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Plagioclase grain shape and size as an indicator of crystallisation regime in propagating dykes

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The shape of plagioclase in igneous rocks is controlled by thermal history. At large undercoolings, diffusion-controlled growth leads to hopper and swallowtail morphologies, whereas interface-controlled growth at low undercoolings leads to tabular grains. The shape of tabular grains is also dependent on crystallisation rates, with more equant shapes indicative of slow cooling.
In basaltic sills, ponded lava flows and lava lakes, the average aspect ratio of plagioclase as viewed in thin section (AR) varies systematically with stratigraphic height, with low AR seen in the slowest-cooled central parts of the magma body and high AR at the margins. The outermost margins of sills and lava lakes contain plagioclase with relatively low AR, leading to an overall M-shaped variation of AR with stratigraphic height. The spatial variation of AR in basaltic dykes comprises two distinct types. The first shows a systematic variation of AR across the dyke, forming a U-shape, whereas the second has constant AR across the width of the dyke with a value similar to the average value of AR seen in sills of comparable size.
Plagioclase grain size (defined as the average long axis length of grain intersections viewed in thin section) becomes larger with increasing size of sills and dykes: the rate of increase in dykes with a U-shaped AR profile is the same as that for sills, but is considerably greater for dykes with constant AR across their width. It has been previously argued that the differences between sills and the coarse-grained dykes with constant AR are due to differences in the crystallisation regime: crystal growth in sills predominantly occurs in marginal solidification fronts, whereas the vertical slot geometry of dykes permits growth of isolated crystals suspended in a vigorously convecting magma. The identification of dykes with sill-like microstructural characteristics demonstrates that not all dykes convect once through-flow has ceased. The dykes with sill-like characteristics are those that propagated laterally from their source for considerable distances (>100km) through the shallow crust. It is likely that significant lateral propagation resulted in the magma containing abundant small crystallites that increased viscosity and damped convection: such dykes therefore crystallised from static magma by the inwards growth of solidification fronts.