NWA 1235: A PHLOGOPITE-BEARING ENSTATITE METEORITE. C. Lorenz[1], G. Kurat[2], F. Brandstätter[2] and M. A. Nazarov[1], [1]Vernadsky Institute of Geochemistry and Analytical Chemistry. Kosygin St. 19, Moscow, Russia, 119991, lorentz@geokhi.ru, [2]Naturhistorisches Museum, Postfach 417, A-1014 Vienna, Austria, gero.kurat@univie.ac.at

Introduction: NWA 1235 (found in 2000) is a patchily weathered (W2-W3) enstatite rock weighing 80 g. No chondrules or relics thereof are present. It has a coarse-grained hypidiomorphic texture, which is, however, finer relative to that of aubrites. Mineral chemistry and metal-silicate relationships suggest that the rock was formed from an enstatite meteorite source under more oxidized conditions than other enstatite meteorites. A unique features of the meteorite are the unusual composition of troilite and exotic sulfides, presence of a wide set of microinclusions in enstatite and the occurrence of fluorphlogopite.

Results: NWA 1235 consists mainly of enstatite $En_{99}Wo_1$ (77 vol%) subhedral prismatic crystals up to 5 mm long (Fig.1). They have a weak mosaicism, undulatory extinction and contain numerous (1-15 μm in size) mineral and glassy inclusions, which are oriented along the long axis of pyroxene crystals. The average composition of the glass inclusions is (wt%): 77.9 SiO_2; 13.0 Al_2O_3; 5.0 Na_2O; 2.0 K_2O; 0.2 CaO; 1.1 MgO. Some inclusions contain well-shaped crystals of Ti-free, Cr-poor (0.36 Cr, wt.%) troilite, Fe,Ni metal (6.5-40.7 wt% Ni) and niningerite.

Minor feldspar $Ab_{74.8-95.6}Or_{0.6-6.8}$ (8 vol%) occurs interstitial to enstatite grains or forms lath-shaped crystals within sulfide. Silica is present as 10-100 μm-sized angular and elongated grains within enstatite or rounded inclusions within metal and sulfide. It usually contains 0.5-1.0 wt% of Na_2O and 1.3-1.5 wt% of Al_2O_3. Rare fluorphlogopite is associated with albitic feldspar. Subhedral or anhedral grains of the phase have 30-60 μm size and show well-developed cleavage planes. The average fluorine content of the phlogopite is about 10 wt%.

Fe,Ni metal (4.8 vol%) is present mostly as irregular aggregates (0.1-1 mm), which consist of kamacite: (wt%) 1.8 Si; 8.35 Ni; Ni/Co=12.8, and minor taenite: 2.0 Si; 24.5-25.5 Ni. The kamacite/taenite volume ratio is about 20. Enstatite prisms are included in the metal aggregates. Taenite shows a weak M-shaped Ni profile with a maximum difference in Ni content of about 1.5 wt%. Distribution of Si in taenite is similar to that of Ni. Taenite is always richer in Si than adjacent kamacite that has a uniform Si distribution. Small Fe,Ni metal inclusions (5-10 μm) within enstatite are poorer in Ni (6.67 wt%) than the large aggregates.

Schreibersite (19.8 wt% Ni) is usually present within the metal aggregates and forms tiny inclusions within enstatite. The aggregates contain commonly graphite, which occurs as clusters of 5-100 μm-sized prismatic and hexagonal crystals.

Cr-Ti-bearing troilite (2.5 wt% Cr and 0.13 wt% Ti) is the main sulfide (7 vol%) of NWA 1235. Troilite occurs in the metal aggregates. It fills also interstitial space between enstatite and feldspar and forms numerous inclusions scattered within enstatite.

Accessory sulfides are oldhamite, FeS-MnS-MgS solid solutions and Fe-rich sphalerite, which occur as rounded (5-15 μm) polymineralic, troilite-containing inclusions within enstatite (Fig.2). The sulfide solid solutions have compositions outside the alabandite or niningerite compositional fields and have intermediate compositions (Fig.3). There are also rounded inclusions of a Mn-rich oxide phase (up to 40 wt% MnO) in enstatite. The phase could be the result of terrestrial weathering of alabandite.

Discussion: NWA 1235 consists of a reduced mineral assemblage that is characteristic of E chondrites and achondrites. The texture is achondritic, no chondrules or relics thereof are present. However, in contrast to aubrites, the texture of NWA 1235 is less coarse-grained and demonstrates textural features that are more compatibel with co-crystallyzation of enstatite crystals rather than accumulation. There is also no textural evidence for metal-silicate liquid immiscibility and thermal metamorphism in the rock.

It is clear that NWA 1235 belongs to the enstatite meteorite family but nevertheless the rock differs from all representatives of this clan. The metal aggregates containing prismatic enstatite crystals, which are widespread in NWA 1235 and which are a common feature of enstatite chondrites [1]. The modal abundance of Fe,Ni metal (4.5 vol%) in NWA 1235 is higher than that in aubrites (0-0.7 vol%) and close to the metal abundance in EL chondrites. The Si content (wt%) of both kamacite (1.75) and taenite (1.99) in NWA 1235 is lower than that of EH metal (1.9-3.8) and corresponds to that of EL chondrite (0.3-2.1) [2] but not to that of aubrite (0.01-0.9) metals [3]. The

Ni/Co ratio of NWA 1235 metal (12.8) is lower than that of E chondritic and achondritic metals (21.1-25.4 [3]). Only the Mayo Belwa aubrite metal has a similar Ni/Co ratio (14.2) [3]. The intermediate compositions of FeS-MnS-MgS solid solutions of NWA 1235 are not common for either E chondrites or achondrites and were reported only from "EH-melt rocks", QUE 94204 [4] and Yamato 793225 [5] and from Itqiy, an unusual E-achondrite [6].

The Cr-content of troilite (2.48 wt%) falls into the E chondrite and aubrite ranges. Based on the Ti content of troilite, redox conditions of the NWA 1235 melt can be constrained. As it was shown by [7], the Ti content of a sulfide melt is increasing when fO_2 is decreasing. Troilite of NWA 1235 contains 0.13 wt% Ti, which is distinctly less than the Ti content of troilites in all enstatite meteorites analyzed so far. Troilite of aubrites, E6 and E4-5 chondrites contains 0.5-5.7, 0.65 and 0.4 wt% Ti, respectively [8]. Therefore, NWA 1235 must have formed under more oxidized conditions compared to all other enstatite meteorites.

The phlogopite occurrence is a special characteristic of NWA 1235. Phlogopite has previously been reported only from the EH melt rock Yamato 82189 [5]. In NWA 1235, phlogopite could have crystallize from a residual melt because there is no evidence for a K-F- bearing fluid activity in the rock.

Apatite, the main F-bearing phase is unstable under reducing conditions and, therefore, F, which is very abundant in E chondrites, needs to enter another phase.

Conclusion. The texture of NWA 1235 is that of an achondrite. Mineral modes, metal-silicate relationships and sulfide chemistry could indicate a close relationship to EL chondrites. The very low Ti content of NWA 1235 troilite indicates that it crystallized under higher fO_2 conditions than the common E chondrites and aubrites.

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References: [1] Okada A. et al. (1988) *Meteoritics, 23*, 59-74. [2] Zhang Y. Et al. (1995) *J. Geophys. Res. 100, 9417-9438.* [3] Easton A. J. (1986) *Meteoritics, 21,* 79-93.. [4] Rubin A. E. et al. (1997) *GCA 61,* 847-858. [5] Lin Y., Kimura M. (1988) *Meteoritics and Planet. Sci. 33*, 501-511. [6] Patzer D.H. et al. (2001) *Meteoritics and Planet. Sci. 36*, 1495-1505. [7] Fogel R. A. (1997) *Meteoritics and Planet. Sci. 32*, 577-591. [8] Watters T. R. and Prinz M. (1979) *Proc. LPSC X*, 1073-1093. [9] Brearley A. J. and Jones R. H. (1988) *Rev. Min. 36,* 3-01-3-370

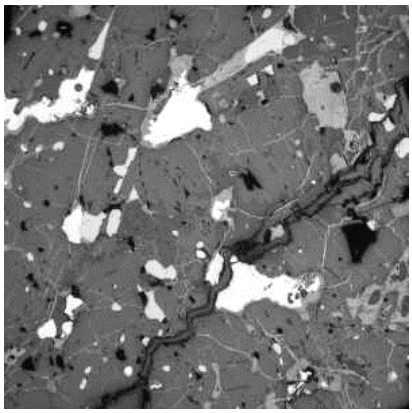

Fig 1. Reflected light microphotograph of NWA 1235 (picture width is 3.5 mm). Enstatite with interstitial albite is dark grey, metal is white, troilite is light gray, iron hydroxide is gray.

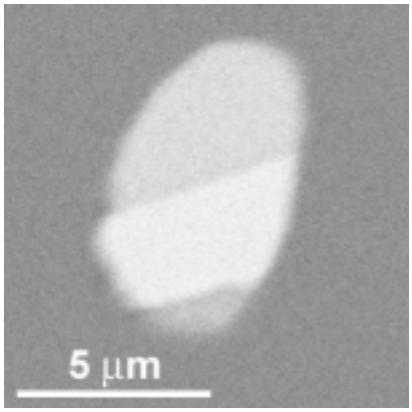

Fig 2. BSE image of a polymineralic sulfide inclusion within enstatite. Troilite is white, FeS-MgS-MnS sulfide is gray, oldhamite is dark-grey.

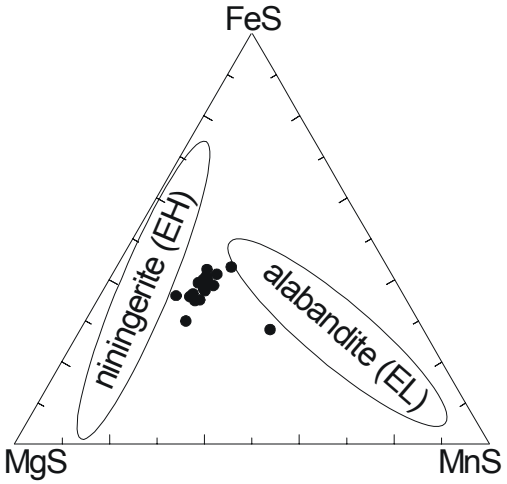

Fig 3. The composition of FeS-MgS-MnS solid solutions of NWA 1235 (EL and EH data from [9]).