Novel seismic imaging approaches to delineate seismically hazardous geological structures

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Mining-induced seismicity poses a significant risk in deep South African gold mines, as it may cause damage to the infrastructure, delay production, and cause injuries or even deaths of mining personnel. Geological structures, such as faults and dykes, are known to be the sources of some of the largest seismic events experienced in deep South African gold mines, as both static and dynamic stresses can be transferred along these structures. Thus, a knowledge of their subsurface location, geometry, and extension is critically important when designing the mining layout and extracting the ore. Seismic methods are getting more attention than ever to address these challenges because they provide high-resolution images of key subsurface geological structures and retain their resolution at great depths.

This study aims to mitigate the risk of rockbursts by utilizing novel surface-borehole-tunnel seismic surveys that incorporate nodal, cabled, and fibre-optic sensing technologies to acquire high-resolution seismic data. This enables the imaging and understanding of geological structures extending up to 4 km below the ground surface. We integrate the active-source seismic data with geological structures (faults and dykes) and mining-induced seismic events to (1) enhance the detection of geological structures that affect the deposits and mining layout; and (2) analyse the correlation between geological structures and mining-induced seismic events to examine their relationship. Three case studies from deep-level gold mines in South Africa are covered. Through this novel approach, we can gain insight into the characteristics of mining-induced seismic events and help mines develop effective mitigation strategies.