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Ultradepleted adcumulates from a late-stage mafic dyke of the Bayantsagaan layered intrusion, Mongolia

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It is commonly expected that late-stage dykes in mafic layered intrusions must be strongly enriched in all incompatible components that are concentrated in the evolved residual melt. Our recent study of one late-stage dyke from the Bayantsagaan layered intrusion (Mongolia) has revealed, however, that this is not always the case. This 11 cm thick dyke is composed of quite fresh, fully crystalline troctolite with no signs of chilling against host leucotroctolite. Texturally, both dyke and leucotroctolite are composed of medium-grained plagioclase-olivine-magnetite cumulate. The dyke is, however, finer-grained and more adcumulate than leucotroctolite as evident from a much less amount of intercumulus material mainly represented by interstitial amphibole (5 vol.% versus 10 vol.%). The dyke shows three distinctive geochemical features. Firstly, it is compositionally more evolved than leucotroctolite as indicated by notably lower real and normative An-content of plagioclase, whole-rock Mg-number and Cr and higher whole-rock TiO_2. Secondly, despite of being more evolved, the dyke is notably depleted in all incompatible components (e.g. K2O, Y, REE). Their concentrations in the dyke are several times lower than in host leucotroctolite (e.g. 0.015 ppm versus 0.112 ppm for Dy). Thirdly, the dyke reveals internal reverse zonation with an inward increase in compatible MgO, TiO_2 and normative An-content and a decrease in all incompatible components (e.g. REE). Such a distribution of incompatible components is indicative of an inward decrease in the amount of trapped melt, in other words, the dyke becomes inwards progressively more adcumulate. In layered intrusions, adcumulates are commonly attributed to the almost complete removal of interstitial liquid enriched in incompatible elements from cumulate pile by some primary cumulus (e.g. in situ growth) or post-cumulus processes (e.g. compaction, compositional convection, thermal migration). These processes are, however, not commonly operative in dykes and therefore the discovery of adcumulates in the studied dyke, especially with such a high degree of depletion in all incompatible elements, is quite surprising. Here we make an attempt to resolve this puzzle by appealing to in situ cumulate growth on dyke sidewalls from residual magma continuously flowing along the dyke. The process implies that the magma flow results in a very effective removal of an evolved liquid boundary layer from in situ growing crystals on dyke sidewalls, producing almost perfect adcumulates. The dyke becomes inwards increasingly more depleted in incompatible components in response to a progressive increase in the proportion of cumulus minerals. The study indicates that the processes responsible for origin of late-stage dykes in layered intrusions are not yet completely understood and require more attention from igneous petrologists.