Contrasting salt tectonic styles on the western versus central parts of the Scotian Margin, offshore Nova Scotia - Part 1

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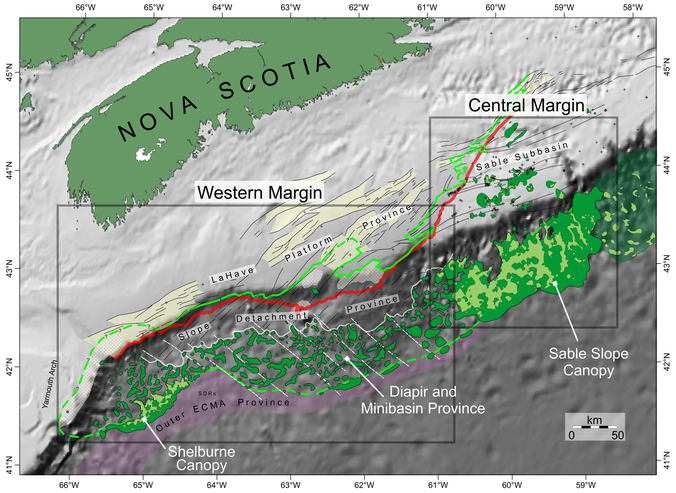
Overview:

A major Late Triassic to Early Jurassic(?) synrift salt basin comprised of the "Argo Formation" underpins much of the Scotian Margin, and formed as Nova Scotia rifted and ultimately broke apart from its Moroccan conjugate. Like other salt basins, the distribution, style and timing of salt-related structures varies widely. Using available 2D/3D seismic data-sets, we contrast two considerably different salt tectonic styles that dominated the western versus central parts of the margin, and provide a higher order structural subdivision of each.

On the **western** parts of the margin, only a small portion of the primary salt basin is found under the present day continental shelf, where minor amounts of postrift subsidence took place. Most of the salt basin is now located in deepwater after subsiding up to 8 km after continental break-up. Increased subsidence seaward of the margin hinge zone tilted the landward parts of the salt basin, generating an important region of gravity gliding and raft tectonics above the autochthonous salt layer. Though it is possible that some seaward inflation of the primary salt basin took place immediately following break-up, vertical diapirism and sediment downbuilding dominated and our preferred interpretation is that increased rift subsidence allowed more salt to accumulate in the seaward parts of the salt basin prior to continental break-up. Proximal to distal variations in salt tectonic style in the west are believed to be controlled by variations in the amount, rate, and symmetry of postrift basement subsidence, but preconditioned by the synrift basement fabric (including transfer zones) and development of rift-related accommodation that controlled the original thickness and distribution of salt.



In contrast to the western parts of the margin, much of the primary salt basin on the **central** parts of the margin occupied a more landward position below the present day shelf. Increased Jurassic and Cretaceous sedimentation here more efficiently expelled salt up to 60 km seaward of its source layer, placing amalgamated salt tongues and canopies, or their equivalent welds, in deepwater settings (see also Shimeld, 2004). Two seaward salt expulsion styles dominate the canopy complex: expulsion rollovers and allochthonous salt based detachments (e.g. roho systems). The relative importance of each can be linked to the density of seaward leaning salt feeders extending from the autochthonous salt layer. In contrast to the west, loading associated with increased deltaic sedimentation was a more important process in the central part of the margin.

- Allochthonous salt bodies
- Canopy: Salt thickness > 500 ms; Salt thickness < 500 ms
- Approximate boundary of the autochthonous salt basin
- Postrift "Hinge Zone" (coinciding with edge of Jurassic carbonate bank in the west)
- Basement faults and grabens from Wade & MacLean (1990)
- Interpreted transfer zone
- Synrift fabric/basement lineaments
- Platform areas showing thin-skinned detach-ment above primary salt basin

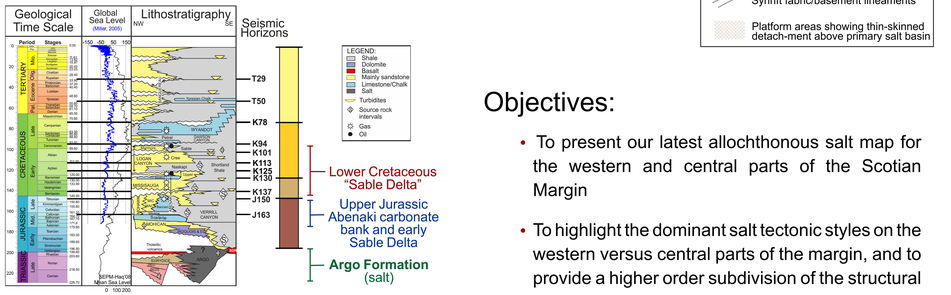
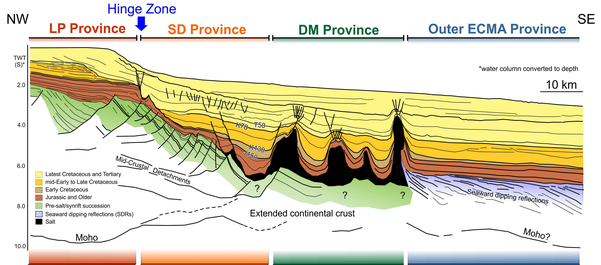


Figure 2 - Litho-chronostratigraphic chart for the Scotian Margin, modified from OETR Association (2011). Stratigraphy adapted from Wade and MacLean (1990) and Tankard and Welsink (1989).

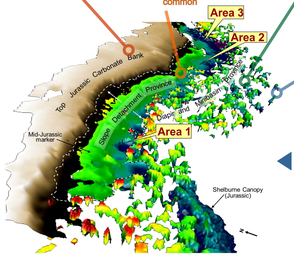
Objectives:

- To present our latest allochthonous salt map for the western and central parts of the Scotian Margin
- To highlight the dominant salt tectonic styles on the western versus central parts of the margin, and to provide a higher order subdivision of the structural styles in each region

Western Scotian Margin



LP Province	SD Province	DM Province	Outer ECMA Province
• Stable postrift platform • Slow subsidence of pre-existing northeast oriented synrift basement elements (horsts, grabens, half-grabens) • Underlain in part by northern parts of the autochthonous salt basin	• Abrupt increase in postrift subsidence seaward of prominent hinge zone • Seaward tilting generated a steep bypass slope • Widespread detachment of Jurassic cover strata above a variably thick autochthonous salt layer (raft tectonics) • Distinct absence of allochthonous salt bodies, but firmly rooted autochthonous "pillows" common	• More uniform subsidence of primary salt basin, dominated by passive loading within minibasins • Bracketed by salt canopies to the west and east • Likely the region of greatest synrift subsidence and thickest autochthonous salt (though some salt may also have "flowed" from the SD Province) • Vertical allochthonous salt bodies (diapirs, walls) dominate	• Region of seaward dipping reflections emplaced during Early Jurassic break-up • Period of subaerial volcanics split and loaded the original salt basin between Nova Scotia and Morocco • Seaward leaning salt tongues extruded above SDRs • Passes seaward into true oceanic crust • Northern extent unknown

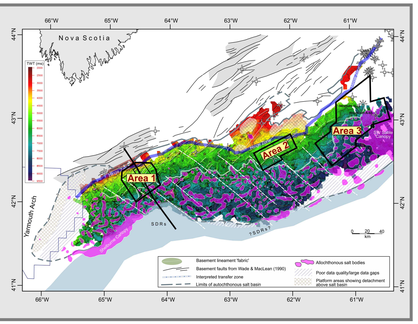


Perspective view from the southwest showing the relationship between the LP (top Jurassic carbonate bank shown), SD (mid Jurassic marker shown), and DM provinces (top allochthonous salt marker shown).

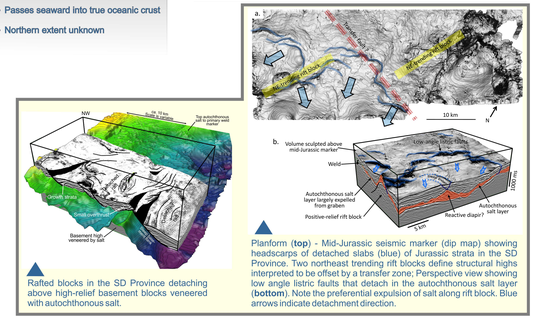
The western margin can be subdivided into four postrift structural provinces:

- LaHave Platform (LP) Province
- Slope Detachment (SD) Province
- Diapir and Minibasin (DM) Province
- Outer East Coast Magnetic Anomaly (ECMA) Province

Each is affected to some degree by salt tectonics. The postrift structural style in each province is believed to reflect the nature of vertical tectonics (degree and symmetry of subsidence) during seafloor spreading, preconditioned by the margin configuration just prior to break-up. The amount and distribution of synrift salt, in particular, played an important role determining the types of postrift structures that formed.



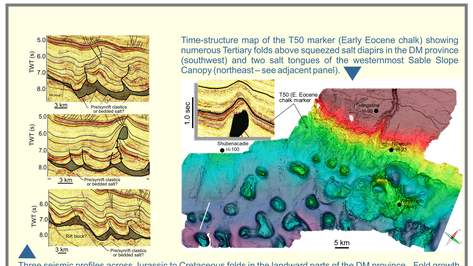
Area 2 - Detached cover strata



Rafted blocks in the SD Province detaching above high-relief basement blocks veneered with autochthonous salt.

Planform (**top**) - Mid-Jurassic seismic marker (dip map) showing headscarps of detached slabs (blue) of Jurassic strata in the SD Province. Two northeast trending rift blocks define structural highs interpreted to be offset by a transfer zone; Perspective view showing low angle listric faults that detach in the autochthonous salt layer (**bottom**). Note the preferential expulsion of salt along rift block. Blue arrows indicate detachment direction.

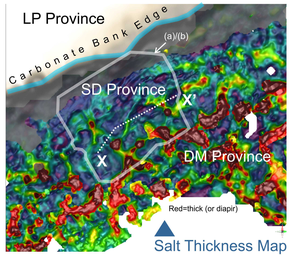
Area 3 - Eastward transition to Sable Canopy



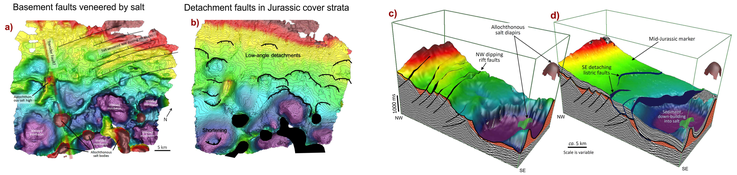
Time-structure map of the T50 marker (Early Eocene chalk) showing numerous Tertiary folds above squeezed salt diapirs in the DM province (southwest) and two salt tongues of the westernmost Sable Slope Canopy (northeast – see adjacent panel).

Three seismic profiles across Jurassic to Cretaceous folds in the landward parts of the DM province. Fold growth was in response to up-slope gravity gliding above the autochthonous salt layer (normal to the hinge zone, above the steeply dipping SD Province). Proximity to the "Sable Island Delta" also complicates fold development in this area, where up-slope gravity spreading causes down-slope shortening and fold growth, and this is superimposed on the gravity gliding system.

Area 1 - Gravity gliding (thin-skinned): Up-slope extension to down-slope shortening (detachment above autochthonous salt layer)

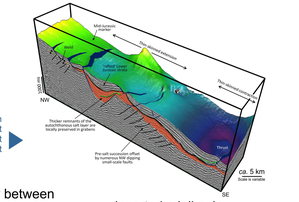


Salt Thickness Map

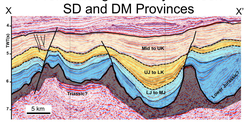
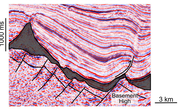


(a) Top autochthonous salt to primary weld marker, showing northeast trending synrift 'fabric' produced by underlying rift blocks where the salt layer is thin; **(b)** Middle Jurassic marker (J163) offset along numerous low-angle listric faults that detach above the autochthonous salt layer (SD Province). These pass down-slope into minibasins rimmed by prominent salt bodies. **(c)** Perspective view sculpted along the top autochthonous salt to primary weld marker, showing the synrift fabric below a thin veneer of autochthonous salt. The landward-dipping (northwest) extensional basement faults are well imaged; **(d)** Perspective view showing a series of seaward dipping listric faults within Jurassic cover strata that sole out into the thin autochthonous salt layer. Fault vergence is in the opposite direction of the northwest-dipping synrift faults. Taller salt bodies were expelled from a chain of minibasins along the base of the image, where the thickness of the primary salt layer is interpreted to have abruptly increased. Offsets in these minibasin are interpreted to be caused by synrift tranfer zones that controlled the original depositional thickness of salt. Shallow areas are red, deep areas are purple.

Thin-skinned detachment and extension above a variably thick autochthonous salt layer, causing down-slope contraction that produces a thrust. Basement below the salt is heavily faulted and rugose.



Profile along boundary between SD and DM Provinces



Inverted minibasin