Contribution ID: **5** Type: **Talk**

Geological and geoelectrical survey of the metamorphic and intrusive rocks on the Einstein Telescope site (Sardinia, Italy)

Monday, 8 November 2021 09:00 (1 hour)

The geological characterization preceding the construction of a large-scale underground structure, such as the Einstein Telescope (ET), is a mandatory step of civil engineering studies. The ET Italian candidate site is located in the Variscan basement of Sardinia because of its geodynamic quietness, very low seismicity and anthropogenic seismic noise. The ET layout is currently projected as an underground triangular infrastructure (10 km long sides), whose vertices are located between the villages of Lula, Bitti and Onanì, and is confined within an area not crossed by main regional faults.
The geological features of the Palaeozoic metamorphic rocks are the result of ductile deformation with folds and related planar and linear anisotropies. This polydeformed metamorphic basement was intruded by several granitic bodies and by mafic to acidic dykes, mostly of early Permian age. A brittle to ductile fault network affects the metamorphic-plutonic ensemble. Within such a structural frame it is difficult to accurately predict lithologies at depth by means of the geological survey alone. Thus, we started an integrated multidisciplinary cartographic, structural and Electrical Resistivity Tomography (ERT) study. The results as far obtained are useful to highlight the structural elements at depth, particularly lithological contacts and fault zones, which are relevant for the prediction of mechanic behaviour of the rocks along the tunnels tracks as well as the groundwater occurrence.
We have merged the lithologic information from published maps (also by comparing satellite images) and new data collected in the field. Newly traced morphostructural lineaments mark the distribution of fault zones from the areas that surround the boreholes drilled at two vertices. The analysis of satellite images has thus allowed to define the segmentation of principal faults, whose length is limited at surface to a few kilometers (2.5 km max).
Field structural results provided evidence of at least two ductile phases (D2+3) almost completely transposing the original bedding and the oldest schistosity (S0+1). Faults are mainly NNW-, and WSW-striking and are associated with either more altered bedrock and/or cataclastic bands. The WSW-striking faults are often conjugated with E- to NE-striking faults. Fault zones can be associated with thick quartz veins, or thin chlorite fibers. Locally, they are crossed by intense fracture arrays, pseudotachilites and gouge that can be as thick as a meter.
Near the vertices that were site of drilling (ca. 250 m total depth), ERT tomography was carried out, providing a complex internal resistivity stratification, that consists of up to three levels with variable distribution and thickness. As supported by field observation, we have interpreted the more conductive electrolayer as regolith and alluvial units, while the most resistive electro-layers correspond with the less-altered granitoids. The sudden trend of the isoresistivity line, that also recognized from satellite images or field evidence, was related to saturated fractured zones.
Thus, matching the vertical information provided by the 2D ERT results and the geological information from the study area, we provide a more accurate estimate of satured fault geometry at depth. Beside the ET vertices, similar approach can be adopted in predicting zone of hazards during the tunnel drillings.

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Session Classification: Sardinia Geology, Long and Short term measurements