SHERGOTTITES OF THE AMAZONIAN. J.M.D. Day[1], C.B. Agee[2], C.D.K. Herd[3], G.H. Howarth[4], A.J. Irving[5], T.J. Lapen[6], C. Peel[4]. [1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92093; [2]University of New Mexico, Albuquerque, NM 87131; [3]University of Alberta, Edmonton, Alberta T6G 2E3, Canada; [4]University of Cape Town, Rondebosch 7701, South Africa; [5]University of Washington, Seattle, WA 98195; [6]University of Houston, Houston, TX 77204.

Introduction: Shergottite meteorites provide insights into a range of martian processes, including the nature of mantle sources within Mars. Shergottites span crystallization ages from at least the early (~2.4 Ga [1,2]) to the late Amazonian (≥0.15 Ga [3]), have a range of bulk rock compositions (4 to 30 wt.% MgO), and span time-integrated Sr, Nd, and Hf isotopic variations unrivalled by terrestrial or lunar basaltic analogues [4]. Of particular note, shergottites have been crucial for establishing metal-silicate equilibrium processes and the likely extent of late accretion experienced within Mars, which appears proportionally similar to that of Earth [5-8]. In this study the nature of martian mantle processes are further considered through the lens of shergottites spanning the Amazonian period of Mars.

Samples and Methods: New bulk rock major- and trace-element abundance data are reported for 12 hot desert meteorite shergottite finds (Northwest Africa [NWA] 2046, 4468, 4925, 7635, 8159, 8657, 10416, 10169, 10818, 13327; Dar al Gani 670, 735). Samples chips were powdered and prepared using methods in [4]. At the time of abstract submission, six samples have been measured for ^{187}Re-^{187}Os and highly siderophile element (HSE: Os, Ir, Ru, Pt, Pd, Re) abundances using methods in [5]. These include unleached, MQ- and HCl-leached measurements of bulk rock powders from NWA 10416.

Results: Major- and trace-element abundances determined for the early Amazonian shergottites NWA 7635 and NWA 8159 are consistent with reported data [1,2]. In general, the new data provide further support that, of shergottites formed in the later Amazonian (<0.6 Ga), enriched varieties are generally higher in total alkalis for a given SiO_2 content than intermediate or depleted shergottites (*Fig. 1*). In contrast, early Amazonian shergottites are depleted (*Fig. 2)*, yet have high total alkalis, with high Na/K. Rare earth element (REE) abundances determined for the new samples are consistent with previously determined shergottite groupings (e.g., [1-4]), although two of the analyzed meteorites have unusual Ce anomalies (NWA 4925 & 10416; see [9] for details).

The HSE abundances of most of the studied samples are consistent with previously reported data for shergottite meteorites [5,7,8] (*Fig. 3*), however, NWA 13327 is unusual in having high Pt+Pd/Ir+Ru+Os reminiscent of MORB or alkali OIB type lavas from Earth [10]. Leaching of NWA 10416 with HCl led to significant loss of Re. Otherwise the HSE abundance variations are consistent with nugget-effects within sample powders. Measured Os isotope compositions range from 0.1233 to 0.2164, with the most radiogenic measured value in NWA 13327, which also has the highest ^{187}Re/^{188}Os of the samples (*Fig. 4*).

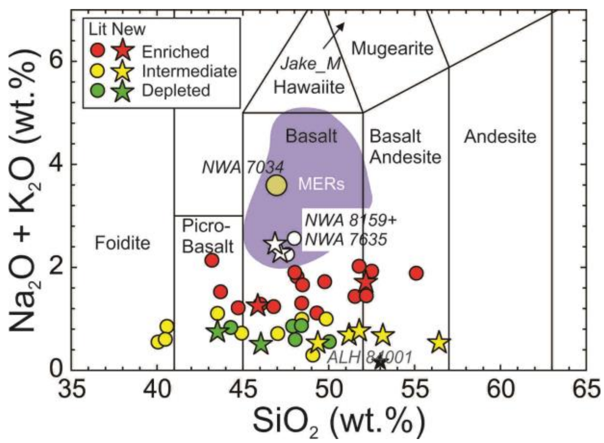

***Fig. 1**: Total alkalis vs. silica diagram for enriched, intermediate and depleted shergottites from this study [New] and from literature [4]. Also shown are new and published compositions of NWA 8159 and NWA 7635 [1,2], NWA 7034, ALH 84001 and Mars exploration rover (MERs) compositions.*

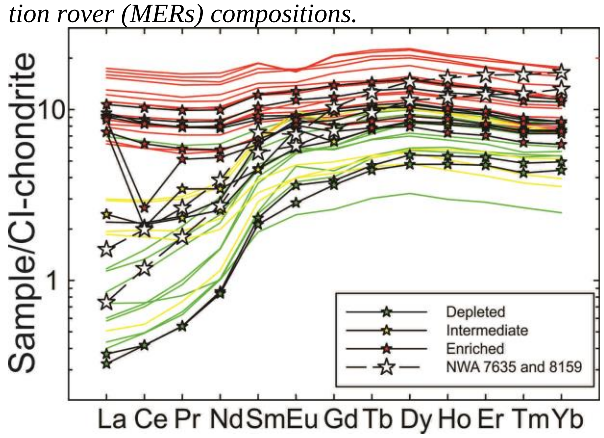

***Fig. 2**: REE patterns for data for new (stars) and published shergottites [4].*

Discussion: Shergottite meteorites now provide coverage across the Amazonian, albeit sampling of the full period is incomplete, notably for the late (<0.15 Ga) and middle to early (0.7-2.4 Ga) period.

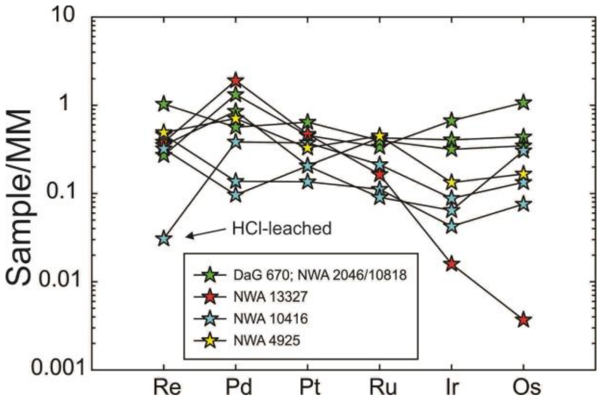

Fig. 3*: Martian mantle normalized [5] abundances for samples measured for HSE (data for NWA 8159 & 7635 forthcoming).*

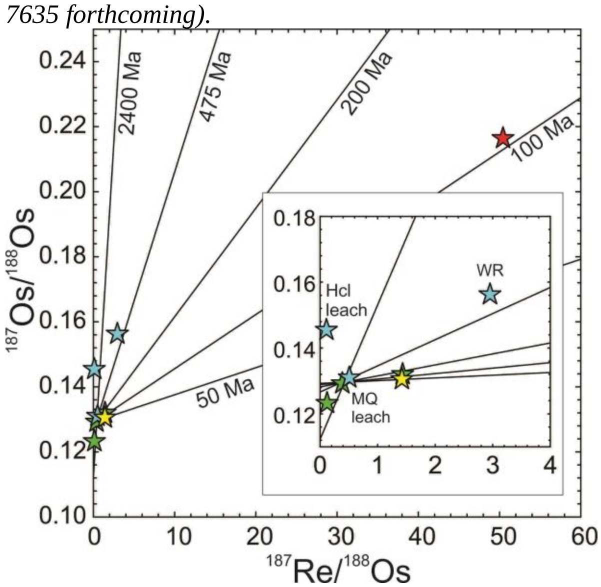

Figure 4*: ^{187}Re-^{187}Os diagram for shergottites reported in this study, showing isochron lines assuming chondritic initial compositions in early Amazonian (2.4 Ga) through to 50 million years before present.*

The new data are consistent with enriched shergottites spanning a significant range in MgO contents and showing significant fractionation of the HSE through crystal-liquid separation processes during magmatic evolution of their parent melts (e.g., [5]). In the case of enriched shergottite NWA 13327, it has a strongly fractionated HSE pattern and high Re/Os, corresponding to an isochron of ~0.1 Ga (*Fig. 4*). In contrast, late Amazonian depleted and intermediate shergottites tend to be MgO-rich (>12 wt.%) and have relatively flat chondrite-relative HSE patterns. In this sense, the early Amazonian depleted shergottites NWA 7635 and 8159 are distinct in having low MgO (~4 wt.%) and determining their Re-Os isotope and HSE abundance compositions will further understanding of the evolution of depleted shergottite mantle sources within Mars.

Shergottites of the Amazonian provide an important archive of the evolution of the martian mantle. This is the case for radiogenic isotopes including Sr, Nd, Hf [1,2] or Os, but also for major-, minor- and trace-element abundance variations. For example, a feature of shergottites and the breccia NWA 7034 is that for a similar range in SiO_2 contents, they span a range in total alkali contents (*Fig. 1*). Excluding, ALHA 84001 (intrusive cumulate), there is a progressive decrease in total alkalis in broadly basaltic martian rocks with time (*Fig. 5*).

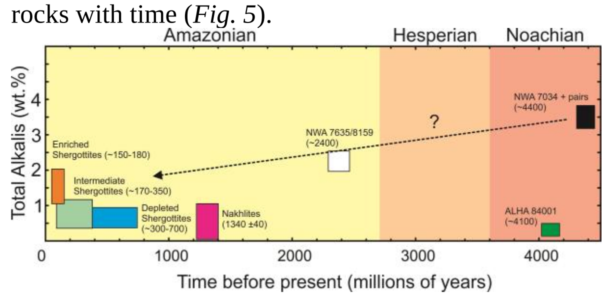

Fig. 5*: Crystallization ages versus total alkalis contents for martian meteorites.*

Several possibilities exist for such a trend, including complex magmatic processes. A simple possibility to explain a decrease in Na and K in martian magmas with time is that earlier magmatic processes on Mars exhausted these incompatible elements, enriching them in the martian crust and depleting them in the mantle. If so, lack of crustal recycling into the martian mantle would lead to progressive 'drying out' of its interior, and late Amazonian intermediate and depleted shergottites, as well as middle Amazonian nakhlites, are recorders of such a process. In contrast, late Amazonian enriched shergottites may represent unmelted 'enriched blobs' within the mantle, or even deep-derived, enriched cores, sheathed by previously depleted material, of mantle plumes reaching the surface of Mars.

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