Hints for electrical anisotropy in a fault-damaged potential hydrothermal area: A case study at Annecy, French Pre-Alps

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SUMMARY

Before modelling and inverting magnetotelluric data, it is crucial to understand the dimensionality of the target area to determine the appropriate inversion approach (1D, 2D, or 3D). In the presence of anisotropy, determining dimensionality becomes challenging as the anisotropy direction can be independent from the structural strike, giving potential unrealistic models.

This study is carried out in Annecy, France, an urbanized area in the external Alps over the Molasse Basin, which lays over Cretaceous to Jurassic sedimentary units. This area features brittle shear structures, such as detachment thrusts and faults, like the active strike-slip Vuache fault. Additionally, a hydrothermal reservoir is possibility located in a karstified Jurassic marlstone-limestone at 1.5-2 km depth. Given the possibility of such environments to present electrical anisotropy, the goal is to determine whether anisotropy in the area results from fluid circulation in the fault-damaged zones, large shear structures, both, or neither.

Data were collected from over 40 sites across 100 km² around the Vuache fault, with recordings from 1 to 12 days and sampling rates from 256 Hz to 65 kHz. A semi-permanent station has been recording at 256 Hz for over 90 days.

Dimensionality and anisotropy on this dataset have been analysed across different frequency bands. The 1 to 10 s frequency band, which is expected to comprise the hydrothermal reservoir contribution, shows predominantly 2D behaviour with a strike parallel to the Vuache fault (perpendicular to the thrust structures). This band contains two clusters of sites, each one at the two blocks of the Vuache fault, that present transfer functions showing distortion and anisotropic features in a 2D environment. The potential anisotropic sites are being reviewed both individually and jointly using isotropic and anisotropic 1D inversions and compared to inverse and direct 2D modelling.

Keywords: Broad-band magnetotellurics, anisotropic modelling, fracture damage, fluid circulation