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The mysterious fate of stoped blocks in magma chambers - a story of disintegration, assimilation, sinking, and floating

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The issue of the emplacement of large volumes of magma in the crust is puzzling petrologists since the infancy of our discipline. Generally, three mechanisms are accepted, namely roof uplift, floor subsidence, and magmatic stoping. The latter mechanism has recently received criticism since large volumes of country rock that have apparently been detached from the margins of magma chambers seem to disappear with little trace of their whereabouts. This discussion about the efficiency of magmatic stoping and the fate of stoped blocks seizes a fundamental problem in the earth sciences with grave consequences for all tectonic settings and the evolution of the Earth's crust, as well as the explosivity of volcanoes. The occurrence of "foamy" xenoliths in, and frequently significantly higher amounts of crustal contamination of, extrusive rocks as compared to their plutonic equivalents argues against the widely accepted view that xenoliths have to necessarily sink to the bottom of a magma chamber to accumulate in "graveyards".
We used the Finite Differences code FDCON to model in two-dimensions the thermo-mechanical interaction of blocks of crustal rocks with magma in a chamber and to assess the key parameters that control this process. Based on the results of petrological and petrophysical studies of foamy xenoliths and high-temperature decompression experiments, our models imply a significant decrease in density as the xenolith partially melts and vesiculates during sinking. This should lead to a gradual halt of the sinking of the xenolith, followed by subsequent buoyant rise. The results of our models might therefore contribute a new perspective on the fate of stoped material, providing the xenoliths a way up and out of the magma chamber. This implies that the bottoms of plutons might, by their nature, be the wrong place to look for xenolith "graveyards" and that magmatic stoping does not require such graveyards since xenoliths can be effectively removed through eruptions.