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Internal structure of a complex lava dome and of its surrounding inferred from gravity and magnetic data

Angélie Portal, Lydie-Sarah Gailler, Jean-François Lénat, and Philippe Labzuy

Clermont Université, Université Blaise Pascal, CNRS/UMR6524, Observatoire de Physique du Globe de Clermont-Ferrand, Laboratoire Magmas et Volcans, 5 rue Kessler, F-63038 CLERMONT-FERRAND (A.Portal@opgc.univ-bpclermont.fr)

The observation of volcanic domes growth (e.g. St. Helens, Unzen, Montserrat) shows that it is often characterized by a series of extrusion phases, domes explosions and collapses. As a result, their internal structure, after the eruptive activity has ended, is complex, including massive extrusions and lava lobes, talus and pyroclastic deposits. On an older dome, the knowledge of its internal structure will, in turn, allow to reconstruct its construction. This requires a combination of geologic and geophysical investigations.

Here we describe a study of the Puy de Dôme volcano (French Massif Central), an 11,000 years old trachytic volcanic dome. This study is based on gravity and magnetic surveys. Furthermore, the analysis of a high resolution topographical survey (LiDAR) allows, on the one hand, to differentiate several specific zones or structures at the surface and, on the other hand, suggests that the dome may be part of a larger system associated with a large shallow intrusive body.
Our gravity survey, carried out in 2012 and 2013, provides a high coverage with 1600 new gravity stations. Differential GPS positioning of the stations and a high resolution DEM allow to construct an accurate new residual Bouguer anomaly map. A complementary ground magnetic survey has also been carried out on the dome itself and its immediate surroundings. The resulting anomaly has been reduced to the magnetic pole to remove the dipolar behavior of magnetic anomalies.

The complex gravity and magnetic anomaly patterns suggest that the internal structure of the dome is heterogeneous. A first qualitative analysis of gravity anomaly shows a globally positive signature in the central part of the dome (with a possible continuation to the North) and a lower one on the other flanks. A positive magnetic anomaly is also associated with the dome central part, but with a significantly larger extent than the gravimetric one. In the neighborhood of the dome several gravity and magnetic anomalies are associated with mafic lava flows and scoria cones. However, a large amplitude magnetic anomaly at the northern foot of the dome has not been clearly identified yet with a known geological structure. Gravity and magnetic models (2D and 3D) allow us to investigate the range of the different internal structures that may account for the observed anomalies. When coupled with geological information, the interpretation of the geophysical models leads to a more restricted domain of solutions. A rather constrained image of the structure of the Puy de Dôme and its surrounding can thus be derived and used to reconstruct the volcanic succession of events in this area.