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Soil degassing surveys as a tool to identify hidden faults in volcanic areas: preliminary results at the Ribeira Grande graben (Fogo Volcano, S. Miguel Island, Azores)

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In volcanic areas, where the sedimentation rates are higher than fault-slip rate, neotectonic surveys are even more difficult due to topography mantling by thick and non cohesive recent fall deposits preventing the surface expression recognition of tectonic structures by traditional field works. In Azores Archipelago adding to this limitation is the presence of dense vegetation.
Large amounts of volcanic-hydrothermal carbon dioxide (CO2) may be released in volcanic areas through constrained zones called diffuse degassing structures (DDS), which are mainly controlled by tectonic structures. Several studies have shown that active tectonic structures can provide preferential pathways for the release of subsurface gases since they are discontinuities with higher permeability than the surrounding areas channelling deep gases towards the surface. For this reason, mapping soil gas heterogeneities have been widely used for the study of fault activity and identification of hidden structures.
The north flank of Fogo volcano is structurally characterized by the Ribeira Grande graben, a distensive tectonic structure whose limits are evidenced by domes, cinder and pumice cones alignments. Due to the insufficient outcrops, structural studies under development in the area have been essentially based on morphostructural analysis by aerial photo and digital elevation models (DEM) interpretation. The geometrical analysis revealed a main set of normal faults trending NW-SE to NNW-SSE and a second set trending NNE-SSW to NE-SW both with two families dipping in opposite senses. Similarly to other neotectonic works carried out in the archipelago, the former structures may also have a shear component (dextral or sinistral).
Low temperature fumarolic fields, thermal and CO2 cold springs and soil diffuse degassing areas are the main hydrothermal manifestations found in Fogo volcano. In the area of Ribeira Grande graben some families were even dislodged due to high indoor air CO2 concentrations.
Several detailed soil CO2 concentration surveys were performed along the Ribeira Grande graben over the last decade and some works are still ongoing. Spatial distribution of soil CO2 degassing suggests that main anomalies trend NW-SE. A second NNE-SSW trend is less evident. Since gas migration is usually controlled by brittle deformation, the geometry of the degassing anomalies suggest the existence of two main sets of hidden faults that control the diffuse degassing patterns, whose trends are compatible with the tectonic data obtained by geomorphologic interpretation and field-based works. The more scattered features of some anomalies suggest that degassing occur not only along the main fault plane but also at close surroundings through hidden minor faults. Discontinuous DDS may be dependent of both fracture patterns and low permeability zones (e.g. hydrothermal alteration).
Preliminary detailed diffuse degassing maps provide clear correlations with the tectonic data. Therefore soil CO2 degassing maps demonstrate, also in this case, to be a useful method to complement neotectonic studies, by revealing tectonic structures helping structural patterns definition in areas where outcrops are scarce.