

Mineralogy and petrology of a rock fragment of felsite in lunar meteorite Northwest Africa 2727 breccia: Implications for silica- and Th-rich volcanism and scientific targets toward a future landing mission on the Moon

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Based on previous study of lunar returned samples and meteorites, the main suites of pristine nonmare igneous rocks have been classified into the following four types: (1) ferroan anorthosite (FAN) or ferroan anorthositic-suite (FAS), (2) magnesian suite (Mg-suites), (3) alkali-anorthosite-suite and (4) KREEP basalt and possibly related rocks such as quartz-monzogabbro (QMG) /monzodiorite (QMD), granite and felsite. The latest suite type, the evolved rock samples related to KREEP, may have been derived from residue of the lunar magma ocean (urKREEP), or from low degrees of partial melting or some other process to account for their high incompatible trace element (high-ITE) compositions. Granite and felsite have Th-rich compositions (10 to 60 ppm), and such lunar samples with bulk SiO₂ content of >60wt% originated from silicic volcanic or exposed intrusive material. Recent global remote sensing data have presented several candidates of silicic volcanism over the Moon based on indicators such as ITE-rich compositions, dome-like topography, characteristic infrared spectra (Christiansen Feature), and high albedo. Silica-rich, broadly granitic samples have been identified in lunar returned samples and lunar meteorites, but are rare. Lunar meteorite Northwest Africa (NWA) 2727 is a breccia paired with NWA 773 and the other meteorites of the NWA 773 clan. An olivine cumulate gabbro (OC) is common to most of these lunar meteorites within the NWA 773 clan; in fact NWA 2977 and 6950 consist entirely of OC lithology. However, in addition to the OC lithology, several clast types, including in olivine phyric basalt, pyroxene phyric basalt, pyroxene gabbro, ferroan symplectite, and alkali-rich-phase ferroan (ARFe) rocks have been discovered from the NWA 773 clan. The ARFe clasts have K-feldspar and/or felsic glass, a silica phase and minerals rich in incompatible elements such as merrillite. In this work, we characterize a felsic clast in NWA 2727 and compare our results with other lunar samples to discuss silicic volcanism.

A polished thin section (PTS) of NWA 2727 was investigated by a combination of petrographic microscopy and electron probe micro-analysis. The NWA 2727 breccia includes a variety of large-scaled lithic clasts (>1mm) including: OC, ferrogabbro, pyroxene-phyric basalt, and the felsic igneous clast. The felsic clast has a modal composition of 37% silica, 34% plagioclase, 14% K-feldspar, 6% high-Ca pyroxene, 5% fayalite, 3% Ca-phosphate, 1% ilmenite, and traces of troilite and chromite. Feldspar compositions of the plagioclase are near An₈₅₋₉₀. Two compositional types of pyroxene were identified—one near hedenbergite (Wo₄₆Fs₅₃, Mg# = 1 [calculating Mg# as $Mg/(Mg+Fe) \times 100$]) and the other with zoning and more magnesian compositions (Wo₂₅₋₃₀Fs₅₅₋₆₅, Mg# = 8-20). The K-feldspar is also zoned with variable concentrations of Ba, clearly detected in elemental X-ray maps (quantitative analyses of Ba are planned). The abundance of silica + feldspars (>80 mode%), the high proportion of K-feldspar to plagioclase, and the very ferroan compositions of mafic minerals attest to the felsic composition of this clast. Subhedral-euhedral olivine crystals up to 0.3 mm in maximum length are preserved, and silica and K- and Ba-feldspar occur in elongate parallel crystals indicating an igneous origin. These observations indicate that this clast was derived from silica-rich magma.

Silicic volcanism is also interesting from the viewpoint of landing site candidates for future

lunar landing mission. Global gamma-ray observations have presented several high-Th regions in PKT, but the main lithology of the Th-rich regions remains a subject of dispute; possibilities include mafic impact-melt breccia, KREEP basalt, QMD, and felsite/granite. If a lander/rover mission to a high-Th region is equipped for analysis of major elements, in situ analyses on the Moon can be compared with silica-rich samples such as the felsic clast in NWA 2727.

Keywords: felsite, lunar meteorite