it does not depend on SNAREs. Although we do not know what proteins promote tethering, they must have a loose hold because when yeast Sec19p is added — a protein that binds the GDP-bound form of Ypt7p — the tethered state decomposes. Tethering may be a proof-reading step that allows fusion partners an opportunity to sample and, possibly, to reverse inappropriate encounters. Similar SNARE-independent tethering was first documented for the attachment of transport vesicles derived from the endoplasmic reticulum to the Golgi complex[7].

At the next stage, membrane docking triggers the flow of Ca^{2+} from a reservoir within the vacuole. Addition of a chelating agent that rapidly sequesters free Ca^{2+} inhibits fusion. Hence, vacuole fusion, like synaptic transmission, is regulated by the local activation of a Ca^{2+} channel. However, unlike at the synapse, a Ca^{2+}–calmodulin complex activates fusion of vacuoles. Although not known, the target of Ca^{2+}–calmodulin must be either the v–t-SNARE complex, or some downstream element of the fusion machine.

Does the v–t complex catalyse fusion or does it activate an as-yet-unknown fusogen? Ungermann *et al.*[3] present a provocative experiment consistent with the second view. They show kinetically that the formation of a v–t-SNARE complex precedes, and is separable from, fusion. When they added excess NSF and α-SNAP at the point where v–t-SNARE pairing was maximal, the SNAREs uncoupled with no apparent delay in subsequent membrane fusion. Although the v–t-SNARE complex is an obligatory intermediate in the reaction, these authors conclude that pairing may trigger an independent event that executes fusion. Work by Tahara *et al.*[8] has shown that SNARE pairs formed on docking of sea-urchin egg secretory vesicles are disassembled by Ca^{2+} at a stage prior to membrane fusion. Of course, in both cases, the SNARE pair may simply be a non-rate-limiting component of the fusion machine. In any case, the identity of a more direct catalyst for fusion remains to be established.

One obvious suggestion is that docking itself potentiates Ca^{2+} flux. The t-SNARE syntaxin 1A binds and stabilizes the inactivated state of N- and Q-type Ca^{2+} channels in the mammalian central nervous system[9,10]. Synaptic vesicles may be tethered to the presynaptic membrane until the formation of a v–t-SNARE pair relaxes the inactivated Ca^{2+} channel. The docked complex would then respond to a depolarizing signal and allow a localized Ca^{2+} flux. But Ca^{2+} channels bound by syntaxin and not engaged in a docked state would remain refractory to a depolarizing signal.

Independent evidence indicates[11] that syntaxin regulates the cystic fibrosis transmembrane conductance regulator channel. The extreme view would therefore be that SNAREs act mainly by regulating the opening of a channel, and are only indirectly involved in fusion. Genetic and biochemical studies on the functional consequences of the interaction between the vacuole SNAREs and Ca^{2+} channel should allow us to distinguish these possibilities. □

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Volcanology

Remote prospects

William I. Rose and Gregg J. S. Bluth

Robust remote sensing of volcanic emissions has been a long-term goal of Earth scientists interested in the relationship of the solid Earth to the atmosphere, and of volcanologists interested in the telegenic 'reading' of gas emissions to forecast volcanic activity. In the studies that appear on pages 563 and 567 of this issue, Love *et al.*[1] and Francis *et al.*[2] have taken major steps towards realizing that goal by demonstrating advances in distance (2–10 km) sensing of gas ratios in volcanic plumes. Their work involved the deployment of Fourier-transform infrared spectrometer (FTIR) instruments near Popocatépetl, Mexico (Fig. 1), and Etna, Italy — two ominously threatening, open-vent volcanoes.

The FTIR instruments take advantage of the spatial frequency characteristics of a spectral image (for example high versus low frequency) to differentiate otherwise obscure features such as minor gas species. The two papers show the feasibility of passive remote sensing using FTIR in the field, aided by solar occultation or using solar radiation scattered by clouds (a key is that solar energy needs to be concentrated in order to detect low burdens of volcanic gas in a high atmospheric background). They also hint at the potential to improve scientific insight into how volcanoes work; and they will re-ignite interest in field measurements at active volcanoes, which will in turn create many new data on volcanic degassing.

Geochemists have tried extremely hard (and have run great risks) in attempting to directly sample high-temperature, gas-emitting vents on or near volcanoes[3]. Vents that allow scientific study are rare gifts, however, for the magmatic gases are usually seriously contaminated by chemical constituents of the atmosphere, groundwater and other sources. They usually do not represent a pre-eruptive magmatic gas composition very well, because they are also already substantially degassed. Moreover, all too often it is highly dangerous to visit vents and sample them directly[4].

Hence the need for remote sensing of volcanic gases. In the past, landmarks have come from the successful ground-based sensing of SO_2 fluxes in volcanic plumes using an independent remote sensor, an ultraviolet correlation spectrometer (COSPEC)[5], and from satellite spectrometry of the burden of SO_2 in drifting volcanic clouds from large eruptions[6]. Overall, remote sensing of SO_2 has told us a great deal[7], but it remains of limited value owing to the lack of data on other gas components such as chlorine and fluorine compounds.

Volcanologists have combined the flux measurements with direct sampling where possible[8,9], and have also used some sensing methods for other gases that involve entering and profiling volcanic plumes with aircraft[10]. Again, however, these techniques cannot be widely used for safety reasons, and adequate sensors to sample gas vents continuously are not yet available.

The new FTIR methods, combined with

AP

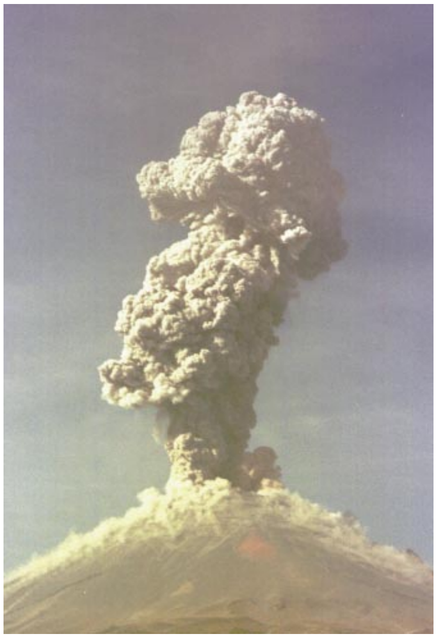

Figure 1 **The ominously threatening Popocatépetl, which has been active in recent weeks.**

100 YEARS AGO

While we were taking sympathetic breaths with the insatiable shag, the latter reappeared – yet again with a 15-inch eel. Four 15-inch eels – all swallowed alive – within the space of about four minutes! … Would he bring up another? Yes, there he was again with another 15-inch eel! A very vigorous eel – just like the others in size and appearance, and swallowed in the same manner, after about 30 seconds' resistance. This made five eels. The question now arose as to what would be the end of this bird. Was he going to die the death of King Henry I before our eyes? … To make a long story short, we counted *twelve* eels! – all stout 15-inchers. The twelfth seemed, perhaps, rather feebler than the others, but it nearly got away. H.R.H. now seemed to reflect that this last misadventure was a warning, swallowed his twelfth, and took flight… . There is, of course, only one explanation of all this; the twelve eels were one and the same eel … . The peculiar procedure of ejecting the prey under water appears very remarkable.

From *Nature* 8 December 1898.

50 YEARS AGO

Since last August there have been reports in the Press of a crisis among biologists in the U.S.S.R. The crisis culminated in a decree from the Præsidium of the Academy of Sciences … . This decree dismisses a number of prominent biologists from their posts, closes two famous laboratories, and removes orthodox geneticists from committees… . The Lenin Academy of Agriculture Sciences, of which body Lysenko has been president for ten years, held a Conference during July 31–August 7 of this year… Lysenko's address followed familiar lines … . It denies the chromosome theory of heredity. It arraigns several Soviet biologists because their work is inconsistent with Marxist ideology and is sterile of practical results … . The objective of Lysenko's attack on Mendelism is not so much its false ideology, but rather its impotence. By insisting on the stability of the germ plasm Mendelism "condemns practical workers to fruitless waiting". The inheritance of acquired characters is a doctrine necessary for the progress of Soviet agriculture.

From *Nature* 11 December 1948.

the SO_2 flux measurements by COSPEC, allow for remote determination of HCl, HF and SiF_4, and of changes in the flux of several gas species with excellent time resolution. (Incidentally, the authors[1,2] use different reporting units, which can be related by tons $d^{-1} \times 0.012 = kg\,s^{-1}$).

Application of these new methods will add much to our knowledge of volcano–atmosphere interactions by giving us improved data on many species, particularly the halogen compounds. For example, the study of the ratios HCl:SO_2 and HCl:HF can provide information about the rise and degassing of magma, and is thus a means of eruption monitoring and prediction[2]. Likewise, quantitative measurements of these species can be used to constrain geochemical models of magma equilibrium and oxidation state, and of the interactions among the solid, liquid and gas phases[3].

These advances[1,2] will also challenge our understanding of volcanic gas measurements. In the case of SO_2, geochemists have had great difficulty in interpreting gas flux data in a consistent way, and many volcanoes have been reported to release 'excess' sulphur[11,12]; that is, they release more sulphur than expected from study of the mother rock. This uncertainty can apparently now be clarified by a better appreciation of how the oxygen fugacity (effective molecular pressure) in melts influences the separation of SO_2 (ref. 13). An understanding of the pattern or 'order of release' of volcanic gases from magmas as related to their relative solubility has been a long-term guiding idea of work in this area[14,15] — there is now hope that intrusion of fresh, gas-rich magma into magma bodies, suggested by some interpretations of volcanic gas data[16], might be unambiguously detected by remote sensing and used to increase the accuracy of forecasts.

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Molecular evolution

A hydrogen-producing mitochondrion

T. Martin Embley and William Martin

Dark, damp (and sometimes smelly) places harbour some of nature's most curious eukaryotes. The likes of swamps and intestines are swarming with mostly single-celled eukaryotes (protists) that, like all cells, must produce ATP to survive. Yet these places lack enough oxygen to sustain ATP synthesis as it occurs in textbook mitochondria like our own. Some protists possess no mitochondria, surviving from anaerobic fermentation in the cytosol. Others have quite odd mitochondria that harbour anaerobic ATP-producing pathways. On page 527 of this issue, Akhmanova *et al.*[1] report a gem of such an odd mitochondrion in the ciliate protist *Nyctotherus ovalis*.

The ciliate lives in the suffocatingly oxygen-poor confines of cockroach intestines, where it helps the insect to digest cellulose. Instead of consuming oxygen, *Nyctotherus*'s mitochondrion has the bizarre property of excreting hydrogen as a by-product of ATP synthesis. Similar hydrogen-generating organelles — hydrogenosomes — have been studied in anaerobic eukaryotes for 25 years[2]. Hydrogenosomes have often been suspected of stemming from the same endosymbiotic bacterium that gave rise to mitochondria. But now, Akhmanova *et al.* report a hydrogenosome that has its own genome, directly betraying its endosymbiotic past.

Cells of *Nyctotherus* (which do not grow in culture and have to be carefully micromanipulated from cockroach hindguts) contain hydrogenosomes that can be labelled by antibodies against DNA. The authors found that the cell produces a ribosomal RNA which, although not proven by *in situ* hybridization to localize to the organelle, bears all the sequence characteristics expected of ciliate mitochondria. Plus, it may look like a mitochondrion, but this DNA-bearing organelle is unquestionably a hydrogenosome because it produces hydrogen — Akhmanova and colleagues found hydrogen-consuming[3] methanogenic endosymbionts inside the cells of *Nyctotherus*. Finally, *Nyctotherus* expresses a nuclear-encoded gene for a