THE K ISOTOPE SYSTEMATICS OF MICROTEKTITES FROM THE AUSTRALASIAN STREWN FIELD P. Koefoed[1,2], L. Folco[3,4], G. Di Vincenzo[5], N.X. Nie[6], B. P. Glass[7] and K. Wang (王昆)[1,2] [1]McDonnell Center for the Space Sciences, [2]Dept. of Earth & Planetary Sciences, Washington University in St. Louis, One Brookings Drive, St. Louis, MO 63130 USA (piers.koefoed@wustl.edu), [3]Dipartimento di Scienze della Terra, Università di Pisa, 56126 Pisa, Italy, [4]CISUP, Centro per l'Integrazione della Strumentazione dell'Università di Pisa, 56126 Pisa, Italy. [5]Istituto di Geoscienze e Georisorse – CNR, via Moruzzi 1, 56124 Pisa, Italy, [6]Earth and Planets Laboratory, Carnegie Institution for Science, Washington, DC 20015, USA, [7]Department of Earth Sciences, The University of Delaware, Newark, DE 19716, USA

Introduction: Microtektites are the submillimeter counterparts of tektites, and are natural siliceous glass ejecta formed by the rapid heating and quenching of terrestrial rocks by the hyper-velocity impact of an extraterrestrial object into Earth's crust [1,2]. While the study of microtektites has advanced significantly over the last few decades, the exact role of evaporation and condensation in their formation, and thus the implications this would have on their formation process, have not yet been conclusively resolved. Additionally, as microtektites provide an ideal terrestrial analog for early solar system hypervelocity impacts, understanding their formation process has significant implications for understanding solar system formation.

Of the five currently known strewn fields, the largest (~10% of Earth's surface area) and youngest (~800 ka) is the Australasian strewn field [1,3,4,5]. While the source crater of the Australasian strewn field is not yet known, it is thought to be in Southeast Asia region [6,7]. As microtektites from this strewn field have been found both close to, and as far as ~12,000 km from their suggested impact region, it is likely they experienced a wide range of temperature/time regimes. Indeed, microtektites from the Australasian strewn field, show a depletion in the moderately volatile elements Na and K which correlates with distance from the suggested source crater region [8]. Previous isotopic studies on K and Fe have investigated this depletion, nevertheless, neither study found conclusive evidence of a definitive depletion process, with both suggesting a mix of both condensation and evaporation [9,10]. With the considerable advances in K isotope analysis achieved since the previous K isotope study (analytical uncertainties of ~0.05‰ are now routinely achievable), the high-precision K isotope analysis of Australasian microtektites has the potential to further resolve their formation mechanism. As such, here we undertook a systematic study looking at Australasian microtektites from multiple locations covering a range from ~1220 km to ~10800 km from the proposed impact location.

Methods: A total of thirty-one microtektites were selected for analysis, consisting of thirteen from the Miller Butte (MB) region in Antarctica, six from ODP site 1143A, ten from ODP site 1144A (both in the South China Sea) and one each from core sites V19-169 and V29-43 (Indian Ocean). The microtektites analyzed range from 0.111 to 0.662 mg in mass and were dissolved in a 3:1 mixture of HF and HNO_3 for one week at 140 °C and then fluxed with HCl and HNO_3. Following dissolution, 10% of each fraction was separated for elemental analysis, while the remaining 90% was used for K isotope analysis. Elemental analysis was conducted using a Thermo Fisher iCAP Q ICP-MS. For the K isotope analyses, K was first separated using AG50W-X8 100-200 mesh cation-exchange resin (double pass) where 0.5 M HNO_3 was used as the elution liquid. All K isotope analyses were conducted using a Neptune Plus MC-ICP-MS. The standard used for all analyses was NIST SRM 3141a.

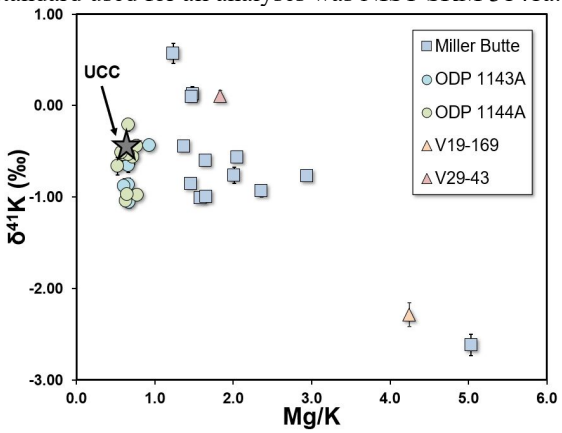

Figure 1. *$\delta^{41}K$ vs Mg/K for all microtektites in this study. Errors shown are 95% C.I. UCC = Upper continental crust composition [11,12]*

Results: As seen in Figure 1, the K isotope compositions of all microtektites analyzed in this study range from −2.62 to 0.57‰ $\delta^{41}K$. Interestingly, this entire range is dictated by the MB microtektites, with the ODP 1143A and ODP 1144A microtektites spanning the more restricted $\delta^{41}K$ range of –1.06 to −0.21‰, and the V19-169 and V29-43 microtektites showing $\delta^{41}K$ values of –2.29 ± 0.13‰ and 0.11 ± 0.06‰ respectively. Compared to the UCC ^{41}K value of −0.42 ± 0.17‰ [11], the ODP microtektites span from the BSE value to slightly lighter values (excluding one sample), while microtektites from the other sites cover ranges both heavier and lighter than the BSE.

The K_2O contents of the microtektites analyzed in this study show significant variation, ranging from 0.63 wt.% to 3.66 wt.%, with the MB, V19-169 and V29-43 microtektites showing lower concentrations (0.63 wt.% to 1.45 wt.%) and the ODP microtektites higher concentrations (2.48 wt.% to 3.66 wt.%). Combined with the K isotope compositions, this results in two distinct groups, the high K concentration and small K isotope variation OPD microtektite group, and the low K concentration and large K isotope variation MB, V19-169, and V29-43 microtektite group. As the high K ODP samples were collected ~1220-1240 km from the proposed impact site, while V19-169, V29-43, and the MB microtektites were collected ~4100-10800 km from this region, the K depletion also seem to correlate with distance from the impact, supporting previous studies [8]. Both these groups do show a possible correlation whereby the lower K concentration microtektites have lighter K isotope compositions. Nevertheless, for the MB group this correlation is largely dictated by two samples, while for the ODP group there is limited overall $\delta^{41}K$ and Mg/K variation (Figure 1).

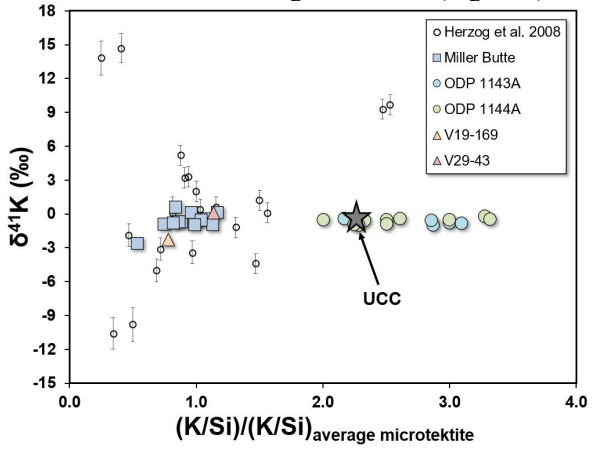

Figure 2. *$\delta^{41}K$ vs K/Si for Australasian microtektites measured in this study compared to those analyzed by [9]. Upper continental crust composition is from [11,12]*

Discussion: As seen in Figure 2, when compared to the previous Australasian microtektite K isotope data from [9], the total $\delta^{41}K$ variation seen in this study is significantly less. Additionally, essentially all the microtektites from [9] reside in the region of the low K samples from this study. Nevertheless, as all the samples from [9] come from the same region as V19-169, and V29-43 (the Indian Ocean), the two studies are consistent in K concentrations. The cause of the difference in $\delta^{41}K$ variability remains unknown, however it may be due to bulk versus *in situ* variability ([9] undertook *in situ* SIMS analyses), or sample selection.

The observed trend seen among both populations of lighter $\delta^{41}K$ values correlating with lower elemental concentration is consistent with condensation experiments [13]. This suggests the dominant process affecting the K isotopic variation observed in the Australasian microtektites measured here is K loss during incomplete condensation. For the ODP microtektites, the bulk UCC appears to represent the initial composition as expected. In contrast, for the more distant microtektite group, the starting composition is unknown. Yet, it appears to consist of a $\delta^{41}K$ composition much heavier than the UCC. Using a preliminary microtektite cooling rate model based off the model used for chondrules in [14], we calculate a cooling rate of ~3000 K/hr for the ODP microtektites measured in this study. This model was calculated using a peak temperature of 2273 K (maximum tektite peak temperature estimate [15]) and a starting composition of UCC. Due to the unknown starting composition of the distant microtektites, their cooling rate was not able to be modeled.

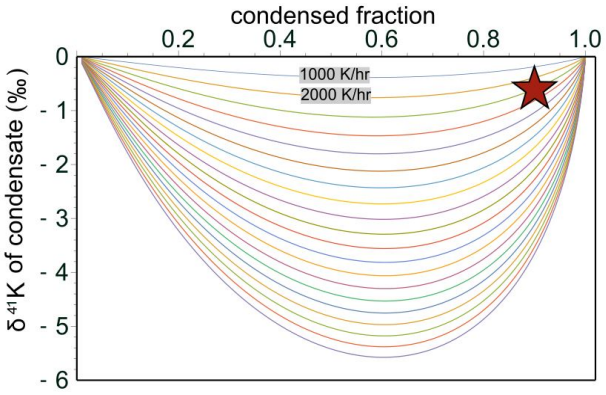

Figure 3. *Isotopic fractionation versus condensed fraction for the ODP microtektites in this study. The red star represents the most fractionated ODP microtektite ($\delta^{41}K$ difference to UCC of −0.63‰ and 90% fraction condensed).*

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