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Probing the interior of an active volcano: 3D seismic tomography at Montserrat

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The island of Montserrat, in the Lesser Antilles, has been the subject of an onshore-offshore seismic tomography experiment with the main aim of studying the magmatic system of the active Soufriere Hills Volcano (SHV). During the experiment, 4413 airgun shots were fired into 244 land stations and 10 ocean bottom seismometers (OBSs). A two-dimensional inversion of a subset of the data collected has provided the first image of the structure of the upper crust beneath Montserrat. The major features of the 2D velocity model are two high velocity regions beneath SHV and Centre Hills Volcano, which we interpret to correspond to the andesitic cores of these volcanic complexes and to an underlying system of intrusions. The 2D inversion was unable to confirm or rule out the presence of a magma chamber beneath SHV, which is predicted by petrological and geodetic studies. We present the results of the three-dimensional travel-time inversion of a larger dataset, including refractions, wide-angle reflections and normal incidence reflections recorded on all 10 OBSs, a representative subset of the land stations, and a multichannel streamer. The ray coverage of the 3D inversion is denser and allows a more detailed resolution of the subsurface. The presence of high-velocity cores beneath the three volcanic centres is confirmed and their extent is now better constrained. The high-velocity regions extend from the surface to a depth of at least 8 km beneath the two extinct volcanic centres in the north, but only to a depth of about 5 km beneath SHV. A zone in which the velocity is lower than the surrounding material, and the material above, is observed beneath SHV at depth between 5 and 8 km, and is interpreted to correspond to the presence of partial melt, i.e. to a magma chamber possibly representing the source of the current eruption. The overlying high velocity region is interpreted to correspond to a system of solidified intrusions. Our results are consistent with petrological and geodetic constraints and will provide new insights into the magmatic processes at Montserrat and other island arc volcanoes.