Volcano-tectonic interactions captured by decade-long GPS monitoring in the Azores

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The Azores archipelago is located across the Mid-Atlantic Ridge, where three mega tectonic plates meet: Nubia, North America, and Eurasia. The archipelago has many active volcanic systems. The Fogo - Congro area in S. Miguel Island has been recognized as one of the most active seismo-volcanic fields. This area has been repeatedly suffering from intense earthquake swarms, at least in last few decades, such as in 1989, 2003-2006, 2008-2009, and 2011-2012. No geochemical and hydrothermal evidences for a magmatic intrusion were reported during these seismic crises. However, geophysical data, both seismic and ground deformation, indicate possible volcanic sources. To understand these repeating seismic swarms and eruption triggering mechanism, the mutual relations between the regional stress field and volcanic deformations were studied.

In the scope of tectonic and volcanic monitoring 11 continuous GPS stations are currently operating in the archipelago. The GPS time series for 2008-2011 shows an extensional stress regime at Monte Escuro - Congro Area (MECA), between the NE flank of Fogo volcano and the western rim of Furnas Caldera. It plays about 38 percent contribution of the total plate spreading. The rest is maybe taking place in other regions from either tectonic or volcanic contributions in different periods. The existence of this extensional regime plays important roles for the present-day magma ascent (failed and possible eruptions) in the area.

One of the stations inside MECA represents an episodic displacement on late 2008 which was accompanied by two seismic significances; (1) the seismic migrations (from NE flank of Fogo to Furnas) and (2) the localized deep swarms (at the depth of 4-7km). The former suggests the close link between Fogo and Furnas volcanic systems through the regional tectonic structures and the latter can be interpreted as minor-scale magmatic injection from upper mantle. On the other hand, the seismic swarms in 2003-2006 and 2011-2012 were accompanied by the edifice-scale deformation. The time series shows the months to years of gradual pressure accumulation inside Fogo volcano. These volcanic inflations may have resulted from successive magma injections at the shallow crust. Decade-long GPS monitoring has revealed volcano-tectonic interactions in the Eurasia-Nubia plate boundary and enabled to distinguish volcanic unrests in S. Miguel Island from the steady-state present-day plate movements. For better characterizing ongoing volcano-tectonic phenomena and assessing the volcanic risks in real time, it is fundamental to reinforce the present continuous GNSS network and extend it to all the active volcanic systems in the archipelago. A new network with 30 new GNSS stations is being prepared which will enable high rate data acquisition (50Hz). Detailed source process of the seismo-volcanic phenomena including co-seismic rupture propagation and time-dependent magma emplacements will be better constrained in the Azores.