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Understanding the natural basalt carbonation formation: the case study of Sverrejfellet Volcano (Svalbard, Norway)

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This study examines the formation and crystallization processes of carbonate cements in natural host rocks, specifically basaltic rocks of the Sverrefjellet volcano in Svalbard, Norway. Sverrefjellet, which erupted about one million years ago, consists of cinder cones, pillow lavas, and dikes formed under subglacial conditions (Treiman 2012). After the eruption, fluid-rock interactions facilitated carbonate cementation in certain zones of the basalt. These carbonate cements display unique mineralogical and chemical characteristics that have been documented in the literature (Blake et al. 2011). However, the origins, crystallization mechanisms, and chemical evolution of these cements remain largely unexplored. In order to clarify the environmental conditions and the processes that drive the formation of carbonate cements, several analytical techniques have been employed. These include i) determining palaeotemperatures of carbonate formation by analyzing clumped isotope, ii) applying hydrogeochemical model using PHREEQC to investigate carbonate precipitation over a range of temperatures and pH conditions, and iii) performing comprehensive mineralogical, geochemical and textural analyses of the carbonate phases using high-resolution scanning electron microscopy with energy dispersive spectroscopy.

Our results show that these carbonate cements consist of calcite-like carbonates within the magnesite-calcite-siderite compositional range. The carbonation process appears to have undergone at least four distinct phases, each characterized by an evolution in the crystal chemistry and chemical texture of the cements. In the first phases, the calcian proto-dolomite formed, then calcium-poor magnesite, and ultimately a mixture of iron-rich carbonates (such as siderite) and non-carbonate cement phases. These results provide valuable insights into the sequential development of carbonate cements, and improving our understanding of mineralogical transformations in basaltic systems under post-eruptive conditions. This

knowledge is particularly relevant to the field of carbon capture and storage in basaltic reservoirs, where the natural carbonation processes observed in Sverrefjellet basalts may serve as a model for engineered CO_2 sequestration.

Blake, D. F. et al. et al. (2011) ‘Carbonate cements from the Sverrefjell and Sigurdfjell volcanoes, Svalbard Norway: analogues for Martian carbonates’, in 42nd Lunar and Planetary Science Conference.

Treiman, A. H. (2012) ‘Eruption age of the Sverrefjellet volcano, Spitsbergen Island, Norway’, Polar Research. Norwegian Polar Institute, 31(SUPPL.)