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Why do Volcanoes (Only Sometimes) Erupt Explosively?

The fragmentation of ascending magma is generally thought to be the key physical process that leads to explosive eruptions. Fragmentation occurs when stresses associated with bubble growth or decompression exceed the strength of the melt, allowing the magma to break into disconnected fragments suspended within an expanding gas phase. Although repeated effusive and explosive eruptions are common at individual volcanoes, the dynamics controlling the transition between explosive and effusive eruptions are unclear. One important constraint on the dynamics is that effusive lavas generally erupt considerably more degassed than their explosive counterparts, even if they erupt from sources with similar volatile contents. One mechanism for degassing during magma ascent is the formation of intermittent permeable fracture networks generated by non-explosive fragmentation adjacent to conduit walls. We will show that such fragmentation, which occurs when shear stresses exceed the strength of the magma, are expected to occur in both explosive and effusive eruptions.

The presence of fracture networks allows for rapid magma degassing and hence can inhibit explosive behaviour. In order to test this hypothesis we will present a quantitative analysis of bands in obsidian from Big Glass Mountain, CA. We show that these bands can be created by the repeated breaking, reorientation, reannealing and stretching of fragments created at conduit walls. We thus conclude that, contrary to conventional views, explosive volcanism is not the inevitable consequence of magma fragmentation.

Explosive eruptions can also be triggered by rapid decompression caused, for example, by dome collapse or landslides. We show, using a series of analog lab experiments, that whether or not rapid decompression leads to explosive eruptions depends on the initial vesicularity of the stored magma and the overpressure P in the bubbles. The product P is proportional to the potential energy of the bubbly magma. If the decompression rate is fast compared to the relaxation time of the magma, as it is when a surface load is suddenly removed, the potential energy is converted to kinetic energy and the speed of expansion v can be calculated. If v is large enough, the magma will fragment and the eruption will be explosive. In summary, whether or not a given eruption will be explosive depends not only on the ability of the magma to fragment, but also whether it is able to lose the volatiles that provide the driving force for eruption.

Biography:

Stealing directly from Dr. Manga's website (http://seismo.berkeley.edu/~manga/rsch.html), Dr. Manga has principally studied geological processes involving fluids, including problems in physical volcanology, geodynamics, hydrogeology, and geomorphology. The common theme running between these disciplines is an attempt to develop a better quantitative understanding of physical processes operating *in* the Earth. Depending on the nature of the problem, combinations of theoretical, numerical, and experimental approaches have been used. Because the intent is to understand natural systems, integration of both active processes and those recorded in the geologic record, with theoretical and model results is an essential component of the research. Often the fluid mechanics that need to be understood have not yet been studied. Consequently, his research typically involves new contributions in applied mechanics. Recent contributions include studies of convection, the properties and dynamics of suspensions, flow and transport in porous materials, percolation theory, and high pressure mineral physics. This work is currently funded by the National Science Foundation, the Petroleum Research Fund, the Sloan Foundation, and Lawrence Berkeley National Lab. Dr. Manga received his BSc, from McGill University (1990; Geophysics) and his PhD from Harvard (1994). He has been as Associate Professor at Cal since 2001.