ENRICHED SHERGOTTITE NWA 5298 AS AN EVOLVED PARENT MELT: TRACE ELEMENT INVENTORY.

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Introduction: Martian meteorite Northwest Africa 5298 is a basaltic shergottite that was found near Bir Gandouz (Morocco). Its martian origin was confirmed by oxygen isotopes [1], as well as Mn/Fe ratios in the pyroxenes and K/anorthite ratios in the plagioclases [2]. Here we present a petrographic and geochemical study of NWA 5298. Comparison of mineralogical and geochemical characteristics of this meteorite with other Martian rocks shows that NWA 5298 is not likely paired with any other known shergottites, but it has similarities to another basaltic shergottite Dhofar 378 [3].

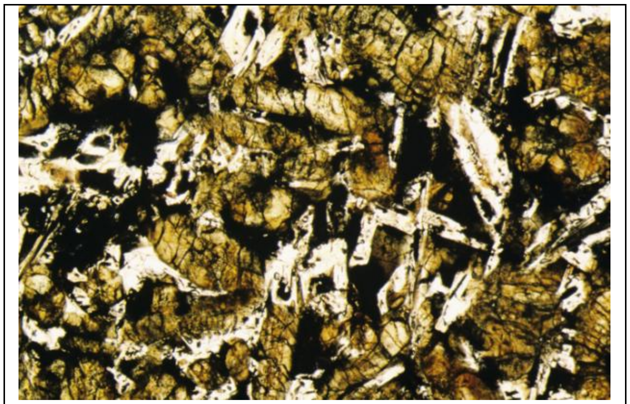

Fig.1 Plane-polarized light optical image of a thin section of NWA 5298 (© T. Bunch). The image width is 9 mm. The white grains are plagioclases, the yellowish ones are pyroxenes and the very dark brown is mesostasis.

Analytical methods: A thick section (~7 mm × ~2 mm) was prepared from a piece of NWA 5298 for petrographic observations and quantitative chemical analyses. Major element concentrations of each phase were analyzed with a Cameca SX100 electron microprobe at NASA-Johnson Space Center. Mosaic element maps and backscattered electron (BSE) image were also obtained with the electron microprobe using 15 kV voltage and 40 nA current. These maps were used to estimate the modal abundances of all phases using NIS-Elements imaging software. Traverse measurements were carried out to analyze the chemical composition of pyroxenes because of their large size and complex chemical zonation.

Concentrations of minor and trace elements in pyroxene, plagioclase and phosphate minerals were analyzed by a Varian inductively coupled plasma mass spectrometer coupled to a Cetac LSX-213 laser-ablation system (LA-ICP-MS) at the University of Houston. Beam sizes were as follows: 50 µm for pyroxenes, 100 µm for plagioclases, and 25 µm for phosphates.

Mineralogy and geochemistry: NWA 5298 is mainly composed of large elongated, complexly zoned pyroxene grains (64.5 %), and lath shaped maskelynite and vesicular plagioclase glass (29.4 %) (Fig. 1). A foliated texture produced by partial alignment of pyroxene prisms, interstitial plagioclase, and other phases, is observed in the thick section. The shock peak pressure may have reached 60-80 GPa as indicated by vesiculation in the plagioclase glass [4, 5].

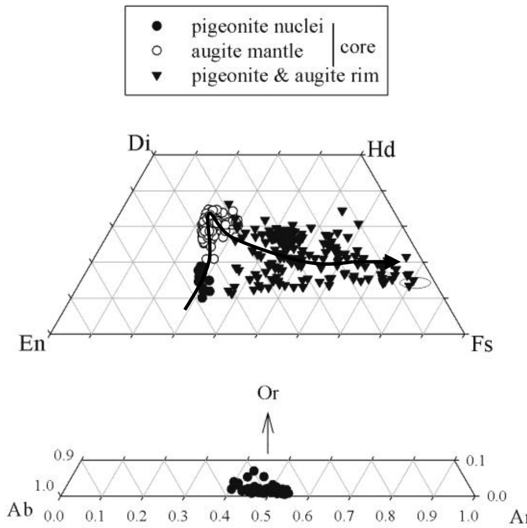

Fig.2 Chemical compositions of pyroxenes and plagioclases in NWA 5298.

The pyroxene megacrysts are compositionally zoned and include both pigeonite and augite compositions, with a general Fe-enrichment from core to rim (Fig. 2). The zone boundaries of pyroxene are highly irregular and curvilinear, which may indicate crystal dissolution/resorption. Pyroxenes are LREE-depleted (Fig. 3), as observed in most Martian meteorite pyroxenes [3, 6]. The rims of the pyroxenes are more REE-enriched relative to their cores (Fig. 2), indicating extensive fractional crystallization. Plagioclase has been converted into either maskelynite or vesicular plagioclase glass by shock impact. Plagioclases have a restricted composition range (An_{55-40}) (Fig. 2) and their REE pattern is characterized by a large positive-Eu anomaly and depleted HREE (Fig. 3). Phosphates occur as both merrillite and Cl-apatite, and are the major carrier of REE. Other phases include Fe-Ti oxides (both ilmenite and titanomagnetite), silica, fayalite, pyrrhotite and baddeleyite.

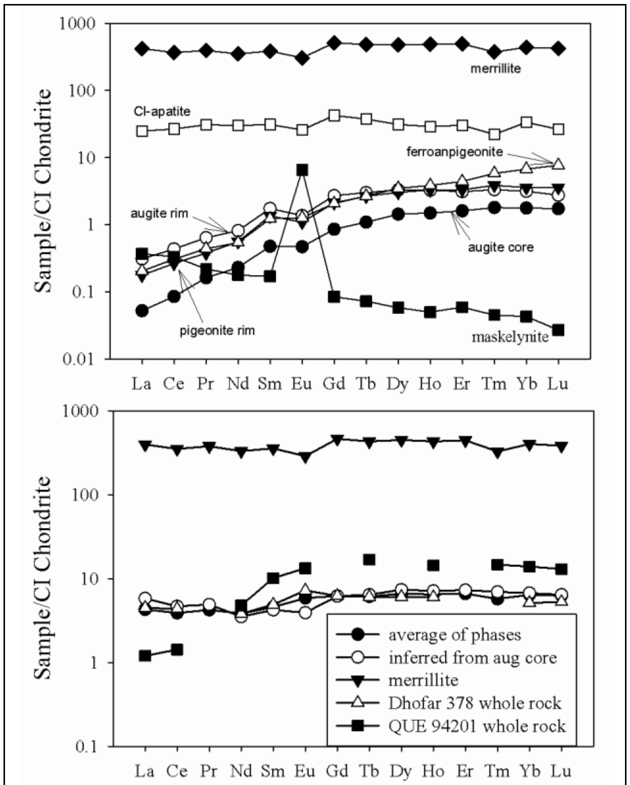

Fig. 2. REE distribution patterns measured in various phases of NWA 5298 (top) and recalculated for the whole rock (bottom). REE data of Dhofar 378 are from [7] and those of QUE 94201 from [8].

Discussion: The REE concentrations of NWA 5298 parental melt are estimated by assuming that the earliest crystallized phase (augite core) is in equilibrium with the parent melt in terms of REE (Fig. 3). REE concentrations for the bulk rock are also estimated using modal abundances and REE contents of pyroxenes, plagioclases and phosphates (Fig. 3). Both patterns are essentially the same, which provides strong evidence for closed-system magmatic behavior of NWA 5298. Major, minor and trace element contents in NWA 5298 pyroxenes vary continuously throughout their entire range, also suggesting that this igneous rock represents the *continuous* crystallization of its parent melt. Melt/fluid infiltration into the system is consequently unlikely during the differentiation of this Martian magma.

The REE pattern of bulk-rock NWA 5298 is generally flat with a slight depletion in the light REE relative to the heavy REE, essentially the same to that of Dhofar 378, but distinct from that of basaltic shergottite QUE 94201 (Fig. 3). The oxygen fugacity recorded by Fe-Ti oxides in NWA 5298 is essentially at the QFM buffer [9], which makes it one of the most oxidized Martian meteorites. Hence, the crystallized parental liquid represented by NWA 5298 is LREE enriched and oxidized compared to that represented by QUE 94201 [10].

References: [1] Rumble D. III and Irving A.J. (2009) 40th LPSC, Abs. 2293. [2] Papike J.J. (1998) *RiM* 36, 7.1-7.11. [3] Ikeda Y. et al. (2006) Antarct. Meteorite Res. 19, 20-44. [4] Yamaguchi A. and Sekine T. (2000) *EPSL* 175, 289-296. [5] Chen A. and El Goresy A. (2000) *EPSL* 179, 489-502. [6] Wadhwa M. et al. (1994) *GCA* 58, 4213-4229. [7] Dreibus G. et al. (2002) 65th Meteor. Soc. Meeting, A43. [8] Kring D.A. et al. (2003) *MPS* 38, 1833-1848. [9] Ghiorso M.S. and Evans B.W. (2008) *AJS* 308, 957-1039. [10] McSween H.Y. Jr. et al. (1996) *GCA* 60, 4563-4569.