Formation of layering in a hypabyssal intrusion by shear-induced fracture, exsolution, and rapid devitrification

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The Butcher Ridge Igneous Complex (BRIC) is a ~6000 km^3 hypabyssal silicic intrusion within the Ferrar Large Igneous Province of Antarctica that contains enigmatic meter-scale layering. Layering is observed in a ~1 km long vitrophyre body, units of alternating vitrophyre and crystalline layers, and units of alternating crystalline layers. Individual layers in all units are laterally continuous for hundreds of meters and generally range from 1 to 3 meters thick. Petrographic observations and geochemical data indicate that crystalline layers have undergone extensive secondary devitrification and alkali ion exchange and represent a completely devitrified counterpart to vitrophyre layers. Field observations suggest that initial layer formation is due to the formation of repetitive parallel fracture networks within the layered vitrophyre body. We suggest exsolved magmatic fluids migrated into parallel fracture networks resulting in secondary hydration and rapid devitrification forming alternating vitrophyre and devitrified layers. Shear deformation experiments on rhyolites indicate that en echelon brittle fractures can form under relatively low strain rates (10^{-2} s^{-1}) in the volcanic conduit and enhance open-system magma degassing and control the explosivity of eruptions [1]. Thus, shear deformation during magma emplacement may best explain the formation of extensive parallel fracture networks in the BRIC. Finally, our data imply that explosivity can be suppressed not only by degassing of exsolved volatiles but also when secondary hydration and devitrification lead to retention of volatiles within formerly glassy bodies.

[1] Okumura, S., Nakamura, M., Nakano, T., Uesugi, K., & Tsuchiyama, A. (2010). *Journal of Geophysical Research: Solid Earth*, ***115***(B6).