SEISMIC IMAGING AND INTERPRETATION OF HYDROCARBON BEARING VOLCANIC BASINS

Planke, S.1; Millett, J.1; Jerram, D.A.2,3; Myklebust, R.4

1 Volcanic Basin Petroleum Research, Norway; 2 DougalEarth, UK; 3 University of Oslo, Norway; 4 TGS, Norway

ABSTRACT: Continental rifting and breakup is closely associated with voluminous magmatism, and igneous rocks are present in a large proportion of sedimentary basins and rifted margins. Well-known volcanic basins include the Vøring and Møre basins offshore mid-Norway and the Campos and Santos basins offshore Brazil. Igneous rocks and processes may have a major impact on basin deformation, temperature history, and fluid migration systems, both in syn-magmatic and post-magmatic times. Most aspects of a working hydrocarbon system are influenced by magmatism; including source rock maturation, hydrocarbon migration, trap and seal formation, and reservoir quality. It is therefore important for petroleum explorationists to be able to identify and map igneous rocks in the sub-surface. Commonly, the top of a volcanic complex is clearly identified as a high-amplitude reflection. However, intra-basalt and sub-basalt imaging is locally difficult and depends on the seismic properties of the volcanic sequence and the seismic acquisition parameters. Detailed studies of the seismic properties of core, wireline, and vertical seismic profiling data of different volcanic facies show a large variation of P-wave velocity, from about 2 km/s in weathered flow tops up to 6 km/s in dense crystalline lava cores. Volcaniclastic sediments display a similar wide range of velocity, from tuffaceous rocks of c. 1.5 km/s up to high-velocity, well-cemented hyaloclastites and pillow breccias generally with peak velocities of 5 km/s or lower. In contrast, sheet intrusions are high-velocity (5-6 km/s) bodies, often displaying symmetrical wireline profiles with minor internal velocity variations. The contrasting seismic properties of the igneous units give rise to lateral velocity variations and anisotropy, mode conversions, attenuation, scattering, and tuning reflections. These effects are important to address during acquisition and processing of seismic data in volcanic basins, however recent carefully processed 2D and 3D broadband data display major uplifts in intra- and sub-basalt image quality. We have developed different methods for identifying and mapping igneous complexes in sedimentary basins using the concepts of seismic volcanostratigraphy, igneous seismic geomorphology, and integrated seismic-gravity-magnetic interpretation. Extrusive rocks are well defined by characteristic seismic facies units (e.g., seaward-dipping reflections, lava delta) and seismic geomorphologies (e.g., lava flow fields), whereas sill intrusions are characterized by high-amplitude reflections crosscutting the sedimentary strata and commonly forming saucer-shaped geometries and associated hydrothermal vent complexes. Volcanological interpretations are constrained by borehole data and outcrop analogues, and the resulting models provide pathways for improved imaging, interpretation, and petroleum systems assessment in volcanic basins worldwide.

KEYWORDS: VOLCANIC BASINS, BASALT INTERPRETATION, SUB-BASALT IMAGING