Impact of Volcanic and Igneous Rocks on Hydrocarbon Exploration

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ABSTRACT

The movement of magma through the shallow crust and its eventual eruption can have a drastic effect on hydrocarbon systems in prospective sedimentary basins. Critically interconnected, low-permeability contact metamorphic zones created surrounding intrusions can act compartmentalise significant volumes of source and reservoir rock. Detailed mapping of intrusive systems has revealed these often consist of complex, interconnected networks of sills that cover large vertical and lateral distances within a sedimentary basin. Furthermore, the propensity for sills in these systems to exploit and intrude along ductile shale horizons raises the possibility of compartmentalisation of reservoirs (and indeed source rocks) by sills and dykes in basins containing high densities of intrusives. The creation of isolated compartments sealed by low-permeability igneous bodies, and/or formation of side or top seals can clearly impact migration pathways and migration efficiency. While surrounding contact metamorphic zones can act in creating low permeability "barriers and baffles", conversely increasing evidence indicates that fractured igneous intrusions can act as migration conduits to hydrocarbons. This raises potential issues with charging of potential reservoirs overlying an extensive sill complex, but can also create opportunities in regard to stratigraphic traps, or charging through impermeable sedimentary sequences within a prospective basin. As hydrocarbon exploration moves towards more complex and often deeper subsurface targets, resolution of what can be resolved on seismic reflection data becomes an issue. An analysis of well data on the Atlantic Margin shows that potentially up to 88% of sills are <40 m in thickness, and thus below the vertical resolution limit of seismic data at depths at which most of sills occur down the margin. This resolution limitation suggests that caution needs to be exercised when interpreting magmatic systems from seismic data alone, as a large amount of intrusive material could potentially be missed. This aspect has implications ranging from incorrect determination of pre-intrusion thicknesses of sedimentary packages and petroleum systems modelling, through to drilling issues, in terms of increased cost and potential interconnection of deeper higher pressure zones via unimaged fractured sills acting as pressure transmission conduits.