text{K}_{\text{BSE}}$ ) vs. K/U ratios of carbonaceous, ordinary chondrites, and terrestrial basalts. For each sample, the error bars represent 2 standard errors (2SE) of  $\sim 10$  repeated measurements. The shaded areas are the averages ( $\pm 2$  standard deviation; 2SD) for the three bulk chondrites ( $-0.075 \pm 0.056\text{‰}$ ) and for all terrestrial basalts ( $0.000 \pm 0.030\text{‰}$ ). The K isotopic compositions of chondrites are from this study and those for basalts are from reference [6]. The K and U concentrations are from this study, USGS certificate of analysis and references [7-12].

**Results and Discussion:** Fig. 1 shows all data for the three bulk chondrite samples (Orgueil, Peace River and Bruderheim) and one chondrite silicate separate (Guareña) in this study. The three bulk chondrite samples are indistinguishable from each other and the average is  $-0.075 \pm 0.056\text{‰}$  (2SD). However, the results of the two aliquots of the Guareña silicate separate are both marginally lower than the average value of the three bulk chondrites. This small difference between them is still within the analytical error, and it cannot be entirely resolved at the current precision.

The new chondrite data are compared with selected terrestrial samples (basalts, seawater and sylvites) from our previous study [6] in Fig. 1. It has been recently reported that there are measurable K isotopic fractionations among terrestrial samples [6, 13]. Prior to these studies, due to large analytical uncertainties, it was concluded that there was no resolved K isotopic fractionation among any samples except for the lunar regolith [14]. These new studies [6, 13] reported that there are  $>0.5\text{‰}$  K isotopic fractionation between terrestrial basalts and seawater (see Fig. 1). Terrestrial basalts from different tectonic settings (MORB, OIB and continental) have an undistinguishable K isotopic compo-

sition of  $0.000 \pm 0.030\text{‰}$  [6]. It seems that K isotopes do not fractionate during high-temperature magmatic processes because K usually forms ionic bonds and it has only one valence state (both preventing large vibrational isotope effect).

The new chondrite data indicate that there is no significant difference between the K isotopic compositions of bulk chondrites and terrestrial basalts. The averages for bulk chondrites and for terrestrial basalts ( $-0.075 \pm 0.056\text{‰}$  vs.  $0.000 \pm 0.030\text{‰}$ ) overlap within error bars. This observation confirms the conclusion drawn from a previous study [4], even though the analytical precision has been improved nearly one order of magnitude ( $\sim 0.05\text{‰}$  vs.  $0.5\text{‰}$ ) over the past two decades. Intriguingly, two aliquots of the Guareña silicate separate both appear to have lower K isotopic compositions than the average value for terrestrial basalts. Because K is a lithophile element, all the K in Guareña should be in the silicate portion. Thus the K isotopic composition of bulk Guareña should be equal to that of the silicate separate. Whether the H6 ordinary chondrite Guareña has a significantly different K isotopic composition needs to be further investigated.

The two terrestrial basalts have K/U ratios  $\sim 10,000$ , the L6 chondrites  $\sim 60,000$ , the CI chondrite  $\sim 70,000$ , and the H6 chondrite  $\sim 90,000$ . Fig. 2 shows the K isotopic compositions of chondrites and terrestrial basalts versus their K/U ratios and it appears that the K isotopic compositions show a negative correlation trend with the K/U ratios even though they are at the limit of our analytical precision. If this correlation is real, then some limited K isotopic fractionation did occur accompanying the volatiles depletion. Such new K isotope data will put new constraints on the nature of the inner Solar System volatile depletion.

**References:** [1] Anders E. and Grevesse N. (1989) *Geochim. Cosmochim. Acta*, 53, 197–214. [2] Arevalo R. et al. (2009) *Earth Planet. Sci. Lett.*, 278, 361–369. [3] Taylor S. R. (1982) *Phys. Earth Planet. Inter.*, 29, 233–241. [4] Humayun M. and Clayton R. N. (1995) *Geochim. Cosmochim. Acta*, 59, 2131–2148. [5] Strelow E. W. E. et al. (1970) *Anal. Chim. Acta*, 50, 399–405. [6] Wang K. and Jacobsen S. B. (2016) *Geochim. Cosmochim. Acta*, in press. [7] Barrat J. A. et al. (2012) *Geochim. Cosmochim. Acta*, 83, 79–92. [8] Kallemeyn G. W. et al. (1989) *Geochim. Cosmochim. Acta*, 53, 2747–2767. [9] Hagee B. et al. (1990) *Geochim. Cosmochim. Acta*, 54, 2847–2858. [10] Jarosewich E. (1990) *Meteoritics*, 25, 323–337. [11] Cumming G. L. (1974) *Chem. Geol.*, 13, 257–267. [12] Fisher D. E. (1972) *Geochim. Cosmochim. Acta*, 36, 15–33. [13] Morgan L. E. et al. (2014) *Goldschmidt Conf. Abstract* #1731. [14] Humayun M. and Clayton R. N. (1995) *Geochim. Cosmochim. Acta*, 59, 2115–2130.