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Complexity on a small scale: Emplacement dynamics and evolution of the Doros layered mafic intrusion, Namibia

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The Doros Complex in Namibia is a relatively small (∼8 km x 4 km), shallow-level layered mafic intrusion that forms part of the ∼132 Ma Paraná-Etendeka Large Igneous Province. It consists of a ∼500 m-thick preserved sequence of roughly concordant, sill-like gabbro layers dipping in towards the centre of the intrusion, cut by syenitic (bostonite) dykes.

The fundamental mineralogy is essentially the same throughout the main package (plagioclase + calcic clinopyroxene + oxy-exsolved Fe-Ti oxides ± olivine), and hence the layering is defined by variations in the modal proportions of these minerals, and in the mineral and rock textures. A detailed petrographic, whole-rock and mineral major and trace element, and Sr-, Nd- and Pb-isotopic study, combined with major element modelling, has shown that the stratigraphic order of appearance of cumulus minerals and overall trends in rock compositions are consistent with fractional crystallisation and accumulation from an uncontaminated basaltic parental magma. However, these data also reveal considerable complexity and stratigraphic trends in mineralogy, chemistry and physical properties incongruent with a simple progressive differentiation path.

Based on a comprehensive set of field, petrographic, geochemical and geophysical evidence, we put forward a compelling argument in favour of an origin for the Doros intrusion by multiple, closely-spaced influxes of crystal-bearing magmas (magma mushes), rather than from the post-emplacement differentiation of a single batch of crystal-free melt. This evidence includes intrusive layer relations, textural evidence for primocrysts, disequilibrium features, and stratigraphic reversals in mineral and whole-rock chemistry and magnetic properties. At least seven distinct major injections of magma have been identified in the stratigraphy, as well as several smaller pulses.

These findings represent a departure from the traditional single-pulse liquid magma model for the formation of such intrusions. This further implies the existence of one or more staging chambers below the Doros Complex and a high magma flux. We suggest that these results may also be applied in part to other, larger layered intrusions, where the emplacement history is more obscure. There is clearly considerable complexity that exists at every scale. Most importantly, these findings emphasise the role of phenocryst-bearing magmas in the construction of LMIs, and the significance of open system processes.