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Detecting Volcanic Rocks on Seismic Data

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ABSTRACT

While exploring for hydrocarbons in rift related basins, predominantly mafic volcanics, volcanoclastics or their erosional products are common lithologies. The presence of igneous rocks and/or sediments affected by post-volcanic re-deposition may lead to lithologies with complex diagenetic overprints at the reservoir level. Partial or complete reservoir substitution, alteration by circulating hot fluids and addition of mineral components have led to a number of unexpected drilling results, both in exploration and field development projects. Volcanic rocks may provide both positive and negative impact on the petroleum system: forming vertical seals or lateral migration barriers for the fluid on its way from the source rock into the trap, or even representing a reservoir facies with certain porosity and permeability. In most cases, highly varied lithologies with wide ranges of inherent rock properties occur. It is therefore essential to understand the distribution of volcanics in the vicinity of the target reservoir. During our work in different basins around the world, we identified distinct features which help us detect volcanics and volcanic related lithologies from seismic data. Those features can be subdivided into two main groups: (1) amplitude expressions, particularly the AVO behavior, and (2) geometries, specifically in comparison with the observed morphology of recent volcanics. Over the past years, a number of publications have dealt with various aspects of the geometry of igneous bodies as identified from seismic data. In this article, we focus on the rock properties derived from well log data and the resulting amplitude response of volcanics as seen on seismic data. We discuss this using a number of case studies from several hydrocarbon bearing basins. In our initial analysis, well and seismic data from the Cretaceous in the Sirte Basin (onshore Libya), the Rotliegendes of Northern Germany, the Tertiary in the North Sea, and from the Cretaceous of the Santos Basin offshore Brazil have been involved. The igneous facies types - supported by FMI data, core and thin section analysis - included extrusive (basalts), intrusive (dolerites) and volcanoclastic (tuffites, lahar sediments) lithotypes. The various igneous lithotypes, depending on their void ratio or porosity, show a broad scatter of p-wave velocities (Klarner, 2012). However, for each of them the well-log derived shear-wave velocity is significantly lower than measured values for sandstones or shales with the same p-wave velocity, and lower than the Vs predicted from Vp by the empirical Greenberg-Castagna relationships for clastics.