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Reconstruction of mid-crustal pluton assembly and evolution using trace elements in augite: Sausfjellet pluton, Bindal batholith, north-central Norway.

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The Sausfjellet pluton is a 445 Ma gabbroic to monzonitic body of 7 Km in diameter emplaced in two stages at ∼700 MPa pressure. Stage 1 is a coarse pyroxene hornblende gabbro. Stage 2 intrudes a steep contact between marbles on the east and pelitic migmatites on the west. Stage 2 displays a gradational transition from hornblende biotite two-pyroxene diorite to hornblende biotite three-pyroxene quartz monzonite. This transition is accompanied by a decrease in the An content of normally-zoned plagioclase from An61 to An27. Much of the pluton consists of cumulate rocks, as illustrated by the presence of anorthosite and pyroxene-rich layers. In the western part of the intrusion, hosted by metapelitic rocks, incompatible element concentrations and bulk-rock [U+F064]18O increase to levels that cannot be explained by fractional crystallization. These increases were originally explained by AFC processes, but because of the cumulative nature of the rocks, it is difficult to assess magmatic processes using bulk rock compositions. Therefore, we analyzed trace element contents and core-to-rim zoning in augite as a proxy to track changes in melt composition.
Augite is normally zoned, with lower incompatible element abundances in the cores than in the rims, consistent with evolution of the melt by fractional crystallization. However, instead of plotting along a single differentiation trend, augite compositions define two trends, which is inconsistent with a closed system. The most mafic rocks define a trend with lower REE contents and smaller (negative) Eu anomalies compared to those from the more evolved part of the pluton, although the two trends overlap in Zr content. The two trends correspond to the central, more mafic zone that intrudes marble and the western, more evolved zone that intrudes metapelites. The trend associated with the western zone consists of the same samples that show bulk-rock [U+F064]18O enrichment, and is best explained as resulting from assimilation of the host metapelites.
The fact that the two trends become distinct at low Zr concentrations indicates that assimilation occurred early in the evolution of the western zone of the pluton and was complete before the bulk of the system evolved.
We conclude that the trace element record preserved in early-crystallizing minerals such as augite preserve information that can be used to understand pluton assembly, estimate the size of potential magma chambers, and identify magmatic processes.