INVITED KEYNOTE ADDRESS

SEISMIC IMAGING OF A RECENT M5.5 EARTHQUAKE RUPTURE BENEATH MOAB KHOTSONG GOLD MINE, SOUTH AFRICA

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In 1984, at the first symposium in this series, I presented a paper entitled *'Recent reflection seismic developments in the Witwatersrand Basin'* in which I described the adaptation of the seismic method to explore for deep gold-bearing strata in a 'hard rock' environment. A wide range of seismic investigations has been conducted in southern Africa since then. I will first review advances in the use of reflection seismics to explore for gold in the Witwatersrand Basin and platinum group elements (PGEs) in the Bushveld Complex. Seismics is used to mitigate the financial and safety risks of deep mining. Seismic imaging has improved mineral resource models by mapping 'potholes' (slump structures that eliminate parts of PGE orebodies), and helped mitigate hazards such as mining-induced seismicity and inrushes of water and flammable gas by mapping faults and dykes. Reflection seismics has also been used for curiosity-driven research, such as the mapping of fluid pathways that support microbial life in the deep biosphere. Next, I will describe 16s TWT seismic profiles and broadband seismometer arrays that have been used to investigate the structure of major geological domains, to explore for diamondiferous kimberlites, and to study the evolution of the continental lithosphere.

Lastly, I will discuss the reprocessing of legacy data to image the source zone of the M5.5 earthquake that shook Moab Khotsong gold mine and nearby towns on 5 August 2014. The strike-slip main shock and numerous aftershocks were recorded by surface and underground seismometer and strainmeter arrays. A successful proposal was submitted to the International Continental scientific Drilling Program (ICDP) to investigate (i) what controls seismogenic processes, (ii) how they scale, and (iii) how faults evolve. The drill rig was installed in a chamber excavated at a depth of ~3 km. Two ~800 m long boreholes were drilled towards the upper fringe of the aftershock zone, some 400 m below the deepest mining levels. The first hole deviated and ran sub-parallel to the zone. The second hole intersected a narrow, highly fractured zone; however, most of the rock fragments were lost. A short 'deflection' hole was then drilled with a triple-tube core barrel to ensure all fragments were recovered. However, the boreholes only sample a tiny part of the ~20 km^2 rupture zone. Fortunately, several 2D reconnaissance profiles that were surveyed for AngloGold Ashanti in 1992 cross the aftershock zone, as well as part of a 3D seismic patch that was surveyed in 1996. These data have been reprocessed using modern techniques. Particular attention was given to velocity analysis, migration and the application of seismic attributes in order to produce the best possible image of the geometry of the near-vertical rupture zone.