UNRAVELING THE CRYSTALLIZATION HISTORY OF POIKILITIC SHERGOTTITE NORTHWEST AFRICA 12002.

S. Benaroya1 and C. D. K Herd2, 1Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada. E-mail: benaroya@ualberta.ca

Introduction: Poikilitic shergottites are olivine and pyroxene-rich cumulate rocks, representing a significant (~20%) proportion of the Martian meteorite collection [1]. These samples increase our understanding of the martian interior, as they have undergone a polybaric crystallization process leading to a bimodality in texture, consisting of poikilitic regions that formed at depth and non-poikilitic regions that typically formed closer to the surface [1, 2]. Here, we present data on the petrology and mineral chemistry of the poikilitic shergottite Northwest Africa (NWA) 12002, a find from 2017.

Methods: A thin section of the sample was analyzed using the JEOL JXA-8900 EMPA at the University of Alberta (UAb) with quantitative point analyses of mineral grains obtained using a 20 kV accelerating voltage and a beam current of 30 nA. Elemental X-ray mapping was done using the Cameca SX100 EMPA at UAb with a 15 kV accelerating voltage and 100 nA beam current. The modal mineralogy of the sample was determined using X-ray maps of Mg, Fe, Ca, Cr, Ti, and P in ImageJ.

Results and Discussion: NWA 12002 is coarse-grained and displays a bimodal texture consisting of poikilitic regions where pyroxene oikocrysts, typically augite (1 – 3 mm), enclose olivine (~250 μm) and Fe-Cr-Ti oxides, typically chromite (10 – 100 μm) chadacrysts. The non-poikilitic regions consist of pyroxene (0.6 – 1 mm), olivine (120 – 1000 μm), and maskelynite (formerly plagioclase; ~1 mm) phenocrysts, along with matrix pyroxene, olivine, maskelynite, Fe-Cr-Ti oxides (150 – 350 μm), phosphates (150 – 300 μm), and minor sulfides. Larger olivine phenocrysts typically contain melt inclusions and occasional pigeonite inclusions. The modal mineralogy is ~43 vol.% olivine, ~33 vol.% pyroxene, ~20 vol.% maskelynite, ~3 vol.% Fe-Cr-Ti oxides, ~2 vol.% phosphates, and minor sulfides, similar to other poikilitic shergottites [2].

Mineral chemistry. Pyroxene in NWA 12002 is characterized by patchy zoning of major elements, particularly when grains contain olivine chadacrysts. Grains are sub to anhedral, and those that do not display patchy zoning consist of high-Ca pyroxene cores of composition Wo32En49 with thin low-Ca pyroxene rims (Wo32En40). The most magnesian pigeonite has a lower Mg#71-72 than coexisting augite Mg#73-74 (Fig. 1A). Generally, in poikilitic shergottites, augite and pigeonite co-crystallize, and have similar Mg#’s; if only one pyroxene compositional type is present in poikilitic regions, it is pigeonite [2], not augite. This suggests that NWA 12002 may be missing earlier formed pigeonite or formed under different conditions than other poikilitic shergottites. Non-poikilitic pyroxene grains overlap compositionally and in size with poikilitic grains (Fig. 1A). Olivine chadacrysts show resorption textures as well as slight Fe-Mg variation with Mg#61-66, while phenocrysts in non-poikilitic regions are subhedral and show extensive subsolidus re-equilibration with Mg#59-62 (Fig. 1B), and no compositional zoning except for a slight enrichment (0.1 wt.%) of CaO in the centers of grains, and fine-scale phosphorus zoning in the rims. Olivine chadacrysts show a depletion in CaO compared to the phenocrysts, which is interesting as CaO content is typical uniform for both olivine chadacrysts and non-grains in poikilitic olivine in poikilitic shergottites [2].

Crystallization conditions. The Ti/Al ratio of high-Ca pyroxene grains indicates that the sample began crystallizing in the upper mantle/lower crust. The fO2 of the sample was calculated using the olivine-pyroxene-spinel oxybarometer [3]. The early fO2 is ~2.8 units below the Quartz-Fayalite-Magnetite (QFM) buffer, which increases to ~QFM-2.1 once plagioclase crystallizes, with a late-stage fO2 of QFM-1.4; within range of other poikilitic shergottites [2]. Chromite and olivine were the first phases to crystallize, followed by high-Ca pyroxene, which led to the formation of the poikilitic texture in the sample, although various non-poikilitic high-Ca pyroxene grains also formed. Low-Ca pyroxene began crystallizing soon after, along with plagioclase. The large size of olivine phenocrysts suggests initial formation at depth, possibly concurrent with the low-Ca pyroxene, leading to the uptake of CaO content in olivine phenocrysts. Fe-Ti oxides, phosphates and sulfides were the last phases to crystallize.