NORTHWEST AFRICA 5790. TOP SEQUENCE OF THE NAKHLITE PILE. A. Jambon[1] J-A. Barrat[2,3], C. Bollinger[2,3], V. Sautter[4], O. Boudouma[1] , R.C. Greenwood[5], I.A. Franchi[5] and D. Badia[1], [1]UPMC Univ Paris 06, ISTEP CNRS-UMR 7193, Paris France albert.jambon@upmc.fr , [2]Université Européenne de Bretagne, [3]Université de Brest CNRS-UMR 6538 IUEM, 29280 Plouzané France, [4]MNHN Paris, Laboratoire de Minéralogie et Cosmochimie, CNRS-UMR 7202, Paris France, [5]PSSRI, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

Introduction: Northwest Africa (NWA) 5790 is the eighth nakhlite, found in the Sahara (Mauritania?) by nomads and purchased in Erfoud (Morocco). As will be seen below it is not paired with any previous find. Dating is reported elsewhere [1]

Petrography: The texture is one of a lava (Fig.1) with dominant millimetric euhedral augite (51%) irregularly zoned in their cores and sharply rimmed. Other phenocrysts are subsidiary euhedral olivine (9%) of slightly larger size, steadily zoned to their core and rare titanomagnetite (<1%). Abundant mesostasis (40%) contains dendritic crystals of oxides, calcic pyroxene, fayalitic olivine, two feldspars, silica, merrilite, Cl-apatite and glass. Minor Cl-amphibole is trapped in melt inclusions. The texture (Fig 1) strongly recalls NWA 817 or MIL 03346 [2-4].

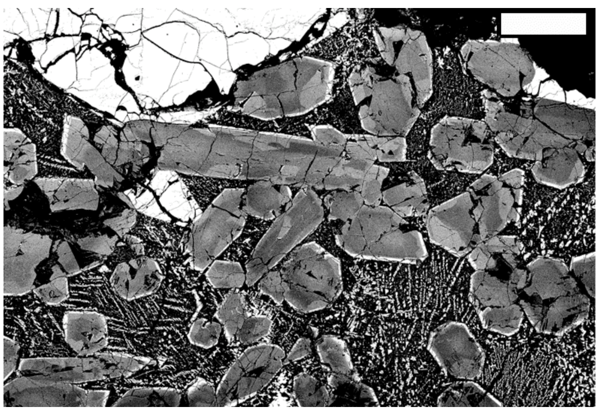

Fig. 1: BSE picture. Scale bar 0.5 mm

Mineral compositions: augite phenocrysts exhibit a MgO depleted core (En_{35}–Fs_{24} Wo_{40} and Fe/Mn = 32), patchy zoning and a sharp rim ($En_{20}Fs_{43}Wo_{36}$ and Fe/Mn= 42) (Fig 1-3) on the order of 20 micrometers. Olivine are steadily zoned from their core (Fa_{65} with Fe/Mn = 47) to their rim (Fa_{80} with Fe/Mn = 40) (Fig 2). Ti-magnetite phenocrysts $Uv_{32}Mt_{56}$-Sp_7Ct_4 exhibit fine ilmenite exsolutions. In the mesostasis dendritic crystals of Ti-magnetite are Al and Cr free $Uv_{52-74}Mt_{38-19}$, acicular pyroxene $En_7Fs_{47}Wo_{46}$ and Fe/Mn = 55, enriched in aluminum (Tschermak component) and olivine Fa_{78-88} are observed. Plagioclase $An_{20}Ab_{71}Or_9$ and K-feldspar $An_2Ab_{17}Or_{81}$ on average, are strongly zoned. The major elements of mesostasis were analyzed by EPM in scanning mode over areas of 0.20x0.15 mm^2 and compared to the mesostasis of MIL 03346 measured under similar conditions.

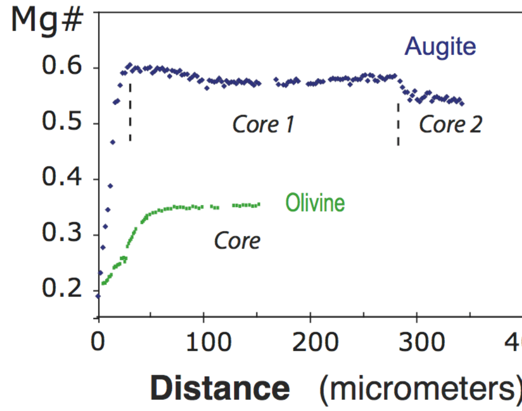

Figure 2. Zoning of olivine and augite.

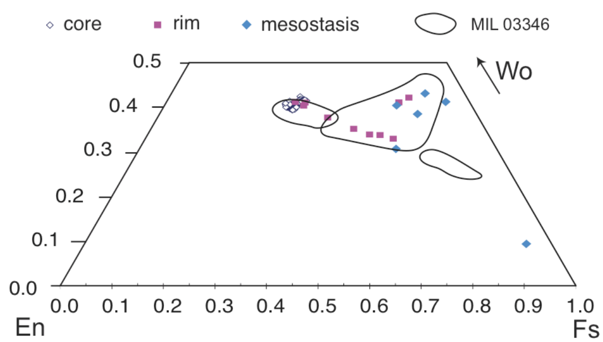

Fig. 3. Pyroxene compositions compared to MIL's [3]

	NWA 5790	error	MIL 03346	Error
SiO_2	54.80	0.20	52.49	0.97
Al_2O_3	14.33	0.09	13.89	0.31
MgO	0.44	0.01	0.42	0.04
FeO	17.13	0.27	16.73	1.17
MnO	0.26	0.01	0.24	0.02
CaO	4.25	0.07	4.00	0.16
Na_2O	5.40	0.04	5.22	0.11
K_2O	1.10	0.02	1.03	0.05
TiO_2	0.81	0.01	0.82	0.14
Cr_2O_3	0.00	0.00	0.00	0.00
P_2O_5	0.96	0.05	0.83	0.04
Total	99.50	0.07	95.67	0.67

Table 1 : Mesostasis composition compared to MIL's

Geochemistry: The oxygen isotope composition of NWA 5790 was determined by laser fluorination [5]. Two distinct fractions were hand picked from the meteorite, one olivine-rich and the other a "grey" mesostasis-rich fraction. The oxygen isotope composition of the olivine-rich fraction is: $\delta^{17}O$ = 2.55‰; $\delta^{18}0$ = 4.32‰; $\Delta^{17}O$ = 0.28‰ and the "grey" mesostasis-rich fraction: $\delta^{17}O$ = 3.22‰; $\delta^{18}0$ = 5.61‰; $\Delta^{17}O$ = 0.28‰ (all $\Delta^{17}O$ values are linearised [6]). The $\Delta^{17}O$ values of both fractions are within error of the Mars Mass Fractionation Line [7] (Fig. 4), thus confirming the Martian origin of NWA 5790. The relatively large difference in $\delta^{18}0$ values between the two fractions is consistent with their mineralogy i.e. one being olivine-rich and the other mesostasis-rich.

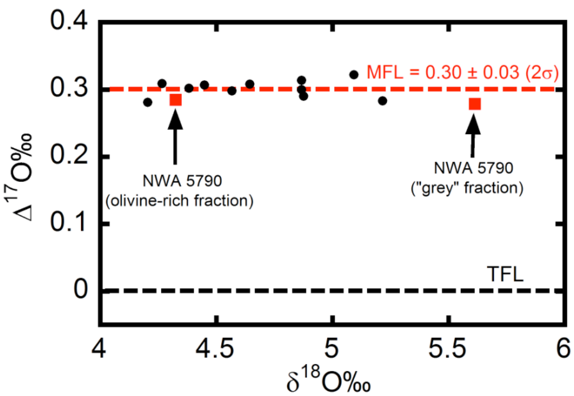

Fig. 4. Oxygen isotope composition of NWA 5790

Bulk major-element chemistry reflects the abundance of mesostasis: MgO= 8.0 %, Al_2O_3= 5.3 %, instead of 11.8% and 1.6% for Nakhla. Element ratios however confirm unambiguously the Martian origin (FeO*/MnO = 38, Na_2O/Al_2O_3 =0.39, K/La = 476, Ga/Al = 3.5 10^{-4}). NWA 5790 displays the highest Th, U and rare earth elements (REE) abundances ever reported for a nakhlite (*e.g.* , Th = 0.85 ppm); the REE pattern (figure 5) is characterized by a strong light REE enrichment: $(La/Yb)_n$ =5.5, and Eu/Eu* = 0.86. Trace element compositions (24 elements) of augite, olivine and mesostasis were obtained by laser ablation ICP-MS (figure 6).

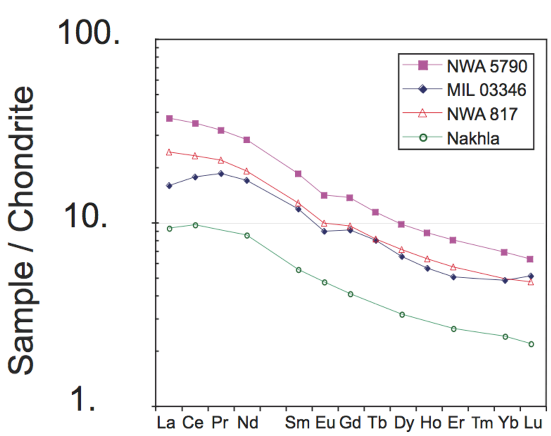

Fig. 5: REE patterns of nakhlites compared [3,4,8].

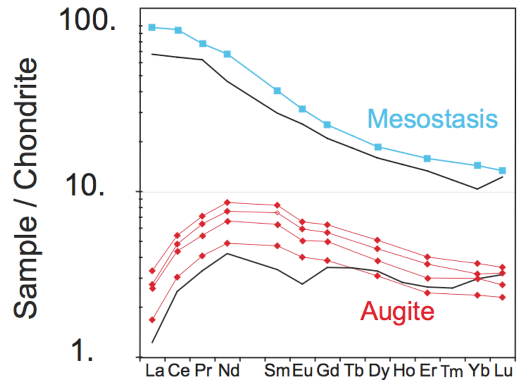

Fig. 6. REE pattern of separate phases compared to MIL 03346 (full lines) [3].

Discussion: According to its texture, mineralogy, chemical and isotopic composition NWA 5790 is a Martian meteorite of the nakhlite group. Augite phenocrysts do preserve complex primary zoning not observed so far in any of the other nakhlites. This indicates a fast cooling rate precluding chemical homogenization. The presence of Cl-rich amphibole suggests localized contamination by small debris of Cl-rich sediments, as previously reported for MIL 03346 [10]. Compared to other nakhlites its characteristic is the abundance of mesostasis which is reflected in the overall chemical composition. In addition to its abundance, the mesostasis is also more evolved, as indicated by the trace element abundances (fig.5-6, table 1) [2-4,8,9]; the composition of the whole rock indicates a large fraction of intercumulus liquid. This latter is out of equilibrium with the phenocrysts, and augite and olivine are not in equilibrium either. We can therefore suggest that NWA 5790 represents the topmost section of a lava pile [11] with a higher quenching rate and less compaction. The more evolved composition however suggests a zoned magma chamber.

References: [1] Shih C.-Y. et al. (2009) this vol. [2] Treiman A. H. (2005) *Chem. Erde,* 65, 203-270. [3] Day J.M.D. et al. (2006) *MPS* **41**, 581-606. [4] Sautter V. *et al*. (2002) *EPSL* **195**, 223-238. [5] Miller M.F. et al. (1999) *Rapid Commun. Mass Spectrom.* 13,1211-1277. [6] Miller M.F. (2002) *GCA,* 66, 1881-1889. [7] Franchi I.A. et al. (1999) *MAPS* 34, 657-661. [8] Nakamura N. *et al.* (1982) *GCA* **46**, 1555-1573. [9] Wadhwa, et al., (2004) Antarct. Meteorite Res. 17, 97-116. [10] Sautter V. et al. (2006) *EPSL* **252**,45-55 [11] Mikouchi T. *et al*. (2005) *LPS* **XXXVI**, CD-ROM #1944.