

## Improving depth prediction accuracy of quantified drilling hazards

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Under-compacted shales are often associated with over-pressured formations. These shales have excess water and tend to be mechanically weak, thus the safe mud window for drilling the under-compacted interval can be quite narrow. Efficient and safe drilling operations require accurate depth predictions of these over-pressured formations as well a knowledge of the magnitude of the over-pressure. In this paper we describe a technique which combines the best aspects of conventional Vertical Seismic Profile (VSP) and Reverse Vertical Seismic Profiles (RVSP) to detect under-compacted shales and predict formation pressures to locate drilling hazards below TD.

The excess water in the under-compacted shales will have a lower acoustic impedance than expected from the compaction trend. Shales that depart from the compaction trend may indicate potential drilling hazards below. Conventional VSPs provide at discrete intervals in the well, high quality reflection data which can be used to accurately predict acoustic impedance below the bit. This acoustic impedance is then interpreted to provide both the location (in time and depth) of the drilling hazard and the mud weight necessary to contain it. The two way time estimate of the hazard location is usually quite accurate but the depth estimate is less certain due to the estimation of formation velocities below TD. The RVSP using the drill bit as a source, provides a continuous time versus depth relationship while drilling. This time versus depth is used to continually update the conventional VSP depth prediction of the drilling hazard and thus provide the most accurate depth of the hazard prior to its penetration.

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