

**NORTHWEST AFRICA 5298: A BASALTIC SHERGOTTITE.** Hejiu Hui (hui@lpi.usra.edu)<sup>1</sup>, Anne Peslier<sup>2,3</sup>, Thomas J. Lapen<sup>4</sup>, Alan Brandon<sup>3</sup>, and John Shafer<sup>1</sup> <sup>1</sup>Lunar and Planetary Institute, USRA-Houston, Houston, TX 77058, <sup>2</sup>Jacobs Technology, ESCG, Houston, TX 77058, <sup>3</sup>ARES, NASA-JSC, Mail Code KR, Houston, TX 77058, <sup>4</sup>Department of Earth and Atmospheric Sciences, University of Houston, Houston, TX 77204.

**Introduction:** NWA 5298 is a single 445 g meteorite found near Bir Gandouz, Morocco in March 2008 [1]. This rock has a brown exterior weathered surface instead of a fusion crust and the interior is composed of green mineral grains with interstitial dark patches containing small vesicles and shock melts [1]. This meteorite is classified as a basaltic shergottite [2]. A petrologic study of this Martian meteorite is being carried out with electron microprobe analysis and soon trace element analyses by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Oxygen fugacity is calculated from Fe-Ti oxides pairs in the sample. The data from this study constrains the petrogenesis of basaltic shergottites.

**Samples and analyses:** A thick section of Martian meteorite NWA 5298 was examined using a Cameca SX100 electron microprobe at NASA-Johnson Space Center. The microprobe analyses, calibrated with natural and synthetic standards, were carried out using 15 kV accelerating voltage and 20 nA current for spot measurements and 40 nA for mosaic element mapping. The latter (for Si, Ti, Al, Fe, Mg, Ca, Na, K, P, S, and Cr) were used for estimating the modal proportion of minerals. Line measurements were adopted to analyze the chemical composition of pyroxene because of its large grain size and complex chemical zoning. Other mineral grains were analyzed point by point with an aperture size of 1  $\mu\text{m}$  (or 10  $\mu\text{m}$  for some components, such as silica, maskelynite).

**Petrology and mineralogy:** This basaltic shergottite is mainly composed of large elongated pyroxene grains with very complex chemical zoning, and vesicular, extensively devitrified plagioclase glass (maskelynite) in lath shape [2]. In our thick section, a foliated texture is produced by partial alignment of pyroxene prisms with interstitial maskelynite and other phases (Fig. 1). This fabric is essentially similar to those shown in other basaltic shergottites [3], and may be explained by a crystal accumulation model [e.g., 4].

The pyroxene grains (core to rim, Fe/Mn = 26.3 to 37.9, Mg/(Mg+Fe) = 0.65 to 0.13) are compositionally zoned from subcalcic augite cores to pigeonite mantles to ferropigeonite rims. For instance, composition in one pyroxene grain varies from core to rim from  $\text{Fs}_{25.6}\text{Wo}_{27.8}$  to  $\text{Fs}_{44.3}\text{Wo}_{22.5}$  to  $\text{Fs}_{58.9}\text{Wo}_{22.6}$  to  $\text{Fs}_{71.5}\text{Wo}_{18.3}$ . These compositional variations may

record cumulate formational processes in the shergottitic magma reservoir. The 100 to 200  $\mu\text{m}$  edges of pyroxene grains are not systematically zoned but instead consist of highly irregularly shaped amoeboid patches of different compositions. This may indicate crystal dissolution/resorption or subsolidus reaction possibly associated with new fluids entering into the parent magma reservoir of this shergottite. Some maskelynite grains ( $\sim\text{An}_{51.9}\text{Or}_{2.8}$ ) show a K-enrichment at the rims with from core to rim  $\text{An}_{52.7}\text{Or}_{1.6}$  to  $\text{An}_{47.4}\text{Or}_{9.5}$  in one grain. This may result from a vapor phase being absorbed by silicate melt [5]. Silica grains occur adjacent to the maskelynite grains and oxide minerals. The oxide minerals in NWA 5298 are ilmenite ( $\text{Ilm}_{87.4}\text{Hem}_{9.3}\text{Gk}_{2.0}\text{Py}_{1.3}$ ) and titanomagnetite ( $\text{Usp}_{62}\text{Mt}_{34}\text{Sp}_{1.5}\text{Chr}_{0.6}$ ). Ilmenite occurs both as anhedral grains intergrown with titanomagnetite and as thin lamellae within titanomagnetite as shown in Fig. 2 and are located within pyroxene or between pyroxene and maskelynite. Other types of minerals found so far in this section are phosphates, pyrrhotite, and silica.

**Oxygen fugacity:** Oxygen fugacity can be derived from various mineral composition and assemblages, such as Eu in pyroxene mineral (e.g., [6], [7]), or olivine-pyroxene-spinel (Ol-Px-Sp) oxygen barometer (e.g., [8], [9]), or Fe-Ti oxides oxygen barometer (e.g., [10], [11]). A detailed comparison between these three oxygen barometers made by Herd et al. [9] suggests that the Martian meteorite oxides record magmatic oxygen fugacity.

As shown in Fig. 2, ilmenite occurs as thin lamellae within titanomagnetite and this made probing titanomagnetite without interference from ilmenite lamellae difficult. Only the part of titanomagnetite grain without ilmenite lamellae but adjacent to ilmenite mineral was selected for determining oxygen fugacity. Our primary results show that the oxygen fugacity of NWA 5298 during crystallization of oxide minerals essentially at Quartz-Fayalite-Magnetite (QFM) buffer curve and the temperature is 1002°C using the Fe-Ti oxides geothermobarometer [11]. The calculated oxygen fugacity makes this shergottite among the most oxidized ones [10]. The presence of quartz in contact with Fe-Ti oxides is consistent with  $\Delta\text{FMQ} = 0$ . Oxygen fugacity may change through the differentiation of magma from the early stage to the late stage in the

magma reservoir [12]. Fe-Ti oxide minerals typically crystallized after the crystallization of pyroxene and plagioclase; hence the oxygen fugacity of the melt during the crystallization of these two minerals crystallization may have been more reduced.

**Conclusion:** Martian meteorite NWA5298 is a moderately-evolved “enriched” shergottite. It may be the most oxidized Martian meteorite found to date.

**References:** [1] Weisberg M. K. et al. (2008) *Meteoritics & Planet. Sci.*, 43, 1551-1588. [2] Irving A. J. and Kuehner S. M. (2008) Meteoritical Soc. Meeting, # 5332. [3] McSween H. Y. Jr. and Treiman A. H. (1998) *Rev. Mineral.*, 36, (6)1-53. [4] Stolper E. M. and McSween H. Y. Jr. (1979) *GCA* 43, 1475-1498. [5] El Goresy A., Wopenka B., Chen M. and Kurat G. (1997) Meteoritical Soc. Meeting, # 5037. [6] McKay G. D. (1989) *Rev. Mineral.*, 21, 45-77 [7] Wadhwa M. (2001) *Science*, 291, 1527-1530. [8] Wood B. J. (1991) *Rev. Mineral.*, 25, 417-431. [9] Herd C. D. K. et al. (2002) *GCA* 66, 2025-2036. [10] Herd C. D. K. et al. (2001) *Am. Mineral.*, 86, 1015-1024. [11] Ghiorso M. S. and Evans B. W. (2008) *Am. J. Sci.*, 308, 957-1039. [12] Herd C. D. K. (2006) *Am. Mineral.*, 91, 1616-1627.

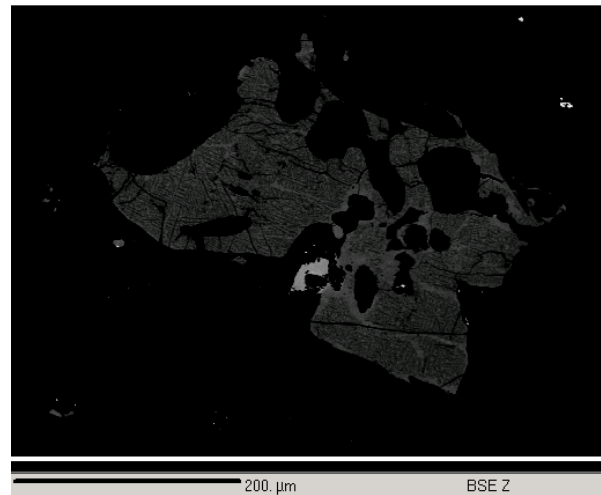


Fig 2. Backscattered electron image of ilmenite (Ilm) in titanomagnetite (TMt) in NWA 5298.



Fig 1. Backscattered electron image of NWA 5298 Arrow shows preferred orientation of pyroxene grains. Px = pyroxene, Mask = maskelynite, oxide = Fe-Ti oxide.