doi:10.1130/ G36556Y.1

Magmatic life at low Reynolds number

Allen F. Glazner
Department of Geological Sciences, University of North Carolina, Chapel Hill, North Carolina 27599-3315, USA

Thanks to Clemens (2014) for his Comment on my paper (Glazner, 2014) that discusses the glutinous behavior of high-silica liquids. His comments are largely spot-on and reinforce many of the points in the original paper. It seems clear that layering in plutonic rocks can form via multiple processes, and it is sensible to rule out only those that violate basic physical or chemical principles.

That said, it remains dangerous to interpret plutonic processes in terms of everyday experience. At viscosities at least 30,000,000× greater than that of water and operative time scales of perhaps 1,000,000,000 minutes, the behavior of silicic magmas is so far outside human experience that common analogies can be highly misleading.

Consider Figure 1, a rather typical pavement of K-feldspar megacrysts in the Late Cretaceous Cathedral Peak Granodiorite in Yosemite National Park, California, USA. Such mosaics have been interpreted as gravitational accumulations (e.g., Gilbert, 1906; Žák and Paterson, 2005). This seems reasonable, based on everyday experience with flowing sediment, and the overabundance of xenoliths in them (~1000× greater than the abundance in the host granodiorite) seems consistent with a slurry of crystals and xenoliths. However, the phase equilibria of such magmas, compositions of the crystals, abundant evidence for thorough recrystallization, and too-high megacryst abundances rule out crystal accumulation (Johnson and Glazner, 2010; Glazner and Johnson, 2013) and require formation by some other process (e.g., Higgins, 1999). I would argue that similar caution should be used when interpreting features such as the "scroll structure" in Clemens (2014).

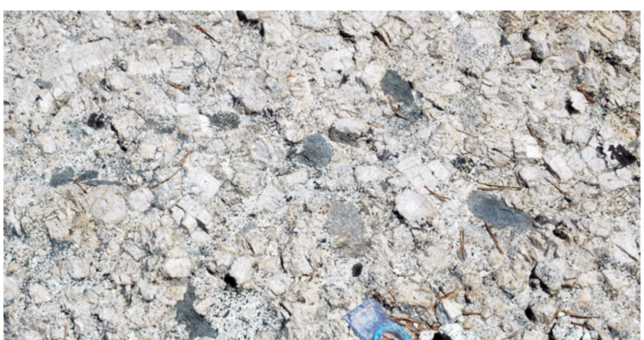

Figure 1. Mosaic of K-feldspar megacrysts in granodiorite 1.4 km southeast of Glen Aulin, Yosemite National Park, California, USA. Megacrysts are 5–10 cm in long dimension and make up 60–80 area% of the outcrop in this area. Gray metaigneous xenoliths 5-10 cm across are found among the megacrysts. Although this may look like a magmatic debris flow of megacrysts and xenoliths, it cannot be. Compass circle is 5 cm in diameter.

Crystal settling in silicic magmas cannot be ruled out (e.g., Shaw, 1965), although whether it can explain observed chemical variations in granites is not clear. Near the outcrop in Figure 1, porous flow of late-stage rhyolitic liquid over hundreds of meters can explain field relations and major- and trace-element abundances in granodiorite (Coleman et al., 2012).

In plutonic systems, explanations that make sense on the outcrop on the basis of visual similarity with something familiar are commonly incorrect. For example, features that look like dunite dikes in peridotite can be replacement structures (Nicolas, 1989). Stoping is a sensible idea, but it fails nearly every test devised for it (Glazner and Bartley, 2006). Truncated layers in granodiorite look like cross-bedding (Gilbert, 1906), but cannot be (Glazner, 2014). Plutons operate in a physical environment so different from the one we share in human experience that we should exercise great caution when drawing any analogies between them.

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