MINERALOGICAL AND SPECTROSCOPIC STUDIES ON NWA 7325 AS AN ANALOGUE SAMPLE FOR ROCKS FROM MERCURY.

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Introduction: The ungrouped achondrite Northwest Africa (NWA) 7325, which is speculated to be the first sample from planet Mercury [1], was found 2012 in Western Sahara. Several analyses identified it as a rock with high plagioclase and Cr-diopside abundances, and minor olivine [1,2,3,4]. Remnants of twinning-like features within the plagioclases as well as zoned and lath-like plagioclase in veins within pyroxene and areas around mafic silicates indicate a secondary heating and (partial) melting event followed by a period of rapid cooling [2]. Therefore, it is not a plutonic gabbro as suggested by [1]. Here, we present detailed bulk and mineral analyses together with mid-infrared and Raman data from a 12g sub-sample of the meteorite. Besides the characterization of the mineralogical composition of NWA 7325 done by electron microscopy, the (infrared) spectral information will be useful for the future space mission BepiColombo, which will have a thermal-infrared spectrometer (MERTIS) on board [5].

Techniques: *Mid-Infrared spectroscopy:* The mid-infrared reflectance measurements were made with a Bruker Vertex 70 infrared system at the InfraRed spectroscopy for Interplanetary Studies (IRIS) laboratory (Institut für Planetologie, Münster). All analyses were carried out under vacuum, with variable incidence and emergence angles (20°/30° and 30°/30°) in the wavelength range from 2 to 25 µm. In order to show the variations, the presented results were normalized to the strongest silicate feature in the 8 – 13 µm range. The crust of the unprepared sample was first analysed in the reflectance mode at an aperture of 4 mm. For a first qualitative study of the mineralogical composition without destroying the bulk sample, random spots on four polished thin sections with apertures of 4 mm and 0.25 mm were measured.

Raman Spectroscopy: Raman measurements were performed with a confocal HORIBA Jobin Yvon LabRam HR-800 Raman microscope. The laser excitation wavelength was 532 nm with a laser power of ~5 mW. A 50 x objective was used.

Electron Microprobe and SEM: An overview and images of all minerals within the section as well as elemental mappings and analyses were obtained with a JEOL JSM-6610LV scanning electron microscope (SEM), using an accelerating voltage of 20 kV. Detailed quantitative analyses of the main minerals and the bulk chemistry with a grid over the whole section have been made with a JEOL JXA-8900 Superprobe Electron Probe Micro Analyzer (EPMA) at the Institut für Mineralogie (Münster) equipped with four wavelength dispersive spectrometers and operating at an excitation voltage of 15 kV and a beam current of 15 nA. Corrections for matrix effects were made using the $\Phi\rho(z)$ procedure [6]. Natural and synthetic standards of well-known compositions were used for standardization.

Results: *FTIR:* The IR spectra in the 10 µm region show characteristic bands at 9.1 µm, 10.5 µm, and 10.8 µm. Further strong bands are at 15.9 µm, ~17.7 µm, ~18.6 µm, ~19.3 µm, and ~20.8 µm. The mid-infrared spectra confirm the homogeneity of the whole rock. Anorthite has characteristic bands at 8.7 µm, 9.7 µm, and 10.6 µm. Typical diopside bands are at 8.8-9.0 µm, 10.4 µm, and 10.9 µm, The mid-infrared features of NWA7325 are explained by a mixture of standard diopsides and anorthites compared with [4].

Raman: Raman spectra, performed on a thin section of NWA 7325, are consistent with our IR analyses. Spectra of anorthite show main features at 486.2 cm^{-1}, 504.9 cm^{-1}, and 559.7 cm^{-1} as well as the double peaks at 326.3 cm^{-1} and 395.8 cm^{-1}. In addition, diopside could be identified by the main peaks at 667.4 cm^{-1} and 1012.1 cm^{-1}. The diopside and anorthite spectra are representative for a series of similar analyses across a thin section. Spectra of both minerals are confirmed by reference analyses [8,9]. Further spectra with main peaks at 825 cm^{-1} and 857 cm^{-1} are evidence for the presence of olivine. In addition, a Fo content of nearly Fo_{100} was determined by Raman [10].

Electron Microscopy: Elemental mapping (Figs. 1, 2, 3) as well as quantitative analyses confirm the presence of the main and accessory minerals found by [1,2,3]. In addition, Ca-carbonate was found in cracks, most probably as a weathering product (Fig. 2). Furthermore, significant abundances of phosphorus were found in the Fe-bearing accessory mineral, which is probably schreibersite in one case (Fig. 2). In addition to prior investigations, we studied the molar Fe/Mg vs. Fe/Mn ratio for the three silicates analyzed in NWA7325. The ratios are given in Figure 4.

Summary and Conclusion: The results of this study are consistent with the scenario suggested by [2]. However, we cannot conclude or exclude that NWA 7325 is from Mercury, currently. The elemental mapping in Fig. 1 shows a higher abundances of sodium in the plagioclase along the grain boundaries of olivine and diopside. This corroborates the presence of a second plagioclase introduced by a secondary melting process. Furthermore, the Fe/Mg vs. Fe/Mn ratios indicate that olivine and diopside may crystallized as cumulates [11] in contrast to plagioclase, which displays a totally different trend probably caused by a post-crystallization reheating process. Further work concerning the high abundances of P in different accessory phases is in progress.

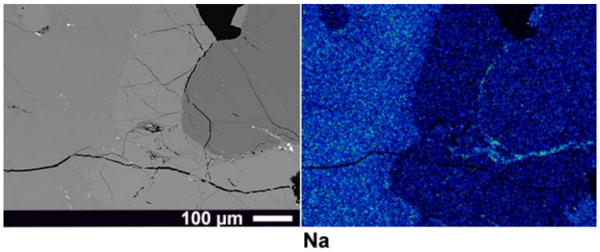

Fig. 1: Left: Backscattered electron (BSE) image of an olivine (Ol, dark grey), plagioclase (Plag, grey), and diopside (Di, light grey). The elemental mapping (right) of sodium shows an enrichment of Na at the grain boundary between Di and Ol.

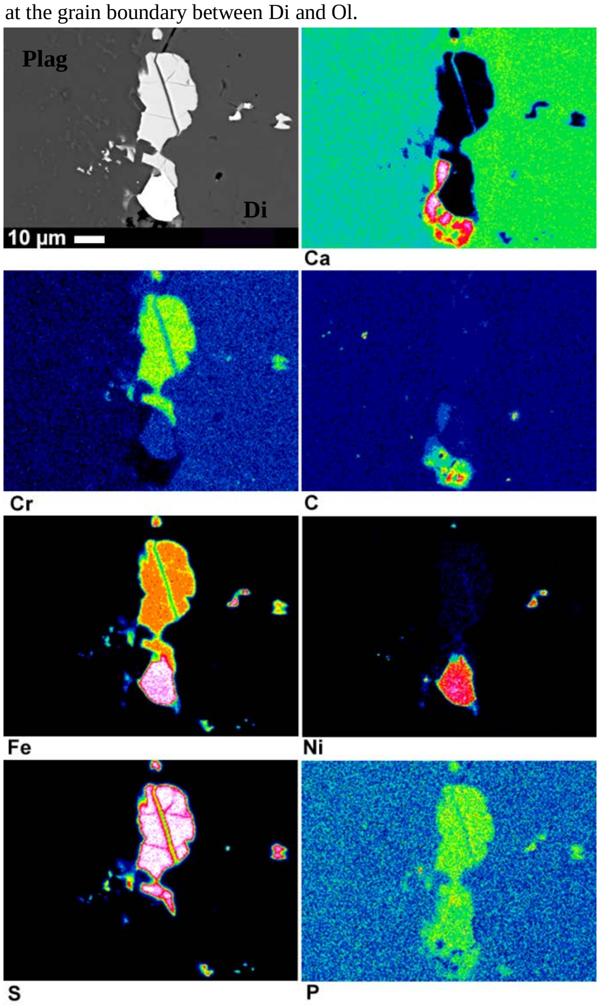

Fig. 2: Top left: BSE image of the accessory minerals in NWA 7325 between the main silicates Plag to the left and Di to the right. The following elemental images identify Cr-FeS (most probable daubreelite), taenite, and calcite. In addition, high abundances of phosphorous is visible in the Fe-bearing minerals.

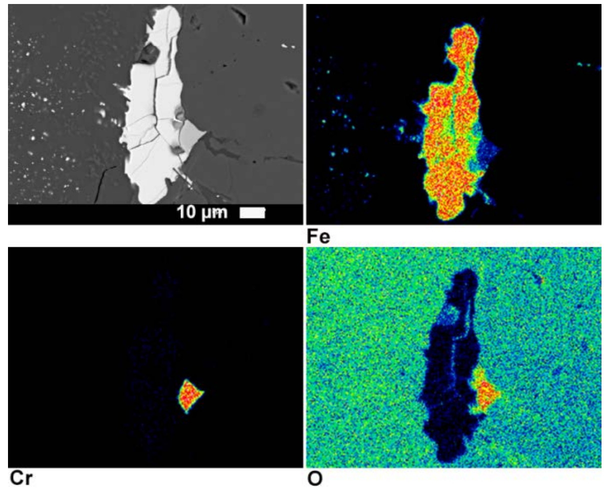

Fig. 3: Left: BSE image and elemental mappings of eskolaite (Cr_2O_3) associate with FeS inside of the main silicates.

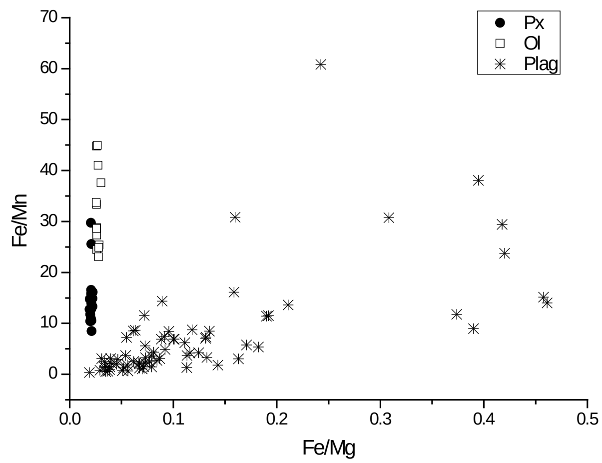

Fig. 4: Fe/Mg vs. Fe/Mn ratios of the silicates in NWA 7325. Ol and Px (Di) show the same linear trend close to the y-axis, whereas Plag is characterized by totally different ratios.

References: [1] Irving et al. 44th LPSC (2013) # 2164. [2] Bischoff et al. (2013) EPSC, #427. [3] Morlok et al. (2013), #114. [4] Helbert et al. (2013) EPSC, #422. [5] Hiesinger et al. (2010) PSS Vol. 58, 144 – 165. [6] Armstrong J.T. (1991) In: Electron probe quant. 261 – 315. [7] Nash & Salisbury (1991) JRL 18, 1151-1154. [8] Freeman et al, (2008) Can. Min., 46, 1477-1500. [9] Tribaudino et al. (2012) Am. Min., 97, 1339-1347. [10] Kuebler et al. (2006) GCA 70, 6201 – 6222. [11] Goodrich & Delaney (2000) GCA 64,149 – 160.

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