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Detailed petrophysical characterization enhances geological mapping of a buried substratum using aeromagnetic and gravity data; application to the southwestern Paris basin

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Mapping the geometries (structure and lithology) of a buried basement is a key for targeting resources and for improving the regional geological knowledge. The Paris basin is a Mesozoic to Cenozoic intraplate basin set up on a Variscan substratum, which crops out in the surrounding massifs. We focus our study on the southwestern part of the Paris basin at its junction with the Aquitaine basin. This Mezo-Cenozoic cover separates the Armorican Massif and the Massif Central which compose of several litho-tectonic units bounded by crustal-scale shear zones. In spite of several lithological and structural correlations between various domains of the two massifs, their geological connection, hidden below the Paris basin sedimentary cover, is still largely debated.
Potential field geophysics have proven effective for mapping buried basin/basement interfaces. In order to enhance the cartographic interpretation of these data, we have set up a detailed petrophysical library (field magnetic susceptibility data and density measurements on rock samples) of the Paleozoic rocks outcropping in the Variscan massifs. The combination of aeromagnetic and gravity data supported by the petrophysical signatures and field/borehole geological information, is carried out to propose a new map of the architecture of the Variscan substratum.
The new synthetic map of geophysical signature of the Paris basin basement combines: i) the magnetic anomaly reduced to the pole, ii) the vertical gradient of the Bouguer anomaly and iii) the tilt derivative of the magnetic anomaly reduced to the pole. Based on this information, the Eastern extension of the major shear zones below the sedimentary cover is assessed. The petrophysical signatures were classified in three classes of magnetic susceptibility and density: low, intermediate and high. Basic rocks have high magnetization and density values whereas granite, migmatite and orthogneiss show low magnetization and density values, Proterozoic and Paleozoic sediments, micaschists and metagrauwackes have intermediate to low magnetization and density values. Detailed lithological attribution of geophysical anomalies was achieved separately for each geological sub-domain (in between 2 major structures).
This methodology will be generalized at the scale of the entire Paris basin in order to propose a tectonic reconstruction of this segment of the Variscan belt, and provide guides for the exploration of hidden resources.