Electromagnetic radiation (EMR) and its interpretation in terms of stresses in the lithosphere *Vortrag*

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Electromagnetic radiation (EMR) as measured at the surface of the lithosphere or underground shows preferred orientations, which can be related to microcracks and other brittle structures at micro and nano scales (see Bahat et al. 2005 and references therein). During the last years, numerous studies showed the applicability of EMR measurements for the determination of active fractures and stress orientations. EMR is determined with a 'Cerescope', which picks up EMR signals at frequencies from 5–50 kHz (Obermeyer, 2005) with a ferrite aerial and processes them electronically so that the results can be displayed on a screen or copied to a computer.

With the help of oriented EMR measurements, intensity variations are determined, which can be related to preferred crack fracture orientations. From this information, orientations of the principal stresses can be calculated. In addition, the intensity of the EMR is related to stress magnitudes. Several EMR measuring methods with the Cerescope can be applied to study regional and local stress fields. For horizontal measurements the aerial is moved in a horizontal circle. Every 5 degrees a measurement is taken. The entire horizontal measurement consists of 72 readings, which are illustrated in a polar diagram. Calculating the directions of the cracks from EMR intensities, the principal directions of the horizontal principal stresses can be determined. For Linear measurements the aerial is moved along a straight or curved line in this method. Every metre (can also be any other distance) a measurement is taken. Using this method it is possible to find loci of high stresses, such as active faults, where stress accumulates. It is also appropriate to find loci of possible rock burst in underground facilities. If several linear measurements are arranged in grids it is possible to map the orientation of structures such as faults, where stress is accumulated. Cross section measurements can only be applied in long underground excavations such as tunnels. The measurements are undertaken along the cross section of the tunnel and are oriented normal to the tunnel's long axis. Beginning with a vertical orientation of the aerial every 5 degrees a measurement is taken until a full circle of 360 degrees consisting of 72 measurements is completed. Fractures around tunnels originate from a secondary stress field which is induced by the regional stress field and the empty space of the tunnel. This secondary stress field is described by radial, tangential and shear stresses. Shear stresses are most likely produce fractures, since shear strength is much smaller than compressive strength. Therefore, the EMR measured in cross section measurements is proportional to shear stress of the secondary stress field. By determining the shear stress distribution along the long axis of the tunnel it is possible to calculate directions and magnitudes of the regional stresses, which induce the secondary stress field. The tun-

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nels in which this technique can be applied have to be curved and need to have a maximum overburden of at least 75 m and a minimum overburden of less than 20 m. These parameters are necessary to produce shear stress distribution along the tunnels' long axis from which regional stresses can be determined reliably and with small standard deviations.

In order to build up experience and a comprehensive database, EMR is determined in different regions and different tectonic environments. Two examples will be presented, one from the shoulder of the Upper Rhine rift (Odenwald) and one from northern Sweden and adjacent Norway.

In the example from the Odenwald (tunnel at Wald-Michelbach), EMR results are generally compatible with published data on the regional stress field (azimuth of major horizontal principal stress 103°). In addition, a minor N-S tensional component and the influence of local faults can be discerned.

In the investigated area of Scandinavia the regional stress field as determined from EMR is uniform, the major horizontal principal stress has a ENE–WSW orientation. Published results from different stress determination methods applied on the eastern coast of Sweden show a major horizontal principal stress with NE–SW orientation.

At the Steinfjellet road tunnel residual stresses with a maximum of 3 times the regional stress magnitude are found at a thrust contact, which represents the Caledonian suture between Baltica and Laurentia. There, the major horizontal principal stress has a NW–SE orientation.

References

Bahat D, Rabinovitch A & Frid V (2005) Tensile Fracturing in Rocks — Tectonofractographic and Electromagnetic Radiation Methods. Springer Verlag, Berlin Heidelberg, pp 569

Obermeyer H (2005) Measurement of Natural Pulsed Electromagnetic Radiation (EMR) with the Cerescope, Ceres GmbH, Staffort, pp 8