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Investigation of karst by combined analysis of seismic and electrical resistivity anisotropy

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Seismic and electrical resistivity anisotropy of a fractured karstic limestone massif in sub-parallel underground galleries of the LSBB (Laboratoire Souterrain à Bas Bruit; Low Noise Underground Laboratory, Rustrel, France) have been studied in a massif composed of a rather homogeneous sub-horizontal thick sedimentary layer of limestone (100m) with vertically oriented fractures. If such fractures are oriented in a predominant direction, physical properties are dependent on the direction of measurements, producing seismic and electric anisotropy. Due to the dominantly vertical orientation of the fractures in the studied site, the resulting anisotropy is approximated by a horizontal transverse isotropic (– HTI) body.

In addition, fractured limestone rock is prone to exhibit physical properties differing during seasonal changes which are connected with different sub-surface water contents. Two geophysical methods are sensible to the variations of water content. Acoustic waves have different propagation velocities in fractures filled with water than in those filled with air. Similarly, the rock resistivity is dependent on water content. Dry limestone has higher resistivities than limestone containing mineralised water within the fractures.

Several data treatment methods and programs were applied to datasets of first arrival seismic travel-times (qP-wave and qS-wave) and resistivities. The applied seismic methods include: isotropic tomography, homogeneous Monte-Carlo anisotropic inversion for horizontal transverse isotropic body and anisotropic tomography for tilted transverse isotropic bodies. The applied resistivity method is azimuthal Monte-Carlo anisotropy resistivity fit. All methods lead to the conclusion that there is indeed an anisotropy present in the rock massif and all coincide on the calculated (inverted) values of searched parameters (such as maximum and minimum velocity, angle deviation of symmetry axis, variation of resistivities with respect to the angle).

Strong seismic anisotropy of about 15-20% is present in the studied area. data from two different years show that this anisotropy varies over time. This variation is interpreted as being due to water content changes, being 10% larger for seismic properties in dry period than wet period of the year.