

The role of volatile elements in cancrinites from the Larvik Complex, Norway

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Minerals of the cancrinite group are microporous feldspathoids with hexagonal or trigonal symmetry, characterised by the presence of zeolitic cages and large channels in their structures. The diversity observed in this group is associated with numerous possibilities of incorporation within the channels, including cations (Na^+ , K^+ , Ca^{2+}), anions (Cl^- , S^{2-} , F^-), anionic groups (CO_3^{2-} , SO_4^{2-} , OH^- , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-}), and neutral molecules (H_2O , CO_2). These minerals are found in various geological environments, including silica-poor alkaline rocks, where they crystallise as primary phases and alteration products of nepheline and sodalite. Numerous crystal-chemical studies have been conducted both on natural and synthetic cancrinites [1]. However, despite a general consensus about the geometry of the aluminosilicate framework, different models often contradict each other when it comes to the extra-framework components [2].

The structure and chemical content of natural cancrinites were reinvestigated through the combination of various complementary analytical techniques, including electron probe microanalysis, single-crystal X-ray diffraction, and Fourier transform infrared spectroscopy. A total of thirty-five samples were investigated, among which representative cancrinites from various alkaline complexes stored in the Mineralogy collections of the Universities of Liège and Oslo, as well as new samples collected on the field in the Larvik Plutonic Complex (LPC) in Norway.

Our study highlighted the significant importance of infrared analysis in studying cancrinites, especially for evaluating the speciation of the carbon atom (i.e., CO_3 , C_2O_4 or CO_2). It was possible to subdivide cancrinites *sensu stricto* into different categories based on their infrared spectra, and correlations were established between the vibrational frequencies of CO_3 groups and their environments within the channels. Electron-microprobe analyses allowed to study the Si/Al substitution mechanism, and to detect the presence of non-carbonaceous volatile elements. Particularly, sulphur and fluorine were detected in significant proportions in some samples.

A focused investigation of samples from the Saga 1/Sagåsen quarries in the Larvik Plutonic Complex shows that cancrinites are associated with saccharoidal albite and aegirine, in pegmatites transitioning from miaskitic to agpaitic regimes. Cancrinites crystallise in those rocks due to extensive late-stage hydrothermal alteration processes [3], and correlations between the volatile contents of cancrinites and their parageneses provide insights into the post-magmatic processes affecting the alkaline pegmatites of the LPC. The distribution of volatile elements within the structure of natural cancrinites was also discussed, suggesting their potential as petrogenetic indicators in different intrusive alkaline complexes, as previously mentioned by Pekov et al. [4].

References:

[1] Chukanov et al. (2021) *Microporous Mesoporous Mater* 323: 111098

[2] Shendrik et al. (2021) *Crystals* 11: 280

[3] Sunde et al. (2019) *Nor J Geol* 99: 93-111

[4] Pekov et al. (2011) *Can Mineral* 49: 1129-1150