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Buoyant rise of anorthosite from a layered basic complex triggered by Rayleigh-Taylor instability: Insights from a numerical modeling study

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Abstract

A major unsolved problem of the Proterozoic is the genesis and tectonic evolution of the massif type anorthosites. The idea of large-scale floating of plagioclase crystals in a basaltic magma chamber eventually generating massif type anorthosite diapirs from the floatation cumulates is not supported by observations of the major layered basic complexes of Proterozoic to Eocene age. In this paper, we test and propose a new genetic process of anorthosite diapirism through Rayleigh-Taylor instability. We have carried out a numerical modeling study of parallel, horizontal, multiple layers of norite and anorthosite, in a model layered basic complex, behaving like Newtonian or non-Newtonian power law fluids in a jelly sandwich model of the continental lithosphere. We have shown that in this pressure-temperature-rheology configuration the model lithosphere generates Rayleigh-Taylor instability, which triggers diapirism of the anorthosite. In our model, the anorthosite diapirs buoyantly rise through stages of simple, symmetrical upwelling and pronounced bulbous growth to a full-blown mushroom-like form. This is the growth path of diapirs in nearly all analog and numerical previous studies on diapirism. Our anorthosite diapirs fully conform to this path. Furthermore, we demonstrate that the progressive diapirism brings in striking *internal* changes within the diapir itself. In the process, the lowermost anorthosite layer rises displacing the upper norite and anorthosite layers as progressively stretched and isolated segments driven to the margin of the rising diapir—a feature commonly seen in natural anorthosite massifs. We propose that a large plume-generated basaltic magma chamber may be ponded at the viscous lower crust or ductile-plastic upper mantle or further down in the weaker mantle of the jelly sandwich type continental lithosphere. The magma may cool and crystallize very slowly and resolve into a thick-layered basic complex with anorthosite layers. Rheologically behaving like Newtonian or non-Newtonian power law fluids, the layers of the basic complex with built-in density inversions would generate RT (Rayleigh-Taylor) instability. The RT instability would trigger a buoyant rise of the unstable anorthosite from the layered complex. The upward driven anorthosite, accumulated as anorthosite plutons, would gradually ascend across the lower and middle crust as anorthosite diapirs.

Keywords: Anorthosite, layered complex, Rayleigh-Taylor instability, diapir, buoyant rise of anorthosite; Dynamics of Magmatic Processes