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FORUM

Dávid Karátson · Jean-Claude Thouret

Reply to the comment on the article "Erosion calderas: origins, processes, structural and climatic control" by Alexandru Szakács and Michael Ort

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We welcome all comments that may arise from our article (Karátson et al. 1999) because we believe that the role of erosion in modifying or forming depressions in volcanic terrains has not been sufficiently considered in volcanology. However, the comment by Szakács and Ort (2001) seems to us to be the result of a simple misunderstanding.

Their comment starts with a summary of our paper: "what the authors consider 'erosion calderas' are (1) erosion-modified volcanic depressions, (2) erosion-induced depressions in volcanic terrains, or (3) erosion-transformed volcanic depressions". In fact, we never said that all these types are erosion calderas. What may have been misunderstood is that, in the title, we used the simple, well-known term "erosion caldera" for the sake of conciseness; however, in the course of our paper, we distinguished unambiguously between different erosional landforms in volcanic terrains that may or may not derive from 'true', i.e. primary craters and calderas.

Originally, the word caldera (in Portuguese, caldeira) means a topographic depression – a 'cauldron' or 'large saucepan' – irrespective of its genesis. Therefore, one has to add a genetic, i.e. volcanological and (or) geomorphological term to define the exact type of caldera. On this basis, a primary caldera can be considered as the result of collapse due to volcanic activity (either collapse related commonly to ignimbrite-forming eruptions of stratovolcanoes, or collapse/subsidence of basaltic shield volcanoes). The primary caldera can then be modified by erosion. As pointed out in our paper, 'erosional depressions in volcanic terrains' can also form without having precursory primary (volcanic) depressions.

As far as erosion calderas are concerned, "the term... refers to a depression formed by completely different processes from the others and leads to confusion, but no alternative has been generally accepted" (Ollier 1988). In our paper, we attempt to define what erosion calderas are and how depressions in volcanic terrains can be classified (numbers 1–3 above). As a consequence of our newly introduced expressions for these depressions, we are aware that a scientific debate over the meanings is inevitable. Our replies to Szakács and Ort (2001), keyed to their comments, are as follows:

1. Szakács and Ort criticise our term 'erosion-modified caldera' because it could apply to "two genetically different types" (i.e. 'true' and erosion calderas) that "may be present in the same place". On the contrary, in our discussion and summary (p. 189), we define erosion craters and calderas as breached, fluvially eroded depressions formed, respectively, from primary craters and calderas of extinct volcanoes. Given this definition, we do not find it confusing that a 'true' caldera and an 'erosion' caldera coexist in terminology, because the term 'erosion' clearly refers to the fact that a primary volcanic depression has been transformed by erosion.
2. Szakács and Ort claim that the category of 'erosion-induced volcanic depression' formed in a precursory crater cluster is "questionable and arbitrary", because part of the original depression is of volcanic origin. In fact, we use the term "erosion-induced" in the sense that a large depression can form from a number of smaller pre-existing depressions by simple erosional, namely fluvial, processes. We might accept the authors' further theoretical subdivision of erosion-induced depressions (in their discussion, points 2a and 2b) on the basis of erosionally removed volume, i.e. greater or smaller than the original volcanic depression. But the question then arises as to how the authors can accurately measure the volume of removed rocks in ancient terrains. This difficulty makes the theoretical distinction unnecessary. As expressed in our paper (e.g. Table 1a, b), over geologic time many transitions occur between erosional landforms, hence one could not draw the precise boundaries in landform classification.

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D. Karátson (✉)
Eötvös University, Department of Physical Geography,
1083 Budapest, Ludovika tér 2, Hungary
e-mail: dkarat@ludens.elte.hu

J.-C. Thouret
Université Blaise-Pascal, UMR 6524-CNRS 'Magmas et Volcans',
5 Rue Kessler, 63000 Clermont-Ferrand, France

3. The ‘erosion-transformed depression' in our paper is a category that includes huge, irregularly shaped, particularly ocean-island depressions related to enormous amphitheatre valleys up to 3–5 km across. In our paper, we demonstrate how rapidly and effectively these valleys can propagate on islands subject to heavy rainfall (>2,000–2,500 mm/year) to form large depressions by masking the original, volcanic depression. We introduced this category because, in contrast to erosion-modified and erosion-induced depressions, erosion may alter the primary negative topography to such an extent that the position or even existence of a former depression cannot be inferred. This alteration can be caused by either post-caldera infill or to the fact that erosion is the causative origin of the depression. Given our classification, we accept that, on a conceptual basis, an erosion-transformed depression, i.e. one transformed from a primary crater or caldera, can also be interpreted as an erosion-modified depression. However, we think that our classification, focusing on the stage and role of erosion in a depression, and based on real examples, is more useful. For example, one can hardly term the cirques of Piton des Neiges (Reunion) as erosion-modified depressions, because we do not know whether erosion really modified any primary calderas as precursors of the present-day depressions. In addition, part of the cirques may have resulted from large flank failures, as shown by debris avalanche deposits at the outlets of the cirques, which form huge fans at sea (Bachélery et al. 1996). Therefore, we might deal here with a combination of three processes: formation of (1) a primary caldera (?), and its transformation by (2) flank failure or landslide and (3) high-energy streamflow-debris flow processes.

Szakács and Ort propose renouncing the term ‘erosion caldera’. In addition to our discussion in point (1), we think that the continued usage of the term is also encouraged by tradition based on field observations. Since the middle of the 20th century, ‘erosion caldera’ has been widely used for depressions that are derived from primary calderas by fluvial erosion (e.g. Cotton 1952; Siebert 1984; Ollier 1988). On the other hand, we agree that terms have their own fates: ‘erosion caldera’ was born in the middle of the last century (von Buch 1825; Lyell 1855) from the proper name Caldera La Palma or Taburiente, whose central depression was thought to be fluvially enlarged (e.g. Middlemost 1970), but has recently been found to be of landslide origin with subsequent fluvial enlargement (e.g. Ancochea et al. 1994; Carracedo 1999).

What is even less acceptable for us is the proposal of Szakács and Ort that they reserve the term caldera to subsidence/collapse depressions formed “during large-volume eruptions” and that it be “no longer used only to describe a morphological feature in volcanic areas”. Whereas we do not use ‘caldera’ only for morphological features, calderas are, in an arbitrary but widely used definition, more or less circular volcanic collapse depressions with diameters considerably larger (>1 km, 1 mile or 5 km) than any included vent (e.g. Cotton 1952; MacDonald 1972; Walker 1984; Wood 1984; Ollier 1988). Because the definition clearly indicates that a caldera is a primary, volcanic landform, we do not agree with the authors that the morphological manifestation of a caldera is secondary. A further weakness of their proposal is that calderas are not always related to large-volume eruptions: besides horseshoe-shaped avalanche-calderas, basaltic subsidence calderas can form by incremental processes (Walker 1984).

In conclusion, given the various, complex, and not fully understood origins of calderas, we are not convinced that a caldera results “from a well-defined genetic process” as claimed by Szakács and Ort. For the sake of observation and interpretation, the descriptive use of ‘caldera’ with self-explanatory volcanological/geomorphological genetic modifier terms is more legitimate than the restrictive genetic use that Szakács and Ort propose.

Finally, we did not credit K/Ar data to Downes and Vaselli (1995). We cited them as a general reference for the volcanoes listed (see Table 1 in Karátson et al. 1999).

References

Ancochea E, Hernán F, Cendrero A, Cantagrel JM, Fúster JM, Ibarrola E, Coello J (1994) Constructive and destructive episodes in the building of a young Oceanic Island, La Palma, Canary Islands, and genesis of the Caldera la Taburiente. J Volcanol Geotherm Res 60:243–262

Bachélery P, Labazuy P, Lénat JF (1996) Avalanches de débris sous-marines et subaériennes a la Réunion. C R Acad Sci Sér II Sci Terre Planètes (with English Abridged Version) 323(6): 475–482

Buch von LV (1825) Physicalische Beschreibungen der Canarischen Inseln. Berlin

Carracedo JC (1999) Growth, structure, instability and collapse of Canarian volcanoes and comparisons with Hawaiian volcanoes. J Volcanol Geotherm Res 94:1–19

Cotton CA (1952) Volcanoes as landscape forms, 2nd edn. Whitcombe and Tombs, Christchurch

Downes H, Vaselli O (eds) (1995) Neogene and related volcanism in the Carpatho-Pannonian region. Acta Vulcanol 7(2):1–290

Karátson D, Thouret J-C, Moriya I, Lomoschitz A (1999) Erosion calderas: origins, processes, structural and climatic control. Bull Volcanol 61:174–193

Lyell C (1855) A manual of elementary geology, vol II. James Murray, London

MacDonald GA (1972) Volcanoes. Prentice Hall, Englewood Cliffs

Middlemost EAK (1970) San Miguel de la Palma: a volcanic island in section. Bull Volcanol 34:216–239

Ollier CD (1988) Volcanoes. Blackwell, Oxford

Siebert L (1984) Large volcanic debris avalanches: characteristics of source areas, deposits, and associated eruptions. J Volcanol Geotherm Res 22(3–4):163–197

Szakács A, Ort M (2001) Comment on the article “Erosion calderas: origins, processes, structural and climatic control” by Karátson, Thouret, Moriya and Lomoschitz. Bull Volcanol DOI 10.1007/s004450100148

Walker GPL (1984) Downsag calderas, ring faults, caldera sizes, and incremental caldera growth. J Geophys Res 89(B10): 8407–8416

Wood CA (1984) Calderas: a planetary perspective. J Geophys Res 89(B10):8391–8406