Vertical and lateral collapses on Tenerife (Canary Islands) and other volcanic ocean islands: Comment and Reply

COMMENT

E. Ancochea
Departmento de Petrología y Geoquímica, Facultad de Ciencias Geológicas. Universidad Complutense, 28040 Madrid, Spain
J. M. Cantagrel
Department de Géologie. U.M.R. 6524. Université Blaise Pascal CNRS, 5 rue Kessler, 63038 Clermont-Ferrand, France
J. M. Fúster
M. J. Huertas
Departmento de Petrología y Geoquímica, Facultad de Ciencias Geológicas, Universidad Complutense, 28040 Madrid, Spain
N. O. Arnaud
Department de Géologie, U.M.R. 6524, Université Blaise Pascal—CNRS, 5 rue Kessler, 63038 Clermont-Ferrand, France

Martí et al. (1997) suggested "that the vertical collapses can play a major role in triggering lateral collapses" in Tenerife. This idea is based on the "coincidence between the formation of the Orotava and Icod valleys and two of the inferred caldera collapse events (Guajara and Diego Hernández)" which "suggest a mechanical connection between these processes." In our opinion, the present data do not support their model. Moreover, the authors did not cite the work of Fúster et al. (1994) and Ancochea et al. (1995), in which another model of the stratigraphy, geochronology, and evolution of the Las Cañadas edifice is presented.

Continuous Volcanic Activity? Martí et al. (1997, Fig. 2), according to the stratigraphy from Martí et al. (1994), indicated the existence of three volcanic cycles of continuous activity during the last 2 m.y. Meanwhile, in the 1994 paper, these cycles were said to be separated by periods of dormancy of more than 100 k.y. The contradiction between both models is difficult to understand if the authors do not give new ages since 1994.

Mafic to Felsic Cycles? In their simple model (Martí et al., 1997), each cycle (Ucanca, Guajara, and Diego Hernández) begins with an important period of mafic volcanism (>40% in their Fig. 2). This is true for the post-caldera Pico Viejo–Teide formation (Navarro and Coello, 1989), but not for their three Upper Group cycles. In the Cañadas wall, where those formations are defined, the mafic rocks are more frequent at the top of the Diego Hernández sections, and there are almost no mafic lavas in the Guajara and Ucanca sections (Martí et al., 1994, Fig. 3). Nor are these cycles well established on the southern flank of the Cañadas edifice, where several tens of pyroclastic levels, often separated by paleosols, are exposed. These are older from southeast (0.15–0.6 Ma) to the southwest (up to 1.5–1.7 Ma). There is no conclusive evidence to prove that some (all or none) of these pyroclastic levels are correlated with great vertical collapse events.

Vertical and/or Lateral Collapses? The characteristics of the resulting calderas theoretically differ significantly, but in Tenerife the choice remains speculative. The volcanological structures are always incomplete, because the northern part of the caldera wall is lacking. Are the normal ring faults (incomplete and scarce) observed in the south Las Cañadas caldera wall bordering faults of a vertical collapse caldera, or instead the hanging end of great listric faults at the base of an avalanche caldera? The geophysical data "suggest that the caldera comprise several separate depressions" (Martí et al., 1997), but from these data it is not easy to deduce if the collapses were vertical or lateral, how many collapses took place, or if the depressions deal with the proposed collapses. It is not demonstrated that the faults (normal or inverse) were active at the time inferred for the formation of the three suggested calderas. At the base of the Tigaiga massif, the only preserved part of the Las Cañadas edifice in the northern sector of the island, there is a polygenic breccia (Bravo, 1962) interpreted by Ancochea et al. (1990 and 1995) as a debris avalanche deposit. It is overlain by 2.3 Ma trachybasaltic flows. Thus it marks an old lateral collapse event and, to date, no vertical collapse has been proposed.

Age Relations Between Vertical and Lateral Collapses. Martí et al. (1997) gave an age of about 1 Ma for their Ucanca caldera and tentatively related this collapse to the formation of the Güimar valley, outside of the Cañadas edifice. Ancochea et al. (1990) demonstrated that this valley, formed by lateral avalanche from the essentially basaltic "Dorsal" edifice, is younger than 0.84 Ma. Thus the two collapse events cannot be associated. Similarly, Martí et al. (1997) gave an age of 0.57 Ma (0.65 Ma in Martí et al., 1994) to the final phonolite of the Guajara cycle (and their Guajara caldera). Ancochea et al. (1995) measured these phonolite at about 0.90 Ma, and Martí et al. (1994) found another equivalent phonolite to date from 0.80 Ma. Therefore, the age of the suggested Guajara caldera could be older than that inferred by Martí et al. (1997). On the other hand, the age of the La Orotava valley, <0.78 Ma (Ancochea et al., 1990) or <0.73 Ma (Ibarrola et al., 1993), is not precisely constrained. Again, in this case, the temporal coincidence between the two collapses is not evident. Finally, there are no direct measurements for the Icod valley. Assuming it was generated during the formation of Las Cañadas caldera, Ancochea et al. (1990) proposed an age of about 0.15 Ma, which agrees with the estimation of <0.20 Ma from Watt and Masson (1995). The Icod valley–Diego Hernández caldera simultaneity remains to be corroborated.

In brief, the existence of three mafic-salic cycles and the ages of the three lateral and suggested vertical collapses are questionable. The coincidence in time and the connection between vertical and lateral collapses in Tenerife are not adequately demonstrated. The starting point of the calculated model by Martí et al. (1997, Fig. 3A) is certainly too simple and does not reflect the internal structure of the Las Cañadas edifice at the time considered, which was already the result of a very long and complex eruptive history. The proposed model is theoretically possible, but the existence in the Canary Islands of very frequent lateral collapses without connection with caldera collapses (Tigaiga breccia in Tenerife, El Golfo in El Hierro, etc.) indicates that vertical collapse is not requisite to generate large landslides. It is certainly too early to extend this model to other volcanic islands, Réunion Island included, where the existence and, of course, the simultaneity of the two types of collapse are not clearly demonstrated. The

"Grand Brulé–Enclos" system may be regarded as a single system derived from a seaward landslide (Lénat, 1990).

In any case, it is valuable that a part of the geological community concerned with Tenerife now considers avalanche processes in the evolution of the Las Cañadas after a long time of denying their importance (Martí et al., 1996).

REFERENCES CITED

Ancochea, E., Fúster, J. M., Ibarrola, E., Cendrero, A., Coello, J., Hernan, F., Cantagrel, J. M., and Jamond, C., 1990, Volcanic evolution of the island of Tenerife (Canary Islands) in the light of new K-Ar data: Journal of Volcanology and Geothermal Research, v. 44, p. 231–249.

Ancochea, E., Huertas, M. J., Fúster, J. M., Cantagrel, J. M., Coello, J., and Ibarrola, E., 1995, Geocronología de la Pared de la Caldera de las Cañadas (Tenerife, Islas Canarias): Boletín de la Real Sociedad Española de Historia Natural (Sección de Geología), v. 90, p. 107–124.

Bravo, T., 1962, El circo de Cañadas y sus dependencias: Boletín de la Real Sociedad Española de Historia Natural, v. 40, p. 93–108.

Fúster, J. M., Ibarrola, E., Snelling, N. J., Cantagrel, J. M., Huertas, M. J., Coello, J., and Ancochea, E., 1994, Cronología K-Ar de la Formación Cañadas en el sector suroeste de Tenerife: implicaciones de los episodios piroclásticos en la evolución volcánica: Boletín de la Real Sociedad Española de Historia Natural (Sección de Geología), v. 89, p. 25–41.

Ibarrola, E., Ancochea, E., Fúster, J. M., Cantagrel, J. M., Coello, J., Snelling, N. J., and Huertas, M. J., 1993, Cronoestratigrafía del Macizo de Tigaiga: Evolución de un sector del edificio Cañadas (Tenerife, Islas Canarias): Boletín Real Sociedad Española de Historia Natural (Sección Geología), v. 88, p. 57–72.

Lénat, J. F., Vincent, P., and Bachèlery, P., 1989, The off-shore continuation of an active basaltic volcano: Piton de la Fournaise (Réunion Island, Indian Ocean): Structural and geomorphological interpretation from Sea Beam mapping: Journal of Volcanology and Geothermal Research, v. 36, p. 1–36.

Martí, J., Mitjavila, J., and Araña, V., 1994, Stratigraphy, structure and geochronology of the Las Cañadas caldera (Tenerife, Canary Islands): Geological Magazine, v. 131, p. 715–727.

Martí, J., Ablay, G. J., and Bryan, S., 1996, The Canary Islands: An example of structural control on the growth of large oceanic-island volcanoes: Comment: Journal of Volcanology and Geothermal Research, v. 72, p. 143–149.

Martí, J., Hurlimann, M., Ablay, G. J., and Gudmundsson, A., 1997, Vertical and lateral collapses on Tenerife (Canary Islands) and other volcanic ocean islands: Geology, v. 25, p. 879–882.

Navarro, J. M., and Coello, J., 1989, Depressions originated by landslide processes in Tenerife: European Science Foundation Meeting on Canarian Volcanism, Madrid, Cabildo Insular de Lanzarote, Abstracts, p. 150–152.

Watts, A. B., and Masson, D. G., 1995, A giant landslide on the north flank of Tenerife, Canary Islands: Journal of Geophysical Research, v. 100, p. 24487–24498.