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Formation of the zoning parttern in moonstones

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Moonstones are a gem-quality feldspar with a special exsolution structure and are well-known for the unique moonshine effect of themselves. However, formation of such “moonshine” is still a mystery. One possibility to reveal it, is by understanding, the formation mechanisms of moonstone exsolution fashion, which is constituted by the lamellae inclusions and the associated zoning patterns (banding structures). Here, by combining the mineralogical- and geochemistry techniques, we investigated the chemistry and textures of the chemical patterns in moonstones in detail. Two different color moonstones (orangish and grayish) are the object of study. Although Raman and EPMA analyses indicate that, both moonstones are orthoclase ($Or_{73.65\sim90.38}$), the orange moonstone is colored by hematite inclusions while the gray one is by magnetite inclusions. The orange moonstone has two lamellae types, which are An-containing albite phase ($An_{6.53\sim18.93}$) and K-high albite phase ($\approx An_{6.23}$). The An-containing albite lamellae demonstrated a μm-size zone with a decrease of An content (18.93 to 6.53) from the zone center to edge. In contrast, the gray moonstone does not show any zoning structure. Those allow for further analyses focusing on the zone structures, in combination of XRD diffraction structure analysis, La-ICP-MS whole-rock principal element analysis and phase diagram simulation, and by which, we proposed a two-stage-growth process for exsolution structure that is formed in the orange moonstone. The first stage of exsolution results in oligoclase lamellae, and the second stage results in K-high albite lamellae, in which part of Ab-rich phase became to individual K-high albite lamellae, while part of Ab-rich phase continues to dissolve around the oligoclase, forming the zoning structure. We formulated that the gray moonstone has only one formation stage which corresponds to the second stage of the orange moonstone. Our detail descriptions of moonstone might be a valuable contribution to further the study of moonshine effect.