Feature

Seismicity and gas emissions on Tenerife: a real cause for alarm?

In recent months the media has been drawing attention to the possibility of a dangerous eruption of the Teide Volcano on Tenerife in the Canary Islands. Before accepting this prediction, which may well be detrimental to the tourist-based economy of the island, it would be wise to examine the evidence on which it is based.

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Teide has long been recognized as a significant volcano. At 3718 m above sea level, it is the third highest volcanic structure on the planet (Fig. 1), after Mauna Loa and Mauna Kea in the Hawaiian Islands, and early drew the attention of renowned scientists such as Leopold von Buch and Alexander von Humboldt. Regrettably this interest was not sustained into the twentieth century; whilst Hawaii attracted intense study, geological investigations of Teide's history languished. For example, hundreds of radiocarbon age determinations have allowed for a precise reconstruction of the Hawaiian volcanic history, but until 2001 only one single radiometric age was available for Teide volcano. With no regular recordings, evidence of historic seismic and volcanic activity has only been by word of mouth.

The situation changed in 2001 when a five-year, joint Spanish–French research project began; a project which produced a detailed geological map of Teide and the NW and NE rifts (Fig. 2), petrographic analysis of numerous samples, and radiometric studies, which produced 28 new radiocarbon ages and 26 new K/Ar ages.

This project completely changed our understanding of the geological and structural evolution of the Teide volcanic complex, and identified the sequence of eruptions that had occurred in the last 10 000 years. For example, one eruption of historic significance was that of 24 August 1492, which Christopher Columbus reported as 'a big fire in the sierra of Tenerife... similar to those of Mount Etna in Sicily'. It seems it was not a summit eruption of Teide; a radiocarbon age from an eruption of the Boca Cangrejo cinder cone (Crab's Mouth cone), located in the NW Rift, is in close agreement with this historic date. It had been believed that the 'Columbus eruption' was the final summit eruption of Teide, but the new radiometric data now shows that eruption to have been much older, 1140 ± 60 years before present, i.e. in the eighth century AD.

One of the interesting features this study has revealed is that the Teide central volcanic complex was a direct consequence of the activity of the rifts. The rifts developed a progressively steepening, unstable volcano at the centre of the island, and about 180–200 000 years ago triggered a massive landslide that generated the impressive horseshoe-shaped collapse embayment, whose headwall is the

Fig. 1. View of Teide volcano from the north east.

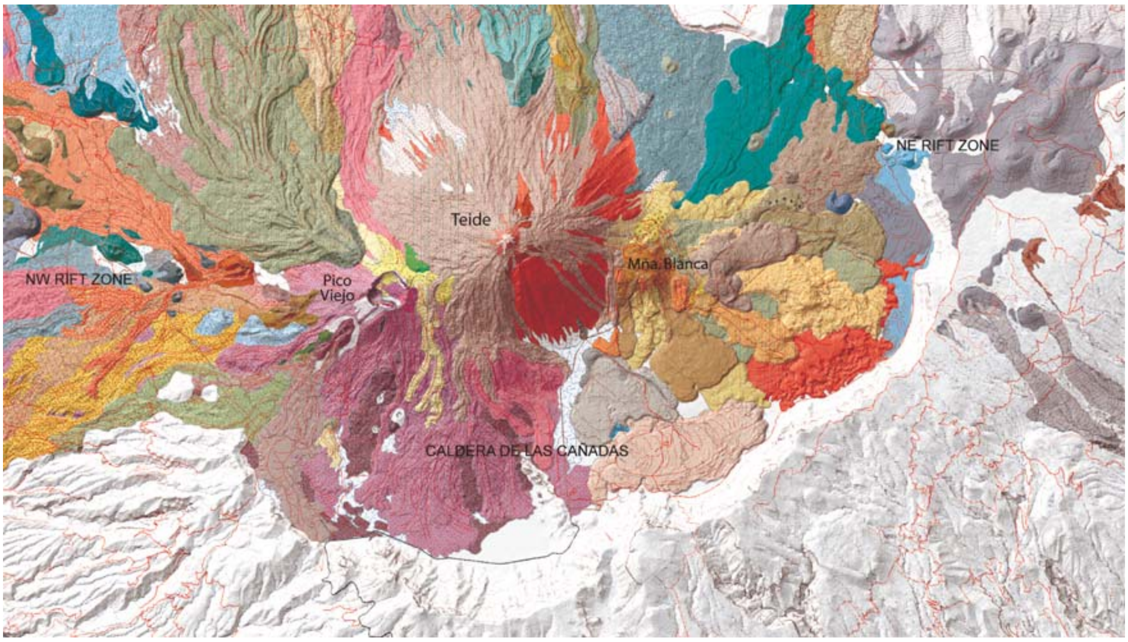

Fig. 2. Geological map of Teide and the caldera, showing in colour the most recent eruptions (last 30 000 years).

famous 17 × 10 km Las Cañadas caldera (Fig. 3). Following this, further rift and central activity progressively filled the embayment and built up the 3718 m-high Teide stratovolcano, nested in the collapse embayment (Fig. 4). The main phase of construction ended 30 000 years ago, since when the stratovolcano has erupted only once. That eruption was the eighth century AD summit eruption, which raised the volcano from a height of 3600 m to its present 3718 m.

This recent eruptive history is in stark contrast to the pre-collapse activity of the Cañadas volcano, which was much more explosive, with frequent plinian eruptions that generated extensive ash flows and ash falls. In the last 30 000 years, eruptions have occurred at a rate of only 4–6 per millennium, the majority (70 per cent) being low-hazard basaltic eruptions from fissure and cones on the rift zones, and the others producing phonolitic lava-domes with only very localized explosive activity (Fig. 5), as for example Mña Blanca, around 2000 years old, which is situated at the foot of the main stratavolcano.

It can be seen from the results of the study that in the present phase of the island's volcanic activity there appears to be little risk of major volcanic hazards, with any eruptions likely to pose only very localized threats to the inhabitants of Tenerife or to visitors to the Teide National Park (about 4.5 million annually). Why then are there dire predictions of volcanic catastrophe (Fig. 6)?

Fig. 3. Western view of Las Cañadas caldera.

Fig. 4. Teide volcano nested in the Las Cañadas caldera. Image by NASA.

Unrest at Teide volcano?

The prediction of an explosive eruption seems to be based on reports of significantly increased earthquake activity and volcanic gas emissions. But is this evidence correct, and does it imply an imminent violent eruption?

From 22 April to 28 July 2004, about 50 low-magnitude (1 to 3) earthquakes were recorded in Tenerife, with most of the epicentres localized on the NW rift zone in the area of the Icod Valley. Only three were actually felt by residents. This frequency is nothing special, such earthquakes are normal in volcanic oceanic islands; about 10 000 are recorded annually in Hawaii, of which only 1200 are greater than magnitude 3. Low magnitude earthquakes (generally less than magnitude 3) have been recorded in all the Canary Islands. In May 1998 a bigger quake (magnitude 5.3) hit Tenerife, but a hazard-disclaiming statement was published in the media and the event promptly forgotten.

So why, in 2004, were the local and international mass media bombarded with persistent reports of unrest at Teide volcano, and predictions made of an imminent, large-scale explosive eruption that became dubbed 'El Volcán de Octubre' (October Volcano)? The publicity had such a bad effect that Tenerife was nick-named 'Terrorife' and residents along the northern coast in the towns of Icod, Garachico, etc., began sleeping fully dressed and panic-buying food and other household supplies. Some even sold their houses! Evacuation instructions were given in schools and hospitals, and gas masks, power generators and other supplies were stockpiled in public buildings.

The situation was made even worse by the authorities who, instead of clarifying the situation, raised the level of alert apparently only on the basis of what was reported as an increase in seismicity and the emission of volcanic gases. However, at no time was there any universally accepted scientific evidence of actual volcanic activity on the island. The 'volcanic crisis' alert was officially maintained until February 2005, with frequent reports in the media of enormous emissions of volcanic gases, boiling of the island aquifer, presumably from raised volcanic temperatures, movements of magma underneath the volcano and an explosive eruption forecast for October 2004.

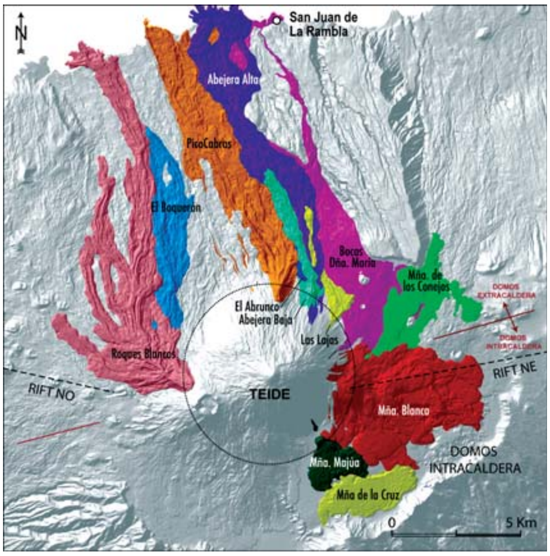

Fig. 5. Geological map of Teide's peripheral phonolitic domes.

Was there really any convincing evidence for any of this?

Firstly, consider the seismicity. Prior to 2000 there were only two seismic stations on Tenerife, both at the far north-eastern end of the island. In that year a third station was deployed inside the Caldera de Las Cañadas, and immediately low-magnitude events within the island began to be recorded for the first time since surveillance began in 1985. Unfortunately the focal depths of these events were not determined, thus depriving observers of one of the most powerful constraints on locating the source of the seismicity. In the initial reports, the activity was interpreted as being due to dyke emplacement at a depth of 3–4 km. However, it is possible that a number of the events may have had a non-volcanic origin, such as traffic or explosions made during the excavation of water tunnels for groundwater mining.

The majority of the epicentres were located far from the rift zone, in an area in the Icod Valley which satellite interferometry has shown to have subsided by up to 10 cm. Groundwater has been continuously and intensively extracted in this area since the 1960s, depleting the aquifer and causing the ground to sink. Microfaulting associated with the subsidence may well have caused seismicity. It is noteworthy that according to the interferometry study this is the only area of recent ground deformation in Tenerife. The putative eruptive region of Teide and Las Cañadas is completely stable.

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TENERIFE

Los científicos sitúan en octubre la fecha de una posible erupción volcánica

De proseguir en aumento la emisión gases a la atmósfera y los movimientos sísmicos de estos días podría producirse una reactivación volcánica en el noroeste de la Isla

R.R.
SANTA CRUZ DE TENERIFE

■ Los movimientos sísmicos y las emisiones anormales de gases a la atmósfera que se han

Fig. 6. 'Scientists' predictions' in the local press.

What is the scientific evidence for the reported increase in gas emissions?

Continuous real-time monitoring of gas emissions at Teide and in the rifts, reported in 1999, gave evidence of a nearly constant total gas emission from the volcanic system. On a day-to-day basis, local emissions may vary and significant diurnal and seasonal variations in gas emission rates do apparently relate directly to systematic changes in barometric pressure. If spot measurements are taken in periods of low barometric pressure, they can show an apparent 'significant' increase in emissions. In 2004, shortly before the predicted October eruption, a visit to the summit crater of Teide, (in which both of us took part), did not reveal any fumarolic activity at all.

In support of the prediction of increasing volcanic activity, observers have cited two apparently new features; fumaroles at the summit crater of Teide and a new fumarole inside the Orotrava Valley. In fact spectacular 'plumes' are commonly seen in the summit area of Teide and are known locally as 'la Toca del Teide' or 'Teide's head-dress' (Fig. 7). These are caused by atmospheric conditions as well as by increases in fumarolic activity related to barometric pressure changes and have frequently been cited over the centuries in ship's logs. They are in no way unusual for the volcano. The new 'fumarole' in the Orotava Valley probably has a quite different explanation. Its water isotope signature is clearly phreatic, not volcanic, and it is located 50 m from an unlined 40 m-deep well used for the disposal of high-temperature wastes from a nearby cheese factory.

It would thus seem that the prediction of an imminent volcanic eruption at Teide is based on distinctly flimsy and dubious evidence, and its dramatic presentation by the media is not only unnecessarily damaging to the tourism-based economy of the island, but also to the credibility of responsible scientists, the true value of which will be crucial for the correct management of any future genuine volcanic crisis.

Suggestions for further reading

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Fig. 7. A. Frequent spectacular 'plumes' in the summit area are locally known as 'Teide's head-dress' and are usually clouds caused by strong winds and pressure-dependant changes in fumarole activity and are not unusual for the volcano (picture by J.C. Carracedo). **B.** Model of cloud formation at Teide volcano (Alvarez and Hernandez 2006, Canary Meteorological Service, see http://www.acanmet.org.es/menu_archivos/documentos/FTLCTeide.doc).