Magnetic signatures of volcanic unrest: learning from long-term data at Mt Etna, Stromboli and La Fournaise volcano

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The long-term monitoring of the geomagnetic field at different volcanoes can give valuable information for improving the understanding of the volcanic structures and the dynamics of eruptions. The modifications of the magnetic properties of volcanic rocks as well as the hydrothermal activity can generate a wide variety of magnetic signals, as piezomagnetic, thermomagnetic and electrokinetic effects. In addition, the local magnetic field changes are strongly related to magma dynamics.

The characterization of these signals, which depends on the structural heterogeneity, the stress field, and the hydrothermal state of each volcanic edifice, is a key step for improving the detection of small magnetic signals and for understanding the mechanisms that produce them.

During the last decades, geomagnetic observations have been intensively carried out at different volcanoes around the world (Japan: Miyake-jima; Italy: Etna and Stromboli; France: La Fournaise Philippines: Taal), and significant correlations between volcanic activity and changes in the local magnetic field have been observed. In particular, a series of coherent observations on Etna, Stromboli and La Fournaise volcanoes have led to significant advances in the systematic study of the amplitude and the origin of measurable volcanomagnetic effects. The spatio-temporal evolution of the signals observed at Etna and Stromboli during the latest eruptions (2003, 2007, 2008 and 2011) are of piezomagnetic origin. They allowed to model the magmatic intrusions at shallow depth and the stress field progress within the volcanoes. Volcanomagnetic signals recorded at La Fournaise, between 1986 and 2004, have contributed to improve the knowledge of the eruptive behavior of this volcano. Signals up to a tens of nanoTeslas were observed in the last weeks to a few hours before effusive activity. The signals were mainly attributed to electrokinetic effect. The magnetic field observations highlight the usefulness of magnetic monitoring networks as complementary techniques to traditional permanent geophysical arrays.

The long and high-quality geomagnetic sequences recorded during the last two decades at Etna, Stromboli and La Fournaise volcanoes are an essential database for a detail comparison between these volcanoes. Their specific magnetic signatures will be highlighted in accordance to the different types of eruptive activity. The expected results should contribute to the evaluation in real time of the typology and the level of activity of the volcanoes. It could help to estimate pre-alarm/alarm thresholds relevant for civil protection decisions.