Foreshock activity of Mw2.2 earthquake in a South African deep mine

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Foreshock activity of an Mw 2.2 earthquake (mainshock) that occurred in a deep gold mine in South Africa was observed by using a network of sensitive high-frequency AE sensors. The foreshock activity selectively occurred on a part of rupture plane of the forthcoming mainshock. It lasted for at least 6 months until the mainshock. Rock samples recovered from the mainshock source region showed evidence of ancient hydrothermal alteration on the mainshock rupture plane, suggesting that the foreshock activity occurred on a preexisting weakness. The foreshocks during 3 months before the mainshock were concentrated in three clusters (F1–F3), which we interpret as representing localized preslip at multiple sites. While the location of mining area, the source of stress perturbations, changed with time, the locations of foreshock clusters did not change, suggesting that the preslip patches were controlled by strength heterogeneity rather than stress distribution. Activity over the entire foreshock area was generally constant, but the largest cluster (F2) showed accelerated activity starting at least 7 days before the mainshock, while mining stress did not increase in this period. The mainshock initiated at a point close to F1, away from F2. All the six foreshocks during the final 41 hours occurred in F1 and F2 and in-between. These suggest that, in the last stage of the preparation process of the mainshock, preslip patches interacted with each other through the stress concentration ahead of the expanding preslip patch (F2), which should be the only driving force of the preparation process under the constant external loading.