STRESS INTERACTION BETWEEN VOLCANIC AND SEISMIC ZONES

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There is increasing observational evidence for mechanical interaction, in terms of stress transfer, between adjacent volcanic and seismic zones. In Iceland, for example, there are strong indications that the 27-km-long feeder dyke associated with the largest historical eruption, Laki 1783, triggered the largest historical earthquakes in the country, that is, the 1784 earthquake sequence in the South Iceland Seismic Zone (SISZ). By contrast, dyke injection (and normal faulting) in the northern part of the North Volcanic Zone in 1976 lead to locking of the Husavik-Flatey Fault, an active transform fault partly exposed on land, for nearly a decade. The effects of dykes on the nearby seismic zones are due to their magmatic overpressures. For regional dykes originating in a deep-seated magma reservoirs beneath the volcanic zones of Iceland, the magmatic overpressure in the upper part of the crust may reach tens of megapascals. Whether an injected dyke locks a seismic zone (suppressing earthquakes) or unlocks it (triggering earthquakes) depends on its location in relation to the nearby seismic zones. When the horizontal crustal displacement associated with the dyke emplacement adds to that associated with the adjacent seismic zone, earthquakes are triggered; when the displacement associated with the dyke subtracts from that associated with the adjacent seismic zone, earthquakes are suppressed. Here we propose that loading of a seismic zone to failure may also lead to stress transfer to nearby volcanoes. We apply the results to the SISZ, an E-W trending seismic zone which was loaded to failure in June 2000, resulting in two M6.6 earthquakes. Boundary-element models indicate that loading of the SISZ to failure generates stress concentrations at its ends: tensile in the northeast and southwest quadrants, and compressive stresses in the northwest and southeast quadrants. The predictions of these numerical models are in agreement with observations. In the years prior to the June 2000 earthquakes,
there was compression, uplift and associated intense seismicity in the central volcanoes of Hengill and Eyjafjallajökull, located in the quadrants of compression; this activity came to an end following the June 2000 earthquakes. By contrast, there were unusually frequent eruptions in the decades prior to the June 2000 earthquakes in the central volcano of Hekla, which is located in one of the quadrants of extension (no central volcano is located in the other quadrant of extension). The numerical models, deformation and seismic data indicate that relatively soft inclusions such as central volcanoes with shallow magma chambers in the vicinity of a seismic zone may be subject to stress transfer from an adjacent seismic zone and be used as precursors to its large earthquakes.