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Observational studies of the rock mass response to mining in highly-stressed gold mines in South Africa

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Abstract

A multi-disciplinary study of the response of the rock mass to mining and mining-induced earthquakes has been conducted in six gold mines in South Africa at sites deeper than 3 km, or with equivalent stress. More than 80 holes (with a total length of more than 2.8 km) were drilled in earthquake-prone areas to locate faults and install instruments. Microfracturing activity associated with an ML2.1 event at 3.3 km depth in Mponeng mine and a highly-stressed rock mass at 1.0 km depth in Ezulwini mine were finely delineated and analysed. A hole drilled through the hypocentre of the ML2.1 event at Mponeng mine allowed the stress and strength in the seismogenic area to be constrained. Previously published in situ stress measurements had been limited to depths or stresses smaller than 2.7 km or 100 MPa, respectively. We successfully measured stress at depths and stresses up to 3.4 km and 146 MPa, respectively, at four mines. These in situ measured stresses were used to calibrate elastic stress modelling and yielded better estimates of stress and strength on the rupture planes of seven earthquakes (ML2.1 to 4.0). Comparison of the elastically modelled stress with the constrained stress in a hole drilled across the ML2.1 fault and the strain change monitored in situ at a close distance showed that the elastically modelled stress was smaller but correctable. The South African National Seismograph Network was enhanced by installing 10 surface strong-motion seismometer stations in the Far West Rand mining district. Two other such dense surface networks are currently operated in mining areas by the Council for Geoscience: 25 stations in the Klerksdorp region, supported by the Mine Health and Safety Council; and 17 stations in the Central Rand to monitor fluid-induced seismicity. Research on the routine processing of spectral parameters was carried out using seismicity recorded by these 52 new surface stations.