The Role of Igneous Centers in Sedimentary Basins and Their Impact on Energy Resource Plays

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Abstract

The overwhelming majority of global sedimentary basins contain a proportion of volcanic rocks associated with their formation or subsequent tectonic re-organisation. Although their importance has long been known, a combination of modern 3D seismic data, frontier hydrocarbon exploration in volcanic basins and traditional outcrop mapping has initiated a leap in understanding of how these systems impact elements such as (amongst others) source rock deposition, maturation, migration and the deposition and mapping of reservoirs. Here, the aim is to demonstrate the role of discrete igneous centres through a series of global examples. It is argued that understanding the fundamentals of volcanic systems allows for decreased uncertainty in tackling petroleum systems or other associated energy resources.

The term ‘igneous centre’ is an umbrella term to describe discrete areas of intensive volcanic activity which can include both intrusive and extrusive processes. Beneath this is a range of process-based terminology including magma chambers, intrusive central complexes and centres of extrusive volcanism. Hydrocarbon exploration in the Faroe-Shetland and Rockall Basins of the United Kingdom identified early offshore examples of ancient igneous centres through gravity/magnetic work, seismic acquisition and drilling. Most famously, this includes a series of laccoliths with associated igneous intrusions wrongly identified as possible reservoir sections in pre-drill interpretations. Indeed, the likely presence of significant associated four-way dip closures presents a tempting target for hydrocarbon exploration. Here we describe how an understanding of these features can help to define energy resource play extent.

The presence of volcanics and especially large igneous centres is a significant marker in defining temperature with any sedimentary basin, the timing of heat flow spikes and the potential impact on maturation. Offshore Norway it has been possible to define a whole suite of examples, both intrusive and extrusive. An understanding of these centres and their association with rift transforms can be used to build significantly improved petroleum systems models. An example from west Africa is also shown. Mapping of good quality deep 3D seismic data has also enabled the identification of large-scale igneous sill complexes at lower crustal levels within the Faroe- Shetland Basin. Linking these deeper processes with the impact on the sedimentary overburden could provide a significant leap in improving both petroleum systems models and an understanding of palaeo-bathymetry. An example from Norway, the Dalsnuten structure, is shown where potential early lower crustal intrusions and upwelling could explain a well exhibiting very poor reservoir development. Understanding the evolution of igneous systems within a basin can have an impact on our understanding of potential reservoir presence and quality. An example is shown where intrusive to extrusive evolution is demonstrated including the development of carbonates on the eventual sub-aerial cone. A basic understanding of igneous processes can help define reservoir thickness pre-drill and de-risk additional prospectivity.