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The effect of giant lateral collapses on magma pathways and the location of volcanism

Francesco Maccaferri (1), Nicole Richter (2), and Thomas Walter (1)

(1) GeoForschungsZentrum GFZ, Potsdam, 2.1, Potsdam, Germany (macca@gfz-potsdam.de), (2) Observatoire Volcanologique du Piton de la Fournaise Institut de Physique du Globe de Paris - Sorbonne Paris Cité, France

Flank collapses, which may displace up to several hundred cubic kilometres of rock, are recurrent processes during the structural evolution of volcanic edifices. Long-term flank instability and flank failure are related to both the magmatic activity and the structural evolution and setting of volcanoes. In fact, it has been shown that magmatic intrusions may trigger movement of a volcano's flank, and that a lateral collapse may change the style of volcanism and the arrangement of shallow dykes. Moreover, it has been observed that new eruptive vents following a major flank collapse tend to cluster within the collapse embayment. However, the mechanical link between a large lateral collapse and the location of a new eruptive centre is still unclear. Here we use a numerical approach to simulate the pathways of magmatic intrusions underneath Fogo Volcano (Cabo Verde) upon a major stress redistribution resulting from a large lateral collapse that occurred approximately 73,000 years ago. Our simulations start deep within the crust and imitate the pathways of magmatic dykes rising towards the base of the volcanic edifice. Our results are quantitatively validated against morphological observations and reveal that a lateral collapse must remove at least 7% of the effective volcanic loading on the crust in order to trigger a significant deflection of the magmatic pathways at depth. At Fogo, the collapse event met this precondition and resulted in the formation of a new eruptive centre, the Pico do Fogo stratocone, which developed within the collapse embayment and was therefore shifted eastward (i.e. towards the direction of the collapse) with respect to the pre-collapse Monte Amarello Volcano's summit. Our results have implications for the long-term structural evolution of intraplate volcanic ocean islands.