GEOCHEMISTRY OF LUNAR REGOLITH BRECCIA NORTHWEST AFRICA 11962 AND ITS POTENTIAL SOURCE REGION/CRATER IN THE PROCELLARUM KREEP TERRANE.

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Introduction: Lunar meteorites are an important addition to Apollo and Luna samples for deciphering the geological evolution of the Moon. However, the main disadvantage is that their locations of origin on the lunar surface are not known. Here we discuss various aspects of the newly described lunar meteorite Northwest Africa (NWA) 11962. Northwest Africa 11962 is a lunar regolith breccia that is composed of a wide range of different clasts. The lunar origin of this meteorite was confirmed by oxygen isotopic composition and the Fe/Mn ratio in pyroxene and olivine [1]. In the petrographic study of [1], the clasts and the matrix of NWA 11962 were investigated by optical and electron microscopy, as well as by electron microprobe studies and micro-Raman spectroscopy. The meteorite has a glassy impact melt matrix, which accounts for 35% of the surface area in the two thin sections examined by [1], and which contains a very large variety of different lithic clasts, monomineralic clasts, and glass fragments. The presence of volcanic and impact related glass spherules led to the classification of this meteorite as a regolith breccia. Lithic clasts include numerous fragments of quartz monzogabbro and lunar felsite, which are quite rare lithologies in the lunar alkali suite. However, the most abundant components in the breccia are gabbroic clasts. The mineral chemistry of the pyroxenes in the gabbroic clasts and the chemistry of various types of glass fragments in the breccia indicate an origin of the regolith from an area with low-Ti to high-Ti mare basalt volcanism. For details on the mineralogy and petrography of NWA 11962, see [1].

Chemical and Isotopic Composition: Bulk samples of this lunar meteorite were measured for chemical and isotopic composition (see [2]). With a Fe content of 9.28 wt%, NWA 11962 belongs to the group of lunar meteorites with intermediate iron concentration. It has relatively high Th (6.59 ppm) and rare earth element (REE) concentrations, as well as a relatively high K concentration of 0.3 wt%. The normalized REE pattern shows an enrichment in the light REE (LREE) and a negative Eu anomaly, typical for lunar KREEP samples. No Ce anomaly is observable (Ce/Ce* = 1.02), indicating that the REE pattern was not affected by terrestrial weathering processes. Beside similarities of the REE pattern and other trace and major element abundances to some of the mafic impact melt breccias, NWA 11962 has lower Ni (124 ppm) and higher Sc (26.6 ppm) concentrations than the mean values of the Apollo 14, 15, 16, and 17 impact melt breccia groups (127-1090 ppm Ni and 9.8-22.0 ppm Sc). The high Sc content possibly reflects a high pyroxene content of the regolith breccia or the relative abundant occurrence of other mineral phases known to contain appreciable amounts of Sc, e.g., zircon or ilmenite. Although Fe-Ni metal particles (Ni contents between 2.2 and 14.6 wt%) are recognizable in the thin sections, the breccia has a comparatively low nickel content of 124 ppm. Likewise, the Ir content of 2.7 ppb is relatively low for lunar regolith. These observations indicate a rather modest amount of meteoritical contamination of the source regolith.

The isotopic compositions of the Sm/Nd and Rb/Sr systems and the relevant elemental concentrations show some similarity to Apollo 15 soils and KREEP basalt. The back-calculated $^{187}Os/^{188}Os$ isotopic ratios and the highly siderophile element (HSE) concentrations are close to the chondritic trend and not too far from values for Apollo 12 samples.

Possible Source Area: The bulk meteorite chemical composition and, in particular, a chondrite-normalized REE pattern are compatible with an origin of this meteorite from within the Procellarum KREEP terrane; this is supported by Rb-Sr and Sm-Nd isotope systematics that show some similarities to Apollo 15 soil and Apollo 15 KREEP basalt compositions. A comparison of the bulk meteorite Fe, Th, and Ti concentrations with lunar surface concentrations of the same elements provided by Lunar Prospector Gamma Ray Spectrometer data revealed potential source regions of NWA 11962. These regions lie mostly in and around Mare Frigoris, Mare Imbrium, and the southwestern edge of Oceanus Procellarum. A comparison with coordinates of young lunar impact crater larger than 300 meters indicated a potential source crater for NWA 11962 in the vicinity of Sinus Medii. Further studies will have to clarify if this crater is of an appropriate age.

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References: [1] Bechtold A. et al. (2021) *Meteoritics & Planetary Science* 56: doi: 10.1111/maps.13659. [2] Bechtold A. et al. (2021) *in review.*