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Response of a subcritically growing macrocrack in the mining environment to induced stress changes

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Microcrack activity observed in underground mines may indicate regions prone to future rock burst and rockfall events and may help mitigating risks in the mining environment. We use observed microcrack activity as recorded in a catalog of acoustic emission (AE) events in combination with calculated stress gradients and transients to test physical seismicity models and their forecast potential in mines. The study deals with the response of the rock mass in an abandoned rock salt mine to stress changes induced by backfilling of an old cavity. The high spatial-temporal resolution of our dataset allows the study of slowly growing fractures and the development of microcrack activity in the fracture damage zone of a growing macrockrack. The physical insights we obtain are important to understand the development of possible sudden rockfall events, but may also be useful to better understand the nucleation of earthquakes.

A pre-existing fracture of about 15 m length within the hanging wall about 15-20 m above the backfilled cavity was identified by careful analysis of the pre-filling AE activity. This fracture was found to be very responsive to small changes in the traction like terms of the stress field transferred instantaneously after backfilling started. This behaviour was indicated by a slowly spreading front of AE activity migrating at a rate of up to about 1 m/month. The recorded AE events likely occur in the fracture damage zone during its outward growth. Their temporal event rate evolution correlates very well with the forecast of stress-based seismicity models suggesting that concepts like the Coulomb failure model are also applicable on the micro scale.

This observation is supported by the response of the microcracking activity of the damage zone to the initiation of a second macrocrack occurring in close proximity. The initiation of this new macrocrack temporally corresponds with a clear break-down of the high positive correlation between AE activity on and the calculated stresses. This suggests a reorganization of the acting stress field and a stress transfer on the scale of 10s meters partly inhibiting further growth of the damage zone. This observation gives insights into the role of a sudden fracture formation or earthquake rupture on subcritical growth of neighboring fractures or fault patches.