CONSTRAINING SHOCK EFFECTS ON THE K-Ar SYSTEM IN METEORITES : ANOMALOUS AGES AND IMPLICATIONS FOR SHOCK AGE INTERPRETATION

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Introduction: The impact history of the solar system is important for constraining solar system dynamics and solar system body surficial processes. Impact history is recorded in shock metamorphism in meteorites which results in full to partial resetting of isotopic ages. Isotopic resetting is measured by $^{40}Ar/^{39}Ar$ step heating analyses and by UV laser ablation microprobe (UVLAMP) techniques. When using the $^{40}Ar/^{39}Ar$ system to date shock melted regions of meteorites, this can produce anomalously old impact ages [1-3]. This is a result of combined Ar retention and K loss [1-3]. In and around shock melted regions heterogeneity of the distribution of K, the parent isotope in the K-Ar system, has also been documented [4] but not related to $^{40}Ar/^{39}Ar$ impact age interpretations. Currently, we understand very little about the K-Ar system under shock pressure and temperature conditions. Our preliminary work on the meteorites Mbale and Yamato 75100 is the first to combine UVLAMP dating and detailed petrographic analyses to fully document the anomalous behavior of K and Ar in shocked samples and constrain how shock artifacts influence the K-Ar system.

Methods

Mbale is an L5/6 ordinary chondrite fall [5] with shock stages including S5 and S6 [6] and a bulk $^{40}Ar/^{39}Ar$ age of 479 ± 7 Ma [7]. Yamato 75100 (Y-75100) is an H6/S6 ordinary chondrite with an ancient and complex impact history, and a plateau age of 4,490 Ma [8]. Small blocks of Mbale and Y-75100 were used to make a 250 µm-thick slab and an opposing polished thin section. The thick slabs were irradiated for 100 hrs in Oregon State University's CLICIT reactor. After irradiation, the slabs were loaded into the UV laser chamber of an ultrahigh vacuum extraction line connected to a Nu Instruments Noblesse noble gas mass spectrometer. Argon was extracted from the slab using a Teledyne/Photon Machines Analyte Excite UV (193nm) laser. Data was reduced using the Mass Spec software (Al Deino, BGC) and reported with uncertainties at 2-sigma levels. The facing section was characterized with a JEOL JXA-8530F electron microprobe. We used backscattered electron (BSE) imaging and energy dispersive X-ray spectroscopy (EDS) to determine the mineralogy, crystallization textures, and for elemental mapping. We used wavelength dispersive X-ray spectroscopy (WDS) for quantitative chemical analyses. Lastly, we used detailed micro-raman spot analyses to determine sample mineralogy and confirm the presence of high pressure (HP) minerals within the melt vein.

Results & Discussion

We find anomalously old ages in shock melted regions of Mbale and Y-75100 75100, reproducing the anomalous behavior of Ar and K documented by McConville, 1988. In both samples we find preferential retention of Ar within the melt vein and vein age of up to 6845 ± 137 Ma in Mbale and 4680 ± 13 Ma in Y-75100. We also measure the K distribution to confirm that our $^{40}Ar/^{39}Ar$ ages are the result of K migration out of the melt where K is preferentially stored outside along the melt vein boundaries in plagioclase glass and is absent within the melt vein. With Raman spectroscopy we find that the melt vein in our sample of Mbale has abundant HP minerals, wadsleyite and majorite, that are preserved inside the melt vein. A relatively high solubility of Ar in silicate melts at high pressure [9], combined with rapid quench, traps Ar in the high-pressure mineral assemblage and expels K to nearby maskelynite at the melt vein boundary. We conclude that the presence of HP minerals in the shocked melt vein of Mbale creates a K-incompatible, Ar-compatible lithology, that when dated using $^{40}Ar/^{39}Ar$ techniques produces anomalously old ages. We posit that other meteorites with preserved HP mineralogy are likely to exhibit similar isotopic behavior in the K-Ar system which necessitates careful, in-situ observations and interpretation if shock age is to be inferred.

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References:

[1] Karageozian, M. E. et al. (2020). 51st LPSC, Abstract #2669. [2] Karageozian et al. (2021). 52nd LPSC, Abstract #2318. [3] McConville, P. (1988). *Geochimica et Cosmochimica Acta*, 52(10), 2487–2499. [4] Chen, M. and El Goresy, A. (2000). *Earth and Planetary Science Letters* 179(3–4), 489–502. [5] Wlotzka et al. (1993) *Meteoritical Society Bulletin* 75. [6] Hu & Sharp (2017) *Geochimica et Cosmochimica Acta* 215. 277–294. [7] Korochantseva et al. (2007) *Meteoritics & Planetary Science* 42, 113–130. [8] Swindle T., and Kimura M. (2008). *Meteoritics & Planetary Science Supplement* 43: A150–A150. [9] Jackson et al. (2021). *Earth & Planetary Science Letters* 553.