Shallow-level processes at Anak Krakatau: crystallisation and late stage crustal contamination

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Anak Krakatau, the post-collapse cone of the infamous Krakatau volcano, breached sea level in 1928 and since the 1950s it has been growing at an average rate of 13cm a week. This activity may represent the very initial stages of an evolutionary cycle that could culminate in the type of catastrophic rhyolite eruption witnessed in 1883 and the even larger pre-1883 caldera. Analysis of a suite of samples from the 1883 and 2002 eruptions may thus provide crucial information concerning evolutionary cycles of subduction zone volcanoes, particularly their early and late stages.

During ascent, magmas are exposed to differentiation processes including crystallisation and interaction with the crust. Differentiation at shallow levels is recorded in e.g. plagioclase phenocrysts with complex zoning and by meta-sedimentary and plutonic xenoliths. The xenoliths show variable degrees of thermal overprinting, plastic deformation and partial melting, including classic contact-metamorphic minerals such as cordierite.

Here we present new major and trace element data of both the 2002 and 1883 products, combined with whole-rock Sr and Pb isotope ratios; and laser-ablation MC-ICP-MS and microdrill analyses of feldspar phenocrysts. The 2002 event erupted a plagioclase and pyroxene-phyric basaltic-andesite with Sr isotope ratios ranging from 0.704406±9 to 0.704442±6, with xenoliths displaying values from 0.704429±6 to 0.709154±6. Analyses of the 1883 rhyolitic-pumices and obsidians range between 0.704378±10 and 0.70469±9. The significant overlap between the igneous and crustal samples, from both 1883 and 2002 samples, suggests continuous crustal contamination during shallow magma storage at Anak Krakatau. This proposition is supported by low He isotope values obtained from recent fumarole gas, implying increasing contamination towards the later rhyolitic stages of Krakatau's evolutionary cycle.

The combined data suggest a complex interplay of processes ranging from fractional crystallisation to assimilation of chamber wall fragments coupled with an input of volatiles, probably from the same crustal source.