Understanding magma chamber dynamics through flow instabilities

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Limited insight is available about dynamics of shallow crustal magma reservoir as its mostly acquired from expelled volcanic products or by using seismic tomography. Microfluidics can significantly contribute in understanding the dynamics of such magmatic systems. We have illucidated application of flow instabilties in deciphering geodynamics of a rhyolite magma chamber intruded by basaltic magma from the Proterozoic Chotanagpur Complex (CC) of Eastern India.

The Ghansura Rhyolite Dome (GRD) of CC preserves a variety of magma mixing zones. The first zone consists of basalt containing rhyolite ocelli. The second zone depicts mingled rocks where viscous folding is observed. The third zone represents hybrid rock displaying emulsion texture. The fourth zone is composed of hybrid andesite displaying synneusis. Major-oxide mixing tests and Sr-Nd isotopic signatures confirm the hybrid nature of the mixed rocks.

GRD was a zoned magma chamber having temperature induced physical boundary layers with varying viscosities when basaltic magma intruded it. The outermost zone was completely solid now preserved as ocelli in basalt. The innermost zone was completely melt, having least viscosity, that interacted with the basaltic magma forming hybrid andesite displaying synneusis. The compositions of plagioclase involved in synneusis are similar to that of the basalt. Between these two zones, there were two transitional zones- the High-Viscosity Outer Transitional Zone (HVOTZ) that was in contact with the solid zone and the Low-Viscosity Inner Transitional Zone (LVITZ) that was in contact with the melt. When mafic magma, containing phenocrysts of augite, came in contact with felsic magma, diffusion of cations like H^+ and Al^{3+} occurred from the felsic to the mafic system. These cations reacted with the augite phenocrysts in the mafic magma to form amphibole (actinolite) crystals that show pargasite and tschermakite substitutions. Formation of amphibole crytals in the mafic system greatly increased the viscosity of the system, allowing amphibole crystals to flow into the adjacent felsic magma as veins. Depending upon the viscosity regime, the veins underwent viscous folding in the HVOTZ, while in the LVITZ formation of emulsions was favoured to facilitate the mixing process.