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Indications for a CO_2-rich fluid cap in the uppermost part of the Laacher See Magma Chamber

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Sanidinites are rare holocrystalline to hypocrystalline magmatic cumulates and are found as volcanic ejecta of potassic explosive volcanoes. They all have trachytic to phonolitic whole rock composition. Main constituent of these rocks is sanidine forming a framework of interlocking crystals creating miarolithic cavities. In this study we were investigating sodalite bearing sanidinites from the tephra deposits of the Laacher See Volcano, Eifel, Germany with the aim to decipher the processes in the uppermost, rigid part of the magma chamber.
Macroscopically three different types can be distinguished: (1) dark haüyne-sanidinites, (2) bright haüyne-sanidinites and (3) nosean-sanidinites. Both types of haüyne-sanidinites contain glass, rich in vesicles, forming a film around most of the mineral grains or sometimes filling up the miarolithic cavities. Minor mineral phases are haüyne occurring within these cavities, mainly adjacent to plagioclase as well as clinopyroxene and biotite. Accessories are apatite, magnetite and titanite. In nosean-sanidinites glass is absent or occurs occasionally as a minor phase. Major crystals within the miarolithic cavities are nosean and calcite, while clinopyroxene and biotite are rarely observed. A special feature is the formation of HFSE minerals as euhedral crystals, including zircon, baddeleyite, pyrochlore and REE-apatites. The difference in mineral assemblage is also reflected in the whole rock composition of the investigated samples. Nosean-sanidinites are compared to haüyne-sanidinites (i) enriched in Na, Ca, Mn, S, Cl, Zr, U, Th, Hf, Zn and REE (+LOI) and (ii) depleted in K, Mg, Si, Ti, P, Ba, Sr and V.
From dark haüyne-sanidinite over bright haüyne-sanidinite to nosean-sanidinites the mineral composition of the major phases shows following systematic trends: Ca content of sanidine decreases indicating decreasing temperature during crystallization. The minerals of the sodalite group show an increase of Na and CO_2 whereas the content of Ca and SO4 decreases. Clinopyroxene observed in the haüyne-sanidinite has diospidic to hedenbergitic composition while in the nosean-sanidinites it is enriched in Mn (ferroan johannsenite with up to 0.55 apfu Mn; 15.5 wt.-% MnO).
Several features indicate the presence of an aggressive fluid phase during formation of the nosean-sanidinites: all silicates expose etching structures such as jagged or rounded mineral surfaces, and/or holes and channels within the mineral grains. To a lesser extent these structures are also observed in the silicates of the bright haüyne-sanidinites. In nosean-sanidinites the etching holes are often filled by calcite. Occasionally these fillings are bounded by a calcite filled fluid vain. All these observations indicate the presence of a CO_2-rich fluid phase.
The sanidinites are suggested to be formed at late magmatic conditions from a phonolitic melt. The systematics in the textures indicates, that the minerals within the miarolithic cavities of the haüyne-sanidinites crystallized from an evolved, volatile rich phonolitic melt. In contrast the crystallization within the miarolithic pore space of the nosean-sanidinites took place in the rigid zone of the uppermost part of the magma chamber where the mineral forming processes are induced by CO_2-rich fluid.