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P-wave velocity structure of Piton de la Fournaise volcano deduced from earthquakes recorded between 1996 and 1999

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Piton de la Fournaise is a highly active basaltic volcano located on La Réunion island, Indian Ocean. In order to gain information on its internal structure, we carried out a 3D tomographic inversion based on P-wave first arrival times for earthquakes recorded by the Observatoire Volcanologique du Piton de la Fournaise between 1996 and 1999. In addition to to the common volcano-tectonic activity which is located at shallow depth, above sea level and below the central cone, we use events which preceded the March 9, 1998 eruption. This pre-eruptive swarm included a large number of events below sea level providing an unprecedented data set which sheds light on the deep structure of the volcano. We use a tomographic technique based on an accurate finite-difference travel-time computation and a simultaneous probabilistic inversion of both velocity models and earthquake locations. The inversion is carried out using a technique which allows to well constrain the inversion parameters. This processing provides high quality stable tomographic images. The obtained P-wave velocity model confirms the presence under the summit craters, above sea level of a high-velocity plug which is interpreted as corresponding to an intrusive, solidified dyke-and-sill complex with little fluid magma storage. It is surrounded by a low-velocity ring known as being lavas and scorias fractured and vesicular located on volcano flanks. Below the high velocity plug and above sea level, a low velocity volume is found, with a large part of the shallow seismicity located in it. This seismicity describes a V-shaped pattern with two branches having a main east-west extension, well correlated with the southern and northern borders of Dolomieu crater. The low velocity zone is limited at its bottom by an area of strong vertical velocity gradient which is found at sea level. Our tomographic results confirm that a major interface in the volcanic structure is located at sea level as already suggested by the spatio-temporal distribution of the seismicity preceding the March 1998 eruption. Below sea level, about 1-2 km b.s.l., a second zone of low velocity is observed with a low seismicity zone in its center. This could correspond to a volume of magma storage that may feed the major eruptions of the Piton de la Fournaise volcano.