Subsolidus cooling of large igneous bodies – a study of the Skaergaard Intrusion, Greenland

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Although the Skaergaard Intrusion is probably the most studied layered mafic intrusion on Earth we are far from completely understanding the processes that led to its formation and cooling. A more comprehensive knowledge about the cooling rates is particularly important to constrain the thermal structure and thermal evolution of such an intrusion.

The application of diffusion chronometers on natural rock samples allows for a quantitative determination of subsolidus cooling rates. In this study we applied the Mg-in-plagioclase and Ca-in-olivine diffusion chronometers to map cooling rates throughout a stratigraphic section of the Skaergaard Intrusion. Both are based on the diffusive exchange of ions (Mg, Ca) during cooling between plagioclase and clinopyroxene and olivine and clinopyroxene, respectively, and allow for cooling rates to be determined in the temperature range between 1100 to 900°C. Application of two independent diffusion chronometers allows us testing the robustness of the derived cooling rates.

It is widely accepted that the Skaergaard Intrusion formed from a single magma injection and crystallized from the rims of the magma chamber inwards. Different models for the cooling history agree that cooling is expected to be fastest at the rims of the intrusion with a decrease in cooling rates towards the center. Surprisingly, our preliminary results indicate the opposite with slow cooling rates at the bottom of the intrusion and faster cooling rates in the center of the magma chamber. This leads to the conclusion that the Skaergaard Intrusion may not have predominantly cooled by conductive heat transport from a single magma chamber, but that other cooling mechanisms / pulsed intrusions must have played an important role at high temperatures.