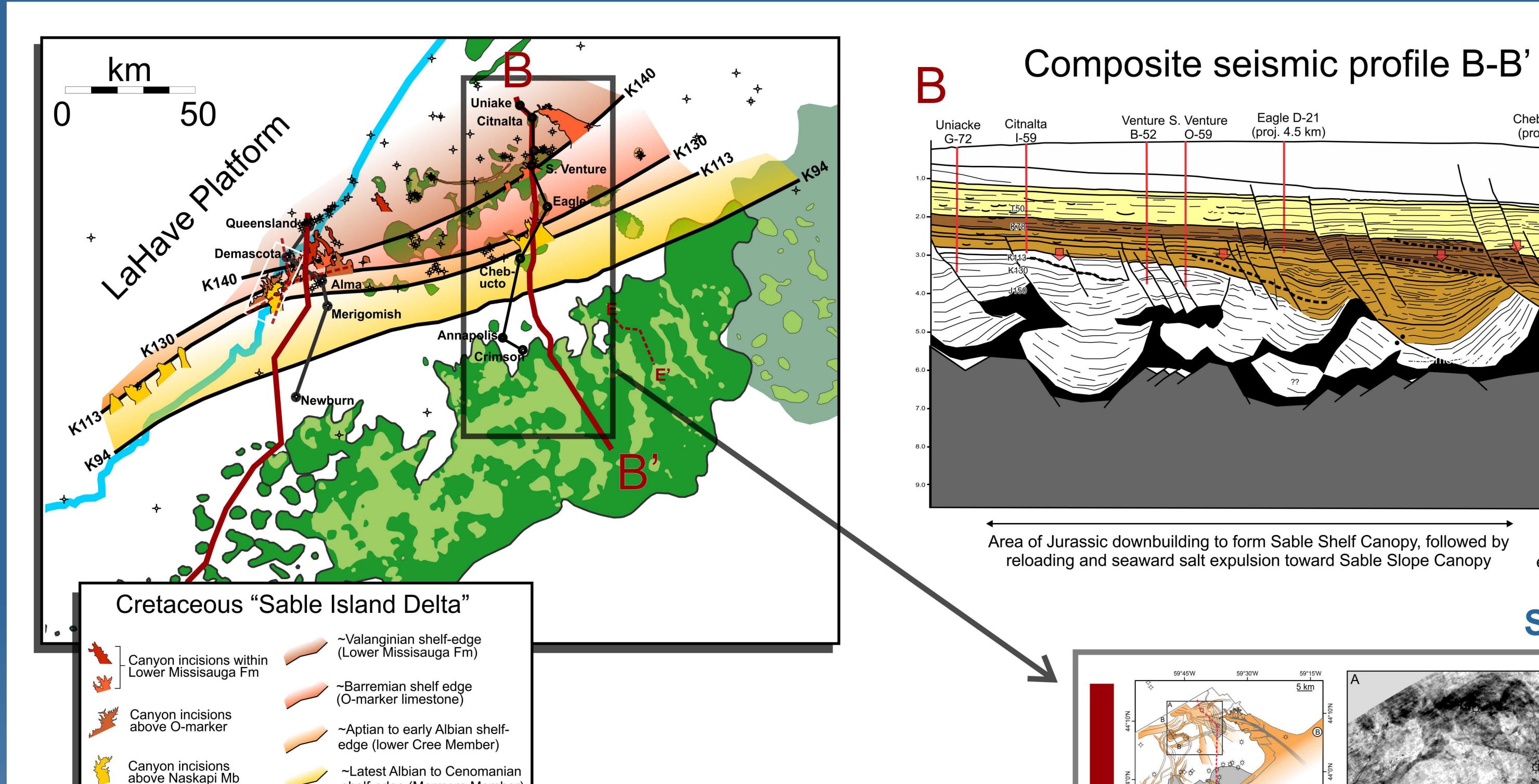
# Lower Cretaceous Shelf-edge Trajectories, Shelf-indenting Canyons and the Potential Transfer of Coarser Clastics into Deeper Water, Sable Subbasin, Offshore Nova Scotia - Part 2

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## Central Sable Subbasin



shelf-edge (Marmora Member

42 m net sand in Lower Cretaceous succession

20 m net sand in Lower Cretaceous succession

"M sand" - two turbidite sands totalling 18.2 m thick

Annapolis G-24:

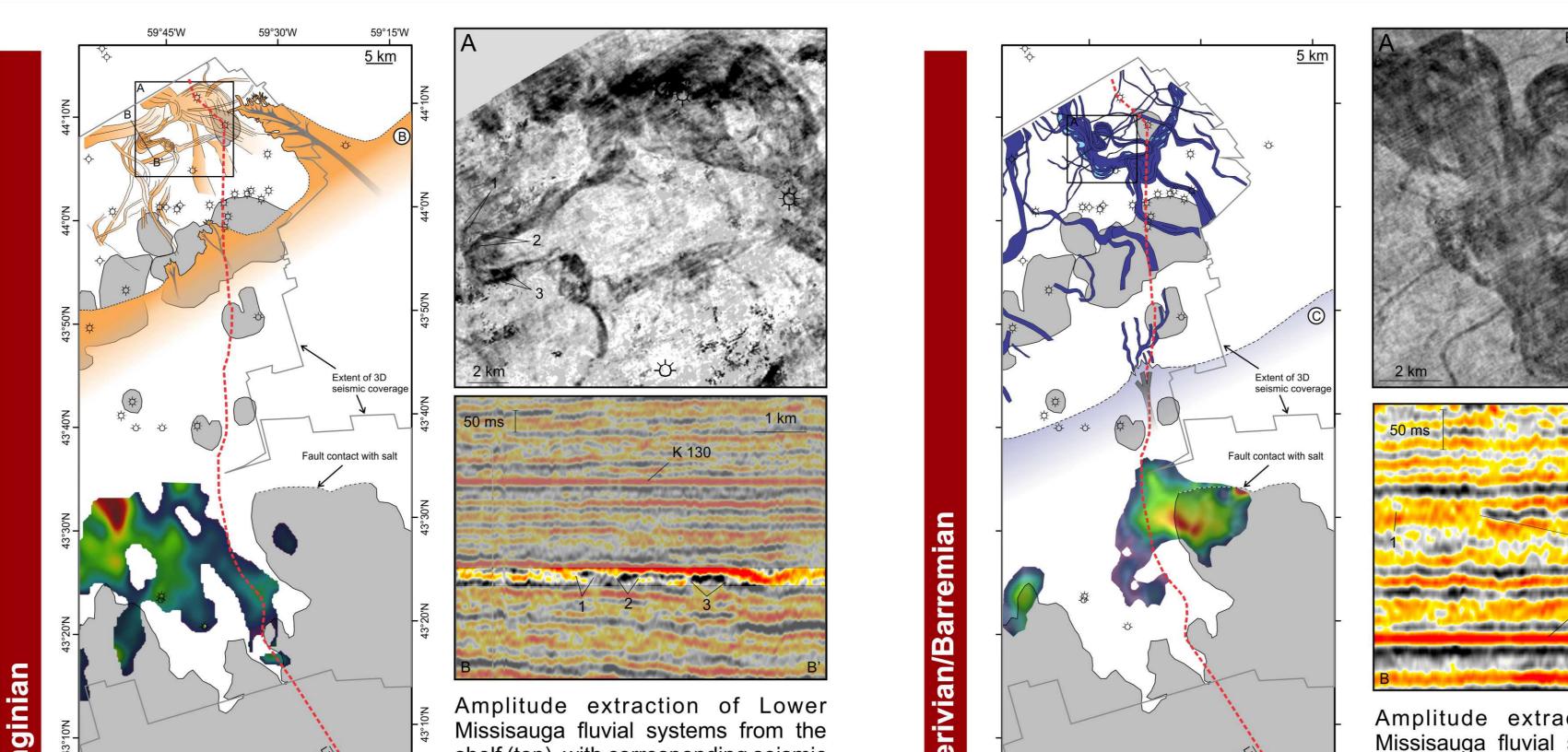
Crimson F-81:

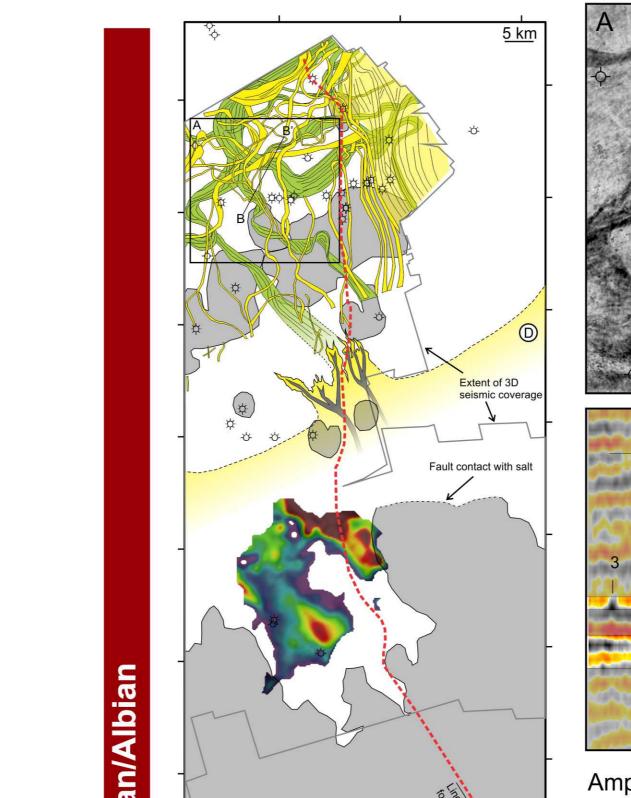
- Lower Cretaceous shelf edge trajectories very difficult to map, but are defined here via canyon incisions and termination of fluvial channels (from 3D seismic)
  - Profile selected to cross shelf-edge canyons, commonly the only indicator of shelf-edge inflections in a heavily growth faulted succession
  - Canyons incised into sandy topsets
  - Ponded canopy seaward of delta system

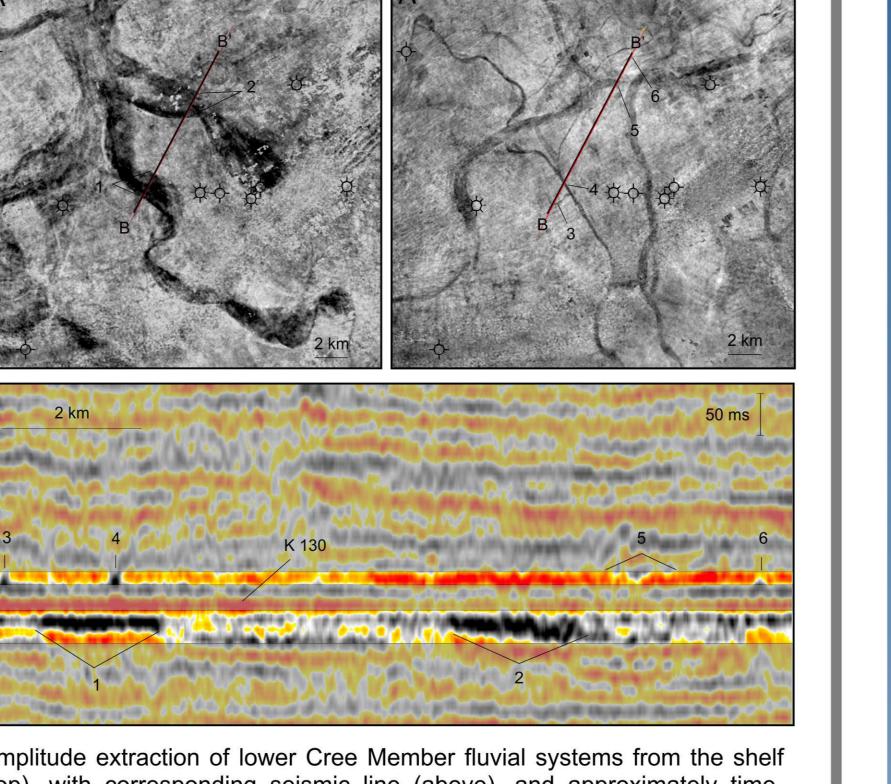
Offlap break

Area of allochthonous salt nappe and canopy loading resulting in salt expulsion minibasins and turtle structures

#### Shelf: Seaward-advancing fluvial distributary channels



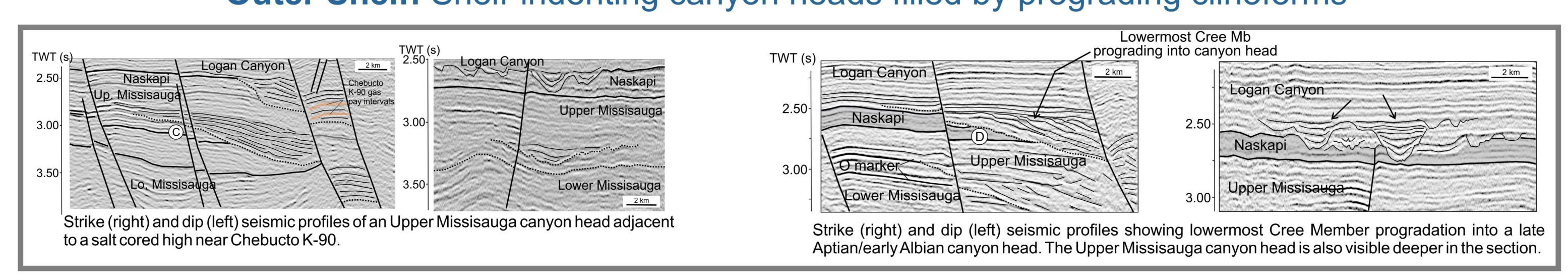




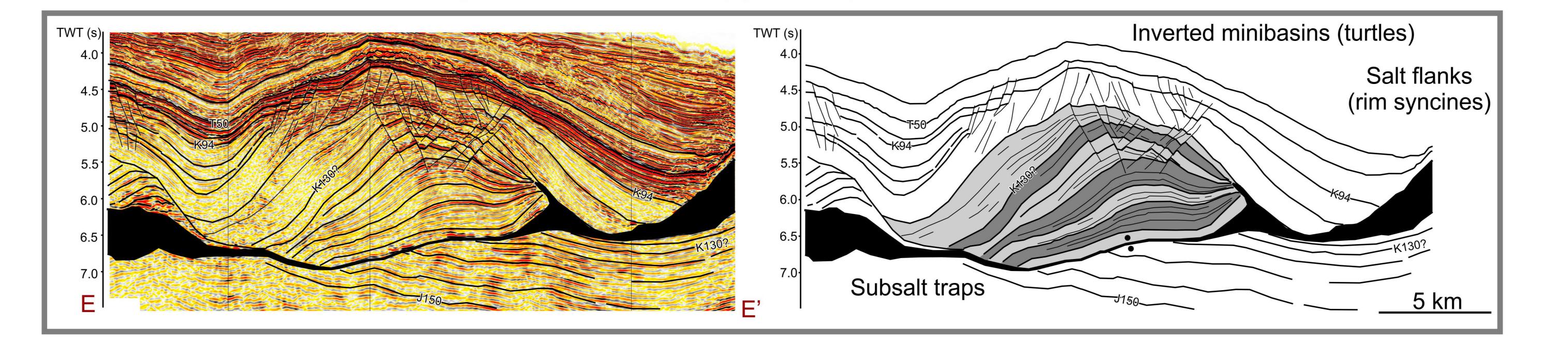
#### Outer Shelf: Shelf-indenting canyon heads filled by prograding clinoforms

shelf (top), with corresponding seismic

line (above), and approximately time-



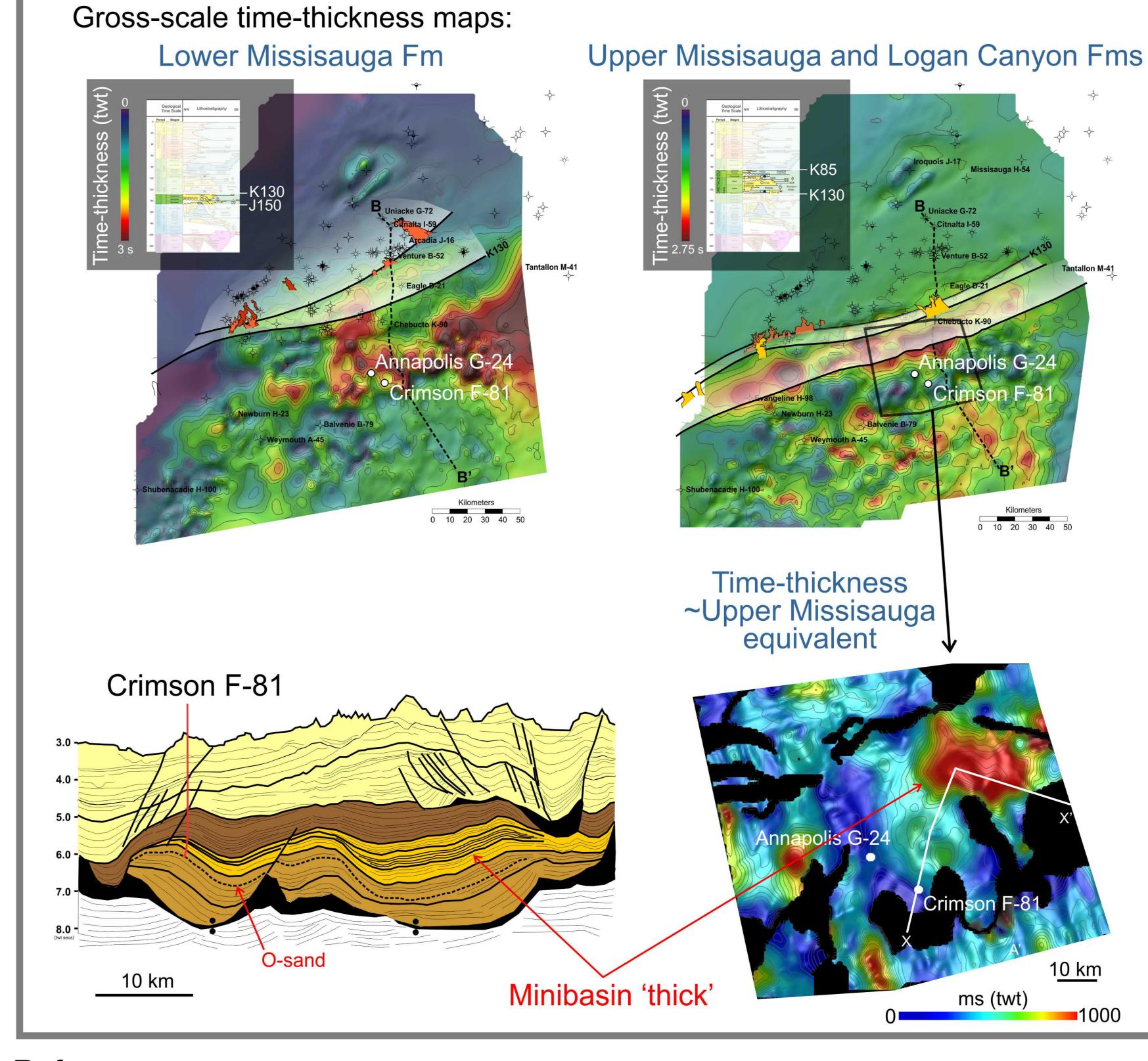
#### Slope: Turbidites trapped in ponded minibasins



### Breaching the shelf edge - linking shelf and deepwater depositional systems:

Evidence from cores for the transfer of Lower Cretaceous sediment into deepwater was presented by Piper et al. (2004, 2010) who documented large slide blocks, debris flow deposits, slumps, and turbidite sandstone beds in Lower Cretaceous strata from Alma K-85, Alma F-67, Merigomish C-52 (from the Upper Missisauga Fm and Cree Mb of the Logan Canyon Fm), and Tantallon M-41 (from Lower and Upper Missisauga Fm and Logan Canyon Fm). Similarly, pebble conglomerates in sidewall cores from Newburn H-23 provide strong evidence for coarse grained channel lags (with cm-sized clasts) within Aptian slope strata and fine-grained turbidites (similar to levee deposits described by Piper and Deptuck, 1997) in numerous other sidewall cores from Lower and Upper Missisauga equivalent slope strata (Deptuck, 2008).

n addition to the evidence from cores, there is strong evidence on seismic profiles for multiple periods of canyon incision during the seaward advance of Missisauga and Logan Canyon Fms. Most canyon incisions are defined by subtle surfaces of truncation mo easily recognized where dendritic canyon heads extend back onto the outer shelf and truncate higher amplitude, more continuous seismic reflections of sand-prone delta topsets (and the oolitic O-marker). Because canyon heads commonly extend back onto the sandprone delta platform, it is unlikely that only muddy turbidity flows were initiated and transported into deepwater during the Early Cretaceous. Similarly, canyon heads are commonly filled by prograding topsets and clinoforms of Upper Missisauga and Logan Canyon shelf-edge deltas that advanced toward the south, implying a direct link to welldeveloped fluvial systems on the shelf. Prominent depositional thicks located seaward the advancing shelf-edge provide additional evidence for the seaward transport of fluvialdeltaic clastics into deeper water settings.



Cummings D.I. and Arnott, R.W.C. 2005. Growth-faulted shelf-margin deltas: A new (but old) play type offshore Nova Scotia, Canada. Bulletin of Canadian Petroleum Geology, v. 53, p. 211–236 Deptuck, M.E., 2008. Subregional Geology, Canada-Nova Scotia Offshore Petroleum Board NS08-2 Call-for-bids Package, available at www.cnsopb.ns.ca OETR (Offshore Energy Technical Research Associateion) 2011. Play Fairway Analysis Atlas – Offshore Nova Scotia. Nova Scotia Department of Energy Report 88-11-0004-01, 349 p. (also available online at: http://www.novascotiaoffshore.com/analysis - accessed October, 2011) Piper, D.J.W., and Deptuck, M.E., 1997. Fine grained turbidites on Amazon Fan: facies characerization and interpretation, in Flood et al., Proceedings of the Ocean Drilling Program, Scientific Results, 155, 79-108.

Piper, D.J.W., Pe-Piper, G., and Ingram, S.I., 2004. Early Cretaceous sediment failure in the southwestern Sable Subbasin, offshore Nova Scotia, AAPG Bulletin, 88, 991-1006 Piper, D.J.W., Noftall, R., and Pe-Piper, G., 2010. Allochthonous prodeltaic sediment facies in the Lower Cretaceous at the Tantallon M-41 well: implication for the deep-water Scotian Basin, AAPG Bulletin, 94, 87-104.

Wade, J.A. and MacLean, B.C., 1990. The geology of the Southeastern Margin of Canada, Chapter 5, In M.J. Keen and G.L. Williams (Eds), Geology of the Continental Margin of Eastern Canada, Geological Survey of Canada, The Geology of Canada, p. 224-225

Welsink., H.J., Dwyer, J.D. and Knight, R.J., 1989. Tectono-stratigraphy of the passive margin off Nova Scotia, Chapter 14, In A.J. Tankard and H.R. Balkwill, (Eds) Extensional Tectonics and Stratigraphy of the North Atlantic Margins, AAPG Memoir 46, p. 215-231.

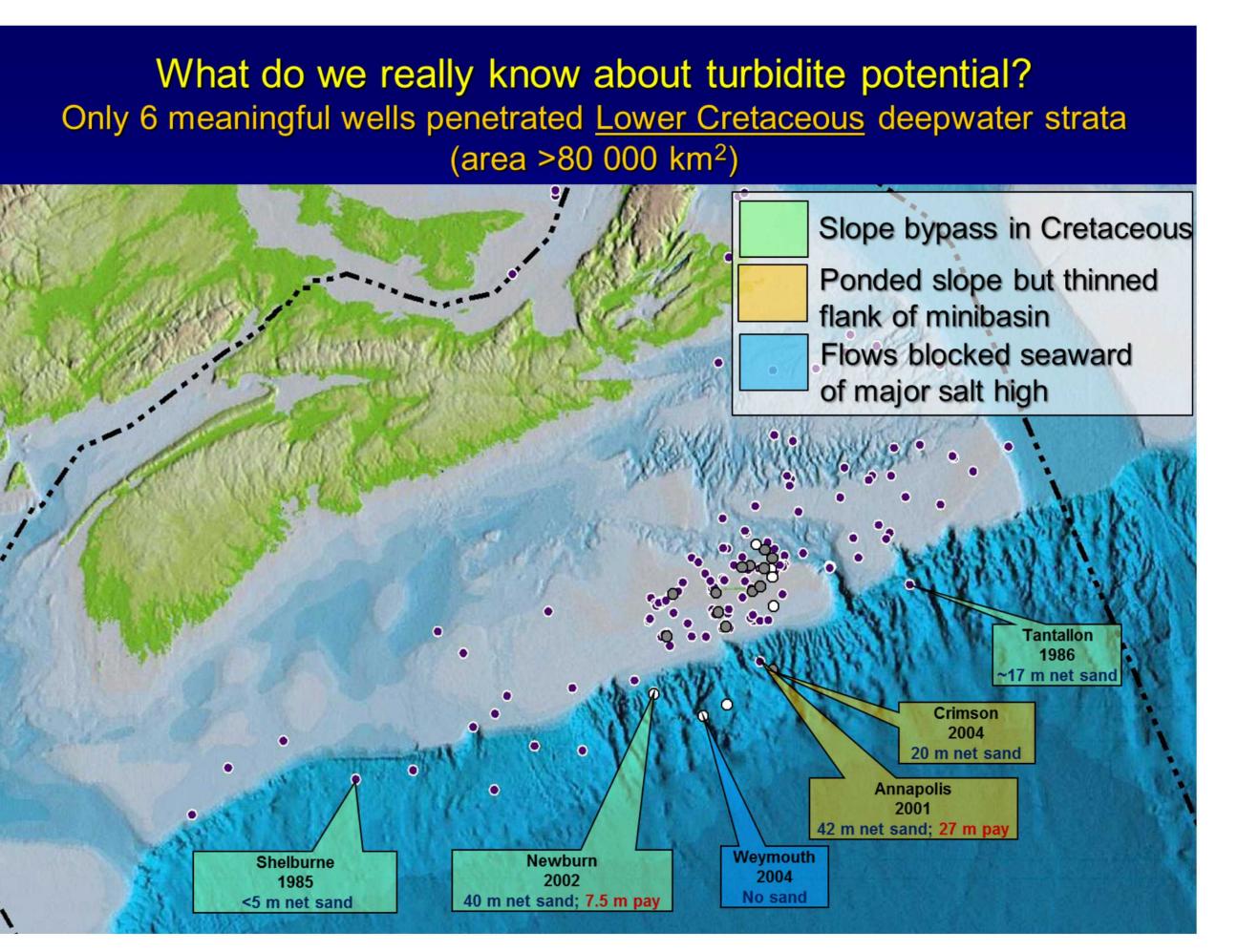
the six deepwater Cretaceou penetrations on the Scotiar

### Conclusions:

We conclude that there is strong evidence to support the transfer of coarse clastics from sand-prone deltas of the Missisauga and Logan Canyon fms into Berriasian to Albian slope and basinal settings. The morphology of the slope seaward of these deltas is likely the most important control on the partitioning of clastics in slope or toe-of-slope settings.

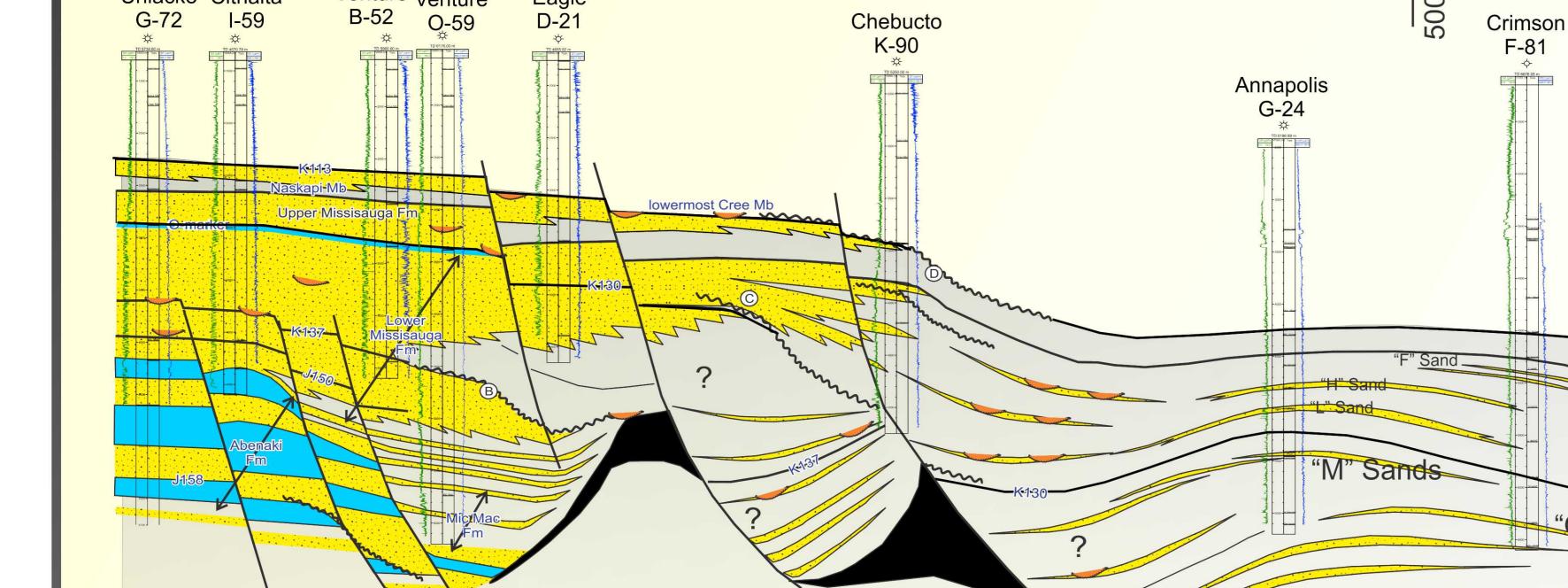
Newburn H-23 appears to be located in an upper to middle slope setting dominated by bypassing Early to mid-Cretaceous sediment gravity flows. Thickness maps show the development of minibasins seaward of the well location, and the pebble conglomerates and multiple intervals with interpreted levee turbidites in Newburn H-23 (left side of first panel) likely indicate that vigorous sediment gravity flows periodically bypassed the well site, transporting coarse-grained material into lower slope and basin floor settings. Tantallon M-41 and Shelburne G-29 are found in similar slope bypass settings (relative to the Cretaceous slope; summary map below).

In contrast, Annapolis G-24 and Crimson F-81 penetrated what we envision as a lower gradient ponded slope above the Sable Slope Canopy. Thickness maps show that both wells were drilled on stratigraphic thins of Upper Missisauga slope minibasins (i.e. wells located on minibasin flanks), where equivalent strata are significantly thicker directly seaward of shelf-edge canyons just a few km to the east (left). Both wells appear to TD within the upper parts of inverted Lower Missisauga-equivalent thicks, but only tested the upper parts of this interval. Most of the sand in both wells was indeed found in the upper parts of the inverted thick, but much of the section has not been tested. Identification of canyons up-slope from these isochron thicks provides a link to the sand-prone Mississauga and Logan Canyon fms on the shelf and supports the idea that significant quantities of reservoir grade clastics were transported into deepwater. Drilling efforts to date have not yet adequately tested the thickest stratigraphic intervals, and it therefore appears to be premature to conclude that deepwater strata seaward of the Sable Island Delta are "sand lean".



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• 3 gas-bearing turbidite sand intervals (27 m total pay, 12-25% porosity)

"O-sand" - 13 m thick fine-grained turbidites with average porosity of 13%

of the Lower Missisauga-equivalent succession

