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The effect of crystallization time on plagioclase grain shape

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The average aspect ratio of plagioclase, measured in thin section, varies systematically across dolerite sills ranging in thickness from 3m to 360m. A symmetrical "M" shaped profile in average aspect ratio is observed in sills thinner than ∼200m. Thicker sills show the same marginal reversal at the base but average aspect ratios continue to increase towards the top, creating a "S" shaped profile. A distorted "M" shaped profile is visible in the prehistoric Makaopuhi lava lake, with the lowest aspect ratio observed in the olivine-enriched horizon close to the base of the lake, thought to be the horizon with the longest crystallization time. Higher overall values of average aspect ratio are observed in thin sills compared to thicker sills, demonstrating that the plagioclase in more slowly-crystallised bodies is more equant than that in more rapidly-crystallised bodies.

While there is no correlation between aspect ratio and grain size across the six bodies examined, and little correlation between grain size and crystallisation time (calculated using a simple one-dimensional thermal model assuming conductive cooling), there is a strong correlation between the plagioclase average aspect ratio in the central parts of the sills and the crystallization time. The cause of the marginal reversals in average aspect ratio are not well understood but are likely to result from early impingement in the developing crystal mushy layer. The difference in behaviour between thin and thick sills may reflect fluid dynamical changes such as the onset of vigorous convection and the preferential erosion of the upper chilled margin.

This empirical relationship between crystallization time and plagioclase grain shape can be applied to layered intrusions to determine the extent by which plagioclase grain shape has been altered by processes such as compaction-driven recrystallisation.