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Silica polymorphs in lunar granite: Implications for granite petrogenesis on the Moon

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Abstract

Granitic lunar samples largely consist of granophyric intergrowths of silica and K-feldspar. The identification of the silica polymorph present in the granophyre can clarify the petrogenesis of the lunar granites. The presence of tridymite or cristobalite would indicate rapid crystallization at high temperature. Quartz would indicate crystallization at low temperature or perhaps intrusive, slow crystallization, allowing for the orderly transformation from high-temperature silica polymorphs (tridymite or cristobalite). We identify the silica polymorphs present in four granitic lunar samples from the Apollo 12 regolith using laser Raman spectroscopy. Typically, lunar silica occurs with a hackle fracture pattern. We did an initial density calculation on the hackle fracture pattern of quartz and determined that the volume of quartz and fracture space is consistent with a molar volume contraction from tridymite or cristobalite, both of which are less dense than quartz. Moreover, we analyzed the silica in the granitic fragments from Apollo 12 by electron-probe microanalysis and found it contains up to 0.7 wt% TiO_2, consistent with initial formation as the high-temperature silica polymorphs, which have more open crystal structures that can more readily accommodate cations other than Si. The silica in Apollo 12 granitic samples crystallized rapidly as tridymite or cristobalite, consistent with extrusive volcanism. The silica then inverted to quartz at a later time, causing it to contract and fracture. A hackle fracture pattern is common in silica occurring in extrusive lunar lithologies (e.g., mare basalt). The extrusive nature of these granitic samples makes them excellent candidates to be similar to the rocks that compose positive relief silicic features such as the Gruithuisen Domes.

Keywords: Silica, polymorph identification, granite, Moon, granophyre, volcanism, Raman spectroscopy