



## **Repeating volcano-tectonic earthquakes at Mt. Etna volcano (Sicily, Italy): characterization and evidences of crustal changes**

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Repeating volcano-tectonic (VT) earthquakes, taking place at Mt. Etna during 1999-2009, were detected and analyzed to investigate their behavior. We found 735 families amounting to 2479 VT earthquakes, representing ~38% of all the analyzed VT earthquakes. Over 70% of the families comprise 2 or 3 VT earthquakes and only 20 families by more than 10 events. More than half of the families have a lifetime shorter than 0.5 day and only ~10% longer than 1 year. On the basis of these results, most of the detected families were considered 'burst-type', i.e. show swarm-like occurrence, and hence their origin cannot be explained by a temporally constant tectonic loading. Indeed, since the analyzed earthquakes take place in a volcanic area, the rocks are affected not only by tectonic stresses related to the fairly steady regional stress field but also by local stresses, caused by the volcano, such as magma batch intrusions/movements and gravitational loading. We focused on five groups of families characterized by the best repeatability over time, namely high number of events and long lifetime, located in the north-eastern, eastern and southern flanks of the volcano. Unlike the first four groups, which similarly to most of the detected families show swarm-like VT occurrences, group 'v', located in the north-eastern sector, exhibits a more 'tectonic' behavior with the events making up such a group spread over almost the entire analyzed period. It is clear how both occurrence and slip rates do not remain constant but vary over time, and such changes are time-related to the occurrence of the 2002-2003 eruption.

We searched for waveform variations in VT earthquakes belonging to the group 'v' and found changes that took place mainly in the 2002-2003 period. These consisted in a decreasing similarity of the late seismogram windows, highlighted by cross correlation analysis, as well as in delays, increasing proportionally to lapse time, detected by coda wave interferometry. Such variations, mainly evident at the stations located in the north-eastern flank of volcano, were likely due to medium changes taking place in this region. In particular, medium velocity decreases were inferred to occur in 2002-2003, followed by successive increases. The velocity decrease was interpreted as being caused by the opening or enlargement of cracks, produced by intruding magma bodies, ground intense deformation and/or VT earthquake activity, accompanying the 2002-2003 Mt. Etna eruption. On the other hand, the subsequent velocity increases were interpreted as resulting from healing processes.