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Empiric field studies of electromagnetic emissions and their relation to active crustal stress fields

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In recent years several empiric studies of electromagnetic (EM) emission in active tectonic regions were made by members of our department. The studied areas are situated in Southern Spain, Sicily, Malta, Czech Republic and in France/Provence as well as in Southern Chile.

The goal of the studies was to detect the maximum horizontal stress direction in the upper crust. Therefore the electromagnetic emissions were measured subject to the orientation of the receiving antenna. The results were compared with active stress directions obtained from doorstopper measurements, borehole breakouts, focal plane solutions and neotectonic structural analysis. The directions of maximum horizontal stresses are in clear concordance with the orientation of maximum electromagnetic emissions.

The EM emissions of rocks under tectonic stress are due to charge dislocations. These dislocations are most probably caused by the formation of microcracks, but there is still an ongoing debate whether there are other influences such as piezoelectric and piezomagnetic effects or not. Our results can be best explained by charge dislocations due to the formation of microcracks but the effect of piezoelectricity cannot be ruled out. Therefore only the empiric results are presented and discussed but no specific model for the creation of electromagnetic emission will be defined.

In Southern Spain EM measurements were taken in 2002 and 2005. The results of the two field campaigns agree within the accuracy of the measurement method and show a horizontal stress predominantly in NW-SE ($\approx$140°) direction. This is in good agreement with the overall tectonic regime in the western Mediterranean region. In Sicily as in Malta the EM measurements were compared with borehole measurements taken in the 1980‘s. The results of both methods agree and match with the overall

tectonic stress situation in this area. An especially remarkable situation occurs in eastern Sicily where tectonic flexuring reveals a totally different local stress field than in other parts of Sicily. The results in the Czech republic can be explained as well by the microcrack theory as by the piezoelectric effect which shows a deviation of 90˚ in the orientation of the principal stress. Both results can be explained in the geological context and therefore the question concerning the creation of EM waves cannot be answered by this dataset. The horizontal stress direction considering microcracks as the main source of EM emission is in good agreement with focal plane solutions of the area whereas the piezoelectric approach would match a theoretical regional tectonic model. The stress determination in Provence (Southern France) exhibits a NNW-SSE direction of the maximum horizontal stress which is in good concordance with recent geodetic measurements in this region. Southern Chile is a tectonically very active area where our neotectonic investigations with structural analysis distinguished four different regional active stress domains related to compression, extension, uplift and strike-slip tectonics. Our measurements on EM emissions fully confirmed these different stress fields.