Paper Number: 5213

Petrophysical and geological study of the seismically non-reflective Carbon Leader Reef: Witwatersrand Basin

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To better understand the physical properties and poor seismic reflection of one of the deepest and richest gold - bearing reefs in the Witwatersrand Basin, the Carbon Leader Reef, we logged 9 boreholes and selected over 50 drill-core samples of the immediate hangingwall and footwall of the reef, for mineralogical and chemical analyses as well as for density and seismic velocity measurements. Ultrasonic measurements of seismic waves were conducted at both ambient and elevated stresses, using two transducer sets for full and half-core samples.

The ultrasonic measurements reveal that P- wave velocities generally increase with increasing density. The Green Bar shale, which constitutes the hangingwall, has the highest velocity (~5123m/s-5913 m/s) and density values (~2.89 g/cm^3-3.15 g/cm^3) as a result of its fine-grained nature, mineral and pyrite content. The Carbon Leader Reef conglomerate has slightly higher P-wave velocity (~5070 m/s-5468 m/s) and density values (~2.78 g/cm^3) amongst the quartzitic units, possibly due to its slightly massive pyrite content. The quartzite hangingwall and footwall rocks exhibit similar P- wave velocity (~5028 m/s-5479 m/s and ~4777 m/s-5210 m/s, respectively) and density values (~2.68 g/cm^3 and 2.66 g/cm^3) which account for the low acoustic impedance and reflection coefficient values of the rocks. The reflection coefficients obtained at the interface of the Carbon Leader Reef conglomerate and its hangingwall and footwall units range between ~0.02 and 0.05 which is below the required minimum reflection coefficient value of 0.06 to produce a strong reflection between two geological units. This suggests that seismic reflection methods might not be able to directly image the Carbon Leader Reef conglomerate as a strong reflector. Samples were also subjected to stresses of up to 65 MPa to simulate *in situ* conditions and investigate the dependence of seismic velocities on applied stresses. P-wave velocities increase with progressive loading, but at different rates in shale and quartzite rocks as a result of the presence of micro-fractures.

A structural model of the West Rand Group was developed from the interpretation of the top of the West Rand Group. Application of volumetric attributes and horizon-based attributes to 3D seismic data highlighted structures which offset the top of the West Rand Group as well as the Central Rand Group. Three dimensional seismic data reveal faults with throws greater than 25 m that intersect the top of the West Rand Group and the Central Rand Group thus intersecting the Carbon Leader Reef as well. Horizon-based seismic attributes were used to enhance faults that had throws of less than 25 m and could not be detected by conventional picking.