

**PETROGENESIS OF THE ENRICHED SHERGOTTITE NORTHWEST AFRICA 7320: A NEW MARTIAN GABBROIC SAMPLE.** A. Udry<sup>1</sup> and G. H. Howarth<sup>2</sup>, <sup>1</sup>Department of Geoscience, University of Nevada Las Vegas, Las Vegas NV, USA. <sup>2</sup>Department of Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa.

**Introduction:** The shergottite Northwest Africa (NWA) 7320 was recovered in Zagora (Morocco) in 2011 and has no known paired meteorites. NWA 7320 is classified as a gabbroic shergottite solely based on its coarse-grained texture. Here we present the mineralogy and petrographic characteristics of NWA 7320, suggesting that this shergottite is an intrusive martian sample.

**Analytical methods:** *In situ* major and minor element compositions were measured using the JEOL JXA-8900 electron microprobe (EMP) at the University of Nevada, Las Vegas. Mineral compositions were determined using an accelerating voltage of 15 kV, beam current of 20 nA, and beam sizes of 1-5  $\mu\text{m}$ . Mosaic element maps were obtained using 15 kV and 60 nA current and were used to measure the phase modal abundances. *In situ* trace element compositions were measured using the New Wave UP213 solid-state laser ablation system attached to a Thermo-Fisher X-series II quadrupole ICP-MS at the University of Cape Town with beam sizes ranging from 55  $\mu\text{m}$  for silicates to 40  $\mu\text{m}$  for phosphates.

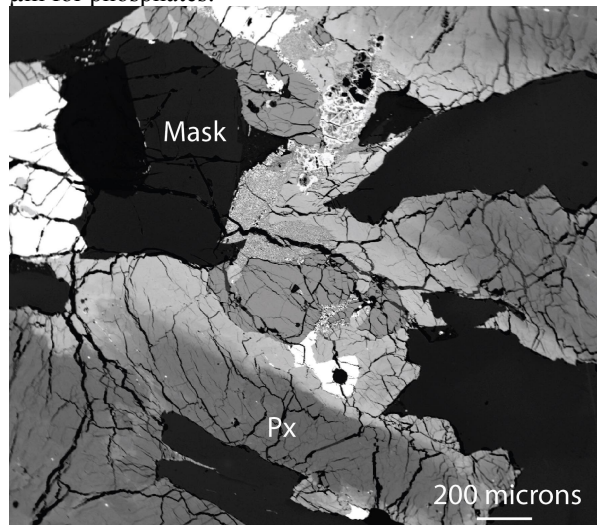


Fig. 1: Backscattered electron image of NWA 7320. Px = Pyroxene and Mask = Maskelynite.

**Petrography and mineral chemistry:** The shergottite NWA 7320 shows a phaneritic texture and is composed of a complexly zoned pyroxene (47%), subhedral to lath-shaped maskelynite (shocked plagioclase: 51%), silica (1%), and merrillite (1%), with minor amount of ferroan olivine, ilmenite, titanomagnetite, and apatites (Fig. 1). Terrestrial calcite and barite are also present in veins. NWA 7320 pyroxenes are elongated

with long-axes up to 3 mm long. They show a complex patchy zoning with pigeonite cores (from  $\text{Wo}_{10}\text{En}_{49}\text{Fs}_{41}$  to  $\text{Wo}_{20}\text{En}_{21}\text{Fs}_{59}$ ), subcalcic augite mantles (between  $\text{Wo}_{21}\text{En}_{20}\text{Fs}_{59}$  and  $\text{Wo}_{37}\text{En}_{39}\text{Fs}_{24}$ ), and pyroxferroite rims (from  $\text{Wo}_{20}\text{En}_{17}\text{Fs}_{61}$  to  $\text{Wo}_{14}\text{En}_4\text{Fs}_{82}$ ) (Fig. 2). Pigeonite cores or augite mantles are not always present and often display irregular boundaries. Augites are slightly more enriched in Rare Earth Elements (REE) than the pigeonites (Fig. 3a). The maskelynite compositions range from  $\text{An}_{40}$  to  $\text{An}_{61}$  and display a large positive Eu anomaly ( $\text{Eu}/\text{Eu}^* = 2 \cdot \text{Eu}/(\text{Sm} + \text{Gd}) = 65$ ). Merrillite is the major carrier for REE in NWA 7320 (Fig. 3a).

Three phase-symplectites (hedenbergite + olivine + silica) were also observed in NWA 7320. The three-phase symplectite is thought to form after pyroxferroite breaks down during slow cooling ( $>1000^\circ\text{C}$  for three days) [5].

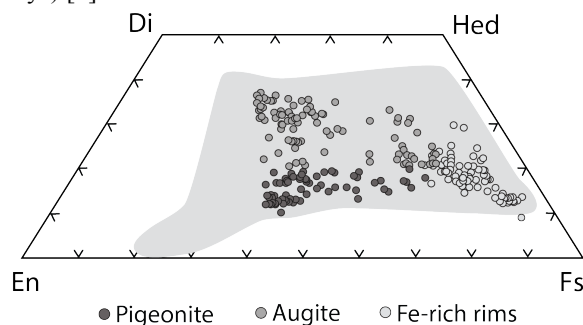


Fig. 2: Pyroxene quadrilateral with NWA 7320 pigeonite, augite, and Fe-rich rim major element compositions with envelopes from NWA 5298, QUE 94201, NWA 480, and Los Angeles [1-4].

#### Discussion:

##### NWA 7320 Oxygen fugacity

Oxygen fugacity was calculated using ilmenite-titanomagnetite pairs by applying both Ca-QUILF model [6] and the Ghiorso-Evans model [7]. We obtained an average  $f\text{O}_2$  at the Fayalite-Magnetite-Quartz (FMQ) buffer with Fe-Ti temperature of  $963^\circ\text{C}$  using the Ghiorso-Evans model and an equilibrium temperature of  $840^\circ\text{C}$  using the Ca-QUILF model. This represents the late assemblage oxygen fugacity.

##### REE bulk composition

The REE bulk composition of NWA 7320 was calculated using the modal abundances of the major phases and is represented in Figure 3. NWA 7320 bulk REE

composition shows a relatively flat profile, showing that this meteorite is an enriched shergottite with  $(\text{La/Lu})_{\text{CI}} = 0.6$  (Fig. 3). In addition, a large positive Eu anomaly ( $\text{Eu/Eu}^* = 2.2$ ) was observed, suggesting that NWA 7320 shows accumulation of plagioclase during fractionation of parental magma. Thus, NWA 7320 likely represents an intrusive sample of the martian crust, as also implied by its very coarse-grained texture and slow cooling suggested by presence of symplectite. The negative Ce-anomaly observed in the bulk REE profile likely indicates subsequent terrestrial alteration in hot desert environment as suggested by [8]. The NWA 7320 bulk rock composition is overall depleted in REE compared to the enriched shergottites Los Angeles and NWA 5298, which both display similar pyroxene composition and texture to NWA 7320. However, only NWA 7320 displays a large Eu positive anomaly.

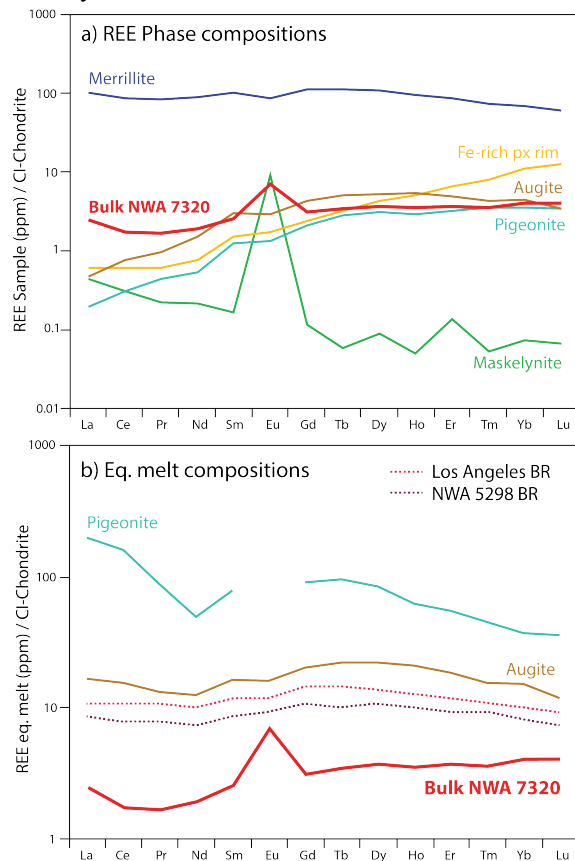


Fig. 3: a) Rare Earth Element profiles of the different NWA 7320 phases. The bulk-rock composition was calculated using modal abundances. b) REE profiles of melt in equilibrium with pigeonite and augite and bulk rock REE compositions of NWA 5298 [1] and Los Angeles [10].

Open-system crystallization is also suggested by the REE composition of melts in equilibrium with the different NWA 7320 phases, which were calculated using partition coefficients from [9]. NWA 7320 pigeonite displays the highest Mg# and is the first crystallizing phase in NWA 7320 magma. The melt in equilibrium with this phase does not match the bulk rock composition, which indicates that NWA 7320 does not represent a liquid.

**Summary:** NWA 7320 is an enriched gabbroic shergottite that underwent slow cooling and accumulation of plagioclase. NWA 7320 is one of the first intrusive samples from Mars along with the NWA 6963 shergottite studied by [11-12].

#### References:

- [1] Hui et al. (2011) *MAPS*, 46, 1313-1328.
- [2] McSween et al. (1996) *GCA*, 60, 4563-4569.
- [3] Barrat et al. (2002) *MAPS*, 37, 487-499
- [4] Warren et al. (2004) *MAPS*, 39, 137-156.
- [5] Aramovich et al. (2002) *Am. Min.*, 87, 1351-1359.
- [6] Andersen et al. (1993) *Computers & Geosciences*, 19, 1333-1350.
- [7] Ghiorso and Evans (2008) *Am. Journ. of Science*, 308, 957-1039.
- [8] Wadhwa et al. (1994) *GCA*, 58, 4213-4229.
- [9] Lundberg et al. (1990) *GCA*, 54, 2535-2547.
- [10] Jambon et al. (2002) *MAPS*, 37, 1147-1164.
- [11] Filiberto J. et al. (2014) *Am. Min.*, 99, 601-606.
- [12] Gross J. and Filiberto J. (2014) LPSC XLV, Abstract #1440.