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Physical property studies to elucidate the source of seismic reflectivity within the ICDP DSeis seismogenic zone: Klerksdorp goldfield, South Africa

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Abstract

Petrophysical properties of cylindrical core specimens from three boreholes from the International Continental Scientific Drilling Program, the DSeis project, measured at ambient pressure and room temperature conditions in various laboratories are presented and compared with downhole petrophysical data (sonic and density). The measured properties are from sixty-six rock specimens constituting metasediments, metabasalts and intrusives. Seismic velocities were measured using 0.5 MHz P- and S-wave transducers. To investigate the source of seismic reflectivity observed on the 2D legacy seismic data, we computed synthetic seismograms for adjacent rock units using downhole petrophysical data and compared them with seismic reflections from the reflection seismic profile. The experimental measurements show that the metasediments exhibit lower bulk densities and seismic velocities than the metabasalts and intrusive specimens. The porosity was found to be less than 2% for all the samples. No clear trends emerge when the Poisson's ratio is plotted against the P-wave velocities and porosities of the samples. A positive relationship is observed between the bulk modulus and P-wave velocities of the rock samples. The highest calculated reflection coefficients (RC) are associated with the metasediment-intrusive interfaces in all three boreholes. The intrusive-metabasalt and the metasediment-metabasalt interfaces exhibit low RC. Synthetic seismograms reveal strong reflections that coincide with high RC calculated using the bulk density and velocity data. The synthetic seismograms also revealed additional strong reflections that were not identified using the reflection coefficients calculated from the rock specimens, due to core loss in some lithological units. Successful correlations are carried out between the synthetic seismic data and the real seismic data, enabling us to correlate the stratigraphic sequence drilled in the boreholes to the seismic reflections observed on the legacy 2D reflection seismic data.