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Effects of volcanoes that behave as soft, elastic inclusions on the propagation of volcanic fissures and rift zones

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Central volcanoes are normally composed of rocks that have lower Young's moduli (are less stiff or "softer") than the crustal segments that host them. This is particularly clear in Iceland where the central volcanoes (stratovolcanoes, composite volcanoes) are commonly made of comparatively soft rocks such as rhyolite, pyroclastics, hyaloclastites, and sediments whereas the surrounding host rocks are primarily comparatively stiff basaltic lava flows. Many central volcanoes are also associated with collapse calderas the ring faults of which often include relatively soft materials such as rhyolite and breccias.

In addition to soft central volcanoes and calderas, many hyaloclastite (basaltic breccia) mountains are partly buried in the lava pile. These mountains, primarily table mountains and hyaloclastite ridges, may also function as soft elastic inclusions in the comparatively stiff basaltic lava pile.

We have made many numerical models analysing the effects that such inclusions may have on the propagation and arrest of individual volcanic fissures. There exist clear examples of soft inclusions arresting the propagation of volcanic fissures, such as the 1783 Laki Fissure. The lateral propagation of two segments of this fissure became arrested in the slopes of the hyaloclastite mountain Laki, located near the centre of the fissure.

We have also modelled the stress effects of the Torfajökull Central Volcano, located in the central part of the East Volcanic Zone (EVZ) in Iceland. Torfajökull includes the largest surface volume of rhyolite within the Neovolcanic Zone. In addition, Torfajökull contains the largest active collapse caldera in Iceland. Torfajökull is located at the southwestern tip of the propagating-rift part of the EVZ. Thus, northeast of Torfajökull the EVZ is a proper rift zone, whereas southwest of Torfajökull it is a "flank zone" with hardly any tectonic elements typical of rift zones.

We modelled Torfajökull and its caldera as soft (low Young's modulus) inclusions in a stiffer surrounding. Our numerical results show clearly that Torfajökull suppresses the tensile stresses related to the spreading vector in this part of Iceland and, thereby, tends to prevent the rift-zone propagation to the southwest. Thus, the formation of this central volcano and its large caldera may be one reason why the front of the rift zone proper became arrested (temporarily at least) on entering the Torfajökull Volcano.