Compositional controls on the rinkite-(Ce)-nacareniobsite-(Ce) solid solution series

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The minerals rinkite-(Ce) ($(Ca_3Ce)Na(NaCa)Ti(Si_2O_7)_2(OF)F_2$) and nacareniobsite-(Ce) ($Ca_3(Ce)Na_3Nb(Si_2O_7)_2(OF)F_2$) are isostructural (Camara et al., 2011; Sokolova & Hawthorne, 2008) and form a solid solution series (Vivalva et al., 2013). As intermediate compositions are produced by substitution of Nb for (Ti+Zr), we report compositions as the rin#, which is calculated as (Ti+Zr)/(Ti+Zr+Nb) (in apfu/apfu). In the Ilímaussaq Complex (Gardar Province, South Greenland), most of the solid solution series is represented. On the intrusion-wide scale, high rin# compositions are represented in the earliest pulaskites (rin#$_{0.88\text{-}0.90}$) and kakortokites (rin#$_{0.63\text{-}0.75}$) and become increasingly low in rin# as crystallization progresses, such that late lujavrite contain dominantly nacareniobsite-(Ce) (rin#$_{0.18\text{-}0.35}$; Rønsbo et al., 2014). In our new data set, three lujavrite samples contain nacareniobsite-(Ce) (rin#$_{0.28\text{-}0.42}$) and three naujaite samples contain rinkite-(Ce) without zonation (rin#$_{0.37\text{-}0.71}$). In addition, two naujaite samples have homogenous rinkite-(Ce) cores (rin#$_{0.60\text{-}0.67}$) with relatively thin overgrowths of nacareniobsite-(Ce) (rin#$_{0.23\text{-}0.34}$). Finally, one naujaite sample shows complex zonations of at least three types: (1) The most abundant type of zonation yields a rounded core of intermediate composition (rin#$_{0.3\text{-}0.6}$) with multiple inclusions of a eudialyte-group mineral and pectolite. The cores are mantled by inclusion-free rinkite-(Ce) (rin#$_{0.7}$). Finally, grains are overgrown by a thin rim of nacareniobsite-(Ce) (rin#$_{0.2\text{-}0.4}$) which is genetically related to small, late-stage nacareniobsite-(Ce) needles. (2) In another type, the rinkite-(Ce) mantles are themselves zoned and yield two distinct compositions. (3) Finally, some grains show extremely complex patchy zoning patterns of irregularly shaped areas of distinct compositions.

We interpret the general trend of decreasing rin# in rinkite-(Ce)/nacareniobsite-(Ce) in the Ilímaussaq Complex as a consequence of progressively decreasing rin# in the magma. Similarly, we interpret thin overgrowth of nacareniobsite-(Ce) on rinkite-(Ce) grains in naujaite as reflecting the progressive magma evolution in trapped interstitial melt. The zoning pattern of intermediate-rin# cores in high-rin# mantles in naujaite is related to the co-crystallizing eudialyte-group minerals with relatively Nb-rich and Ti-poor cores, relative to rims. We suggest that the initial crystallization of relatively Nb-rich rinkite-(Ce) could be caused by local depletion of TiO_2 and ZrO_2 in a diffusional boundary layer. This stage is then followed by partial resorption of the core and overgrowth of Ti-rich rinkite-(Ce). The study highlights the complex distribution of economically important elements such as REE, Y, Nb, Zr and Ta, and the importance of understanding the petrogenesis of their host rocks.

References

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