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An unusual bed of giant pumice in Mexico

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We report here that a remarkable bed of giant-sized pumice blocks occurs within an old caldera of the major late Quaternary rhyolitic volcano of Sierra La Primavera, Mexico (Fig. 1*a*). The bed lies within a 100-m thick sedimentary sequence distributed over a near-circular area 10 km across. The margin of this circular area closely parallels an incomplete ring of prophyritic comendite lava domes (Fig. 1*b*), some of which may be shallow intrusions emplaced into the sediments. The vents of these domes are believed to lie on a ring fault (Fig. 1*b*). The sedimentary sequence, now gently updomed (Fig. 1*c*), is believed to have accumulated in a caldera lake, the shoreline of which lay up to 1 km outside the ring fault.

The lake sediments are floored by an ignimbrite (Rio Caliente Ignimbrite) produced by the biggest explosive eruption of the volcano[1,2]; many of the deep gullies within the badland terrain, which characterize the area of lake deposits, cut down into the floor. The lake deposits have a maximum exposed thickness of ~100 m, and rest on top of the ignimbrite which was eroded before their accumulation. Locally, the non-welded top of the ignimbrite (at least 15 m) was stripped off and box canyons were incised into the incipiently welded zone. Some of these canyons are infilled with cross-stratified and pumice-rich fluvatile deposits.

The lake deposits are planar-laminated white vitric ashes and pumice layers. Some ash beds contain diatoms; discrete beds of diatomite also occur. The sediments commonly have current-ripple laminae and load casts indicative of deposition under water. Diatom assemblages indicate that the water was shallow (G. H. Evans, personal communication) and less saline than present-day lakes in this area (J. P. Bradbury, personal communication).

The most distinctive unit in the lake-sediment succession is the giant pumice block bed (Fig. 2*a*), which is 1.5–15 m thick and can be traced over practically the entire former lake area (Fig. 1*d*). It has an extreme bimodal size distribution, the coarse mode consisting of giant blocks of light grey porphyritic pumice averaging 1.3 m in size (Fig. 1*e*), commonly grain supported, with the finer mode consisting of fine white ash occurring between the large blocks. The giant pumice blocks (Fig. 2) range in diameter from 0.2 to generally less than 6 m and are thus quite well sorted for their size; the maximum diameter measured of any block was 8.5 m. Locally, the giant pumice block bed is underlain by a thick accumulation of smaller-sized pumice. Near the northern edge of the lake area, the bed occurs as two or three beds separated by stratified reworked ash and pumice. The giant pumice blocks in the upper two beds are more matrix supported than is usual for this deposit, and may be reworked.

The ash matrix in the giant pumice bed is laminated, and the laminations are disturbed and contorted around the pumice (Figs 2*a*, 3); this is interpreted as gentle settling of the pumice blocks into waterlogged ash. However, the laminations are also disturbed above the pumice blocks, which is interpreted as a compactional feature. The pumice forms are oblate spheres and poorly rounded blocks (Figs 2*b*, 3). Some have a glassy, poorly vesicular outer sheath about 1 cm thick, but this is discontinuous. Many of the blocks have a crude prismatic jointing normal to their margins, most clearly developed in the outer part of the blocks; occasionally this jointing is very well developed (Fig. 2*b*). These features indicate that the giant pumice blocks

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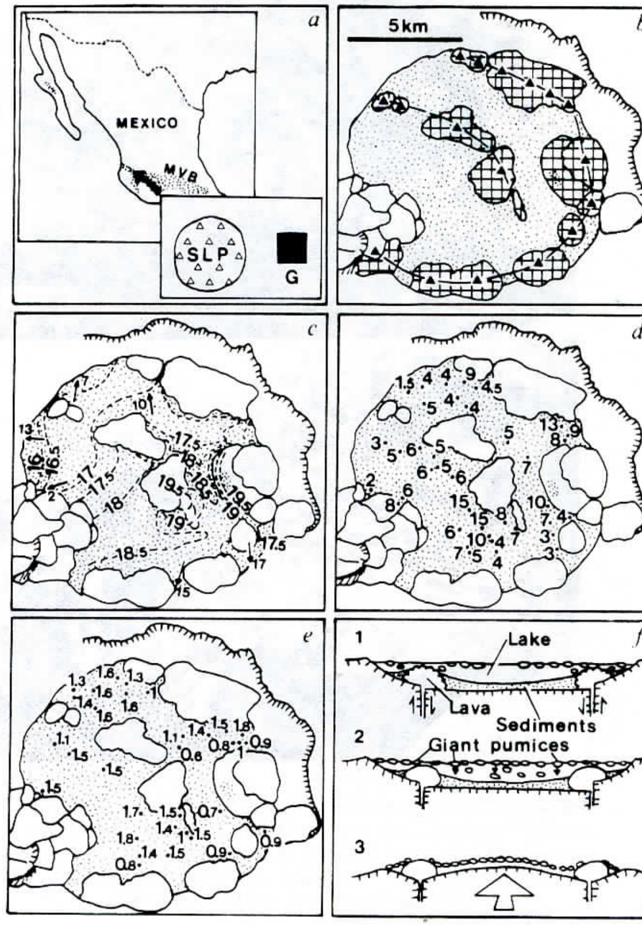

Fig. 1 The giant pumice block bed and lake sediments, and their relationships to the young rhyolite lavas of La Primavera volcano. *a*, Index map of study area: MVB is the Mexican Volcanic Belt which is a locus of Quaternary volcanism in Mexico; G is Guadalajara; SLP is the Sierra La Primavera. *b*, Distribution of the lake sediments and rhyolite lavas: stipple is lake sediments; cross-hatch is porphyritic comendite lavas lying on an 'inner-ring' with a transverse zone; triangles represent inferred vent positions; unornamented lavas are aphyric comendite lavas lying on an 'outer-ring' which is not fully shown or discussed here; hatched line is a low escarpment, possibly an embryo caldera rim. *c*, Altitude contours of the top of the giant pumice block bed in hundreds of metres above sea level. Heights were determined in the field using an altimeter. Dip of lake sediments is also shown (arrows). *d*, Thickness of giant pumice block bed in metres. *e*, Median diameter of giant pumice blocks in metres; 65–20 blocks were measured at each outcrop. *f*, Three stages in the envisaged formation of the giant pumice block bed.

have been chilled. A small amount of abrasion evidently took place before deposition.

Features such as relative uniformity of pumice size, relative uniformity in thickness (Fig. 1*d*), maximum pumice sizes (Fig. 1*e*) of the bed over practically the entire former lake area, and the lack of bomb sags make the giant pumice block bed sufficiently unique to demand an unusual mechanism of formation. Pyroclastic processes are inadequate to account for these features. The following mechanism (Fig. 1*f*), consistent with all the observed field relationships, envisages porphyritic comendite lava extrusions forming on the floor of a lake. It is common for the carapace of a silicic lava extrusion to be pumiceous, and in this case pumice blocks became detached from the carapace and floated to the lake suface. Eventually, the entire surface was covered with giant blocks of floating pumice, and these blocks became evenly distributed by jostling against one another. Size-sorting occurred as smaller pumice fragments rapidly sank close to the extrusions. Eventually, however, the largest pumice

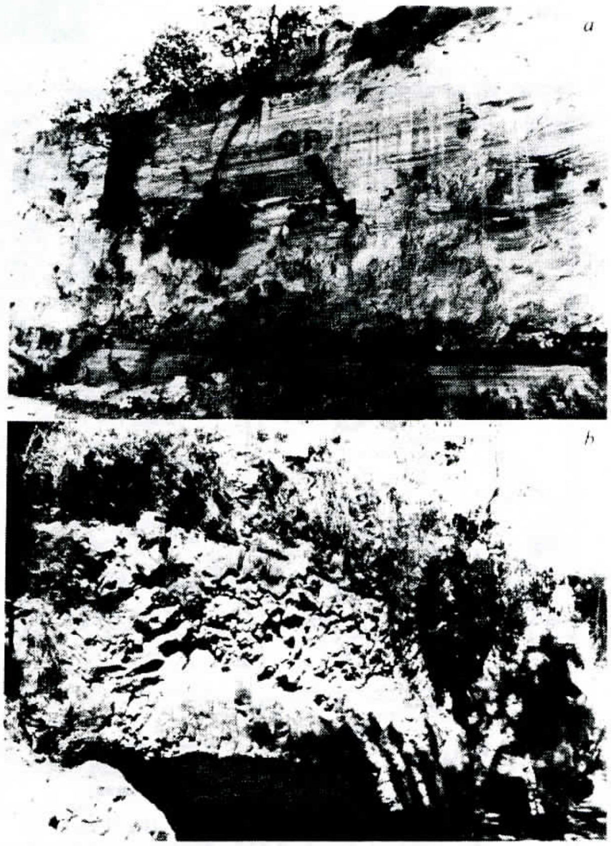

Fig. 2 *a*, Giant pumice block bed (GP), at this location approximately 5 m thick, and laminated lake sediments which are disturbed and contorted. *b*, Giant pumice block; this example has a largest diameter of ~6 m, and also has very well developed prismatic jointing normal to its margins.

blocks became waterlogged and sank to generate the coarse mode of the bed. In places the bed mantles prophyritic lava, and here rests on a thick apron of less coarse pumice which sank earlier (if, indeed, it floated at all).

Various lines of evidence indicate that the porphyritic lavas were emplaced in water or wet lake sediments: These include, (1) an unusually thick carapace of glassy rocks which is invariably present, (2) particularly well developed jointing (in places the rocks are extensively brecciated), (3) anomalously close spacing of microfractures and a resulting very pervasive perlitic alteration, and (4) an absence of spherulites and lack of post-eruption crystallization in general. In contrast, the aphyric

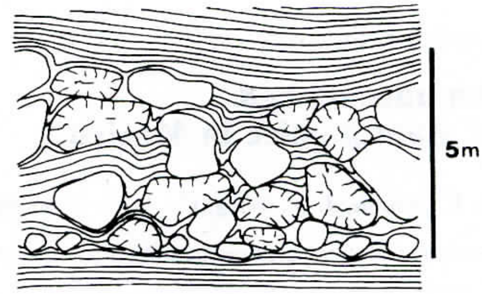

Fig. 3 Field sketch showing disturbed and contorted lake sediments with blocks of giant pumice. Some blocks show cooling joints normal to their margins.

comendite lavas of the volcano (Fig. 1*b*) are thought to have been erupted 'dry'. They have a carapace of fresh or slightly perlitized obsidian interbanded with stony and spherulitic rhyolite, and close-spaced foliation planes which are steeply inclined and intensely contorted.

The origin of the lake depression in which the sediments accumulated is not immediately apparent, because subsequent uplift of the central part of the volcano masks the original relationships (Fig. 1*c*). Geological relationships, however, suggest that the lake occupied a caldera. The sediments extend up to 1 km outside the limit of the rhyolitic ring, which conforms with observations that the topographic rim of a caldera commonly lies outside the ring fault[3] (as marked by lava extrusions or explosive vents). There is, in fact, a low escarpment 1–2 km outside the lava ring on the northern and eastern side (Fig. 1), but this could be a second outer embryo caldera of a nested pair. Resurgent updoming[4] has caused an inversion of topography so that the lake deposits now stand well above any possible shoreline. The updoming took place relatively late in the history of the volcano and did not follow closely on the climatic ignimbrite eruption. At La Primavera this could indicate the arrival of a new pluton beneath the volcano. If so, the apparently youthful age of the updoming indicates that possible future activity of the volcano should be considered seriously[2]. Numerous hot springs within the volcano point to the existence of a hydrothermal system driven by heat from a hot rock or magma body.

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1. Wright, J. V. thesis, Univ. London (1979).
2. Walker, G. P. L., Wright, J. V., Clough, B. J. & Booth, B. *Geol. Rundsch.* (in the press).
3. Lipman, R. W. *Geol. Soc. Am. Bull.* **87**, 1397 (1976).
4. Smith, R. L. & Bailey, R. A. *Geol. Soc. Am. Mem.* **116**, 613 (1968).

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