^{40}Ar-^{39}Ar age of an impact-melt lithology in lunar meteorite Dhofar 961

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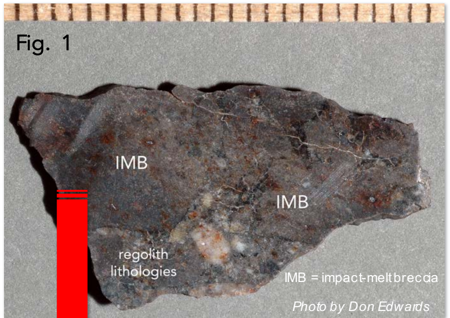
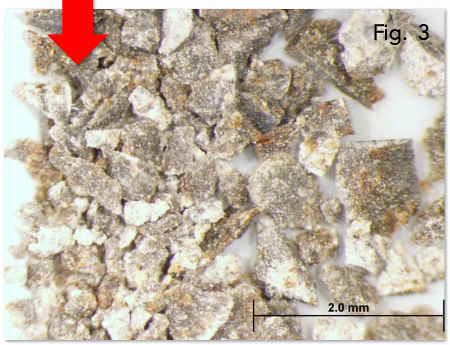




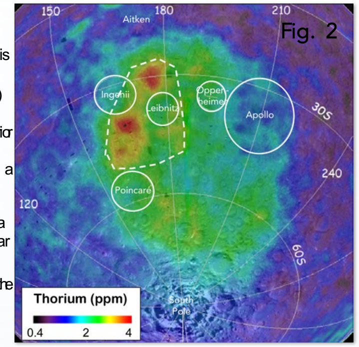
Background and Motivation

The Dhofar 961 lunar meteorite was found in 2003 in Oman. It is texturally paired with Dhofar 925 and Dhofar 960 (though Dhofar 961 is more mafic and richer in incompatible elements).

Several lines of reasoning point to the South Pole-Aitken Basin (SPA) basin as a plausible source (Figure 2):

- Mafic character of the melt-breccia lithic clasts consistent the interior of SPA, rules out feldspathic highlands.
- Compositional differences from Apollo impact-melt groups point to a provenance that is separated and perhaps far distant from the Procellarum KREEP Terrane
- SPA "hot spots" where Th concentrations reach 5 ppm and it has a broad "background" of about 2 ppm, similar to lithic clasts in Dhofar 961 subsamples

If true, impact-melt lithologies in this meteorite may be unaffected by the Imbrium-forming event that is pervasively found in our Apollo sample collection, and instead record the early impact history of the Moon.



Ar-Ar dating

We investigated a large clast of IM Lithology B in Dhofar 961 (~17% Al_2O_3, 12% FeO, and 10% MgO, distinctly more mafic than the Apollo mafic IMBs) (Figure 1) in the MNGRL laboratory (*see poster #2760 in this session for more details!*)

- Crushed into multiple aliquots weighing ~300 μg each (Figure 3)
- Irradiated in the University of Oregon TRIGA reactor cadmium-lined core position for 375 hours to achieve a J-factor of ~0.1
- ^{40}Ar-^{39}Ar dating of one unirradiated (-01) and two irradiated (-02 and -03) aliquots by high-resolution step heating (50 steps)

Conclusions

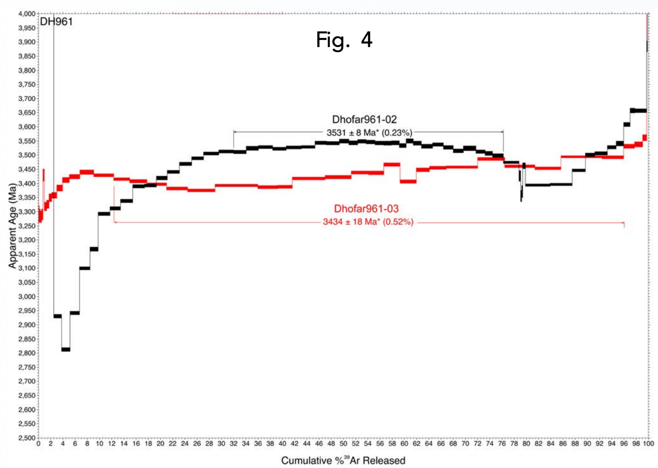
Impact melt age (weighted average) of **3532 ± 43 Ma**

Younger than any of the U-Pb ages reported for phosphates in this meteorite by Joy et al., 2014

- U-Pb ages are commonly slightly older than their Ar-Ar counterparts, having a higher closure temperature and being less susceptible to low-temperature losses.
- This particular IMB lithology was not sampled by Joy et al., so possible that this IMB could be the youngest in the meteorite

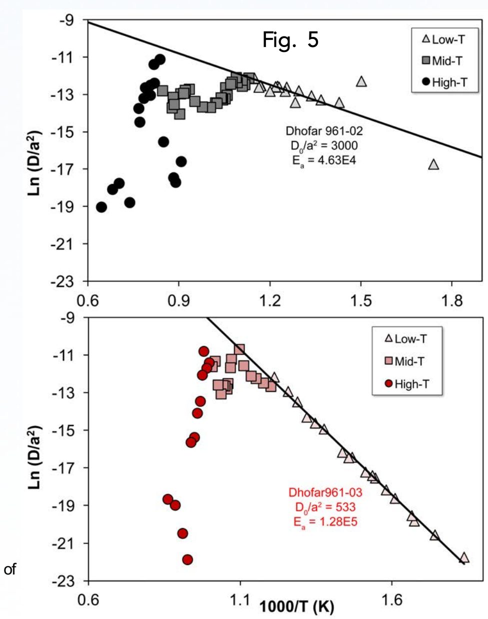
We have **several additional splits** to investigate of both the IMB and regolith, planning cyclic heating schedules to enable thermal diffusion studies of the impact melt lithology and cosmic-ray exposure age determinations for both lithologies

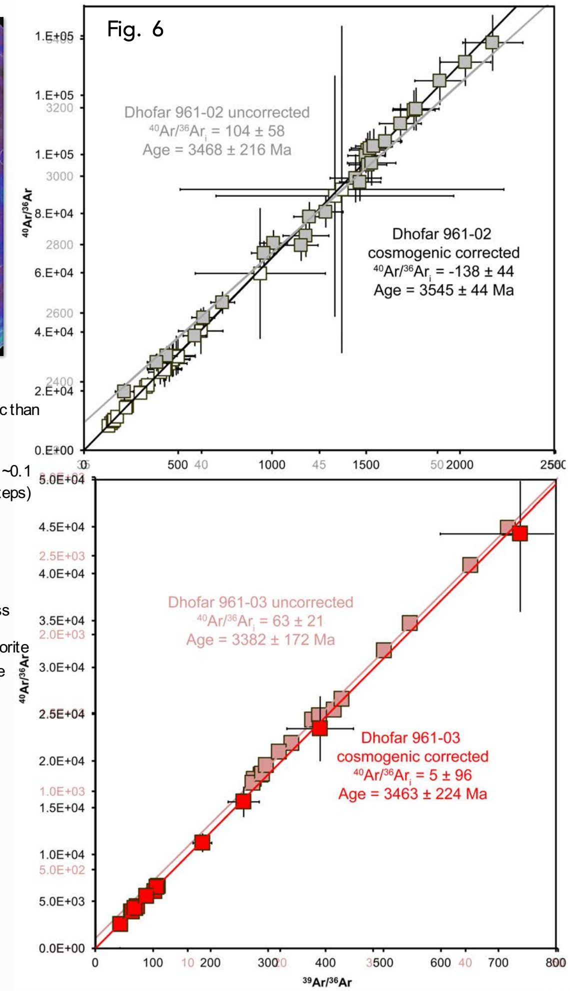
The range of mafic impact-melt ages within these meteorites needs to be further explored for clues to the impact history of the Moon in regions beyond where we have directly sampled



Results: Gas release profiles (Fig 4)

- Low-temperature steps consistent with Ar diffusive loss from the fine-grained matrix
- Broad (80% ^{39}Ar release) set of mid-T steps form a poor plateau in both splits but lie along a well-constrained isochron (Fig. 6)
- Upturn in apparent ages in the last 10% of ^{39}Ar degassing at high temperatures, likely related to recoil of ^{39}Ar into neighboring locations due to the long irradiation





Results: Cosmogenic and trapped gases (Fig 6)

- Both samples had relatively high initial $^{40}Ar/^{36}Ar$ ratio due to significant amounts of cosmogenically produced ^{36}Ar and ^{38}Ar
- Subtraction of the cosmogenic gases corrected nearly all the trapped component and brought the isochrons (only mid-T steps shown) in line with the plateaus (Fig. 6)

Results: Diffusion (Fig 5)

Y-intercept: $\ln(D_0/a^2)$ = pre-exponential factor for spherical geometry
Slope: $-E_a/R$ = activation energy
Steeper slope= higher activation energy

- Low-temperature steps in both samples exhibit a clear diffusive loss pattern (Fig. 5). The time of the loss on the lunar surface appears to be different between the two subsplits, but this effect needs to be verified with further subsplits.
- The mid-temperature steps do not show the same loss. Therefore, we used these mid-temperature steps in our isochron approach (Fig. 6) and to define the "plateau" age (Fig. 4)