Integrated interpretation of 3D seismic data to enhance the detection of the gold-bearing reef: Mponeng Gold mine, Witwatersrand Basin (South Africa)

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Abstract

The authors present an integrated approach to the seismic interpretation of one of the world's deepest gold ore body (Carbon Leader Reef) using three-dimensional seismic data, ultrasonic velocity measurements at elevated stresses, and modified instantaneous attribute analysis. Seismic wave velocities of the drill-core samples (quartzite, shale, and conglomeratic reef) from the mine are sensitive to uniaxial stress changes, i.e., they slowly increase with increasing pressure until they reach maximum value at ~25 MPa. For all the samples, seismic velocities are constant above 25 MPa, indicating a possible closure of microcracks at stress corresponding to 1.0 km–1.5 km. A reflection coefficient of 0.02 computed between hanging wall and footwall quartzites of the Carbon Leader Reef ore body suggests that it may be difficult to obtain a strong seismic reflection at their interface. Our modified seismic attribute algorithm, on the other hand, shows that the detection of the lateral continuity of the Carbon Leader Reef reflector can significantly be improved by sharpening the seismic traces. Three-dimensional seismic data reveal that faults with throws greater than 25 m that offset the Carbon Leader Reef can clearly be seen. Faults with throws less than 25 m but greater than 2-m throw were identified through horizon-based attribute analysis, while most dykes and sills with thickness less than 25 m were invisible. The detection of the lateral continuity of the Carbon Leader Reef reflector and its depth position is greatly improved by integrating the modified instantaneous attributes with controls from borehole observations. The three-dimensional visualization and effective interpretation of the Carbon Leader Reef horizon shows a host of structurally complex ore body blocks that may impact future shaft positioning and reduce its associated risks.