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VLF-EM prospecting for the characterization of a fault zone and the evaluation of its permeability conditions.

Silvana Fais (1,2), Paola Ligas (1), Francesco Cuccuru (1), Enrico Maggio (3), Alberto Plaisant (3), Alberto Pettinau (3), and Antonio Pala (1)

(1) University of Cagliari, DICAAR, Department of Civil and Environmental Engineering and Architecture (DICAAR), Cagliari, Italy (sfais@unica.it), (2) Consorzio Interuniversitario Nazionale per l'Ingegneria delle Georisorse (CINIGeo), (3) Sotacarbo S.p.A.

An electromagnetic VLF survey was carried out to characterize a fault zone in south-western Sardinia (Italy) and to investigate its permeability conditions. The VLF method is passive because instead of a transmitter-receiver system, as in an active electromagnetic method, it uses signals from distant radio stations operating in the very low 15-25 kHz frequency range used for military transmissions. In this survey the station UMS (Moscow - Russia) operating at 17.1 kHz was used to perform four NW-SE electromagnetic profiles at 10m station intervals over the study area where a NE-SW fault zone was supposed. A WADI-ABEM system was used for the VLF data acquisition survey. The VLF-EM data were first interpreted using the Karous–Hjelt linear filter (Karous-Hjelt, 1983; Ogilvy and Lee, 1991) which allows the generation of apparent current density pseudosections by filtering the in-phase data. The pseudosections provide a representation of the depth of the various current concentrations and hence the spatial arrangement of subsurface geological features such as faults, fracture zones and geological contacts. However, on analyzing the Karous-Hjelt current density pseudosections, VLF data are useful to produce a qualitative view of the subsurface structure.

The quantitative interpretation of the VLF data was done with a 2-D code for the VLF data inversion. The initial model was constrained considering the results of previous resistivity laboratory measurements carried out on samples from the main geological formations outcropping in the survey area. In all the Karous-Hjelt pseudosections as also in the 2D resistivity models many conductive zones are present (resistivity lower than 440 Ωm in good agreement with the results obtained from the previous laboratory measurements). Some of the conductive zones are located along an ideal alignment that can be linked with a structural discontinuity whose presence was hypothesized in the area. The conductive zones detected with the EM-VLF method could be also the signature of a preferential path of the water circulation but in this respect it is important to point out that other parameters can play an important role in the electrical signature and investigation depth (e.g. the clay content). Considering that the electrical resistivity can be normally easier to measure than permeability both in the laboratory and in-situ, starting from the resistivity data a method of correlation between electrical resistivity and permeability (Archie, 1942) was used to define the water flow into the investigated geological formation close to the fault zone. .

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