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Endogeneous and exogeneous evolution of Lemptegy cinder cone, Chaîne des Puys, France.

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Intrusions are essential features in volcano growth and can constitute a large part of a volcanic edifice. Lemptegy volcano quarry offers a unique opportunity to study in detail scoria cone construction mechanisms. The study of structures in Lemptegy 2 (western part of the volcano) allows not only reconstruction of its history, but also provides evidence for intrusion emplacement mechanisms. Three early spatter cones and several fissures were first built. Then small spatter fed lava flows spread from the crater rims. The activity then became dominated by one major eruptive fissure that buried the earlier features. Different intrusion morphologies have been highlighted, such as bulges localised on the eastern part of Lemptegy 2. These bulges are due to blockage created by the pre-existing Lemptegy 1 edifice. In contrast, the western part of Lemptegy 2 is unconfined and dykes are thinner. Surprisingly, two cryptodomes are located on this side as well. They deformed scoria layers and fed late flank lavas.

The contact surfaces of the dykes preserve many shearing-related structures, such as tension gashes, Riedel shears, and elongated vesicles, allowing the reconstruction of magma movement inside the dykes. Most of the kinematic indicators show a general magma flow towards the principal central conduit. We propose that these dykes converged to feed the central eruptive fissure. However, some dykes have no major transport direction and swell parallel to their boundary to produce cryptodomes and associated lavas. The main eruptive fissure or dykes extending southwards probably fed the main Lemptegy 2 lava flow.

Ductile and brittle structures formed during emplacement and cooling of the dykes that cut non-welded scoria, which is frequently brecciated and mixed with the dyke magma. Autobrecciation of the dyke margins is common. Dyke tips and marginal

structures show that they propagated by infiltration and shear fracturing, rather than tensional cracking.

The excavated Lemptegy cinder cone thus reveals a wealth of features that will help to unravel processes at active volcanic systems. For example, the puzzling presence of basaltic domes simultaneous to fire fountaining at Cerro Negro (Nicaragua) in 1995 may be explained by a Lemptegy-type plumbing system. Thus, studying intrusions in old volcanoes provides us with a window into the hidden nature of active basaltic volcanoes.