

DIRECTIONAL BOREHOLE RADAR SYSTEM – A REVIEW ON TECHNIQUE AND EXPERIENCES

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Abstract

The exploration of internal salt dome structures by the application of geophysical methods either from the surface or from boreholes reveals some specific characteristics: A geophysical exploration from the surface very often yields inaccuracies concerning the shape and the position especially of steep internal structures within the salt dome. A detailed exploration from several boreholes is expensive and may cause problems e.g. as leakages of surrounding caverns.

Most caverns are constructed by using one single borehole. For this application Deutsche Montan Technologie GmbH (DMT) developed a borehole and cavern radar system, which allows the detection of salt heterogeneities in distances up to 250 m from a specific borehole or cavern, respectively. The system works according to the well-known radar principle: Electromagnetic radar waves are emitted from the transmitting antenna of the system within the cavern or borehole. Structural or lithological heterogeneities (e.g. potassium layers) within the salt dome which cause abrupt changes of impedance are acting as reflectors. Reflections are recorded by the radar system via receiving antennas. In addition to one dipole antenna for the electric field, two directionally sensitive magnetic field receiving antennas are included. This configuration results in a directional sensitive system, which yields important information about the three-dimensional distribution of reflectors in the vicinity of the cavern or borehole.

A successful service with this DMT borehole and cavern radar system is depending on several boundary conditions determining the quality of the results: First, an important boundary condition refers to the medium in which the system is run. The most important condition in this context is that the system so far can only be used in fluids. A system applicable in gaseous media is under development. In general, the working medium must be highly resistive (e.g. oil). This is determined by the physical propagation conditions for electromagnetic waves and does not only apply to the operating fluid but also to the consistency of the borehole wall (e.g. the existence of a mud cake). Second, the cavern geometry is of some importance for the quality of the measurement results: The maximum operation depth is 2,000 m due to restrictions in pressure and temperature conditions. A rough and irregular surface of the cavern wall minimizes the loss of energy due to strong cavern wall reflections, which are typical for even and nearly vertical cavern walls. Thus, much more electromagnetic energy is available for penetration into the surrounding geological formations. Third, experiences so far have shown that the composition of the salt determines the quality of the results, as well. The amount of insolubles dispersed in the salt obviously has an impact on the absorbing behavior of the electromagnetic waves, determining the depth of penetration into the surrounding geological structures.

Key words: Cavern Mapping, Cavern Development, Geology, Geophysics, Salt Properties