

Carboxylate ions and nordstrandite growth: AFM surface observations

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The aluminum hydroxide minerals are important in the production of aluminium, the regulation of aluminum in natural waters and the adsorption of ions. The polymorphs of Al(OH)₃ (gibbsite, nordstrandite, doyleite) differ in terms of the stacking of their unit layers. Nordstrandite occurs in many soils and has industrial uses. The presence of carboxylate ions in solution during crystal growth causes nordstrandite crystals to be less well-formed in overall appearance, compared to when grown without the presence of the carboxylate ions. In order to gain more understanding of the effects of carboxylate ions on Al(OH)₃ growth, atomic force microscopy (AFM) was used to observe the nanometer scale surface morphology of nordstrandite crystals synthesized from Al metal in ethylenediamine solutions in the presence of malonate, aspartate, oxalate and citrate ions. The AFM images showed that crystal faces were smoother overall for the nordstrandite crystals synthesized without carboxylate ions. For crystals synthesized in solutions with the largest concentrations of carboxylate ions, the nanometer scale images showed that the surfaces were very irregular and were characterized by elongated islands. Our AFM observations were the same for nordstrandite samples grown with large differences in the amount of stirring of the crystallizing solutions, indicating that the effect of bulk diffusion alone could not have been responsible for the effect of the carboxylate ions on crystal growth. Moreover, only a weak correlation existed between the concentration of carboxylate ions in the crystallizing solution and the amount of nordstrandite produced. On the {110} basal faces of the nordstrandite crystals, which are oriented parallel to the stacking of the unit layers, steps having a height of one nordstrandite unit layer were observed. 2-dimensional growth was primarily observed on these faces. For the nordstrandite crystals synthesized without carboxylate ions, the steps were oriented along crystallographic directions, and extended all or most of the way across the crystal faces. Many of these steps were parallel to each other. The nucleation of new terraces occurred primarily at the edges of the crystal faces, and few if any islands nucleated in the centres of the faces. The crystals synthesized with the highest concentrations of carboxylate ions had steps on the basal surfaces that were more rounded and conformed less to the crystallographic directions. The carboxylate ions also promoted the nucleation of small monolayer islands in the interiors of the crystal faces.

Melt-rock reaction in Canadian Cordillera mantle xenoliths

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The xenoliths found at alkali basalt volcanic centers of the southern Canadian Cordillera represent the mantle lithosphere located between the cratonic root of the Canadian continent and the Pacific oceanic lithosphere. They mainly comprise Cr-diopside peridotites that formed by the extraction of basaltic melts. Two centers, however, also comprise 30 to 50 % of augite-bearing xenoliths (dunites, wehrlites, pyroxenites, opx-poor lherzolites) with cumulate textures, forsterite contents between 83 to 90, and Al₂O₃ contents between 0.2 and 9 wt%. This compositional range cannot be explained by closed system crystallization alone. Modeling using the MELTS program (Ghiorso & Sack, 1995; Asimow & Ghiorso, 1998) shows instead that the augite xenolith suites may result from the interaction between crystallizing alkaline melts and their peridotitic wall-rock. Assimilation-Fractional-Crystallization (AFC; DePaolo, 1981) modeling using the same mass ratios as in the MELTS models does not change the trace element pattern of the initial liquid. The trace element patterns of liquids in equilibrium with the augite xenoliths are thus considered to be representative of the initial melts that reacted with peridotite. Moreover, the composition of these melts is similar to some glasses observed in mantle xenoliths. The formation of wehrlite and orthopyroxene-poor lherzolites by melt-rock interaction may thus be a viable mechanism for the formation of some of the Si and alkali-rich glass in peridotites. Augite xenoliths are abundant in the two xenolith sites located the closest to the Canadian craton only suggesting that circulation of melts might be facilitated at the orogen-craton transition in the mantle.

References

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