NWA 11119 – PROBING AN YET UNKNOWN EARLY PLANETARY BODY

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The new ungrouped achondrite NWA 11119 – a new type of meteorite

Introduction

Northwest Africa 11119 represents a completely new and so far unknown type of meteorite which was classified as an ungrouped achondrite [1,2]. Petrographically, NWA 11119 was described by the classification team as a porphyritic volcanic rock with an andesitic-dacitic bulk composition. A modal abundance of free silica polymorphs of about 22% was found (dominating cristobalite and tridymite) which is significantly higher than in any other known meteorite [2-4].
In terms of oxygen-isotopy, which plots in the ureilite field, possible relations could exist to the also unique achondrites NWA 7325/8409 (petrologically classified as a plagioclase-rich cumulate olivine microgabbro [1,2]), and to the Almahata Sitta individuals MS-MU 011 and 035 (classified as plagioclase-enriched trachy-andesites [1,2,5-8]). These specific Almahata Sitta individuals are interpreted as being related very likely to the ureilite parent body crust.

Samples
The main mass of NWA 11119 which was found in Mauritania in 2016 consists of a large stone with a mass of 453 gr and several smaller fragments. The material is highly friable and partly covered with an unusual light green colored fusion crust. For our investigations we have obtained a set of samples which are typically representative for the meteorite as a whole, see figure 1.

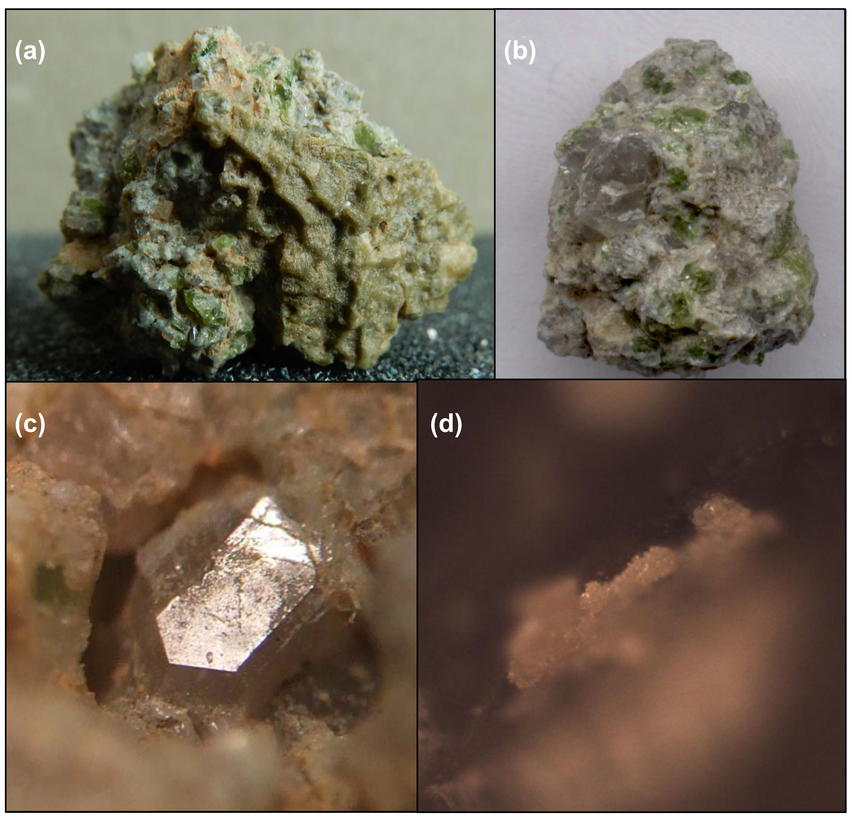

Figure 1: Some of the NWA 11119 samples under study: (a) 4.25 gr and (b) 0.90 gr fragments with dominating clinopyroxene (green, diopside), SiO_2 phases (grayish, cristobalite-tridymite) and greenish-colored melt crust (in a). (c) An idiomorphic plagioclase (anorthite-rich), a nearly mm–sized crystal in a small cavity, is absolutely unique for any known meteorite. (d) Rarely quartz is found as radial prismatic, yellowish crystals in small cavities on the surface of cristobalite/tridymite or plagioclase (anorthite) matrix.

Mineralogy and phase composition
The aim of these investigations is primarily on the mineralogy and phase composition, and on the magnetic classification based on Magnetic Susceptibility (MagSus X). LASER Micro Raman Spectroscopy is best suited for identifying and discriminating (extra-) terrestrial mineralogy in high-resolution mappings on natural, broken surfaces without any preparation in 2- or 3 D. Moreover, Raman Spectroscopy is the only available technique which allows to investigate and analyse samples like the new and unique NWA 11119, specifically to fully "catch" all present phases even in small vugs and little pockets (see figure 1). For us it was very important to fine-tune our Laser Raman System in a way that it would allow to access the real situation in any kind of rock/mineral sample in its original situation, excluding or avoiding any modification due to cutting/preparation etc. which would completely "destroy" reality.

NWA 11119: comparison with unique NWA 7325 and Almahata Sitta trachy-andesites

We have used a Horiba XploRA Raman System for our systematic mineralogical and shock investigations. High-resolution mapping (up to 15x15 points) was performed in partly less than 1 µm steps in order to control the real petrographical / mineralogical situation within this unique material. We also could investigate numerous inclusions within the dominating matrix phases (cristobalite-tridymite, diopside, anorthite) which is topic of a different contribution [11]:

Dominating phases
- Clinopyroxene (CPX), diopside
- Silica – phases:
- Cristobalite
- Tridymite (only in intergrowth with Cristobalite)
- Plagioclase (anorthite-rich, see fig. 1c)

Minor / rare phases
- Fe-Ti-Cr oxides (chromite)
- Rutile, anatase
- Ilmenite (?)
- Fe – sulfides: troilite
- Phosphates: apatite, merrilite
- Orthopyroxene (OPX): enstatite as idiomorphic transparent, prismatic crystals in small cavities
- Ca-Mg carbonate (near calcite), terrestrial?
- Quartz SiO_2 (see fig. 1d)

Carbon – phases: a spectrum of different carbon phases in significant amounts – amorphous and highly crystalline - could be detected, for example graphite. This topic is part of a different contribution [11]. Olivine or metal could not be found which confirms [1-4], we also could not detect zircon or baddeleyite so far.
The shock degree was found to be low for all investigated fragments.

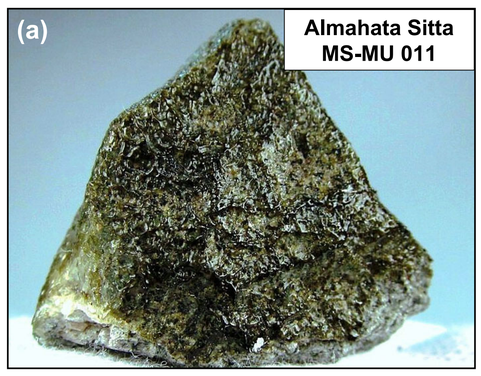

Fig. 2a, b: The two known Almahata Sitta trachy-andesite individuals. (c) NWA 8409 – paired with NWA 7325: these reveal significant similarities in a number of parameters with NWA 11119 [12]. © S. Decker (a,b).

Summarizing, the unique NWA 11119 does not represent the first direct indication pointing towards the existence of silica-rich volcanism: as mentioned above, Almahata Sitta individuals MS-MU 011 and 035 were the first samples of this kind [5-8, 12], interpreted as crustal extrusive volcanism on the ureilite parent body. Recently, also in lunar rocks (Apollo 12 samples) and on the Martian surface (Gale crater by Mars Science Laboratory rover Curiosity) low pressure, high temperature polymorphs of SiO_2 have been found [9,10], as well as in certain HED meteorites, eucrites [13].

Formation and existence of trachy-andesitic rocks requires active plate tectonics on a respective parent body, and is mainly connected with subduction zone volcanism, including partial melting of lower crust / upper mantle material.

More detailed investigations on these unique cristobalite – tridymite rich meteorites and its phase relations, formation and cooling conditions are topic of further investigations [see also 12,13].

The unique silica - rich meteorites: Fe – poor parent body with very early extrusive volcanism?

Magnetic Classification
The uniqueness of NWA 11119 and related meteorites is also confirmed by their distinct magnetic signature. We can demonstrate this fact by classifying the meteorites using magnetic susceptibility (X, MagSus).

Magnetic susceptibility was studied by the SM 30 and SM 100 instrumentation, ZH Instruments (Brno, CR). As mentioned above, due to the certain similarities in several properties, we decided to also include the two Almahata Sitta trachy-andesite individuals, as well as NWA 7325 and pairs in our investigations.

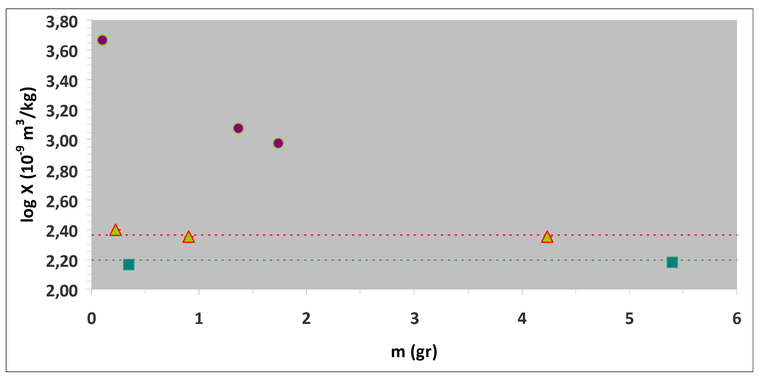

Figure 2: Magnetic susceptibility: (a) ▲ NWA 11119, (b) ■ NWA 7325 and pairs, (c) ● Almahata Sitta MS-MU 011/035. For (a) and (b): the dotted lines indicate the average values, respectively. It is evident that NWA 11119 and NWA 7325 / pairs represent a different group of meteorites.

MagSus values of NWA 11119 and the NWA 7325 group represent the lowest MagSus values which have been measured so far on any meteorites to our best knowledge. Please note that both meteorite groups represent finds. Therefore, one has to state that these values are not directly comparable with Almahata Sitta MS-MU 011/035 values which are part of a fall. On the other hand, the concentration of strongly magnetic Fe-bearing phases is so low, and terrestrial alteration effects (and related phases) could not be found, so that the magnetic signature of NWA 7325/11119 can be expected to represent the original – space conditions.

Also in comparison with terrestrial equivalents, MagSus values are quite low. Terrestrial trachy-andesitic and similar volcanic rocks, including silica-rich pumices, reveal significantly stronger magnetism and higher MagSus values.

This fact could point toward an indication that the NWA 11119 /7325 parent body could have been much lower in Fe than the present terrestrial planets and the ureilite parent body. This view is confirmed by the findings of [14,15] that NWA 7325 might represent the first essentially non-magnetic material from a highly differentiated parent body.

Our preliminary results could support a general conclusion that NWA 11119 including NWA 7325 (and pairs), revealing oxygen isotopy data in the range of some ureilites, may probe a yet unknown and different (proto-) planetary body which existed only in a very early period of time of our planetary system.

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