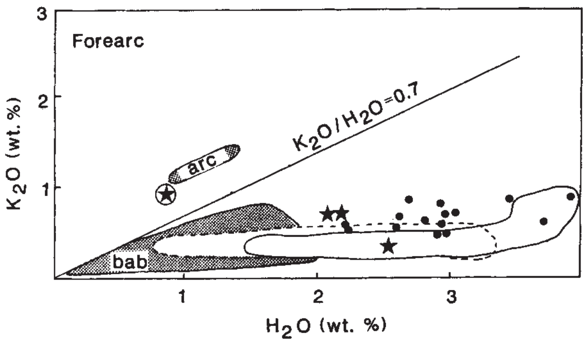
Tectonic origins

SIR—Muenow *et al.*[1] provided an intriguing example of the use of volatile abundances in submarine lavas as a discriminant of tectonic origin. They demonstrated some of the problems involved in measuring primary water contents in submarine volcanic rocks and documented a distinct difference in K_2O/H_2O between ocean-island basalts and mid-ocean or back-arc basalts. But their suggestion that K_2O/H_2O values are a sufficient criterion to discriminate island-arc basalts from back-arc basin basalts is, in our view, premature.

The field defined for arc volcanics by Muenow *et al.* is based on analyses of lavas from Fukujin Seamount in the northern Mariana island arc[1,2], which is erupting lavas of a medium-K_2O volcanic series (0.5–1.5% K_2O at 53% SiO_2). But both the ancient and active Mariana–Bonin arcs have erupted lavas with both higher and lower K_2O contents[3]. Active or dormant volcanos in the Mariana arc erupting low-K_2O series lavas (less than 0.5% K_2O at 53% SiO_2) include Nikko (23°05'N, 0.2–0.4% K_2O), Ruby (15°45'N, 0.45% K_2O) and Supply Reef (20°08'N, 0.4% K_2O) seamounts[4]. The oldest arc units in the Mariana-Bonin system (Eocene–Oligocene) include abundant low-K_2O series volcanics. These volcanics are tholeiites and boninites in the forearc[5,6] and on Guam[7], and are arc tholeiites on the Palau–Kyushu ridge[8].

The high K_2O/H_2O of the arc field described by Muenow *et al.* is in part due to the absence of low-K_2O lavas among their analysed samples. There are few accurate analyses of volatile abundances in arc lavas, both because of the scarcity of fresh submarine arc glasses and because of the problems of separating primary from secondary water[1]. The best available estimates of H_2O or total volatile concentrations in low-K_2O submarine volcanics from the Mariana–Bonin system suggest that the arc field is much broader than that defined by Muenow *et al.* (see figure). Mass spectrometric analyses of several boninitic submarine glasses and one arc tholeiitic submarine glass from forearc volcanic rocks[5,9,10] fall at much lower K_2O/H_2O than Fukujin. Hydrogen and oxygen isotope evidence indicates that primary water contents in these rocks are 1.6 to 2.4% H_2O (ref. 5). Tholeiitic and boninitic volcanics on Guam have bulk rock compositions similar to those of the forearc volcanics[7]; such low K_2O, low K_2O/H_2O volcanics probably comprise a large part of the initial subduction-related volcanism in the arc. Total volatile concentrations (by difference from microprobe analyses of glasses) for tholeiitic and boninitic rocks from the forearc[6] also cover a wide range of values at low K_2O/H_2O. These are upper limits to H_2O contents. But H_2O is the most abundant volatile in arc volcanics[2] and halving, or even quartering, most of these values will leave them in the low K_2O/H_2O field.



K_2O and H_2O concentrations for low K_2O series lavas from the Mariana–Bonin forearc. Shaded fields are for arc and back-arc (bab) volcanics from ref. 1. Dots are boninite glasses with mass spectrometric H_2O values from Chichi-jima[5,10], stars are boninite glasses and one arc tholeiite glass from Mariana forearc with mass spectrometric H_2O values[9]. Field within solid line is for tholeiite glasses from forearc[6] (H_2O inferred by difference from probe analyses of glasses); dotted field is the same for boninitic glasses[6]. Circled star is mass spectrometric analysis of a Fukujin Seamount glass[9]; the value is similar to those obtained by Muenow *et al.*

There are no reliable measurements of H_2O concentrations in low-K_2O volcanic glasses from the active Mariana arc. Volcanic rocks like those from Nikko or Supply reef with 0.2–0.4% K_2O would have to have less than 0.3–0.6% H_2O to have K_2O/H_2O higher than 0.7. These are much lower than values typically reported for arc volcanic rocks[2,5,10].

K_2O/H_2O values certainly provide a useful tool for examining the origin of submarine volcanic rocks. They may yet be a useful discriminant for arc and back-arc lavas if low-K_2O arc lavas generally have higher H_2O than back-arc basin lavas of similar K_2O content, as appears to be the case based on limited data. But without careful analyses of low-K_2O arc glasses, volcanic samples like those from the Troodos ophiolite[1] cannot be confidently assigned a back-arc or arc origin on the basis of K_2O/H_2O.

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Toxin arrest

SIR—Bradshaw in Scientific Correspondence[1] has suggested the interesting idea that the *Kluyveromyces lactis* toxin may arrest the growth of sensitive yeast cells by interfering with cell-wall biosynthesis. The hypothesis is based on the observation that a region of the largest (α) subunit of the toxin shows sequence similarity to the chitin-binding domain of several plant chitinases.

Unfortunately, it is very unlikely that the toxin arrests sensitive cells at the G1 stage by acting as a chitinase, as Tokunaga *et al.*[2] have shown that the activity of the toxin resides in the γ-subunit alone. The γ-subunit has no similarity at all to chitinases[3] but is insufficient alone to arrest cells when added exogenously[2]. This suggests that the α- and β-subunits must be required for entry of toxin into the cell.

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Domestic olive

SIR—Since at least the Bronze Age, the olive (*Olea europaea*) has been one of the most economically important plants in the Mediterranean basin[1]. Nevertheless, little is known of the origin of the human use of this plant. The discovery of a carbonized olive pit, dated to the seventh millennium BC and associated with cultural remains, sheds light on the beginning of the association.

The olive seed is from the site of Cova de la Falguera, a rock shelter less than 10 km southwest of the town of Alcoy, midway between Valencia and Alicante. The site was discovered in 1981 and staff at the Museo Argueológico de Alcoy made a limited test sounding[2]. Seven stratigraphic units were defined in the excavated area, all but the lowermost containing abundant cultural material. The two lowermost artefact-bearing strata (II and III) produced assemblages of chipped stone artefacts characteristic of early Holocene hunter–gatherer societies of the Spanish Epipalaeolithic (about 9000–5000 BC).

A single carbonized seed was the only datable material recovered from stratum II, the earliest evidence for human occupation at the site. Routine identification of the seed before dating indicated that it was olive (*Olea spp.*) and of a size (11 mm long) generally considered domestic[3]. Hence, we felt that the seed was probably intrusive from the late Neolithic or early Chalcolithic strata and not associated with the Epipalaeolithic stratum II. Because the presence of olive in Bronze Age contexts has been well documented at various sites[1,3,4], we were not surprised by its appearance here and took no photographs of it. As part of a project to date early prehistoric sites of the region, we submitted the seed to the NSF Accelerator Facility for Isotope Analysis at the University of Arizona in the hope of obtaining a terminal radiocarbon date for the site.

Unexpectedly, the seed returned an uncalibrated date of 7410 ± 70 radiocarbon years BP, with a calibrated age of 6430–6090 BC (ref. 5). This is well within the range of the late Epipalaeolithic in eastern Spain[6]. The correspondence in age between the cultural material and the directly dated seed, and fact that the seed was carbonized, indicating it was burned, suggest that it was directly associated with the Epipalaeolithic human occupation of La Falguera. These circumstances also reduce the possibility that the seed was contaminated by older carbon.

The age of the seed, its size and its association with cultural material raises questions of whether it is a domestic olive and how the plant was used by the Epipalaeolithic inhabitants of La Falguera. Unfortunately, it is not possible to answer these questions on the basis of a single seed. Regardless of its domestic status, however, it now appears that the use of this economically important taxon began before the Neolithic 'revolution' which brought agricultural economies to western Europe.

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Eruption terms

SIR—Our observations[1] of Etna's vigorous pyroclastic eruption in September 1989 prompt us to draw attention to a significant misapprehension concerning the kind of eruptive activity that yields an important class of volcanic deposit. 'Strombolian' is a term used by volcanologists to describe two different phenomena: a well-known style of eruptive activity and an important class of pyroclastic fall deposit. Unfortunately, the deposits commonly termed 'strombolian' are not the results of strombolian activity. We argue that basaltic scoria cones and their associated tephra deposits are not formed by strombolian activity, but by microplinian activity, similar in nature to plinian and subplinian activity, but of lesser intensity, giving rise to lower eruption columns.

In its earliest usage, the term strombolian was applied only to the style of eruption[2]. Logically, the style of activity denoted by the term should be that displayed by Stromboli volcano itself. Most volcanologists would agree that the outstanding aspect of Stromboli's characteristic activity is that it is episodic: discrete slugs of incandescent pyroclasts are explosively ejected at intervals which may range from seconds to hours. Cotton[3] followed Mercalli in defining strombolian activity as follows: "liquid lava is thrown up by explosions or gas fountains, and some of this accumulates round about as spatter, scoria and bombs. There is no dark smoke-like cloud emitted". An important consequence of the discontinuous nature of the activity is that a convecting eruption column is not sustained: material in the ejected slug rapidly falls out and only a small ash cloud is dispersed by the wind. Ejecta seldom ascend more than 200 to 300 metres above the vent.

Deposits that have been termed strombolian include basaltic scoria cones and air-fall mantles of tephra that have measurable thicknesses several kilometres from the vent. Thus, detailed studies of the distribution of grain sizes are possible, and the deposits have been well characterized in terms of the fragmentation and dispersal indices[4,5]. Formation of such deposits has often been observed, for example during the 1973 eruption of Heimaey, Iceland[6], and the 1975–76 Great Tolbachik Fissure eruption, Kamchatka[7], so the nature of the activity giving rise to them is well documented. Rather than discrete slugs of material being ejected as in strombolian activity *sensu stricto*, sustained blasts take place, which may continue for periods of several hours. During the Great Tolbachik Fissure eruption, for example, there was "steady, non-stop emission of an enormous volume of cinders, bombs and ash in a mighty gas jet. The incandescent pyroclastic material formed a fiery torch up to 1.2 km high"[7]. Sustained convection carried the eruption column at Tolbachik to a height of 10 km, almost two orders of magnitude higher than strombolian bursts *sensu stricto*. Similar behaviour has been observed in many other basaltic pyroclastic eruptions, including that at Etna in 1989 where there was commonly a sustained tephra column 300–400 m high[1].

These studies demonstrate that 'strombolian' tephra deposits form an important and easily defined volcanic phenomenon. They do not, however, result from true strombolian eruptive activity. It has been clear for some time that there is no basic difference in eruption mechanism between the largest basaltic pyroclastic eruptions producing widespread plinian basaltic scoria deposits (such as Tarawera 1886) and those of silicic eruptions producing plinian pumice deposits[8]. Similarly, differences between eruptions producing widely dispersed basaltic plinian deposits and those producing less dispersed basaltic 'strombolian' deposits are only differences in magnitude (the total erupted mass) and intensity (the magma discharge rate). The deposits form a continuous size spectrum[9].

We suggest using the term microplinian for the basaltic scoria fall deposits with grain size and distribution characteristics currenty described as strombolian, and for the style of eruptive activity giving rise to them. This would emphasize the continuity of the spectrum of pyroclastic fall deposits, and would be consistent with other terms such as subplinian, ultraplinian and phreatoplinian (see ref. 10). It would also depict more accurately the nature of the eruption process which gives rise to the deposits.

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