NEW HIGH-PRECISION POTASSIUM ISOTOPES OF TEKTITES. Y. Jiang[1,2], H. Chen[2], B. Fegley, Jr.[2], K. Lodders[2], W. Hsu[3], S. B. Jacobsen[4], K. Wang (王昆)[2]. [1]CAS Key Laboratory of Planetary Sciences, Purple Mountain Observatory, Chinese Academy of Sciences (yjiang@pmo.ac.cn), [2]Dept. Earth & Planetary Sciences and McDonnell Center for the Space Sciences, Washington University in St. Louis (wangkun@wustl.edu), [3]Space Science Institute, Macau University of Science and Technology, [4]Dept. Earth & Planetary Sciences, Harvard University.

Introduction: Tektites are natural glassy objects formed from the melting and rapid cooling of terrestrial rocks during the high-energy impacts of meteorites, comets, or asteroids upon the surface of the Earth [1]. Chemical and isotopic compositions indicate that precursor components of tektites are the upper terrestrial continental crust, rather than extraterrestrial rocks. Tektites are characterized by the depletion of volatile elements and water, and heavy Cd, Sn, Zn and Cu isotopic compositions [2-5]. Since volatilities of elements are defined by their 50% condensation temperature (T_c) of the solar nebula gas at 10^{-4} bars [6], there is no reason to expect them to be universally applicable to other processes/conditions, such as the tektite formation. Nevertheless, this volatility scale is commonly used for evaluation of condensation/evaporation processes in environments other than the solar nebula. Alternatively, because of the Moon's depletion in many volatile elements, it may be useful to directly compare volatility pattern of tektites with those of the Moon and various groups of chondritic meteorites.

Previous isotope work such as Si, Mg, B, and Li do not show any isotopic fractionation in tektites [7-10]. In contrast elements such as Cd, Sn, Zn, and Cu, considered volatile in the nebula, also show significant isotopic fractionation compared to the inferred terrestrial source rocks [2-5], consistent with their loss by volatilization. Potassium is a moderately volatile element with a nebular 50% condensation temperature (T_c) of ~1006 K between Zn (726 K) and Cu (1037 K) [6]. However, no K isotopic fractionation was reported so far between tektites and related terrestrial rocks [11, 12]. We developed a method for high-precision K isotope measurements by MC-ICP-MS [13, 14]. Here we report new K-isotope data for tektites to further investigate the problem of K-volatilization during the tektite formation.

Samples and analytical methods: Seven tektites from three different strewn fields are studied: (1) Five Australasian tektites: one tektite from Hainan, China, one Australite, one Indochinite, one Philippinite, and one Thailandite. (2) One North American tektite: one Bediasite from Texas. (3) One Central European tektite: one Moldavite from the Czech Republic. Also, two geostandards, the Columbia River continental flood basalt (BCR-2) and a tholeiitic basalt from the Kilauea

crater of Hawaii (BHVO-1), are also analyzed. Hainan Tektite is a typical splash-form tektite from Hainan Island, China and of a dumbbell shape. We analyzed K isotopes of 15 chips along the longitudinal axis of its profile, on a Neptune Plus MC-ICP-MS at Washington University in St. Louis [14]. Except for Hainan tektite, all other samples were only analyzed in bulk, with a GV Instruments IsoProbe P MC-ICP-MS at Harvard University following the description in [13]. K isotope compositions are reported using the per mil (‰) notation, where $\delta^{41}K = ([(^{41}K/^{39}K)_{sample}/(^{41}K/^{39}K)_{standard} - 1] \times 1000)$. The laboratory standard used in this study is Suprapur® 99.995% purity potassium nitrate (KNO_3) purchased from Merck KGaA. We report data relative to the Bulk Silicate Earth (BSE) value, as $\delta^{41}K_{BSE}$.
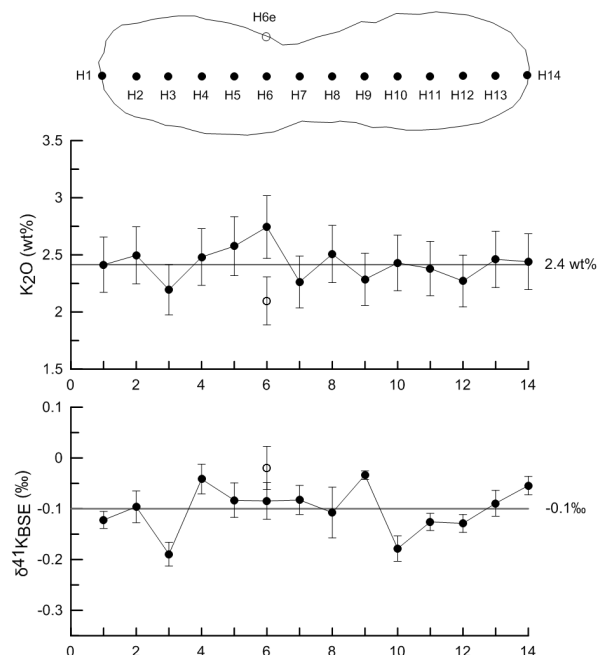

Fig. 1. *The distributions of K contents and isotope ratios throughout the Hainan tektite profile as indicated by the sketch map above. Gray lines indicate the average values of K_2O (2.4 wt.%) and $\delta^{41}K_{BSE}$ (−0.1‰).*

Results: Both the "bulk" analysis of 15 chips by the iCAP Q ICP-MS and the "in-situ" measurements by the electron microprobe confirmed the chemical homogeneity of the Hainan tektite, with their differences are not significant within the error bars (**Fig. 1**). The

average K_2O is ~ 2.4 wt.%. Volatile trace elements Zn and Cu similarly show no gradient from the center to the edge, with average contents being 14.6 ppm and 1.7 ppm, respectively. The $\delta^{41}K_{BSE}$ values of Hainan tektite also span a narrow range and vary insignificantly across the profile (**Fig. 1**). The edge (H6e; $\delta^{41}K_{BSE}$ = $-0.02\pm0.04‰$) is indistinguishable from the center (H6; $\delta^{41}K_{BSE}$ = $-0.08\pm0.04‰$). The $\delta^{41}K_{BSE}$ values of Hainan and other six bulk tektite samples all overlapped if error bars are taken into account. The average of the K isotopic compositions of all tektites ($0.04\pm0.03‰$) is indistinguishable from the Bulk Silicate Earth value ($0.00\pm0.03‰$; [13]).

Discussion: The K isotopic compositions of bulk samples of seven tektites from three different strewn fields span a narrow range, and the data scatter around the Bulk Silicate Earth value (**Fig. 2**). There is no correlation between K contents and the $\delta^{41}K_{BSE}$ values of different groups of tektites. Isotopically normal potassium suggests that no significant K isotopic fractionation between tektites and BSE has been produced due to the evaporation during tektite formation, which is in contrast with other moderately volatile elements such as Cd, Sn, Cu, and Zn (**Fig. 2**). Copper and Zn both exhibit significant elemental depletion and isotopic fractionation in tektites ($\delta^{65}Cu$ up to 6.98‰, [5]; $\delta^{66}Zn$ up to 2.49‰, [4]), which are generated by the evaporation during impact melting process, but not inherit from source materials [15]. Among the three moderately volatile elements, Cu shows a larger degree of isotopic fractionation than Zn and K in tektites. Copper and Zn are more volatile than K in silicate vapor [16, 17] and volcanic gas [18] than in solar nebula gas. We used the IVTAN code to model gas-melt volatility of Cu, K, and Zn during vaporization of average continental crust. Results at 1000 K and 2000 K at 1 bar show most K remains in the melt while most Zn and Cu are vaporized as $ZnCl_2$ and CuCl. Higher temperatures (> 2000 K) also vaporize K. This behavior reflects geochemical affinities and activity coefficients (γ) in silicate melts with $\gamma(K) \ll 1$ [19], while $\gamma(Cu)$ and $\gamma(Zn)$ are ~ 1 or > 1 [20, 21]. Cu and Zn partition into gas while K stays in the melt at the P,T conditions modeled.

We compare the K, Cu, and Zn isotopic composition of tektites, the Earth and the Moon in **Fig. 2**. Copper and Zn are much more volatile than K, and the isotopes of Cu and Zn can be easily fractionated (*e.g.*, via impact melting, magma ocean, and volcanic degassing) [22]. The K isotopes are much more difficult to fractionate and it is only seen in the lunar samples. A new version of the catastrophic Moon-forming giant impact event is consistent with K isotopes in the Moon [23].

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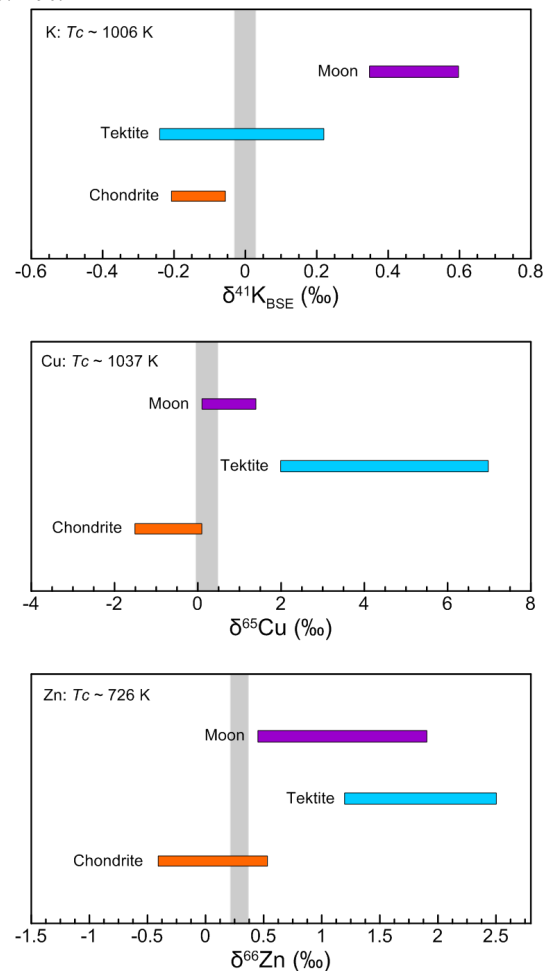

Fig. 2. *Comparison of K, Cu, and Zn isotopic compositions in the Earth, chondrites, tektites and the Moon. The vertical shaded areas are the Earth as represented by igneous rocks.*