Lessons from 40+ years of volcanic eruptions around the world

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Roughly 50 volcanoes erupt every year. Some, like Kilauea, Sakurajima, Stromboli and Etna, are continuously active and make wonderful laboratories. Others wake up from years or decades of repose and produce large explosive eruptions or voluminous, viscous domes – also wonderful laboratories for as long as activity persists. Each volcano and eruption has its own unique character, but there are enough similarities and differences that we can draw lessons from a search for systematics.

One of the most important discoveries from eruptions of the past 40+ years, especially from El Chichón and Pinatubo, is that the enormous mass of volatiles released during these eruptions resided primarily in a discrete, supra-saturation volatile bubble phase, rather than being dissolved in magma. Silicate MELT was already degassed at depth, into bubbles that accumulate in the MAGMA. When that magma is decompressed, the bubbles can expand instantly and power plinian eruptions. It appears that most large plinian eruptions require such accumulation. While rates of gas resupply from depth are poorly known, it also appears that accumulation over several centuries is required to power a Volcanic Explosivity Index (VEI) 6 eruption (Pinatubo and several times larger), while a millennium or more of accumulation may be required to power a VEI 7 eruption (Tambora and several times larger).

In contrast, magma that can degas efficiently never accumulates gas much in excess of saturation. Most volatiles in such magma remain dissolved until very shallow depths, where they can produce a permeable foam from which gas can easily escape. Eruptions at such volcanoes tend to be frequent and small to moderate in size, e.g., at Stromboli, Mayon, and similar. Except for rare periods when the conduits of these volcanoes get plugged, most eruptions are of VEI 4 or smaller. Products of unusually large eruptions of Stromboli in 2003 and 2007 were of fresh, relatively undegassed, crystal poor magma, while those of everyday, smaller eruptions are of relatively degassed, crystal rich magma. Similar results are known from Mayon, Llaima, Merapi, and elsewhere.

An intermediate style of degassing occurs in some volcanoes where magma ascent is sufficiently slow that most magmatic volatiles leak out enroute to the surface. The resulting eruptions tend to be of sluggish, viscous lava domes, except when ascent rate occasionally gets tweaked to faster rates and modest size vulcanian explosions occur. The positive correlation between magma ascent rate and explosivity was first demonstrated at Soufrière Hills Volcano and has since been noted elsewhere, though with variable thresholds for explosive activity.

Plugged systems are prone to greater buildup of gas pressure in magma, leading to strong seismicity both beneath the volcano and on nearby active faults. Open-vent systems, in contrast, produce relatively modest seismic and deformation precursors. WOVOdat, a database of volcanic unrest worldwide, is under development and will serve for tests of this and other hypotheses about relations of precursors and ensuing eruption styles. Working hypotheses of how different groups of volcanoes work, with special emphasis on degassing style, give us a head-start in understanding unrest and forecasting the potential explosive magnitude of eruptions.

Lessons re: the effects of eruptions and re: volcanic crisis management are beyond the scope of this talk, but are equally important and will be widely discussed in the Cities on Volcanoes 8 meeting in Yogyakarta, Indonesia, September 9-13, 2014.