Salt Structures and the petroleum potential of the continental margins in Western Iberia, Newfoundland and South Atlantic

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ABSTRACT

As widely known in the geological community, sedimentary basins showing marked salt tectonics comprise main target areas for hydrocarbon exploration. They can form competent structural and stratigraphic traps, at the same time promoting the flow of fluids in regions adjacent to salt diapir flanks. A comprehensive set of (2D) seismic-reflection profiles, tied to borehole data, allowed the mapping of deep-offshore regions of West Iberia where salt structures are evident. Their geometry, age and importance in the tectono-stratigraphic record of offshore basins are compared with their counterparts in Newfoundland and South Atlantic (Espírito Santo Basin, Brazil and Angolan Margin, West Africa).

In essence, developed salt structures not strictly related to Cenozoic inversion are only observed north of 39°15'N on the proximal region of the western Iberian margin. They comprise Late Triassic-early Jurassic evaporites and shales that were not deposited uniformly north of the latter parallel. Onshore, salt pillows predominated in a structural style resembling that of the Jeanne D'Arc Basin, also in a proximal position on the Canadian margin. Direct comparisons with basins in Newfoundland show salt structures to be more developed at the base of the continental slope. Thus, the structural styles observed in deep-offshore basins offshore Iberia are similar to those recorded in deep-offshore basins in the Scotian Shelf and in the Salar Basin, to cite two examples.

This analysis proposes: a) the presence of salt in depth to contribute to form structural traps in deep-offshore basins and, b) renewed salt tectonics being associated with the inversion of older halokinetic structures. As demonstrated for the shallow-offshore region (Lusitanian Basin), Newfoundland Basins and South Atlantic, the petroleum potential of such structures will depend on: a) timing of tectonic inversion, b) relative thickness of overburden sediment above the salt. Considering the existence of a significant tectonic activity in west Iberia during the Late Cenozoic, deep-rooted inversion structures covered by thick overburden units will present the largest potential for hydrocarbon accumulation.

KEYWORDS: Salt tectonics, North Atlantic, South Atlantic, structural traps.

1. Introduction

North Atlantic passive margins are characterised by the presence of Triassic-early Jurassic evaporites at depth, with significant variations in the evaporite layer thickness controlling the structural style of overburden units (Jansa et al., 1979; Alves et al., 2003). In contrast, Aptian salt layers in the South Atlantic effectively divide syn-rift from post-rift units, comprising at the same time an effective detachment layer to gravitationally-unstable continental slope units (Vendeville et al., 1987; Nohriak et al., 2004; Davison, 2005; Mohriak et al., 2008). This work presents an overview of the structural styles of deep-offshore basins of Brazil, West Africa and North Atlantic. The role of deep-rooted evaporite units in the formation of structural traps in the Atlantic is summarised in this presentation. Direct comparisons with deep-offshore basins in west Iberia reveal that salt tectonics is an important factor in controlling the structural evolution of syn- and post-rift units north of 39°15'N.
FIG. 1 – Seismic data sets currently in use in the 3D Seismic Lab highlighting regions of significant salt and shale tectonics.

FIG. 2 – Seismic line from offshore Central Portugal depicting a developed salt structure piercing Mesozoic and Cenozoic units.
2. Salt structures: Fracture patterns and fluid flow on 3D seismic data

The South Atlantic is characterised by extensional tectonics in upper slope regions, changing into diapir and compressional regions towards the base of the continental slope (Brun and Fort, 2004; Mohriak et al., 2004). Pre- and post-salt reservoirs are affected by several fault families that promote fluid flow from syn-rift to post-rift reservoirs. Data from a 3D seismic block from the Espírito Santo Basin, Brazil, is used to illustrate the complex geometry of the different sets of faults that cut the post-salt overburden (Alves et al., 2009). The preservation of pre-salt oil is in great part a function of how effective faults are in promoting fluid migration onto shallow (post-salt) reservoirs. A similar setting is observed in West Africa, with several fault-bounded compressional structures comprising fluid-flow paths from pre-evaporite source units. Post-shortening either formed large structural traps and/or lead to vertical stacking of reservoir units in adjacent synclines.

In West Iberia, a similar setting to the South Atlantic is observed in areas of thick Triassic-early Jurassic evaporites. However, it is proposed that in West Iberia the thickness of pre-salt units is not fully resolved on seismic data, with speculative Triassic (and older?) source units potentially leading to the formation of petroleum plays that are unknown in the proximal margin. Subsequent phases of basin inversion are always more evident in salt-rich areas of the margin, and led to the formation of regional traps (Rasmussen et al., 1998; Uphoff et al., 2002).

3. Conclusions

Main conclusions are:
- Offshore west Iberia, thick strata occur below Triassic-early Jurassic evaporites, thus increasing the petroleum potential of such regions
- In salt-rich parts of west Iberia, the post-salt overburden is apparently deformed similarly as key regions in the South Atlantic. If reservoir units similar to those in the South Atlantic are to exist in West Iberia, there is a strong potential for fault-controlled fluid migration from pre-salt and post-salt source rocks to occur around main salt structures.

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