NORTHWEST AFRICA 8694, **A FERROAN CHASSIGNITE.** R.H. Hewins[1,2], B. Zanda[1,2], S. Pont[1], M. Humayun.[3], N. Assayag[3] and P. Cartigny[3]. [1]IMPMC, MNHN, 75005 Paris, FR. [2]Rutgers University, Piscataway, NJ 08854, USA. [3]Florida State University, Tallahassee, FL 32310, USA. [4]IPGP, Univ. Paris Diderot, F-75005 Paris, FR.

Introduction: NWA 8694, the third chassignite, has an olivine composition intermediate between those of Chassigny and nakhlites and may be the key to the origin and relationships of these groups of meteorites.

Oxygen Isotopes: Oxygen isotope analysis by laser fluorination gave $\partial^{18}O = 4.74 \pm 0.10$ and $\partial^{17}O = 2.80 \pm 0.07$. The $\Delta^{17}O$ of 0.32±0.04 places NWA 8694 exactly on the SNC line or MFL, but $\partial^{18}O$ is higher than for other chassignites and close to nakhlite values.

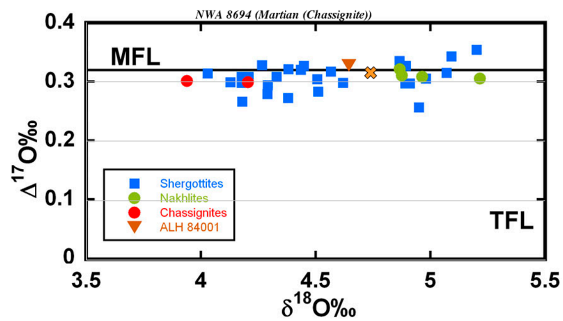

***Fig. 1** Oxygen isotopic compositions of chassignites and nakhlites [MetBull]. The orange X is chassignite NWA 2737.*

Petrography: NWA 8694 is a cumulate dunite with 85% olivine grains up to 1 mm in size. It has an adcumulate texture except in small patches where abundant interstitial material gives an orthocumulate texture.

***Fig. 2** False color BSE map of NWA 8694. Yellow-olivine; pink-pyroxenes; vermilion-chromite; dark blue-glass.*

The main intercumulus phases are pigeonite and augite, both with very fine (1µm) exsolution lamellae, and glass. Minor phases include chromite, partly enclosed by olivine, and ilmenite. Image analysis shows that NWA 8694 contains less cumulus chromite and more intercumulus pyroxene than the other chassignites, though these phases are heterogeneously distributed (Table 1, Fig. 1).

Table 1	*NWA 2737[1]*	*Chassigny[2]*	*NWA 8694*
Olivine	87.9	91.6	85.2
Chromite	3.5	1.4	0.8
Pyroxenes	6.7	5	11.6
Glass/Fsp	3.2	2.0	2.4
Phosphate	0.2	-	0.1
Carbonate	0.9	-	-
Modal abundances	[1]Ave in [1]	[2] from [2]	

The olivine contains largely crystalline melt inclusions, surrounded by radial fractures. The main phases in melt inclusions are orthopyroxene and K- and Na-rich glasses; rare phases include apatite, Fe sulfide, amphibole and biotite.

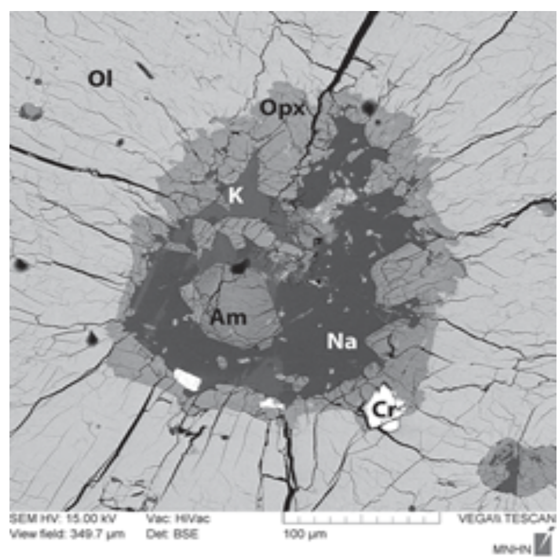

***Fig. 3** Melt inclusion in olivine in NWA 8694 (BSE): orthopyroxene (Op); amphibole (Am); K-rich glass (K); and Na-rich glass (Na).*

Mineral Compositions: The olivine composition is $Fo_{53.2\pm0.3}Fa_{46.8\pm0.3}$, with FeO/MnO 50.0±1.6, n=24. The crystals are equilibrated in Fe-Mg, but retain a weak depletion of Ca towards crystal rims, with a total range of 0.29 – 0.08 wt. % CaO. This partial loss of Ca and the fine pyroxene exsolution suggest a shallow emplacement.

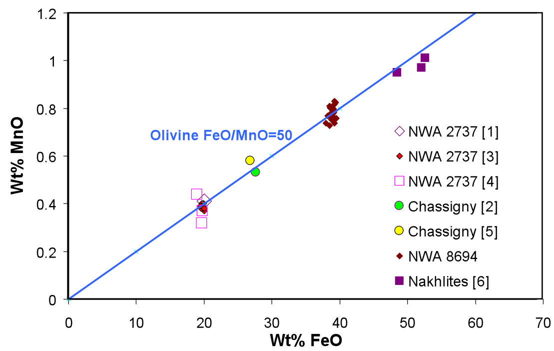

Fig. 4 Olivine compositions for chassignites and nakhlites [1-6].

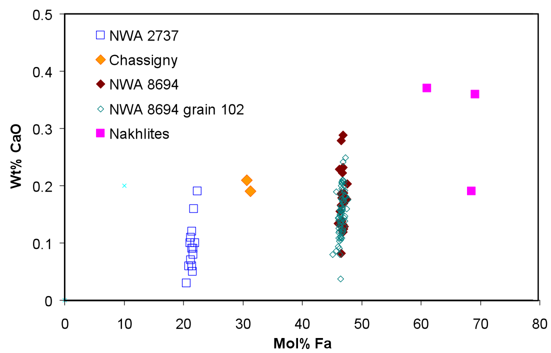

Fig. 5 Ca-Fe data for olivine in chassignites and nakhlites [1-6].

The pigeonite composition is $En_{55.8}Fs_{37.5}Wo_{6.7}$, s.d. 0.9, 1.0, 1.3, n=26, and FeO/MnO of 28.7, s.d. 1.9; the orthopyroxene is $En_{59.9}Fs_{37.7}Wo_{2.4}$, s.d. 0.4, 0.9, 0.8 and FeO/MnO ratio of 30.2, s.d. 3.0; and the augite is $En_{40.6}Fs_{16.1}Wo_{43.3}$, s.d.0.2, 0.6, 0.5, with an FeO/MnO ratio of 27.4, s.d. 3.2, (neglecting overlap compositions). The orthopyroxene in the melt inclusions varies from En_{56} to En_{59}, with Al_2O_3 up to 4 wt. %, whereas interstitial orthopyroxene has only 0.4 wt. % Al_2O_3 (s.d. 0.3).

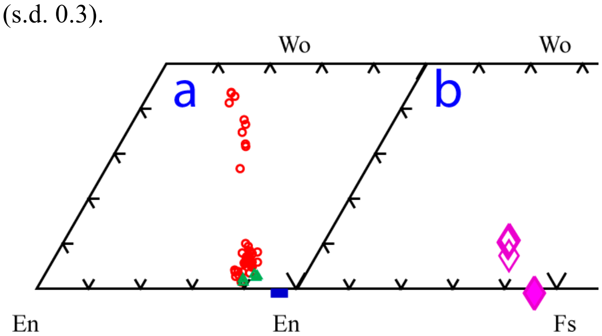

Fig. 6 *(a) EMP and (b) LA-ICPMS analyses. Intercumulus pigeonite and augite; orthopyroxene of melt inclusions (green); olivine (below quad).*

The amphibole is close to pargasite in composition $(\square_{0.34}Na_{0.60}K_{0.06})_{1.00}(Ca_{1.79}Na_{0.21})_{2.00}(Mg_{3.20}Fe_{0.85}Mn_{0.02}Ti_{0.44}Cr_{0.08}Al_{0.41})_{5.00}(Si_{6.14}Al_{1.86})_{8.00}O_{22}(OH_{1.62}F_{0.34}Cl_{0.03})_{2.00}$ with 3 wt% TiO2. The biotite is magnesian $(K_{0.80}Na_{0.02}Ca_{0.01})_{0.83}(Mg_{2.11}Fe_{0.78}Mn_{0.00}Ti_{0.02}Cr_{0.01}Al_{0.08})_{3.00}(Si_{3.03}Al_{0.97})_{4.00}$ O_{10} $(OH_{1.70}F_{0.18}Cl_{0.12})_{2.00}$. the phosphate is fluorapatite $Ca_{4.80}$ $A^*_{0.17}(PO_4)_{3.00}(F,Cl)_{1.06}$ on a 3 P ion basis, where A* is other cations.

Geochemistry: The three chassignites record extensive fractionation of olivine, from Fo_{79} to Fo_{53}. This cannot be achieved from a single chassignite (or komatiite) parent magma unless pyroxene crystallization is suppressed. The augite that replaces olivine is much more magnesian than that in nakhlites. Despite the different major element olivine and pyroxene compositions in the three chassignites, their REE concentrations show some overlap (Fig. 7) and the glasses are LREE-enriched. The $\partial^{18}O$ of NWA 8694 is higher than the values for the other chassignites and suggests contamination with country rock. Such an AFC process could add a fluid, increase the $\partial^{18}O$, and modify the REE concentrations due to fractional crystallization. We plan a complete study of all three chassignites to clarify their origin.

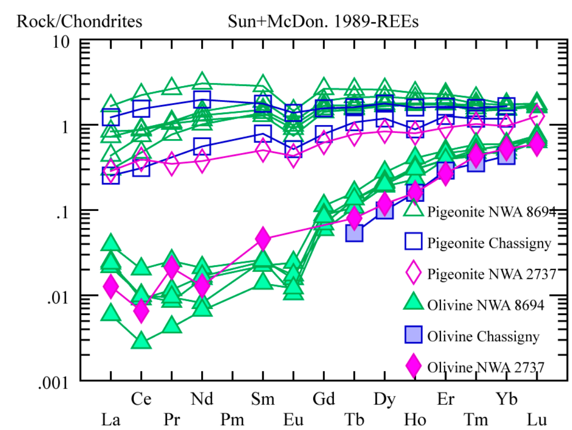

Fig. *7 REE data for olivine and pigeonite: NWA 8694 (this work); Chassigny [7]; NWA 2737 [4].*

References:
[1] Trieman A.R. et al. (2007) *JGR,112*, E04002. [2] Floran R. et al. (1978) *GCA, 42,* 1213–1229. [3] He Q. et al. (2013) *Meteoritics & Planet. Sci., 48*, 474–492. [4] Beck, P. et al. (2006), *GCA*, 70, 2127 – 2139. [5] Smith J.V. et al. (1983) *Proc. 13th Lunar Planet. Sci. Conf., JGR, 88,*B229-B236. [6] McSween H.Y. Jr. and Treiman A. H. (1998) *Planetary Materials, Reviews in Mineralogy 36,* 6-1 – 6-53. [7] Wadhwa, M., and G. Crozaz (1995), *GCA, 59*, 3629–3645.