OVERVIEW OF SHERGOTTITE LITHOLOGIES EJECTED FROM MARS AT 1.1 MA

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Introduction: A 1.1. Ma ejection event launched at least 13 incompatible trace element (ITE)-depleted shergottites, which have crystallization ages spanning 0.347 to 2.4 Ga, from the surface of Mars [1, 2]. This ejection event is currently one of perhaps 11 recognized ejections groupings of martian meteorites [1]. Specimens with 1.1 Ma ejection ages (which is the sum of cosmic ray exposure and terrestrial residence ages) include: Dar al Gani (DaG) 476, Larkman Nunatak (LAR) 12095/12240, Northwest Africa (NWA) 1195, NWA 2046, NWA 2626, NWA 4925, NWA 5789, NWA 6162, NWA 7635, NWA 8159, Sayh al Uhaymir (SaU) 005, Tissint, and Yamato-980459 (Y-98). Other shergottite specimens with similar textures and trace element concentrations, including NWA 10416, NWA 10693, NWA 12450, NWA 13467, NWA 4222, and SaU 002 [17, 19, 20], may also have 1.1 Ma ejection ages, but results for them are not yet available. Examining the igneous and metamorphic textures, geochemistry, and ages of this suite of rocks presents a unique opportunity to understand the evolution of ITE-depleted mantle sources, emplacement, shock features, and duration of magmatism from an igneous pile partially excavated by a single ejection event.

Petrography: In general, these launch-paired specimens are porphyritic and composed of olivine and/or pyroxene megacrysts surrounded by a groundmass of silicate minerals (plagioclase/maskelynite, orthopyroxene, pigeonite, augite), sulfides (pyrrhotite; with the exception of NWA 8159), phosphates (apatite, merrillite), and oxides (spinel, ilmenite, ulvospinel) [3,9-16]. It is noted that these megacrysts can be xenocrysts, phenocrysts, or antecrysts [1]. Several comparative studies have been conducted on specimens with similar bulk composition, crystal size, and mineralogy but upon further inspection had several differences. For example, NWA 1195 and NWA 2046 both have orthopyroxene megacrysts that have a preferred orientation; however, they differ in crystal size and degree of compositional zoning [13]. NWA 7635 and NWA 8159 are both ~2.4 Ga in age and lack the presence of pigeonite [18] but differ in their texture and perhaps some isotopic compositions. DaG 476 and SaU 005 have very similar bulk compositions and crystal sizes, but SaU005 is more iron rich based on the absence of magnesian orthopyroxene and olivine core composition [15]. Despite the numerous chemical similarities between NWA 5789 and Y-98 they differed in mesostases features [11]. These data are essential in developing a volcanic stratigraphy model and possibly a terrestrial analog.

Crystallization Ages: Not all specimens have been assigned a radiogenic igneous crystallization age, including NWA 6162, NWA 4925, NWA 2046, NWA 2626, NWA 5789, LAR 12095/12240. Crystallization ages determined by Sm-Nd include, NWA 1195 (347 ± 13 Ma) [3], SaU005 (445 ± 18 Ma) [4], Y-980459 (472 ± 47 Ma) [5], DaG 476 (474 ± 11 Ma) [6], Tissint (590 ± 49 Ma) [7], NWA 8159 (2370 ± 250 Ma) [18], and NWA 7635 (2403 ± 140 Ma) [2]. Assigning crystallization ages using the Rb-Sr system has been attempted [3-6] but was unsuccessful due to the susceptibility to alterations and terrestrial contamination from the surrounding terrestrial terrain. Leaching attempts were not successful in removing calcite precipitated in the Saharan desert which uptakes Sr [6], and mafic minerals pyroxene and olivine have been observed to accumulate Sr during alteration [8]. Tissint has bypassed these analytical challenges because it was quickly retrieved as a fall and avoided possible terrestrial weathering and contamination.

Radiogenic Isotopes: ITE compositions in concert with chronology can reveal how mantle sources have varied over time. One would assume that, with progressive melting of the mantle source(s), emplacement of the melts in the crust, and lack of crustal recycling (subduction), a succession of rock would become more depleted with time. Except for Tissint, this trend is observed, even with some ITE-depleted specimens that are not launch paired. Thus, it is likely that the mantle plume may locally become progressively depleted, but the plume structure is complex. Whether this indicates source variability or source depletion trends is important in understanding the distribution of depleted and enriched components in the Martian mantle.

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