Overpressure, Seal Integrity, and Reservoir Connectivity in the Scotian Basin

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Summary

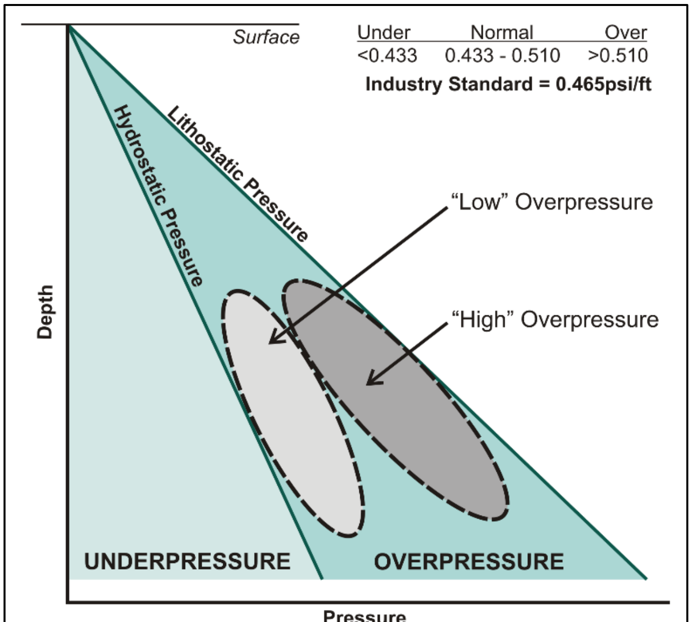

Figure 1: Generalized hydrostatic and lithostatic pressure gradient curves defining underpressure and overpressure. "Low" overpressure is significant for determining reserves and areas with previously unrecognized potential. "High" overpressure controls exploration risk for breached traps, and determines connectedness of reservoirs.

Overpressure is abnormally high subsurface pressure that exceeds hydrostatic pressure at a given depth, and occurs when connate fluids are unable to escape the surrounding mineral matrix (Figure 1). Causes for overpressure include the compaction effect (undercompaction), formation foreshortening, faulting, massive evaporite deposition, mineral phase change, repressuring, and hydrocarbon generation. Often obstructed fluid migration pathways are also a factor, and more than one of the above reasons contributes to the formation of overpressure in a system.

To maintain overpressure within a reservoir, compartmentalization is required, where a petroleum accumulation is separated into several discrete fluid/pressure compartments, which occurs when hydrocarbon migration is prevented across sealed boundaries within the reservoir. The boundaries can be divided into two groups: static seals that completely seal and are able to trap hydrocarbons for a geologic time-frame, and dynamic seals that are low permeability baffles to flow that decrease rate of flow to essentially zero at the production scale but will allow for eventual equalization over a geologic scale.

Overpressured sediments tend to exhibit better porosity than would be normally be predicted from their depth, therefore make attractive prospects for hydrocarbon reservoirs. Difficulty

managing abnormal pressures during drilling is frequently cited for abandoning wells or for unexpected, expensive changes in the casing program. The causes of overpressure in the Scotian Basin are poorly understood, and with the recent increase in exploration for hydrocarbons offshore Nova Scotia, understanding the development of overpressure is important for maximizing safety, production, and developing new opportunities.

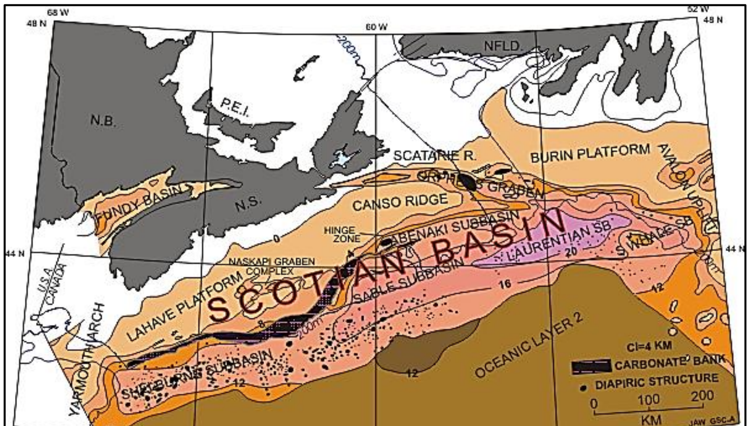

Figure 2: Major tectonic features of the Scotian Basin including platforms, ridges, and sub-basins (NRC, 2010).

The Scotian Basin comprises Mesozoic and Cenozoic sediments overlying a Paleozoic basement, creating a structurally-complex basin containing carbonate banks, platforms, and ridges within a set of differentiated sub-basins (Figure 2). There has been over 250 Ma of continuous sedimentation to the basin, predominantly sourced from the Appalachian Orogen then transported by the paleo-St. Lawrence River. The Mesozoic-Cenozoic infill of the basin reaches a maximum thickness of 16km (Wade, MacLean, and Williams, 1995). Several intervals have potential as reservoirs (e.g. Eurydice, Missisauga and MicMac formations) with several of these in production.

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 both vertically and laterally. Richards et al. (2008), identified that reservoirs in the Scotian Basin are often connected, and where reservoirs are thick and well developed there tends to be an absence of sufficient seals. This 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 Basin may be associated with particular trap styles.

The reservoir connectivity analysis is important to understanding the overpressure systems of the Scotian Basin, and includes: reservoir architecture, definition of seal integrity, and determination of connectedness for compartments. The use of analogous basins with similar formation and depositional histories is also essential, as data available from the Scotian Basin is limited; other systems on the Atlantic conjugate margin include Jeanne d'Arc Basin, Porcupine Basin, Northern North Sea Basin, and the Eastern Venezuela Basin. Overpressure is a risk element in all of these basins including the Scotian Basin, and needs to be understood to safely develop and produce offshore resources.

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