Seismic tomography of Stromboli volcano: results from the 2006 active source experiment

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An active source seismic experiment has been carried out at Stromboli volcano from 25 November 2005 to 2 December 2006 (project DPC-INGV 2004-2006, sub-projects V2_03 and V2_13) in order to study the volcanic plumbing system by seismic tomography. To obtain a well sampled target volume, more than 1500 off-shore shots have been fired along profiles and rings around the volcanic structure (see Fig. 1). The shots have been recorded by 33 inland stations (13 permanent and 20 temporary) and 10 ocean bottom seismometers (OBS). P-wave arrival times have been manually picked on seismograms. Using active sources to generate seismic waves, the waveforms quality is strongly related to the shots energy and to the source-receiver distances. However, on seismograms recorded by OBS, the waveform complexity is increased by the presence of water phases that are characterized by very clear onsets, masking the refracted first arrivals. In order to avoid erroneous first break identifications, the travel times computed with a reference 1D model have been added on the seismograms as reference for picking. In many cases the picked P phases are within 1s whit respect to the reference times. We have collected a total of 11000 P-wave traveltimes that have been inverted for the Vp structure by means of an iterative damped least squares procedure using the code Simulps13q (Thurber, 1993). The starting model consists of a 3D grid of nodes 0.5 km spaced in X, Y, Z from -0.5 to 2 km depth (see Fig. 1). Using nodes with at least 30 hits and a damping value of 30 as the best compromise between data variance reduction and model complexity, after 5 iterations steps we have determined 987 velocity parameters, reaching a final rms of 0.11 s and a variance improvement of 35%. The tomographic model show P-wave velocity of about 1.8-2.8 km/s for the exposed part of the volcano. Slower Vp (1-8-2.0 km/s) are located around the summit craters. In the deepest part of the model, from 0.5 to 2 km depth, the main findings are the relative high velocity regions with Vp ranging from 3.5 to 5 km/s, that could suggest the presence of intrusive bodies related to the volcanic plumbing system, indicating the directions followed by magma uprising at shallower depths.

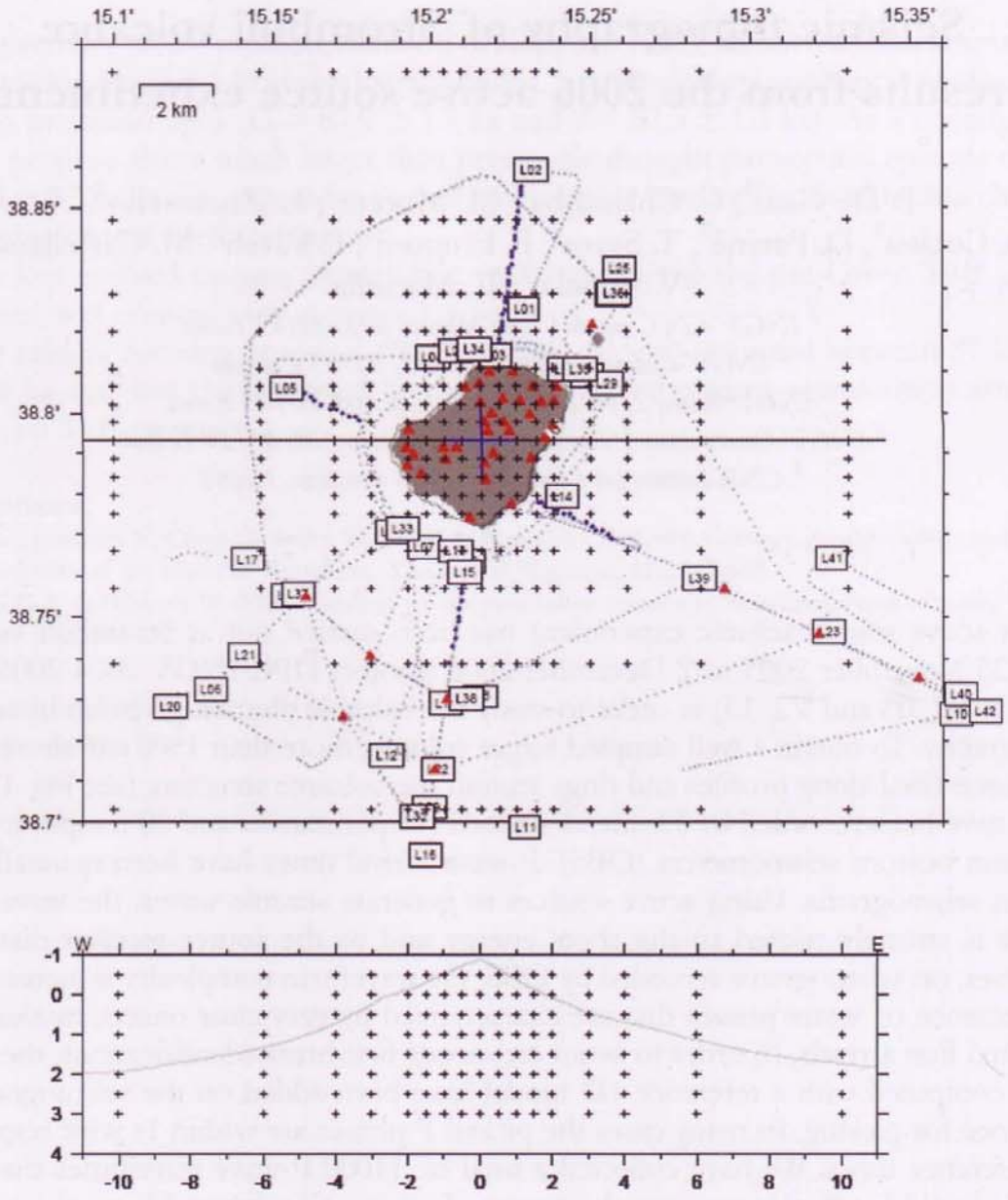

Fig. 1. Top: Shots (blue points) fired in the experiment. Each shot profile is labelled by a number preceded by L. The largest blue points are shots processed to test picking procedure and tomographic inversion. Red triangles are seismic stations while black crosses indicate the nodes of tomographic model. The WE black line is the trace of section shown in the bottom figure. Bottom: View of the tomographic nodes in a WE vertical cross section passing through the centre of the model.

References

Thurber, C.H., Local earthquake tomography: velocity and Vp/Vs theory, in Seismic Tomography: Theory and Practice, edited by H.M. Iyer and K. Hirahara, pp.563-580, CRC Press, Boca Raton, Fla., 1993.