Analysis of Intrusive and Extrusive Volcanism and Volcanic Related Features: A Case Study from Extensional/Early Volcanic Passive Margins

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Abstract

This study utilizes 3D seismic data to examine Paleocene volcanic features associated with volcanic centers in the northern North Sea. Seismic cross sections through the 3D seismic data and 3D visualization surfaces have been used to fully describe the key volcanic-related features, e.g., basalt flow, hyaloclastite deposits, fissures, hydrothermal vents (pipes, craters), escarpments, igneous dyke/sills and how sills create inflation anticlines, which causes Paleocene palaeotopography. This is used with 2D seismic lines, magnetic and gravity data to make a coherent regional and sub-regional structural interpretation. The volcanic features have been described in two-way time (sec). The following are key findings: the age of sill emplacement is from the early to mid-Paleocene and is similar to published results from Smallwood & Maresh (2002), Trude et al. (2003), and Egbeni et al. (2014). Scanning 3D seismic data for high-level intrusion and extrusive features are good techniques for understanding the interrelationship with the surrounding geology. Paleocene palaeotopography (jack-ups) was influenced by igneous sill emplacement as evident from the area. The semicircular and circular geometries observed overlying this feature, coupled with onlapping stratigraphy, differentiates them from structures formed by other processes. Volcanic intrusions, when they pierce top seal, are observed to be major causes of trap breach in the Paleocene, and this can be used as a de-risking tool in volcanic related basins around the world. Inflation anticlines caused by igneous intrusions, volcanoes, basalt escarpments, individual flow terminations, fissures, vents and hyaloclastite deposits all occur during the Paleocene and are observed to form a key part of the evolutionary history of the basin and as analogues to other similar basins; onlaps onto the created anticlines, and demonstrate an age range for sill jack-up in the Paleocene from the syn-kinematic into the post-kinematic period. The determination of a dominant flow direction of volcanic related materials, in regional sub-aerial flows, from the southwest to south/southeast, was also made possible through the analysis of the obliquity of the volcanoes surface expression. The influence of volcanic activities, if well understood, has positive implications for hydrocarbon exploration in basins with similar tectonic history or volcanically active, e.g., in the Southern Red Sea.