Overpressure conditions and reservoir compartmentalization on the Scotian Margin

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Overpressure has been identified as a serious risk element in several offshore basins around the world including the Scotian margin; it has been mapped on the Scotian margin at a low resolution but the causes for overpressure have not been resolved. Previous work (Yassir and Bell, 1994; Wade, MacLean and Williams 1995; Wielens 2003; Play Fairway Analysis 2012) indicated overpressure on the Scotian margin was variable and not readily predictable. Negative aspects and unknowns of overpressure are it can occur with similar magnitude at varying depth in wells in the same field, and may not be related to specific formations or burial depths, formation temperature and hydrocarbon maturity. High pressures exceeding the expected hydrostatic pressures are present in some wells but not in others; the regional pressure gradient and distribution outside the wells is unknown. A positive aspect of overpressures is they are recognized as a potential indicator element for active hydrocarbon systems.

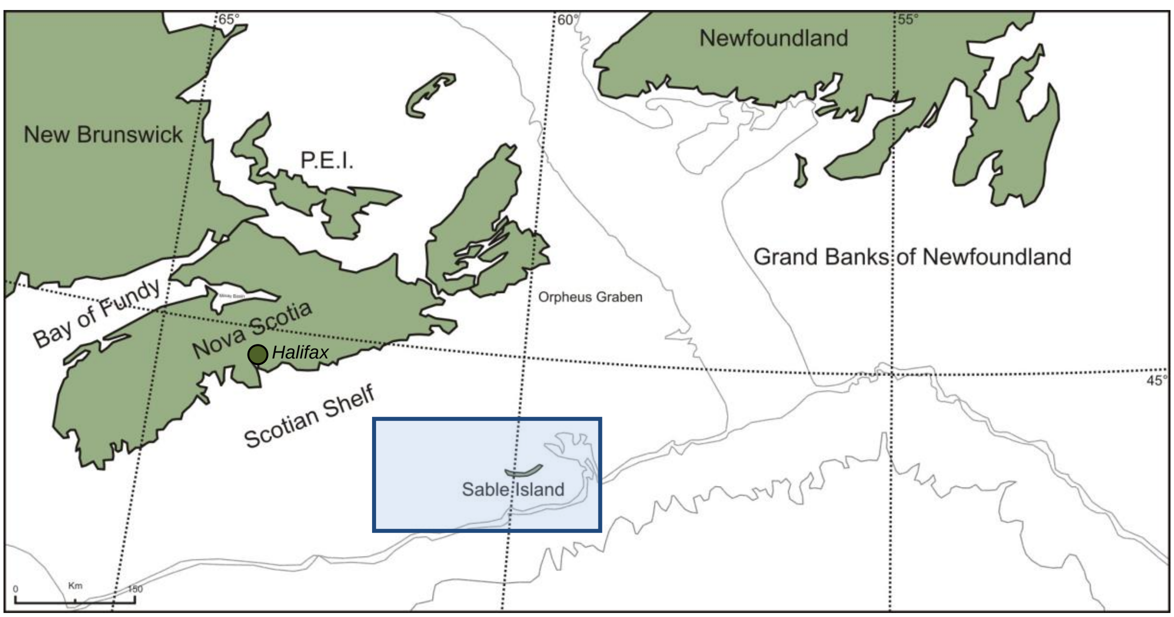

Figure 1: Atlantic Provinces with location of Scotian Shelf and Sable Island marked. Primary study area located approximately 250km southeast of Halifax, as indicated in blue box. (modified from O'Connor, 2012).

In the Venture Field of the Sable Subbasin, overpressured hydrocarbon accumulations within the stacked sandstone reservoirs (Missisauga and MicMac formations) are related to intra-field and reservoir stratigraphic and structural complexities (Wach, 2012), and the timing of regional normal growth fault development (Richards et al. 2008). Previous studies (e.g. Wielens 2003) assumed that the faults are sealing, however recent work by Richards et al. (2008) suggest that these faults may be transmissive. There is evidence of fill-and-spill in the fields of the Sable Subbasin, and there may be similar behavior of the faults in the Scotian margin. The overpressure may have been the trigger for initiation or reactivation of the normal faults, and may be related to salt tectonics on the Scotian margin.

The Mesozoic-Cenozoic sediments of the Scotian margin reach a maximum thickness of 16km (Wade, MacLean, and Williams, 1995). Several intervals have potential as reservoirs (e.g. Eurydice, Missisauga and MicMac formations) with some of these producing and others with hydrocarbon shows (e.g. Iroquois J-17). The petroleum system of the Sable Subbasin as identified by Grant et al. (1984) showed that hydrocarbon accumulations were prone to gas, small volumes, and scattered vertically and laterally (Figure 2). Richards et al. (2008), in their Reservoir Connectivity Analysis (RCA), identified that reservoirs in the Scotian margin are often connected, and where reservoirs are thick and well developed there tends to be an absence of sufficient seals. The study investigated hydrocarbon distribution, resource potential, and production performance of the Sable Subbasin and included structural geometrical controls on the fluid distribution and pressures in the region. They suggested overpressure on the Scotian margin may be associated with particular trap styles. Wielens (2003) suggested possible causes for the overpressure on the Scotian margin including (1) a closed system for the hydrocarbon generation and migration, (2) rapid burial or (3) shale diagenesis. The Webster et al. (2011) study on the Taranaki Basin (New Zealand) demonstrated that multiple pressure regimes may be present in overpressured basins.

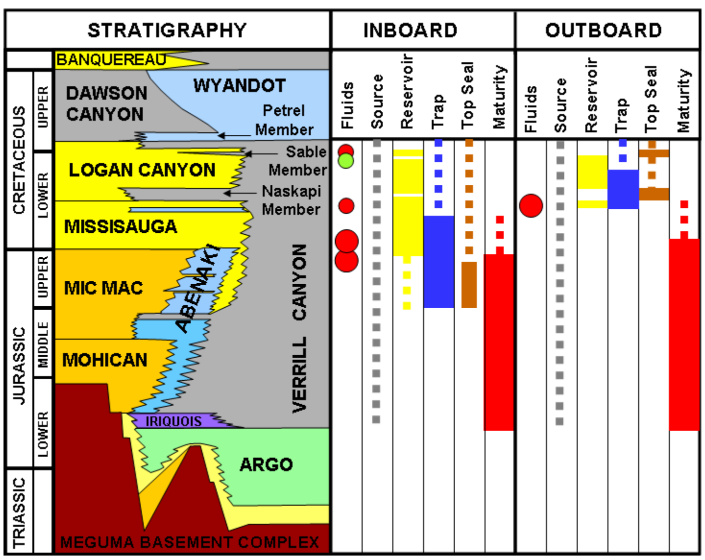

Figure 2: Stratigraphic chart and play elements for the Scotian Margin (Richards, et al. 2008).

The overpressure conditions and reservoir compartmentalization on the Scotian margin will be studied in four phases. Phase (1) will focus on a petrophysical analysis and data compilation: log data from identified overpressure conditions will be analyzed, overpressured zones will be tied to seismic horizons, and screening methodologies and criteria used in other basins will be tested to determine if elements can be applied to the Scotian margin. Phase (2) will focus on a seal and porosity analysis: clay mineralogy and thin section analysis will be completed to define characteristics of the seals and lithological properties. Results will be compared with lithofacies away from the faults and potential fault conduits to determine whether the faults in the region are leaking. Phase (3) will focus on overpressure mapping: 3D seismic interpretation and mapping of identified overpressure zones will be integrated with petrophysical and reservoir quality analysis. Seismic data will be analyzed to better document faults and determine if there is a change reflected in amplitude response (internal velocities) at the top of overpressured zones (Madatov, 2005a). Finally Phase (4) will be developing a risk methodology for the Scotian margin from the data and analysis in the previous three phases.

It is important to determine the causes of the overpressure systems on the Scotian margin as there has been a dramatic increase in the exploration for hydrocarbons offshore Nova Scotia. New data and analysis of the regional distribution and pressure gradient of the Scotian margin, and the risk methodology developed from the results of this project will be directly relevant to this upswing in the Nova Scotia petroleum industry. The petroleum systems present in the Scotian margin are different than those of the Gulf Coast, including the reservoir elements, lithologies, sediment or overburden thickness, and depositional history. This means the development of an innovative risk methodology that applies to the Scotian margin is required.

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