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New insights on the structure of La Soufriere dome from joint inversion of P-wave velocity and density

Marie-Lise Bernard (1), Olivier Coutant (2), and Francois Beauducel (3)

(1) LaRGE, Université Antilles-Guyane, 97159 Pointe-à-Pitre, France (mlbernar@univ-ag.fr), (2) ISTerre, CNRS, Université Joseph Fourier, 38041 Grenoble, France, (3) Institut de Physique du Globe de Paris, 75252 Paris, France

One objective of the french project Domoscan (2009-2013) was to obtain better constraints on the geological structure of La Soufriere hydrothermal system, that is the dome inner structure but also its basement that has not yet been imaged, while it may play an essential role in potential flank destabilization.

In this framework, we performed a 3D gravity and P-wave travel time joint inversion to obtain density and P-wave velocity images of La Soufriere hydrothermal system (Coutant et al., 2012). The joint inversion approach was proposed to overcome the lack of resolution of the two methods taken separately. In this study, the coupling between P-wave velocity and density relies on a relationship derived from laboratory measurements on 58 samples from La Soufriere and Mt Pelee deposits. The laboratory data cover a large range of porosity (1-73%) with P wave velocity ranging from 2 to 5.4 km/s and density from 1.5 to 2.8 g/cm3 in water saturated samples.

The joint inversion results show that P wave velocity model benefits from density resolution at the volcano summit, while density resolution improves at depth. The improved images allow new insights on La Soufriere structures. As an example the resistive zones that have been so far only seen by electromagnetic surveys may not be due only to argilization but may also be explained by the presence of dense massive zones, that we interpret as andesite spines resulting from 3100 B.P. or 1530 A.D eruptions. These dense bodies may have implication on the stability of the edifice and then the destabilization risks at La Soufriere of Guadeloupe.

This work also shows that laboratory studies on physical properties of volcanic rocks and their relationships can be useful in the interpretation of geophysical observations on structurally complex areas such as volcano or geothermal system.