Density and magnetic susceptibility relationships in non-magnetic granites; a "wildcard" for modeling potential fields geophysical data.

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Geophysical surveying (both gravity and magnetic) is of great help in 3D modeling of granitic bodies at depth. As in any potential-field geophysics study, petrophysical data (density [r], magnetic susceptibility [k] and remanence) are of key importance to reduce the uncertainty during the modeling of rock volumes. Several works have already demonstrated that δ¹⁸O or [SiO₂] display a negative correlation to density and to magnetic susceptibility. These relationships are particularly stable (and linear) in the so-called “non-magnetic” granites (susceptibilities falling within the paramagnetic range; between 0 and 500 10⁻⁶ S.I.) and usually coincident with calc-alkaline (CA) compositions (very common in Variscan domains). In this work we establish robust correlations between density and magnetic susceptibility at different scales in CA granites from the Pyrenees. Other plutons from Iberia were also considered (Veiga, Monesterio). The main goal is to use the available and densely sampled nets of anisotropy of magnetic susceptibility (AMS) data, performed during the 90’s and early 2000’s, together with new data acquired in the last few years, as an indirect measurement of density in order to carry out the 3D modelling of the gravimetric signal.

We sampled some sections covering the main range of variability of magnetic susceptibility in the Mont Louis-Andorra, Maladeta and Marimanha granite bodies (Pyrenees), all three characterized by even and dense nets of AMS sites (more than 550 sites and 2500 AMS measurements). We performed new density and susceptibility measurements along two main cross-sections (Maladeta and Mont Louis-Andorra). In these outcrops, numerous measurements (usually more than 50) were taken in the field with portable susceptometers (SM20 and KT20 devices). Density data were derived from the Arquimedes principle applied on large hand samples cut in regular cubes.
weighting between 0.3 and 0.6 kg (whenever possible). These samples were subsampled and measured later on with a KLY-3 susceptibility bridge in the laboratory. Additionally, some density data were derived from the geometry and weighting of AMS samples.

After the calibration of portable and laboratory susceptometers, density and magnetic susceptibility were plotted together. Regressions were derived for every granite body and they usually followed a linear function similar to: \( r = 2600 \text{ kg/m}^3 + (0.5 \times k \times \text{S.I.}) \). As previously stated, this relationship is only valid in CA and paramagnetic granites, where iron is mostly fractioned in iron-bearing phyllosilicates and the occurrence of magnetite is negligible (or at least its contribution to the bulk susceptibility). These relationships allow transforming magnetic susceptibility data into density data helping in the 3D modelling of the gravimetric signal when density data from rock samples are scarce. Given the large amount of AMS studies worldwide, together with the quickness and cost-effectiveness of susceptibility measurements with portable devices, this methodology allows densifying and homogenizing the petrophysical data when modelling granite rock volumes based on both magnetic and gravimetric signal.