DISCUSSION

NATURAL ELECTROMAGNETIC RADIATION (EMR) AND ITS APPLICATION IN STRUCTURAL GEOLOGY AND NEOTECTONICS by R.O. Greiling and H. Obermeyer. Jour. Geol. Soc. India, v.75, 2010, pp.278-288.

Michael Krumbholz, Geoscience Center of the Georg - August University Göttingen, Goldschmidtstrasse 1, 37077 Göttingen, Germany comments

Greiling and Obermeyer present measurements of natural microcrack-induced electromagnetic radiation (EMR) using the Cerescope, to detect faults and to determine main horizontal stress directions (s_H) and stress magnitudes. However, the following points cause serious concern about the applicability of the method in its actual state of development:

Firstly, the recorded signal strength over time (Figs.8a,b; cf. Lauterbach, 2005), which is discussed as related to e.g. tidal movements or short-term stress variations in the lithosphere, show extreme "lows" exactly between 9.00 and 10.00 UTC. In fact, these lows can be directly correlated with a regular daily intermission in the broadcasting pattern of DHO38 (www.sidstation.com), a military VLF transmitter in north-western Germany. As a consequence, signals recorded outside of the intermission time are most likely to be related to DHO38, i.e., they are artificial and have no geological significance.

Secondly, the authors presume that the antenna of the Cerescope is most sensitive in the direction of long axis (unidirectional). However, ferrite core aerials, such as the one used, are most sensitive perpendicular to this direction (omnidirectional) (Poole, 2003, pp.112). This is problematic, because the measuring methods presented by Greiling and Obermeyer are based on a unidirectional receiving pattern. At the very least the vertical measurements in Figs.3b,c by Lichtenberger (2005, 2006a), used to detect stress concentrations and to calculate stress magnitudes in tunnels, should be re-evaluated.

Thirdly, the authors mention that during EMR measurements of s_H, one to four main peaks in the data are observed. They assume that one peak is caused by propagation of extensional fractures parallel to s_H, while two peaks could be explained by conjugate shear fracture systems symmetrically arranged around s_H. However, it is difficult to explain more than two peaks occurring at the same or even at different times at one location. Stress data from Lichtenberger (2006b), as presented in Fig.4a, are derived from up to four main EMR maxima, all of which were observed in measurements made at different times. Lichtenberger (2006b) determined s_H as the bisector between the two most often observed peaks, which is a very questionable approach.

Fourthly, results of EMR studies by Mallik et al. (2008) and Lauterbach (2005), which are inconsistent with the World Stress Map (Heidbach et al. 2008), are not cited. I believe that the detection of faults (Figs.4b, 5c) is possible with this tool. However higher measurement levels are not due to increased microcracking rates, but instead record VLF signals. Since the antenna is oriented vertically during measurements, it is insensitive to signals from the ground (see point 2) and to the horizontally propagating magnetic component of the primary VLF signal, but it is sensitive to the magnetic component of the secondary electromagnetic field that is generated at structures with lower electric resistivity (e.g. faults). As the physical background of the method, as known from laboratory studies, is logical and convincing (Rabinovitch et al., 1999), careful and more detailed investigations are needed to successfully apply the laboratory-scale observations in the field.

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We thank M. Krumbholz for providing an opportunity to clarify misconceptions on the potential use of the natural electromagnetic radiation (EMR) method, its application in structural geology, and the Cerescope instrument.

His first point that a low in EMR signals at a particular time of the day may be related to the activity/inactivity of a particular transmitter is interesting. However, our observations (Greiling and Obermeyer 2010, e.g. Fig.8) show numerous lows throughout the day, which cannot be explained by a particular transmitter. Furthermore, the observed signal variations with time are unlikely to be caused by a regular transmission signal. In effect, the Cerescope is a registration device for electromagnetic signals. It has to be emphasized that the Cerescope provides the necessary filters to suppress regular, artificial EM-signals. However, these filters have to be applied and tuned by the user before the registration procedure.

The second point clearly shows a misunderstanding of our description of the Cerescope instrument and the function of its aerial. Whilst ferrite aerials in radio receivers are optimized to pick up the electrical component of the EMR signal, the Cerescope aerial is shielded against the electrical component so that only the magnetic component is registered. As outlined in Fig.1 of Greiling and Obermeyer (2010), this magnetic component is at a maximum in the direction parallel with the long axis of the aerial, a fact that is experimentally evident. This information is also relevant for the second but last section in the comment, where the direction characteristics of the aerial are mentioned again.

With regard to the third point, we refer to the extensive discussions of Lichtenberger (2005, 2006a, b, c), who showed the relation between tension cracks and a single EMR direction, and conjugate shear fractures with two EMR directions both theoretically and with field examples. Lichtenberger (2006c) also provides extensive references on the problem, including rock mechanics. For further relevant references see Bahat et al. (2005).

The meaning of the fourth point is unclear to us. We do not see any conflicts between the results by Mallik et al. (2008) and Lauterbach (2002, 2005) with the world stress map. We referred to the earlier edition of the world stress map (Reinecker et al. 2004), which does not show substantial differences to the new edition (Heidbach et al. 2008).

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