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Volcano hazards implications of rhyolitic melt or magma at shallow depth under Krafla Caldera

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Krafla Caldera in northern Iceland is a well-monitored and extensively drilled caldera system that underwent a major rifting and eruption episode in 1975 to 1984. The recent surprise discovery of ∼900oC “magma” (crystal+melt felsite and possibly crystal-poor rhyolite magma as well) in the Iceland Deep Drilling Project borehole #1 (IDDP-1) in 2009, as well as previous less publicized drilling encounters with rhyolite melt, challenges our understanding of caldera unrest. Further drilling may lead to improved understanding of volcanic hazards in calderas and better interpretation of precursory deformation and seismic signals that may herald eruption.

Salient features of the IDDP-1 discovery relative to volcanic hazards are:
1. The rhyolite magma is at only 2.1 km depth. If such magma were known to have intruded to such shallow depth in a populated caldera, there would likely be serious discussion of evacuating the population.
2. The drill site was chosen because magma was not expected at shallow depth, based on the occurrence of seismicity to twice that depth beneath the site during the last eruption, and on 3-D resistivity structure.
3. The eruption was entirely basaltic; no rhyolite reached the surface.
Thus, rhyolite magma intruded to shallow depth and was stored there without erupting and without being detected either geophysically or petrologically. An alternative, which seems unlikely, is that the rhyolite evolved from basalt or by basalt-induced partial melting after 1984.

If it is possible to return to this magmatic body through further drilling, as recently proposed to the International Continental Scientific Drilling Program (ICDP) by the Krafla Magma Drilling Project, complementary field, laboratory experiments, and computational experiments can be conducted to understand the “source” and how it produces deformation, seismic, and geochemical signals at the surface. Experiments could include injection of fluid with tracers directly into the melt-bearing zone. Results should be directly applicable to densely populated Campi Felgrei, where complementary ICDP drilling is not targeted at a magmatic source, but may reveal similar structures. Solidified magma bodies that did not erupt have been imaged seismically at Campi Flegrei at depths of even less than 2 km. Modeling of convection and mixing processes inside shallow chambers show that such bodies may not be visible during emplacement from seismicity and deformation, and would instead "point" to larger depths even if most of the dynamics are much shallower.