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Challenges of Core-Log-Seismic Integration in metamorphic environments: A case study for the ICDP drilling project COSC-1, Sweden

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Core-log-seismic integration (CLSI) can be used to construct a high-resolution seismic stratigraphy to better understand the deep orogenic processes in mountain belts. We have applied CLSI methods developed for sedimentary basins to the Paleozoic Caledonian orogen, in western Scandinavia. The COSC-1 borehole was drilled in 2014 to a depth of 2.5 km, through three main tectono-stratigraphic units: (1) a gneiss complex, (2) an 800 m thick mylonitic thrust zone, and (3) lower-grade metasediments. By calculating synthetic seismograms from borehole logs and matching them to 2D and 3D seismic data, we were able to identify the lithological boundaries that represent seismic reflectors and to correlate them with changes not only in acoustic impedance but also in seismic anisotropy. In terms of compositional variations, these reflections correspond to interfaces between mafic and felsic rock units. We then compared physical properties measured on the cores in the laboratory and under in-situ conditions inside the borehole using multivariate statistics. Here, large discrepancies due to micro-fracture formation leads to a significant decrease in the P-wave velocities in the cores compared to the downhole sonic logs. Only the velocities that we have measured in the laboratory under in-situ pressure and temperature conditions show similar results to those measured by the borehole logs. Our study shows that there are two main challenges when attempting core-log-seismic integration in metamorphic environments. Firstly, core samples are particularly strong affected by depressurization and excavation damage during drilling and measurements at ambient pressures, and are therefore a poor proxy for in-situ seismic properties, which hinders correlation of core and borehole logs. Secondly, the high seismic velocities (>5 km/s) at shallow depths and their strong variability leads to poorer seismic imaging when compared to sedimentary basins, particularly, in the offshore domain. Consequently, this requires additional seismic processing efforts for successful core-log-seismic integration.