Study reveals how topography influences emplacement of small-volume pyroclastic flows

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A view of the Arico Ignimbrite deposits where it is visible the columnar disjunction, a signal of its high emplacement temperature (>600º). Credit: Joan Martí (ICTJA-CSIC)

The emplacement of small-volume (less than 0,1km^3) pyroclastic flow is strongly controlled by topography, according to a new study by

researchers of the Institute of Earth Sciences Jaume Almera of the Spanish National Research Council (ICTJA-CSIC) and the University of Barcelona. The paper has been published in the journal *Sedimentology*.

The work focused on the study and characterization of the Arico ignimbrite, located in the southern slopes of the Las Cañadas volcanic complex (Tenerife, Canary Islands). These rock formations were originated by the deposition of a 670,000-year-old pyroclastic flow.

Guajara was the emission zone of this cloud, which was made up of a mix of hot gases, volcanic ashes and rock fragments. The cloud showed fast downslope movement, and was finally deposited in the valleys of the southern zone of the island, forming the studied ignimbrites.

"It is well known that pyroclastics flows are density currents controlled by the gravity and thus they tend to flow through valleys or depressed topographical zones," explains Joan Martí, researcher at ICTJA-CSIC and first author of the study. "Now, we have been able to demonstrate that, besides the slope, the emplacement of small-volume pyroclastic flows is controlled by the shape of the channel through which they flow. The bedrock morphology, obstacles, sudden slope variations or changes in the channel width are some of the topographical drivers that influence the emplacement and deposition of these types of pyroclastic flows."

To do this, the team conducted fieldwork in the Barranco de los Ovejeros where they found and described a total of 57 outcrops. In this valley, the ignimbrite deposits are well exposed. Researchers studied the lithology, stratigraphy and the sedimentological features of the ignimbrite outcrops. They also measured the slope of the previous ground, depth and width of the channels that guided the transport and the final emplacement of the flow. Researchers also took 41 samples to conduct a paleomagnetic study to estimate the emplacement temperature of the Arico ignimbrite.

According to Joan Martí, despite its age, the Arico ignimbrites is a "well-preserved and exposed deposit that permitted us to reconstruct the paleo-topography with precision. Therefore, we were able to observe how the lithological, stratigraphical and sedimentary features of the ignimbrite deposits vary on the basis of the changes of the valley's shape where they were finally emplaced."

With all the field data, researchers were able to develop a theoretical model that explains the critical mechanisms from which topography guided the emplacement of the flow.

"Besides the usual parameters that define the flow regime of this type of volcanic material current, our model includes the contour conditions imposed by a particular topography which allows establishing how the flow conditions vary along with its emplacement," notes Joan Martí.

According to the authors, this new model is "of general applicability and will help to explain other deposits of similar characteristics."

The researchers describe in their study the different features of Arico ignimbrites along 7 observation points. The paper notes that in the areas closest to the emission centre, the pyroclastic flow was efficiently channelled by the existing valleys that acted as efficient conduits. In these areas, the ignimbrite corresponds to a homogeneous moderately welded deposit.

The study also reports that in the intermediate zones, significant changes occurred in the steepness of the slope, and here, although still channelled, the flow was influenced by hydraulic jumps, which controlled the way it was emplaced. In this area, two different sedimentary units can be clearly seen in the ignimbrite: the lower unit is orange, and the upper unit is grey.

Finally, in the distal areas near the present-day coastline, where the slope is very gentle or null and without a channelling relief that provoked a radial dispersion and fast degassing of the flow, only the upper unit can be found.

The researchers say that this work allows to a better understanding of the emplacement mechanisms of ignimbrites and to improve the volcanic hazard assessment. "This study opens the door to forecast the flow regime of the small-volume pyroclastic flows as long as we know the previous topography."

Dario Pedrazzi and Domenico Doronzo, both researchers at ICTJA-CSIC, and Ferran Colombo, from the Faculty of Earth Sciences of the University of Barcelona, are the other authors of this new study.

More information: Joan Martí et al. Topographical controls on small-volume pyroclastic flows, *Sedimentology* (2019). DOI: 10.1111/sed.12600

Provided by Institute of Earth Sciences Jaume Almera

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