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In situ AE records in cyclically loaded rock salt - The stress memory effect and spatio-temporal characteristics

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We study acoustic emission (AE) activity caused by cyclic thermal loading due to the backfilling of a cavity in an abandoned salt mine to answer questions regarding the stress memory effect of rock (Kaiser effect), the dependence of AE rates and b-value on the stress state as well as the stress rate and the spatio-temporal evolution of the AE activity. Event rates and b-values of the frequency magnitude relation are calculated for a region well covered by a network of piezo-electric receivers from an event catalog corrected for incomplete recording times. Results are compared and correlated with the output of a 2D thermo-elastic stress modelling performed with an FE program. The high quality of the AE dataset as well as the good control of the input parameters of the FE program allows us to study the in situ activity in the mining environment with exceptionally high precision and temporal resolution. The backfilling period can be subdivided into two AE activity regimes. The first one exhibits a clear and pronounced Kaiser effect as well as an upward migration of the AE event front away from the ceiling of the cavity which correlates with the calculated stress field. This observation of the Kaiser effect implies that no healing effect is observed for these first few loading cycles. The maximum event rate observed during a loading cycle scales with the absolute stress increase of this cycle with respect to the former maximum. This behavior is also observed for later loading cycles which show a deteriorated Kaiser effect with an onset of AE activity well before the former maximum stress and a smaller slope of the relation between maximum event rate and absolute stress increase. During later loading cycles also time periods showing a pronounced anti-correlation between event rate and Coulomb stress with event rate maxima during minima of the Coulomb stress are observed. These time periods are generally characterized by a b-value of the frequency magnitude relation much higher than during times of positive correlation between event rate and Coulomb stress. One possible explanation for this behavior might be a loss of cohesion in the rock salt due to the influence of moisture which is introduced during the backfilling process. The resulting temporal event rate changes might be explained by a Coulomb failure model incorporating the thermal stress changes as well as a time-dependent cohesion coefficient. However, other explanations are also possible and will be discussed. The results of this study indicate that the observation of the AE activity during cyclic loading is able to detect changes in the system and is well suited for monitoring purposes.