VOLCANOLOGY

What goes up could come down

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WHEN Mount Pinatubo erupted last year, the huge amount of ash and gas that it pumped into the upper atmosphere blocked sunlight, lowering temperatures worldwide. At the same time, hot debris from the eruption cloud raced across the Philippine countryside as superheated pyroclastic flows that destroyed villages, crops and rainforests. Figuring out why explosive eruption columns sometimes rise and sometimes fall is the goal of a newly published laboratory study by A. W. Woods and C. P. Caulfield (*J. geophys. Res.* **97**, 6699–6712; 1992). By injecting buoyant mixtures of various organic solvents into tanks of water, they replicated the evolution of eruption plumes, defining the conditions associated with their growth and collapse. While confirming earlier theoretical models, their elegant experiments can also help us predict the dangers accompanying the most catastrophic of volcanic eruptions.

As the deaths of several volcanologists have shown, gaining a close-up view of a convulsing volcano rarely provides data worth the risk. Recent advances in remote sensing allow weather satellites, airborne radar, infrared spectrometers and gas 'sniffers' to obtain information safely from otherwise inaccessible eruption clouds. Numerical methods that use supercomputers to model volcanic explosions are also increasingly popular although, with a few notable exceptions (G. A. Valentine, K. H. Wohletz & S. W. Kieffer *Bull. geol. Soc. Am.* **104**, 154–164; 1992), their value has come more from quantifying suspected processes than from identifying new ones.

The most common way to study eruptions is to map and interpret what they leave behind. For instance, sediments that rain down from high ash clouds form regular layers that drape evenly over hills and valleys, whereas deposits left by pyroclastic flows are more chaotic and tend preferentially to fill depressions. By comparing such sequences from different volcanoes, geologists have been able to reconstruct a whole catalogue of typical eruptive histories.

More and more volcanologists are supplementing these methods with laboratory simulations so they can systematically study otherwise unobservable phenomena. Recent experiments have replicated mantle hot spots, magma chambers, igneous intrusions, lava domes and pyroclastic flows using such mundane analogues as wax, clay, corn syrup and gelatin. Continuing this trend, Woods and Caulfield created a set-up that let them safely turn miniature explosive 'eruptions' on and off. They simulated magma with buoyant combinations of methanol and ethylene glycol injected downwards into a tank of fresh water.

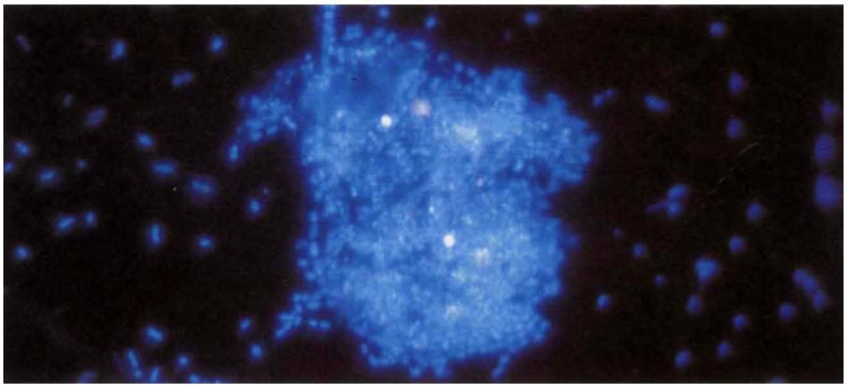
When mixed with enough water, these solutions had the unusual property of becoming more dense than either their organic constituents or the water itself. Normally the fluid jets would rise back up and spread across the top of the reservoir as soon as their momentum was dissipated. But injected forcefully enough to take in sufficient fresh water, they could become heavy and sink. The authors could precisely control whether the jets went down or up by varying their initial density and momentum, mimicking (in an inverted way) the transition from sustained eruption columns to collapsing 'fountains' that shed pyroclastic flows. Continued growth of the experimental plumes required only that they add enough water to remain denser than their surroundings.

Thermal effects complicate the analogous natural situation. Erupted ash is more dense than air, so its presence tends to promote column collapse. But these suspended fragments of magma also heat and expand the entrained air, giving it buoyancy. As a result, fallout of ash generally increases the bulk density and weakens the lift of an eruption cloud. Woods and Caulfield develop an analytical model that defines the critical eruption rate necessary to sustain columns in nature as well as in the laboratory. As was shown in calculations more than 10 years ago (L. Wilson, R. S. J. Sparks & G. P. L. Walker *Geophys. J. R. astr. Soc.* **63**, 117–148; 1980) tall eruption clouds are sustained by high ejection velocities and temperatures, low concentrations of ash, low particle densities and small-diameter vents. Subtle changes in any of these conditions can lead to column collapse and the formation of pyroclastic flows.

Although such experiments elegantly reproduce details of explosive volcanism, how reasonable is it to simulate giant eruption clouds in a glorified fish tank? As engineers have known for decades, properly constrained scale models are an inexpensive way to gain powerful insights into complex natural systems. They are best suited for identifying behavioural transformations like those between rising and collapsing eruption plumes. Also, many processes first recognized in the laboratory have later been confirmed by observations in nature.

For instance, Woods and Caulfield found that in some transitional experiments the sinking columns first stagnated and then gave off sporadic pulses of heavy fluid, like upside-down smoke signals. Although corresponding periodic clouds have not been described by volcanologists, their existence could explain why the deposits from some of the most

Decline and fall of marine snow



THE thriving colonies of bacteria (stained here with fluorescent dye) that inhabit 'marine snow' do not look after their hosts too well, it seems from the report of D. C. Smith *et al.* on page 139 of this issue. Indeed, much of the snow is rendered soluble by the enzymes released by the bacteria. This solves a puzzle of some years' standing. The downward flux of marine snow (aggregated particulate organic matter) rapidly shrinks with increasing depth, yet the microbial consumption of the snow is too small to account for its disappearance. But with solubilization rates 1–2 orders of magnitude greater than the rate of consumption it becomes clear why the aggregates last days not months. Keeping track of the various dissolved and particulate fluxes of organic and inorganic carbon in the oceans is one of the main tasks in unravelling the global carbon cycle, itself central to the question of atmospheric CO_2, so many will be relieved to see this particular puzzle cleared up. R.P.