Large localized damage structures detected by acoustic emissions at an active mining front in South Africa gold mine.

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We observed around 300 thousand of AE (Acoustic Emission) events by a high-resolution monitoring network close to the active front of a tabular mining stope in the Cooke 4 Gold Mine in South Africa. The AE monitoring was conducted during mining operation by 6 three-component accelerometers and 24 single-component AE sensors in a volume measuring approximately 95 m (N–S)×50 m (E–W)×30 m (depth). Three of the accelerometers had a flat frequency response up to 25 kHz and the other three up to 10 kHz. The AE sensors covered up to 50 kHz and were very sensitive. The arrival times of P- and S-waves were automatically detected, and the source locations of AE events as small as −4 in moment magnitude (M_w) or even smaller were estimated. The source locations were re-located by using the JHD (Joint Hypocenter Determination) and the double-difference relative location algorithm, where the AE events that had at least 10 P-wave travel-time readings and root-mean-square (RMS) residuals of 0.2 ms or less were used. The application of the double-difference relative location algorithm resolved seemingly continuous, dense cloud of AEs that extend about 20 m ahead of the stope front into several discrete, steeply dipping tabular clusters a few meters thick and 10–30 m in dip extent, separated by quiet intervals a few meters thick. These tabular clusters contrast with much more sharp (about 30 cm thick) clusters observed on existing faults. The tabular clusters had a strike parallel to the stope face and a dip of around 65°, resembling commonly observed large shear fractures along the plane of maximum shear (i.e. Ortlepp shears). The activity of these clusters started as the mining face approached within several meters and ended when the mining face reached the clusters. These observations suggest that discrete tabular clusters of AEs represent macroscopically localized damage structures that formed in the highly stressed intact rock ahead of the stope face and may culminate in dynamic shear events and the concomitant formation of Ortlepp shears.