Imaging rapidly deforming ocean island volcanoes in the western Galápagos archipelago, Ecuador

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Using finite-difference body-wave tomography methods to determine 3D seismic velocity structure, we imaged, for the first time, the plumbing system of Sierra Negra volcano, Galapagos, as well as parts of the island platform. This volcanic chain overlies a hotspot track and includes some of the fastest deforming volcanoes in the world, making this an ideal location for studying shield volcano plumbing systems. We inverted P- and S-wave arrivals recorded on a 15-station temporary array, SIGNET, installed between July 2009-June 2011 and used a minimum 1-D velocity model constrained by offshore refraction studies. Owing in part to seismicity from nearby volcanoes in the chain, as well as the frequent earthquakes along the caldera ring fault system, the model resolution is good between depths of 3km and 15.5 km beneath Sierra Negra, and adjoining Cerro Azul. Our results indicate that a shallow melt sill below the caldera, interpreted from geodetic data, must be shallower than ~4 km subsurface. The 10 km wide Sierra Negra caldera and ring fault systems are underlain by two small (<50 km^3) low-velocity zones, one just east of the caldera and one to the west. Another small (~70 km^3), shallow low-velocity zone is imaged beneath a line of eruptive centers with shallow earthquakes. We image a high-velocity zone around the site of a lower crustal magma intrusion in June 2010. Here, the steepest velocity gradients are ringed by the intense earthquake swarms, suggesting that the intrusion occurred at a petrological and/or thermal boundary. The crustal velocity beneath the northern flanks of Sierra Negra and the platform between Alcedo volcano to the north is lower than the initial 1-D model. Although resolution is poor at depths greater than ~15 km, we find no evidence for a velocity increase marking the base of the crust, suggesting that the crust is thicker than implied from earlier gravity models. Our results, interpreted in light of results of geodetic and petrological studies, provide tests of models for the construction and evolution of ocean island volcanoes, and help constrain the processes of oceanic platform construction above mantle plumes.

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