AN ASSESSMENT OF SHOCK- AND IMPACT-RESETTING OF ARGON AGES AT THE MANICOUAGAN IMPACT CRATER, CANADA

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Introduction: In order to synthesize the context of impact events in the Solar System, they must be precisely and accurately dated. Unfortunately, this can frequently be challenging [1]. For Mars, dating impact events directly relates to our interpretation of ages from the martian meteorites. Measured ages for the basaltic shergottites appear to be unexpectedly young between ~150 and ~450 Ma and impact-resetting has been suggested [2-3 and refs therein] as an explanation. However there is not a consensus on this point.

We are testing whether there is impact resetting of $^{40}Ar/^{39}Ar$ ages at the Manicouagan Impact Structure by dating a variety of mineral separates including: 1) plagioclase from unshocked target rocks from the adjacent area, 2) maskelynite, 3) coherent impact-melt rocks, and 4) individual relict grains of the target that are now included within the clast-rich melt-breccias. Because these samples are complex – heterogeneously shocked, and in some cases polymict – samples were characterized with Raman and micro-FTIR spectroscopy prior to to irradiation for argon analyses to test for systematic variations with shock level.

Methods: Feldspar grains were hand-picked and analyzed with micro-Raman and micro-FTIR spectroscopy in the Vibrational Spectroscopy Laboratory at Stony Brook University. Raman spectra were collected using a WiTec alpha300R confocal imaging system equipped with 532 nm Nd YAG laser and a 50X objective. Micro-FTIR spectra were collected using a Nicolet iN10MX FTIR microscope, equipped with a liquid nitrogen-cooled MCT linear array detector capable of acquiring images between 715 and 7000 cm^{-1}, with a spatial resolution of 25 μm/pixel.

$^{40}Ar/^{39}Ar$ analyses were conducted in the Argon Geochronology for the Earth Sciences (AGES) Laboratory and Columbia University's Lamont-Doherty Earth Observatory using a Micromass VG 5400 mass spectrometerr. Samples were co-irradiated with Fish Canyon sanidine monitor and an additional internal standard. Samples were either fused in a single step with a CO2 laser or were wrapped in Ta-tube and incrementally heated with a diode laser.

$^{40}Ar/^{39}Ar$ Results: Unshocked feldspar grains from the surrounding country rocks yeield an integrated age of Mesoproterozoic with no evidence of younger disturbance. This is similar to earlier K-Ar work [4] indicating target rocks of Grenville age. Single-step heating of individual feldspars from coherent impact-melt samples yield a range of %radiogenic Ar, and form an isochron that gives a date of 215.6±0.4 Ma (1s), m.s.w.d,=1.9, n=35, with implied initial $^{40}Ar/^{36}Ar$ of 305±2 . Single-step fusion ages of maskelynite scatter between 450 and 600 Ma, and although there is a wide range of $\%^{40}Ar^*$, they do not fall on an isochron. Step-heating experiments of the maskelynite yield a plateau age of 569±6 Ma, m.s.w.d.=3, but also reveal a compositional control on the systematics suggested by a significant correlation between Ca/K and apparent age. Clasts from within the impact melt give variable ages between 320 and 400 Ma.

Discussion: We interpret the 215.6 Ma age of melt feldspars as the time of impact, as it is in agreement with both the U-Pb zircon age [5] and with the (U-Th)/He age [6]. Xenocrystic grains and clasts within the impact melt-rock yield ages that are older than the impact, in some cases by more than 100 Ma. This result is different from (U-Th)/He analyses of xenocrystic zircons in the impact melt at Manicouagan [6]. The (U-Th)/He ages of zircons from Haughton and Mistastin [7] are also completely reset to the time of impact. Our $^{40}Ar/^{39}Ar$ work suggests that while (U-Th)/He in zircons can be reset by conductive heating from the impact melt, there is either insufficient heat or time to fully reset $^{40}Ar/^{39}Ar$ in feldspars.

Maskelynite grains appear to be partially reset. Although a plateau can be formally defined (>50% of the Ar-39 and >3 steps), this age is between that of the impact age of 215.6, and the Mesoproterozoic target age. Interestingly, the step-heating experiments reveal some compositional variations with apparent age, and this could be due to different retention of different composition or possible different susceptibility to excess $^{40}Ar^*$.

Importantly, this suggestets that maskelynite may not be a reliable phase for argon chronology, even when there is an apparent plateau age. As illustrated at Manicouagan, the calculated age does not reflect the timing of either the impact or pre-impact geologic events.

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