Near surface fracture field to deep basement features assessment in the Rhine Graben from a 50 m above ground level magnetic survey using a compact drone solution

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The upper Rhine Graben is currently a target for different geothermal projects: deep projects for electricity and heat production and shallower heat and lithium extraction projects. Two type of target are of interest: the basement rocks at >3000 m depth, and fractured fields at the border of the basin. Unfortunately, the structural features of the different reservoirs are poorly known. Classic seismic investigations (2D profiles every 1 to 3 km), ground gravimetric measurements and an aeromagnetic helicopter survey at 300 m above ground level have been performed on the french side but their resolution is too poor to assess the sub-kilometer features of the fracture fields or the details in the geometries of the units of the basement. Currently, the main faults in the basement are thought to be mostly NNE-SSW, but the occurrence of strong E-O faults in the analogous nearby Vosgian massif, and the inconsistencies between parallel seismic profiles in the basin weaken this hypothesis.

To assess both deep basement and shallower fracture field features, an experimental magnetic survey at 50 m above ground level was performed with a very compact drone system (DJI mavik pro) weighting less than 1.2 kg (Figure 1). Acquisition procedures and data processing workflows were tested, especially to deal with the magnetic compensation of the device and the merging of all the data, following the results of previous work of integration of magnetic sensor on larger drones (DJI matrix 100, 210, 600 and ECA IT 180). This acquisition part was financed by the consortium GEODENERGIES through its DONUTS research project. In the end, a very high resolution magnetic grid was produced with an accuracy of 1 to 2 nT (assessed by the standard deviation of the differences at crossing points between profiles and tie-lines), of which the upward continuation is coherent with the results of the helicopter survey at 300 m.

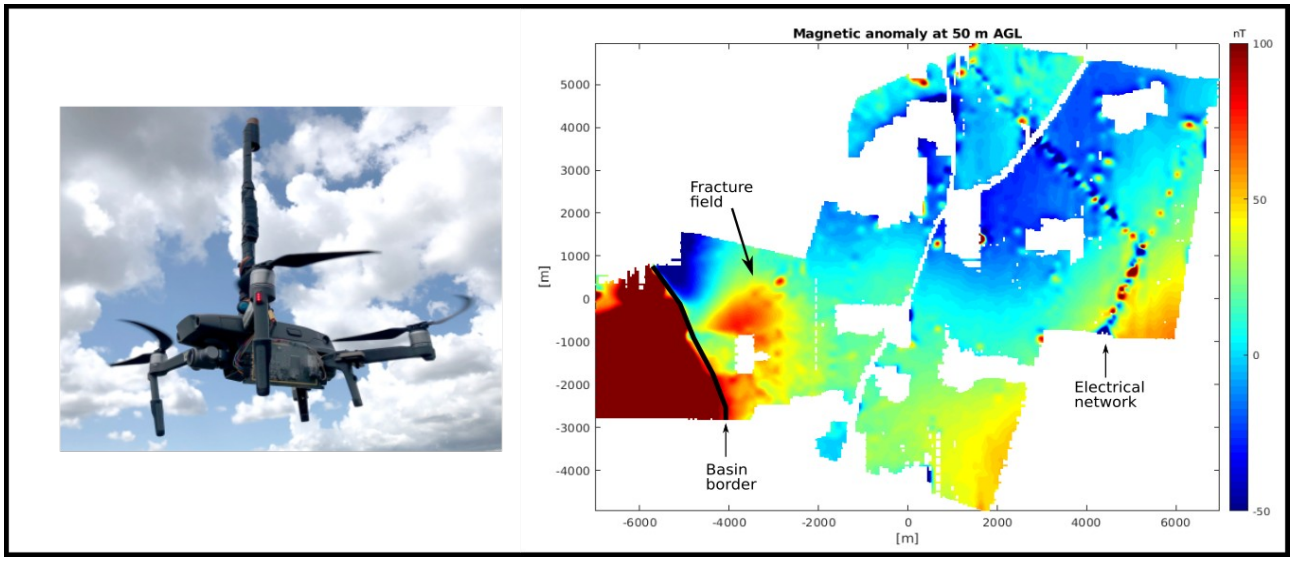

Figure 1. Left – system used for the survey at 50 m ; Right – map of the magnetic anomaly at 50 m and highlight of the border of the basin, a fracture field and electrical network

In the studied area, the first qualitative results of the drone survey show that the main limits in the basement are not only NNE-SSW as previously thought, but that other main orientation appear,

especially perpendicular to the NNE-SSW orientation, delineating successive blocks with complex geometries from the border to the central part of the rift. The new orientations explain the inconsistencies between the 2D seismic lines. The good fitting of the anomalies with the lithological and structural limits in the massif part of the survey where the basement is outcropping allow to build hypothesis on the continuation of the lithological units in the basin. Such a result is of major importance for resource evaluation.

Additionally, field transforms of the anomaly grid at 50 m reveal the previously unknown extent under a tertiary sediment cover of a partially known fracture field, south of the more well known Saverne fracture field which is a current target for heat and lithium production.

This qualitative study shows the capabilities of very high resolution magnetic surveys using very compact and cost-effective solutions to assess geological features in both deep basement unit and shallower fractured field in a rift system. In the studied area, the high potential of application for resources exploration in high to low energy geothermal project is shown. In a more general framework, such a survey would be a valuable result for any project requiring high resolution mapping of geological limits.