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Miyake-jima anorthite: A lunar crustal material analog

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Abstract

High-calcic (~95% anorthite) plagioclase is the key mineral comprising the primary lunar crustal suites that cover over 60% of the Moon's surface. Pristine crystals of similar high-calcic plagioclase are rare occurrences on Earth, which creates a roadblock to using terrestrial material as lunar crustal analogs. We discuss the potential of a particular megacrystic anorthite ($An_{95.51\pm0.31}$) occurring in the basaltic lava flows of the island arc volcano in Miyake-jima, Japan, as a material analog. A comprehensive analytical routine for the Miyake-jima anorthites has been performed to explore intra- and inter-crystalline heterogeneities in major, minor, and trace elements. These anorthites show flat concentration gradients across core profiles for all major elements (Si, Al, Ca, Na), minor elements (Mg, Fe), and most trace elements (La, Ce, Pm, Nd, Eu). Comparing the chemical composition of the samples with that of different lunar crustal suites like ferroan anorthosites, high-magnesium suites, and high-alkali suites shows that the Miyake-jima anorthites are overlapping or depleted in most minor and trace elements except for a slight enrichment in Li, Ti, Fe, Sr, Eu, Ba, and Pb. Given the low abundance of most trace elements in the Miyake-jima anorthites, we can treat this sample suite as a "blank slate," which provides the opportunity to dope the crystalline matrix with the elements of interest at different levels and use them for geochemical, petrologic, and spectroscopic studies. The lack of typical magmatic zoning and overlapping elemental compositions across the different megacrysts make the Miyake-jima anorthites very well suited as a lunar crustal material analog. Highly calcic, crystalline anorthite is shown to have unique spectral signatures from less calcic anorthite, and intermediate and sodic compositions of plagioclase feldspar as calcium and iron contents control the wavelength position and shape of the diagnostic spectral features in the thermal infrared region of the electromagnetic spectrum. Thus, near- and thermal infrared spectral measurements of the Miyake-jima anorthites highlight the importance of developing chemically and mineralogically consistent terrestrial material analogs for remote sensing studies.

Keywords: Natural anorthite megacrysts, lunar material analog, major and trace elements, near-infrared and thermal infrared spectra