

Proximal to distal postrift structural provinces of the western Scotian Margin, offshore Eastern Canada: Geological context and parcel prospectivity for Call for Bids NS11-1

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Introduction and scope

This report is a product of an ongoing long-term CNSOPB initiative aimed at improving the general understanding of the structural and stratigraphic evolution of the Scotian Margin using available 2D and 3D reflection seismic data-sets tied to wells. The report is intended to provide the reader with a higher fidelity view of the western half of the margin than is available in the *Regional Geology* section on the CNSOPB Call for Bids packages. Improved seismic imaging, afforded by the comparatively smaller size of salt bodies, the general absence of salt overhangs over wide areas, limited seafloor canyon incisions, and the generally thinner postrift stratigraphic interval, makes the western Scotian Margin a more attractive area to study deep-seated structural elements than areas to the east. These structural elements record the synrift to postrift evolution of the margin. The reader is also directed to Wade and MacLean (1990) and the references therein for an excellent account of the broad scale stratigraphic and structural evolution of the Scotian Margin and to the OETR Association (2011) Play Fairway Study that provides a more granular view of the margins evolution and key hydrocarbon elements.

First-order structural subdivision

The western Scotian Margin includes areas of the modern shelf, slope, and basin floor located west of the Sable Subbasin, and is underlain in part by a Late Triassic to Early Jurassic primary salt basin that formed as Nova Scotia rifted and ultimately broke apart from its Moroccan conjugate (Figure 1a). The western Scotian Margin can be subdivided into four proximal to distal postrift structural provinces, from landward to seaward referred to as the LaHave Platform (LP), Slope Detachment (SD), Diapir and Minibasin (DM), and Outer East Coast Magnetic Anomaly (ECMA) provinces. All four structural provinces were influenced to varying degrees by salt tectonics (Figure 2). The distinctive, common structural style observed in each province reflects a combination of the nature of vertical tectonics during seafloor spreading (for example, the amount and

symmetry of postrift subsidence), preconditioned by the margin configuration just prior to continental break-up. In particular, the amount and distribution of synrift salt is believed to have played an important role in determining the extent and style of postrift deformation as different parts of the margin subsided in different ways.

This four-way proximal to distal structural subdivision provides useful geological context for the eight parcels in the NS11-1 Call for Bids (a mix of four industry nominated parcels and four non-industry nominated parcels), and provides a first-order assessment of the structural setting of each (Figure 1b). Parcel 1 straddles the SD, DM and Outer ECMA provinces while Parcels 2 and 5 straddle the DM and Outer ECMA provinces. Parcels 3 and 4 lie almost exclusively above the DM province,

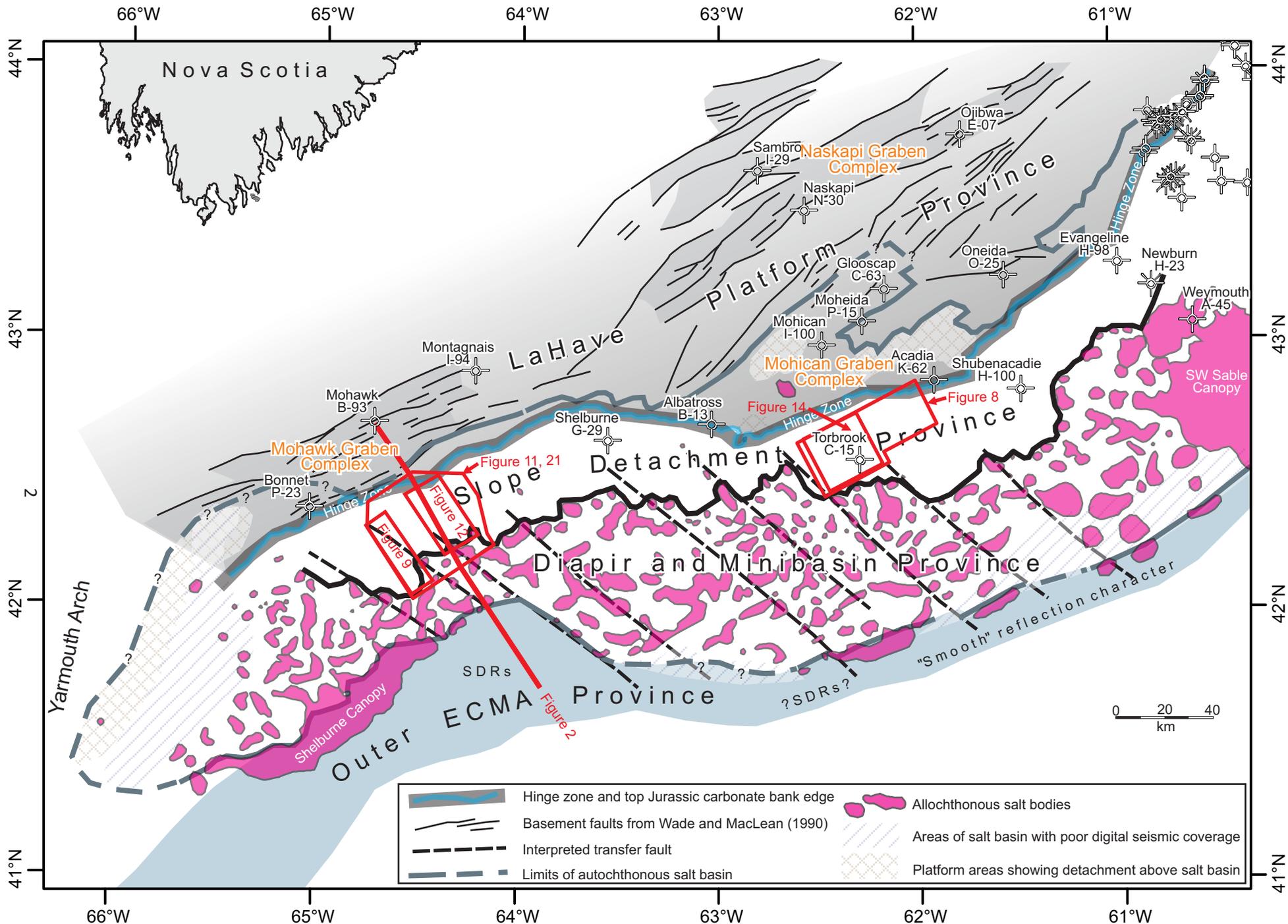


Figure 1a - Map showing key structural elements and four-way post-rift structural subdivision of the western Scotian Margin. Fault traces on the LaHave Platform are from Wade and MacLean (1990). Note that parts of the autochthonous salt basin underlie the LaHave Platform, Slope Detachment, and Diapir and Minibasin provinces. Some parts of the autochthonous salt basin have poor data coverage and hence its margins in these locations are poorly constrained. See text for details.

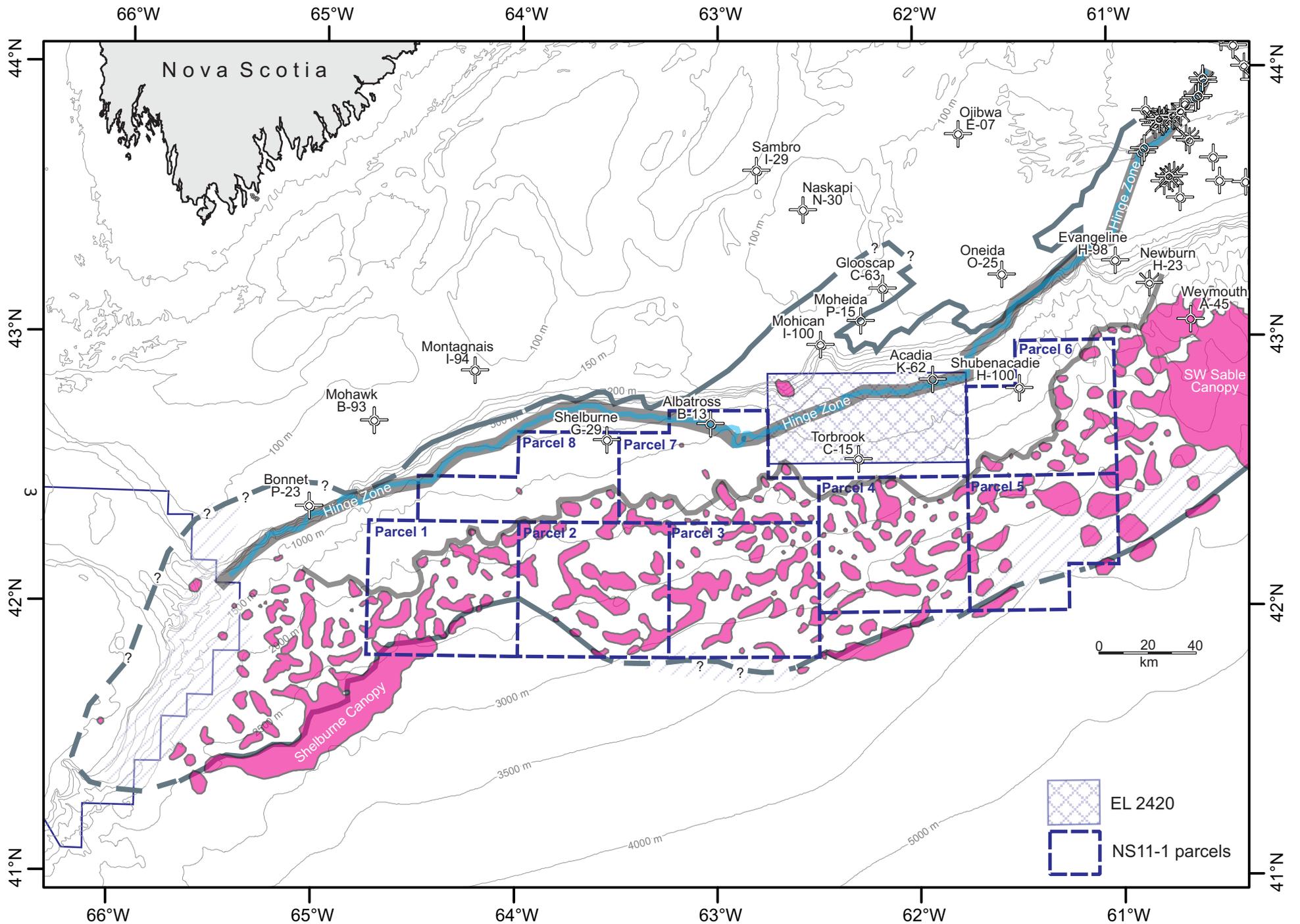


Figure 1b – Map showing location of NS11-1 parcels. Limits of autochthonous salt basin and boundaries between structural provinces are the same as in Figure 1a.

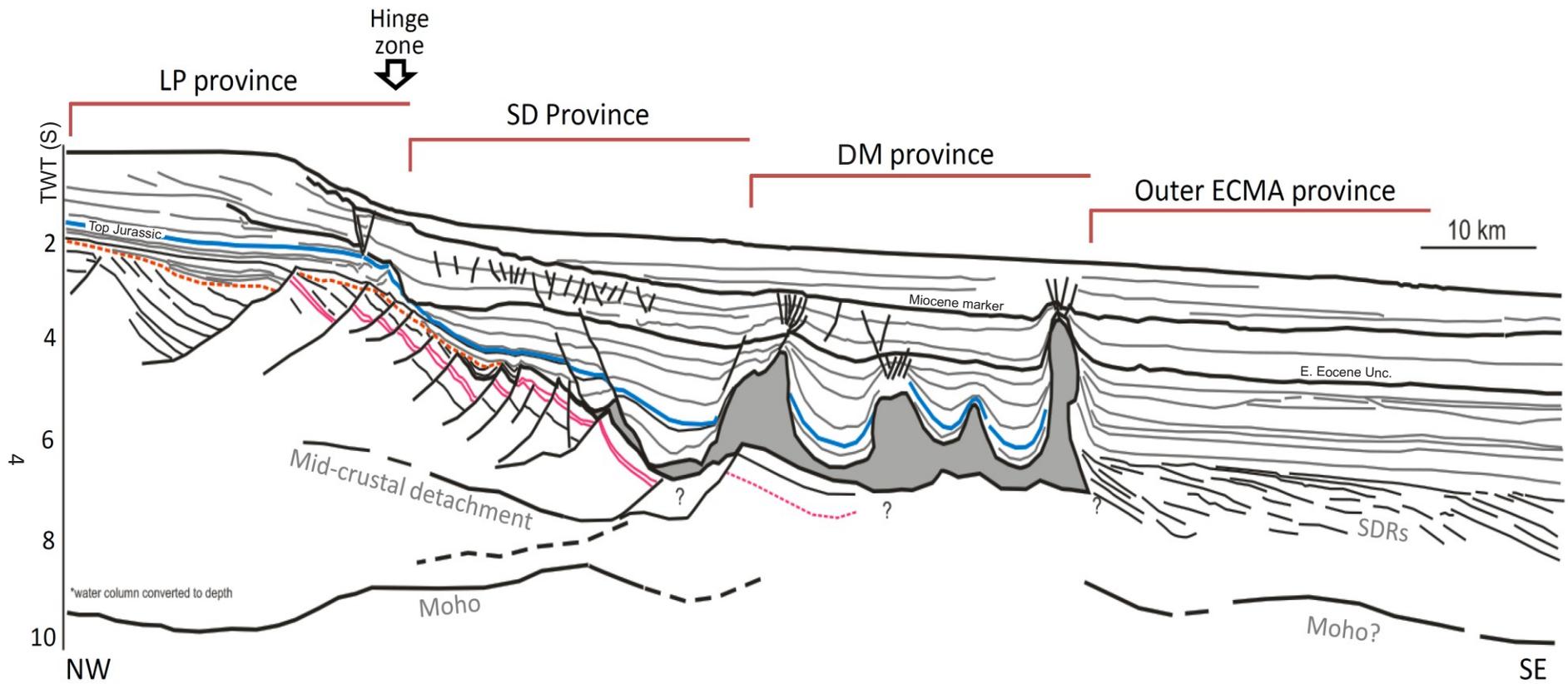


Figure 2 – Line drawing of a composite seismic profile extending from the LaHave Platform (LP), across the Slope Detachment (SD) and Diapir and Minibasin (DM) provinces, and terminating in the Outer ECMA province where Seaward Dipping Reflections (SDRs) are recognized. Water column was depth converted, but remaining section is in two-way travel time. See Figure 1a for location.

while Parcels 6, 7, and 8 straddle the SD and DM provinces. The northern part of Parcel 7 also extends onto the LP province.

Each structural province is described more thoroughly below.

LaHave Platform Province

The 'LaHave Platform province' (LP province) is an area underpinned by thick continental crust broken locally by Triassic to Early Jurassic rift basins and intervening basement highs (Welsink et al. 1989; Wade and MacLean 1990; Keen et al. 1991). The synrift autochthonous salt basin is known to extend onto the LaHave Platform in the Mohican Graben area where bedded Triassic salt was encountered by the Glooscap C-63 well and probable autochthonous salt was encountered at the base of the Mohican I-100 well (Figure 1a). Lateral facies changes from interbedded salt to immature synrift clastic units are also apparent in the Mohican Graben area where Moheida P-15 encountered time-equivalent rocks of the Eurydice Formation.

The seismic character of the bedded salt interval at Glooscap C-63, capped by the Glooscap volcanic layer, was mapped toward the northeast, where the succession is present in a graben on the edge of the LaHave Platform along the western margin of the Sable Subbasin (Figure 1a, north of Evangeline). Further west, the primary salt basin may also extend landward onto the platform in parts of the Mohawk Graben Complex where an interpreted expanded Lower Jurassic section may have been accommodated through salt expulsion in addition to rift subsidence.

Periods of folding and faulting of the bedded salt to Glooscap volcanic interval in the

Mohican Graben area and towards the western margin of the Sable Subbasin attest to the complex synrift evolution of grabens beneath the LaHave Platform. It is clear that the LaHave Platform experienced both extension and localized inversion during rifting that folded the bedded salt interval and also the Glooscap volcanic layer.

There is also clear seismic evidence for sediment loading and salt expulsion throughout the southern parts of the Mohican Graben Complex. Salt appears to have been expelled towards the southwest where several autochthonous pillows and more allochthonous (in the loosest sense of the term) salt diapirs are present near the mouth of the complex. Several listric detachment faults are also recognized along the outer parts of the LP province in the Mohican Graben area (Figure 1a). They offset Jurassic strata above the autochthonous salt layer and, combined with the expulsion of salt, are probably responsible for the increased subsidence of the outer LP province in this area (see top Carbonate Bank marker, Figure 3).

A distinct hinge zone defines the seaward boundary of the LaHave Platform, across which basement depth increases abruptly (Figures 1, 2). The hinge zone separates the relatively stable platform to the north, where rift extension caused only minor crustal attenuation (Tankard and Welsink 1989), from heavily faulted and significantly thinned continental crust to the south. The hinge zone cuts across the primary autochthonous salt basin, particularly in the Mohican Graben area, and likewise steps across numerous other rift-related basement elements. The continuity of basin fill across the hinge zone indicates that sediment loading and salt expulsion in the Mohican Graben area took place at least in part

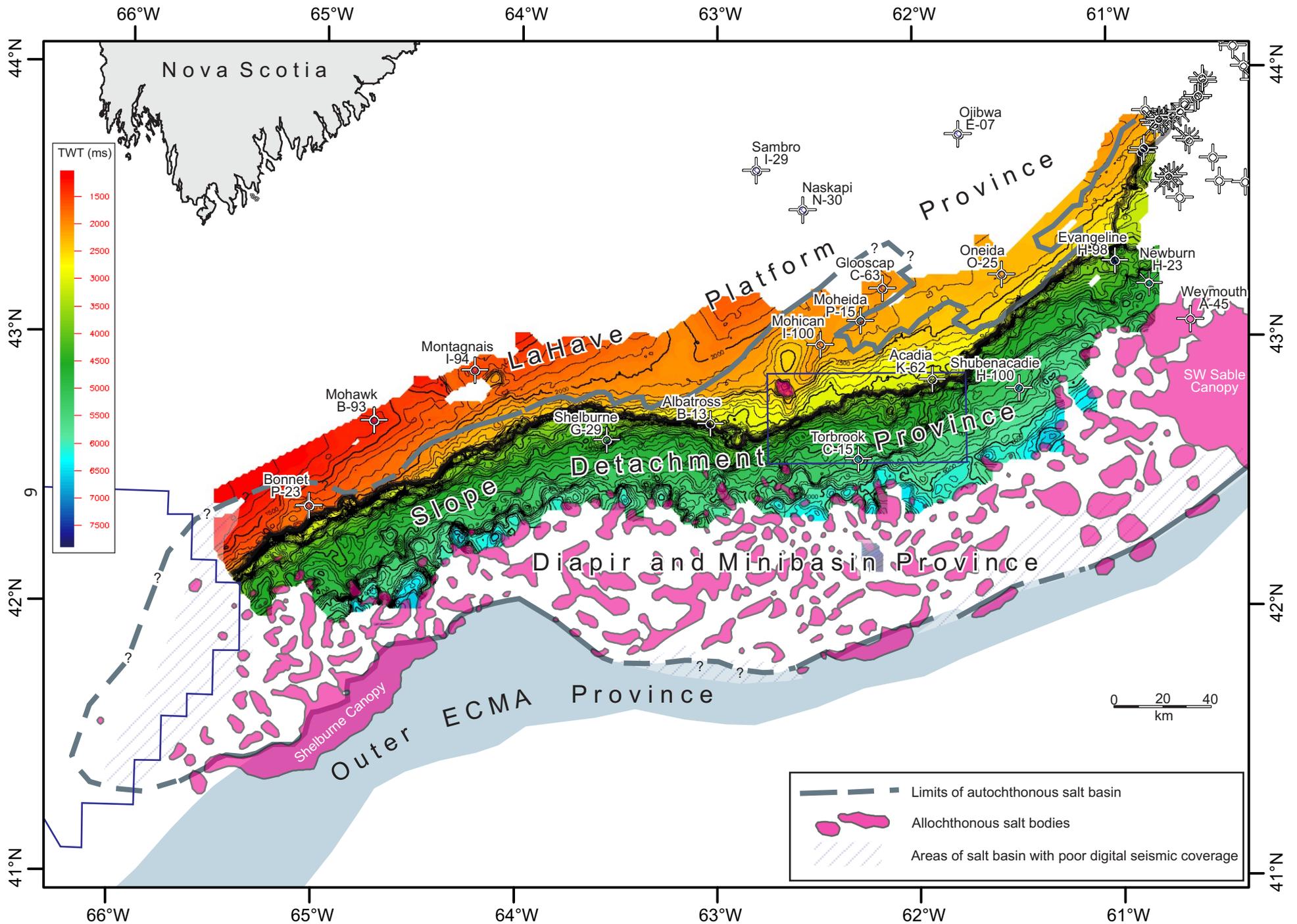


Figure 3 – Gridded time-structure map on the top of the Jurassic carbonate bank.

before the hinge zone developed. As such, the hinge zone is believed to have formed after rifting, likely initiated during Early to Middle Jurassic postrift thermal subsidence of the margin (Wade and MacLean 1990; Deptuck 2010).

At the termination of rifting, the LaHave Platform experienced low overall subsidence rates and has been dominated by non-marine to outer neritic depositional environments for most of its history. The stable platform is home to a widespread carbonate bank that developed later in the Middle Jurassic after most rift grabens were filled and intervening basement highs were planed off. A time-structure map of the top of the Jurassic carbonate bank shows that the seaward limit of the bank coincides closely to the edge of the LaHave Platform (Figure 3), indicating a close association between carbonate aggradation above a low accommodation shelf and hinge zone development (Welsink et al. 1989). The platform remained a relatively low accommodation shelf through most of the remaining postrift history of the margin, and much of the present day continental shelf still sits directly above it (Figures 4a, 4b).

A unique and important structural feature on the LaHave Platform is an Early Eocene (50.8 Ma) impact crater penetrated by the Montagnais I-94 well (Jansa et al. 1989). The impact event caused Cretaceous and Paleocene strata on the outer part of the LaHave Platform to fail catastrophically across a wide area (covering up to 4000 km²). A 65 km wide multi-tiered sub-circular failure scarp developed in the immediate area surrounding the 13 km wide central high (the target of Montagnais I-94), with a second arcuate failure scarp developing west of the impact location (Figure

5a). These scarps cut down as deep as the top of the Jurassic carbonate bank, and are open to the south where a series of deep canyons erode and converge across the slope detachment province (Figure 5b). Additional foundering of the outer LaHave Platform appears to have taken place east of the impact site, where Cretaceous strata are truncated or offset along a series of detachment faults (though at least some of these features appear to be diachronous and hence not exclusively associated with any single event). A widespread mass transport deposit directly down-slope from the failure scarps, up to 300 ms (TWT) thick, is presumed to be the product of the bolide impact and covers an area greater than 14 000 km² (Figure 5b). It accumulated between salt diapirs and above the Ypresian seafloor seaward of the salt basin, extending for an unknown distance onto the paleo-abyssal plain, beyond data coverage.

The Montagnais structural element is noteworthy because erosion associated with the impact event removed a significant amount of the Cretaceous and Paleocene stratigraphic record across a 170 km long and 10 km to >30 km wide swath of the outer shelf (Figure 6). Therefore the event has potentially erased any record of, for example, shelf-edge deltas above the carbonate platform that may otherwise have been preserved on the seaward parts of this low-accommodation shelf.

Slope Detachment Province

The 'slope detachment province' (SD province) is a *ca.* 350 km long and 15 to 55 km wide area on the western Scotian Margin dominated by raft tectonics. It runs parallel to, and outboard of, the LaHave Platform in current water depths

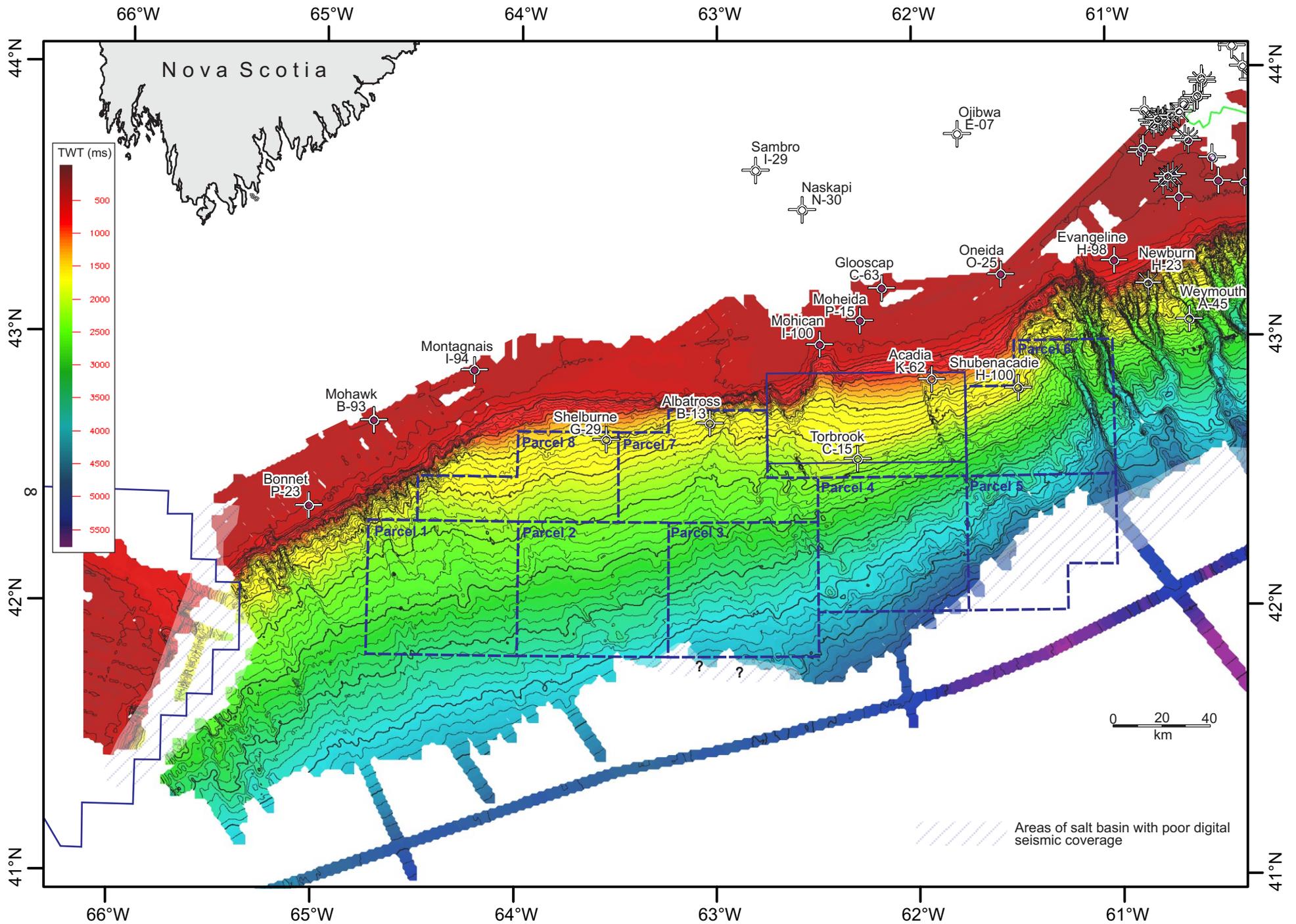


Figure 4a – Gridded time-structure map of the sea floor marker, showing parcel locations.

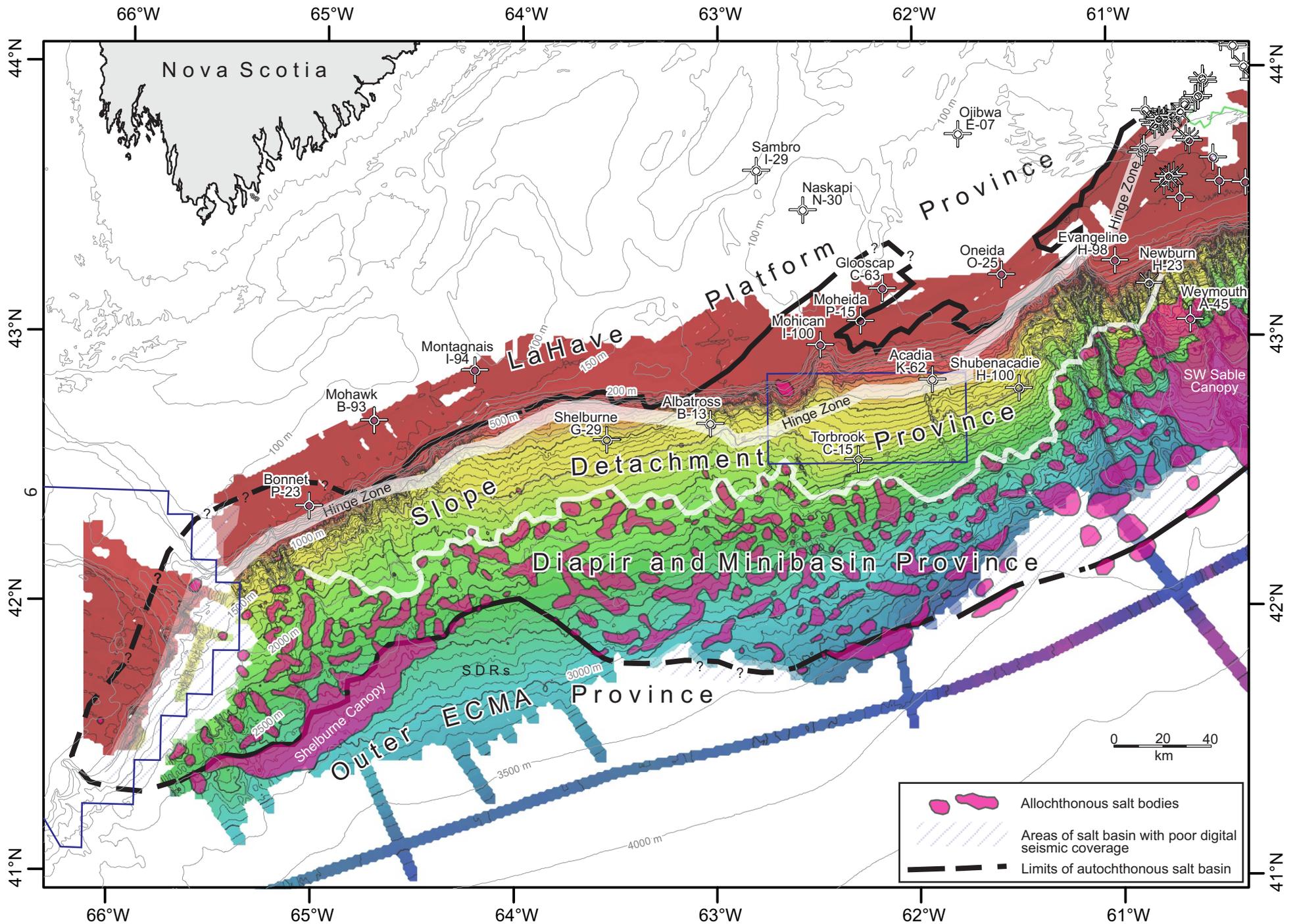


Figure 4b – Gridded time-structure map of the sea floor marker, overlain by key structural provinces described in this study.

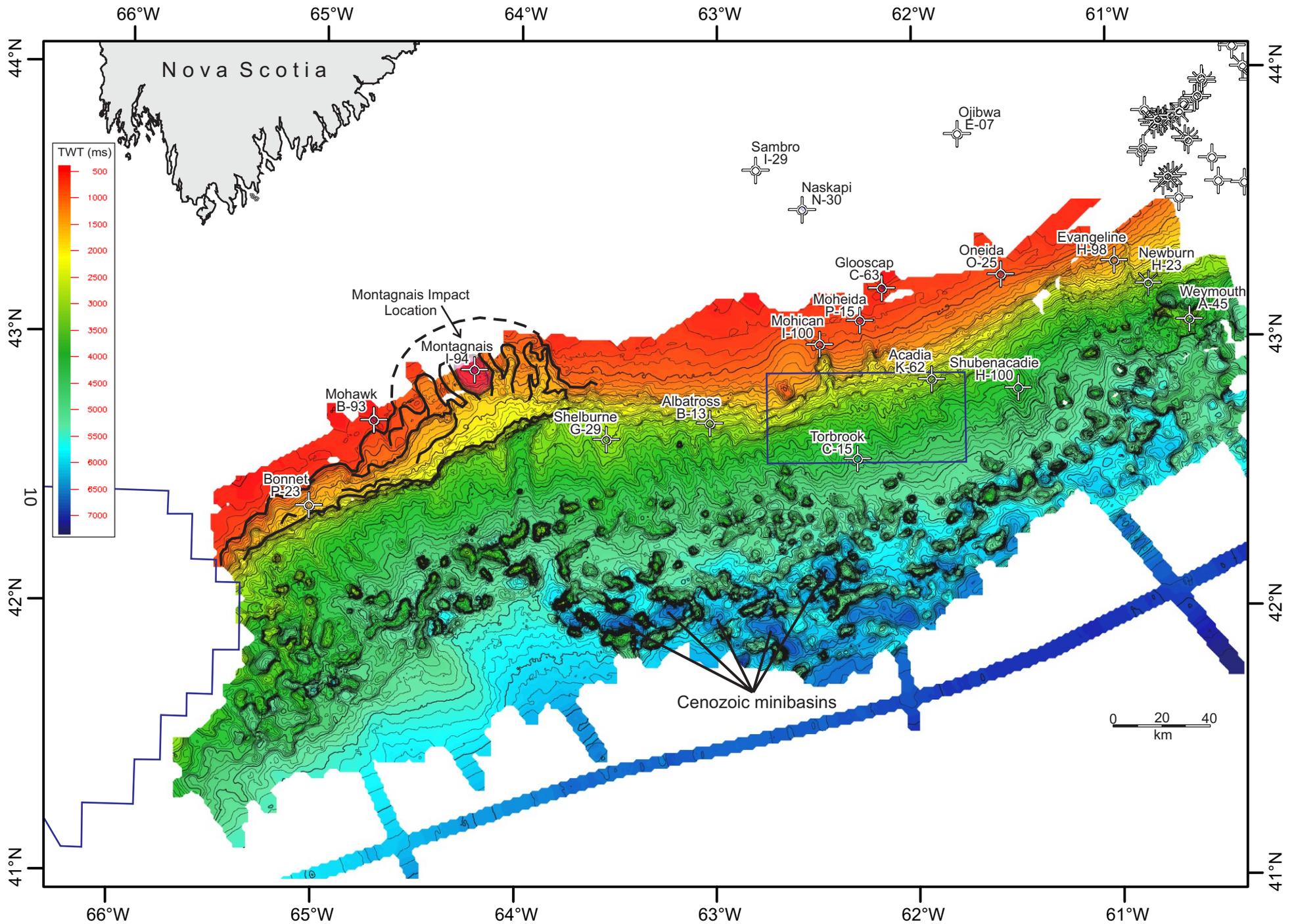


Figure 5a – Gridded time-structure map of a prominent Early Eocene unconformity that formed, at least in part, in response to a 50.8 Ma bolide impact. Scarps and canyon heads within the impact crater are highlighted.

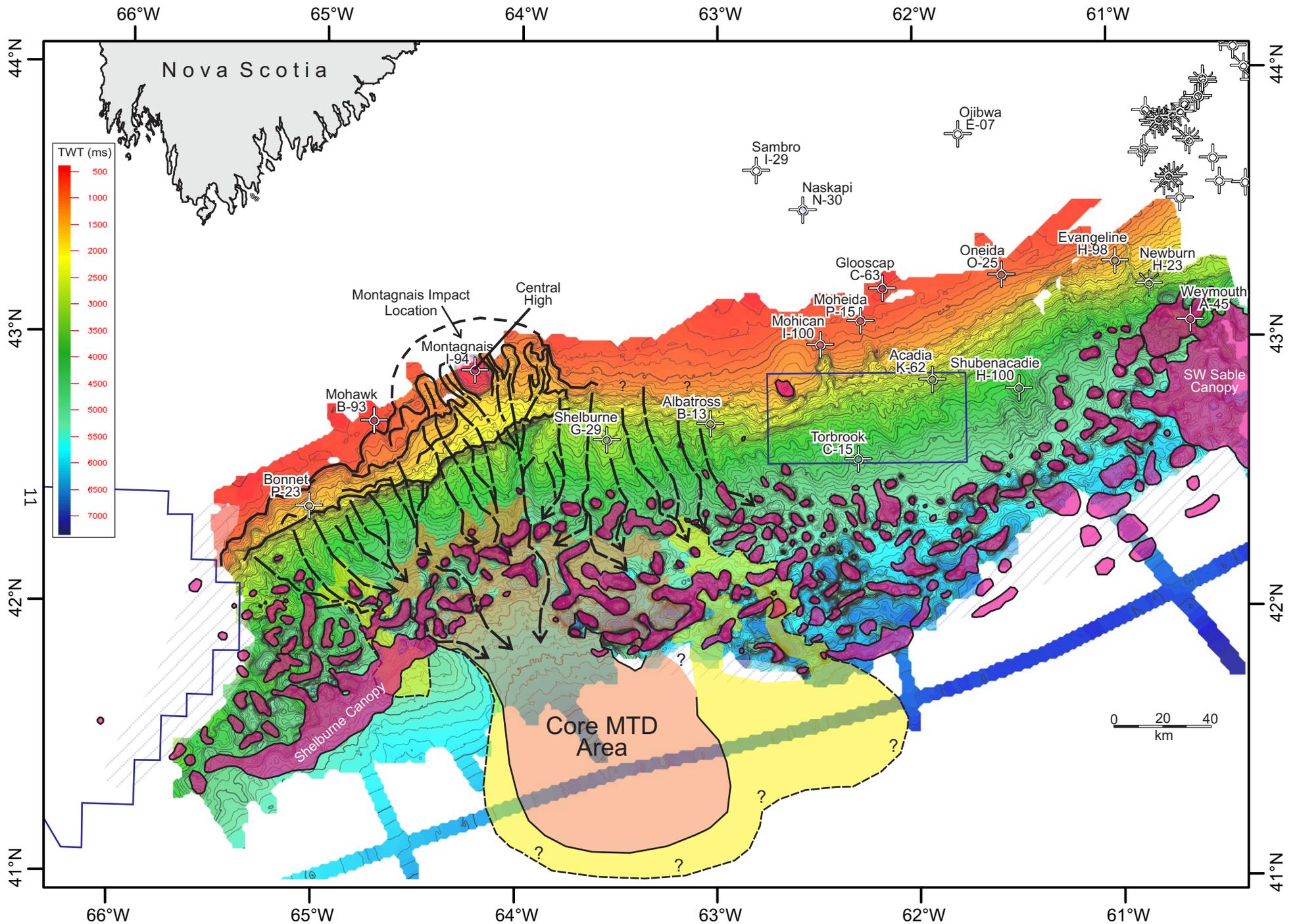


Figure 5b – Gridded time-structure map of the Early Eocene unconformity, annotated to show canyons that transported failed material directly down-slope from the impact site, where a widespread mass transport deposit is recognized. Orange indicates the primary core of the mass transport deposit, while yellow indicates peripheral mass wasted material. There is a high degree of uncertainty about its distribution in deepwater.

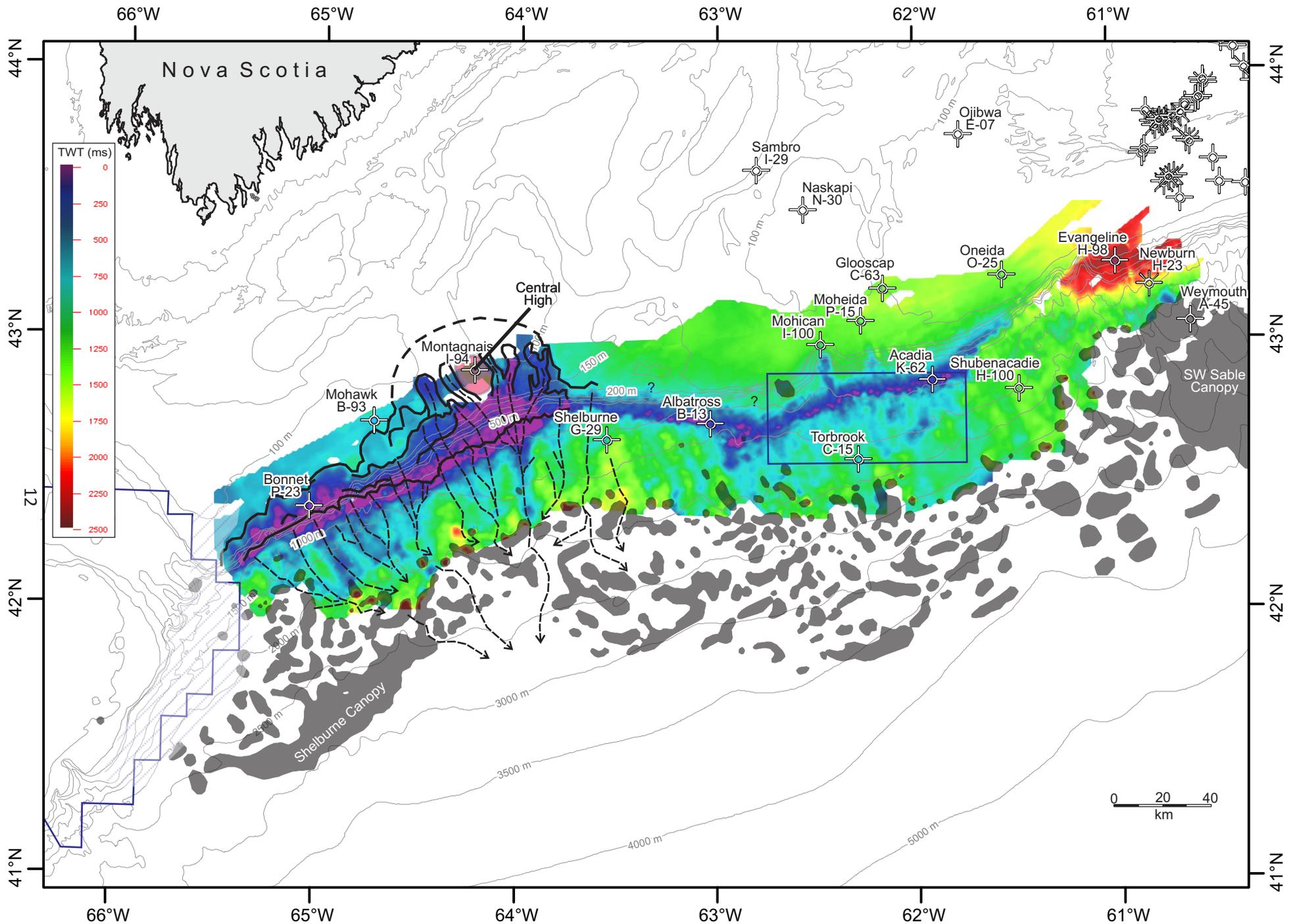


Figure 6 – Time-thickness map between the top Jurassic carbonate bank marker and the Early Eocene unconformity, showing the widespread erosion of the Cretaceous to Paleocene stratigraphic succession caused, at least in part, by the bolide impact.

generally between 500 and 2500 m, covering an area of ~13 000 km² (Figures 1, 7). The SD province was named in recognition of the tendency of Jurassic and to a lesser extent Cretaceous cover strata to detach above the autochthonous salt layer across wide expanses of this structural province (Figures 8, 9; Deptuck 2010).

The landward boundary of the SD province closely corresponds to the structural hinge zone that parallels the Upper Jurassic carbonate bank (Figures 3, 7). Its distal boundary follows the seaward margins of a chain of subcircular minibasins from which salt bodies were widely expelled along the leading edge of the diapir and minibasin province (Figures 10, 11).

In areas where the Moho can be identified, the SD province coincides with the region of most rapidly thinned continental crust (Figures 2, 10) (see also Keen et al. 1991). Mid-crust detachment surfaces, along which rift block faults sole out, are also common (see Deptuck 2010). In contrast to the consistently low regional gradients above the LaHave Platform, the depth of rifted basement (and the autochthonous salt basin above it) increases abruptly seaward of the hinge zone, producing a steep postrift slope that dominated this structural domain throughout most of its postrift history. Even the modern seafloor on the western part of the margin ultimately owes its steep gradients to the foundering of deeply buried rifted basement across the SD province, producing a slope that commonly exceeds 5° (see figure 16 of Piper et al., In Press) (Figure 4b).

Allochthonous salt bodies are rare or absent in the SD province, and most salt bodies form cone-shaped pillows or swells that are firmly rooted to the autochthonous salt layer (and

hence the salt is still situated in its original stratigraphic position; Figures 8, 9). Where more 'allochthonous' bodies (in the loosest sense of the term) do exist, they tend to be clustered around the mouth of the Mohican Graben Complex (Figure 1a). The general absence of salt overhangs improves seismic imaging compared to the area down-slope that is dominated by salt bodies with some degree of overhang. Crustal seismic markers, faults, the autochthonous salt layer, and cover strata are locally very well imaged in the SD province, particularly in 3D seismic data (Figures 10, 12).

A distinct northeast to southwest fabric exists on the top autochthonous salt to primary weld marker across much of the SD province (Figures 11, 12, 13c). This fabric is believed to be an expression of the underlying highly rugose rifted basement that underlies, and is partially masked by variably thick remnants of autochthonous salt. Faulted basement blocks, including their internal stratigraphy, are particularly well imaged in the Barrington 3D seismic survey (program NS24-P3-4E) (Figure 12). The orientation of these basement lineaments is consistent with that of the half-grabens and intervening horst blocks on the LaHave Platform (Welsink et al. 1989; Wade and MacLean 1990), lending support to the idea that the rugose basement fabric is a product of rifting. It is not clear if the synrift succession in the SD province experienced a period of inversion as seen in the bedded salt to Glooscap volcanic interval on the LaHave Platform.

The deformation style within Jurassic cover strata above the autochthonous salt layer (or its primary weld) in the SD province is dominated by thin-skinned detachment and associated raft tectonics (Figure 14). The resulting structures

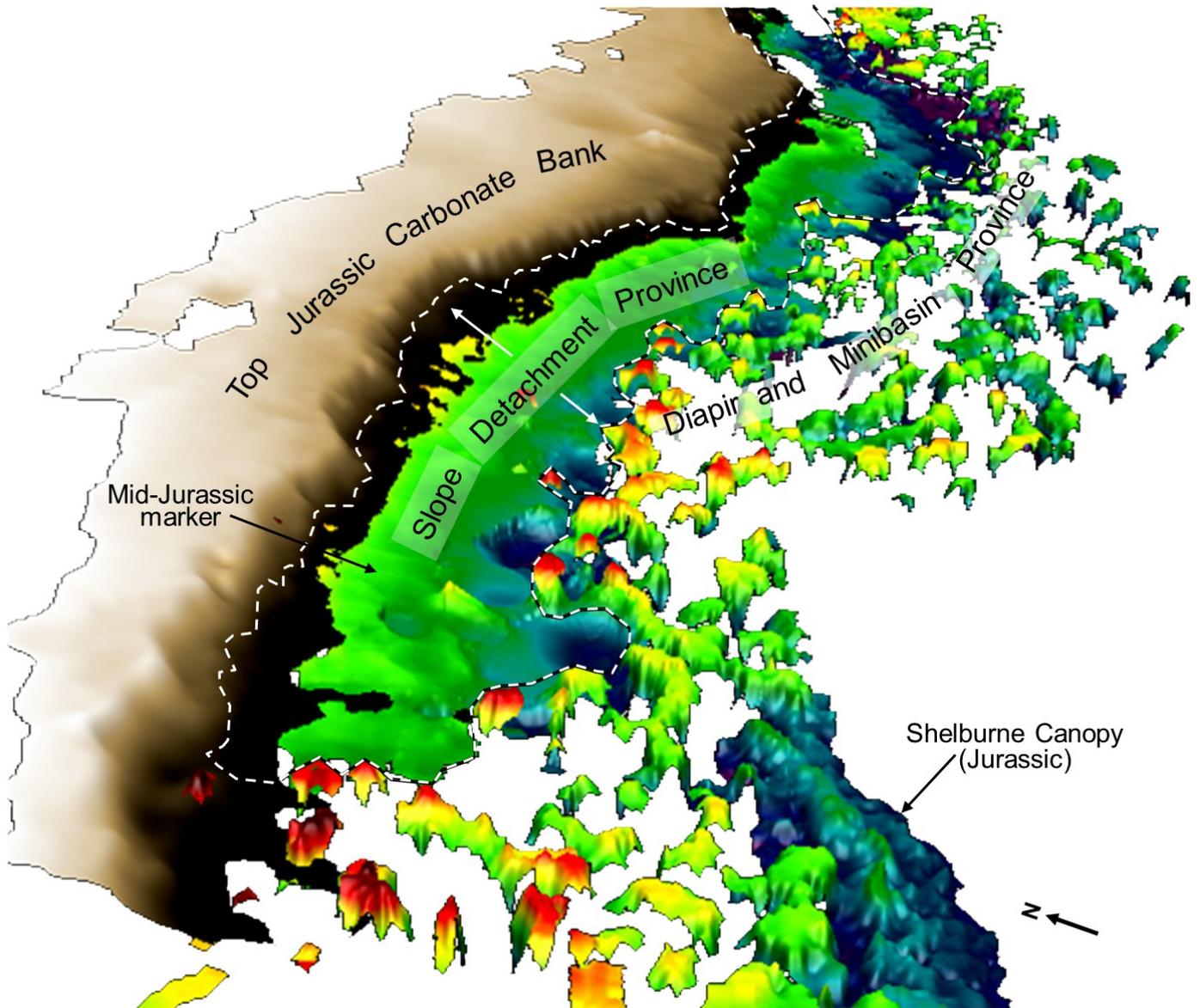


Figure 7 – Perspective view from the southwest showing the relationship between the Jurassic carbonate bank, slope detachment province, and the diapir and minibasin province. This image illustrates the striking absence of prominent salt diapirs in the slope detachment province.

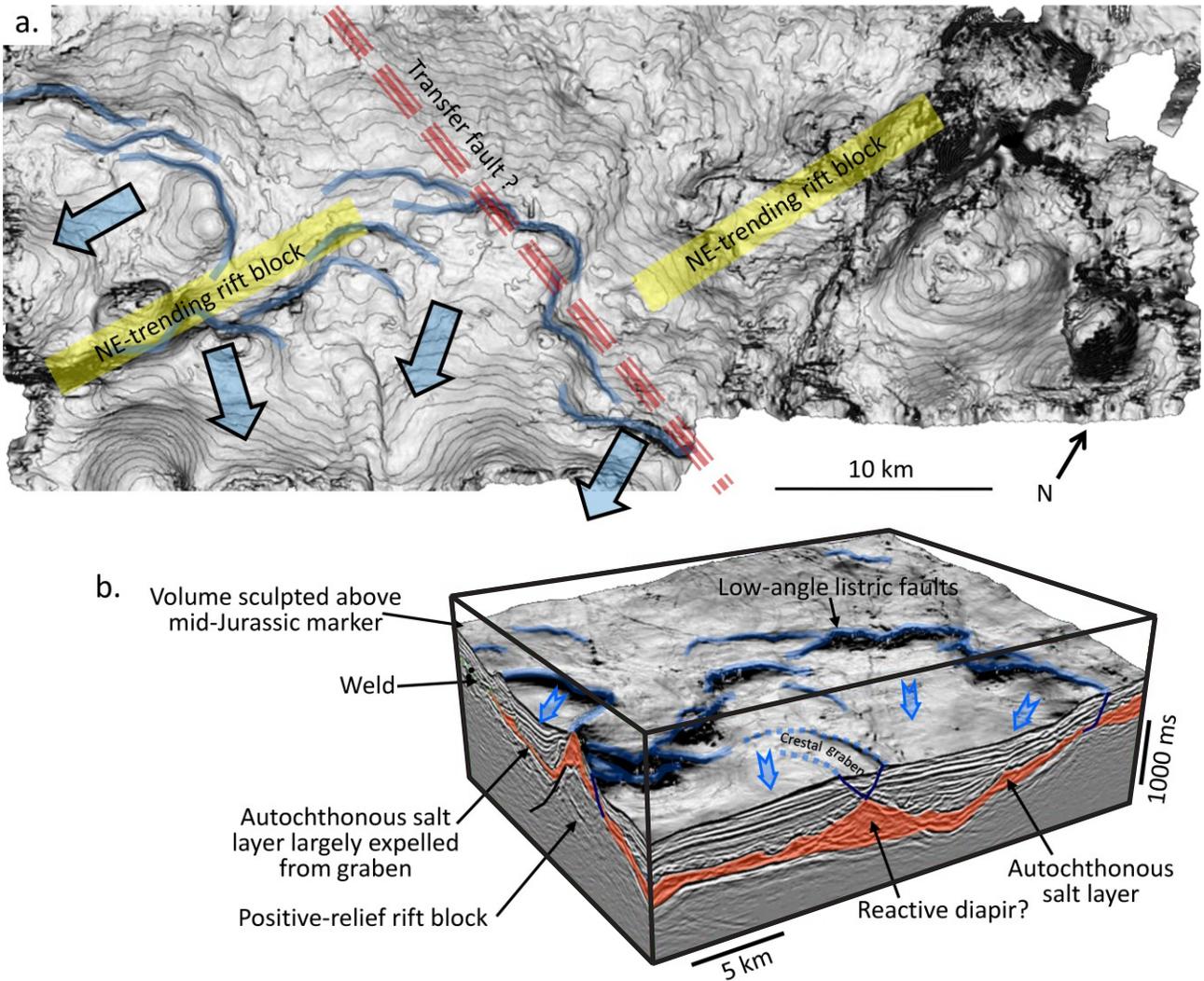


Figure 8 – a) Planform view of a mid-Jurassic seismic marker (dip map) showing headscarpes of detached slabs (blue) of Jurassic strata in the Slope Detachment province. Two northeast trending rift blocks define structural highs in the 3D seismic survey that may be offset by a transfer fault; b) Perspective view showing low angle listric faults that detach in the autochthonous salt layer. Note the preferential expulsion of salt along rift block. Blue arrows indicate detachment direction. See Figure 1a for location.

Proximal to distal postrift structural provinces of the western Scotian Margin

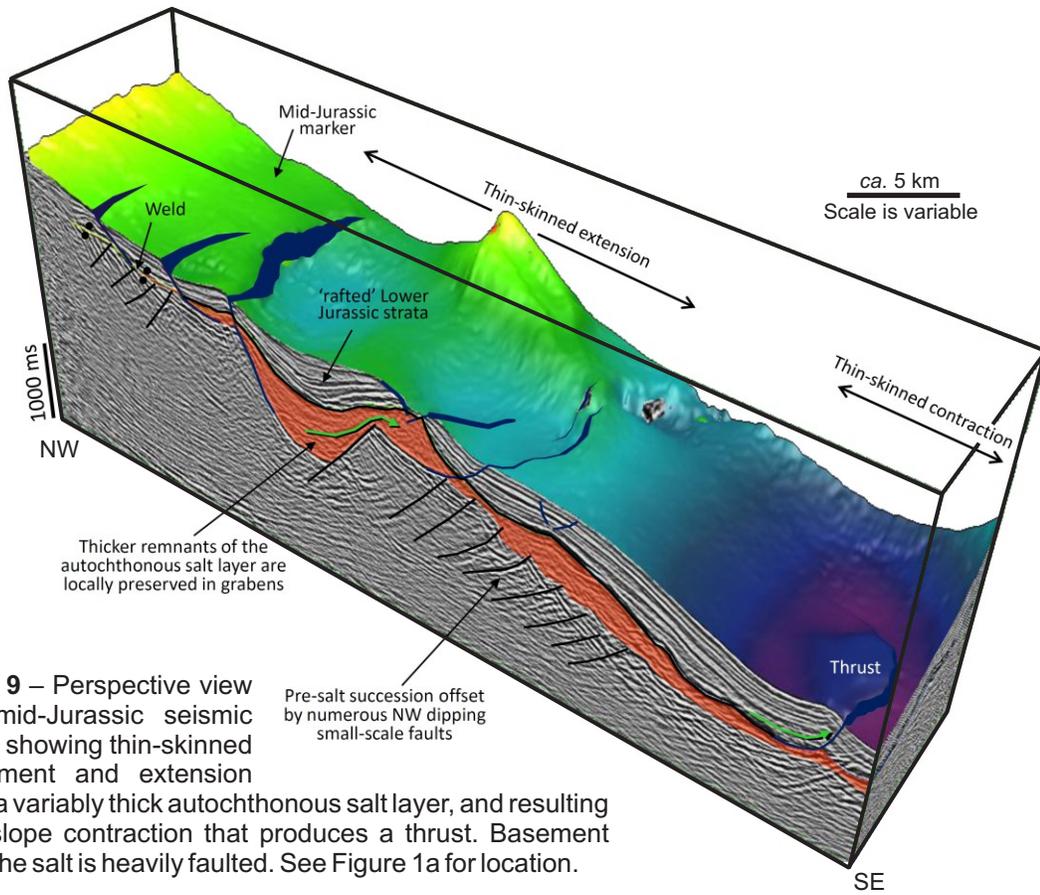


Figure 9 – Perspective view of a mid-Jurassic seismic marker showing thin-skinned detachment and extension above a variably thick autochthonous salt layer, and resulting down-slope contraction that produces a thrust. Basement below the salt is heavily faulted. See Figure 1a for location.

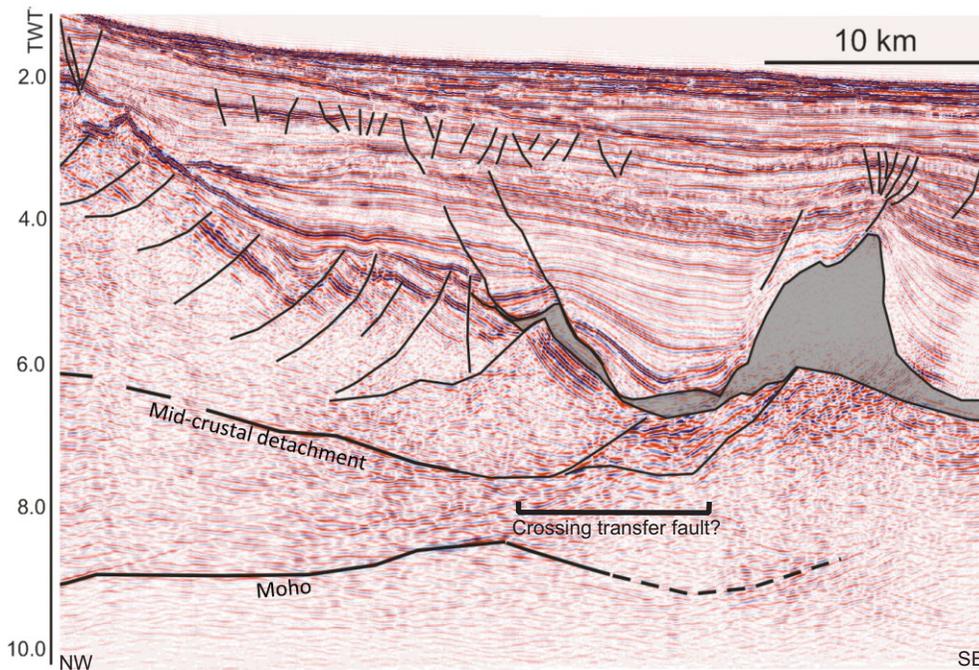


Figure 10 – Close-up seismic profile of middle parts of Figure 2 (SD to proximal DM province), showing prominent northwest-dipping faults that may detach in a mid-crustal detachment surface. Slow water column velocities were depth converted, but remaining section is in TWT.

look quite similar to the raft tectonic structures documented above postrift Aptian salt on the Angolan Margin (e.g. Fort et al. 2004), with the exception that the base salt surface is faulted and consequently highly rugose in the SD province on the Scotian Margin (Figures 8b, 9, 12, 14). Jurassic strata are commonly offset along low angle listric faults that sole out in the autochthonous salt layer. These faults define the headward parts of detached 'slabs' of Jurassic strata, and are commonly composed of a series of shorter arcuate fault traces that link-up to produce longer detachment trends extending along strike for >60 km. The headscarps of some detached slabs coincide with the steep flanks of underlying basement fault blocks, presumably because of the increased propensity for gravity gliding (detachment) in such areas (e.g. southeast side of Figure 14). Where the autochthonous salt basin extends northward below the Middle to Upper Jurassic carbonate bank (e.g. in the Mohican Graben area), parts of the outer bank foundered in a similar manner, with rotated limestone dominated blocks as thick as 1.2 sec (tw) detaching above the autochthonous salt layer near the margin hinge zone.

In general, slab detachment is normal to the margin hinge zone, however, the northeast orientation of some positive-relief basement blocks locally alters the detachment trajectory (Figure 8), particularly on slope segments where the hinge zone is oblique to northeast trending basement elements (like much of the margin between the Shelburne and Acadia wells; Figures 1, 13c). Detachment of cover strata was likely initiated in the late-Early to Middle Jurassic and is probably coincident with over steepening of the margin during hinge zone development (Deptuck et al. 2009; Deptuck 2010). Though extensional structures dominate

the SD province, some detached rafts are overthrust above equivalent strata (Figure 14).

It is noteworthy that several periods of widespread canyoning are recorded across the SD province, where Late Jurassic, Cretaceous and lower Paleogene slope strata are deeply incised, indicating that during postrift subsidence of the margin the SD province repeatedly formed an important slope bypass zone. As such, in addition to structural decoupling of strata above the autochthonous salt layer, the steep gradient across the SD province makes it prone to sediment bypass, an idea with important implications for the distribution of turbidite sands along the western margin (discussed in the Parcel Prospectivity section).

Diapir and Minibasin Province

The 'diapir and minibasin province' (DM province) is a ca. 350 km long and 22 to 80 km wide area located outboard the SD province. The profile in Figure 2 crosses its narrowest part. The DM province is a region dominated by well-developed minibasins and intervening salt bodies in present day water depths between 1700 and 4050 m, and covering an area greater than 21 000 km² (Figure 1). Most salt bodies form diapirs or walls that are broader near their tops than their stocks, and as a result are commonly mushroom or bulb-shaped, with variable amounts of salt that overhang younger strata (locally forming salt tongues). Most salt bodies are no longer in their original stratigraphic position, and in the loosest sense of the term are considered 'allochthonous'.

The DM province is bracketed between a

Proximal to distal postrift structural provinces of the western Scotian Margin

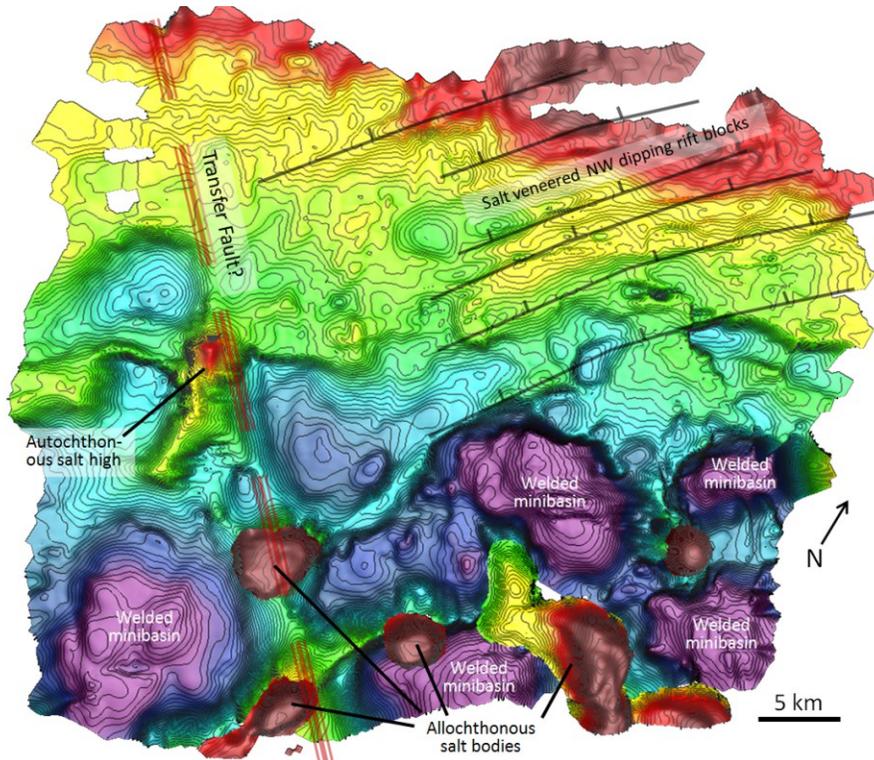


Figure 11 – Close-up of the top autochthonous salt to primary weld marker, showing the synrift 'fabric' produced by underlying rift blocks, with offsets on minibasins interpreted to be caused by a transfer fault. The figure also illustrates the transition from the SD province to the DM province where prominent salt bodies were expelled from a chain of minibasins along the base of the image. Shallow areas are red, deep areas are purple. See Figure 1a for location.

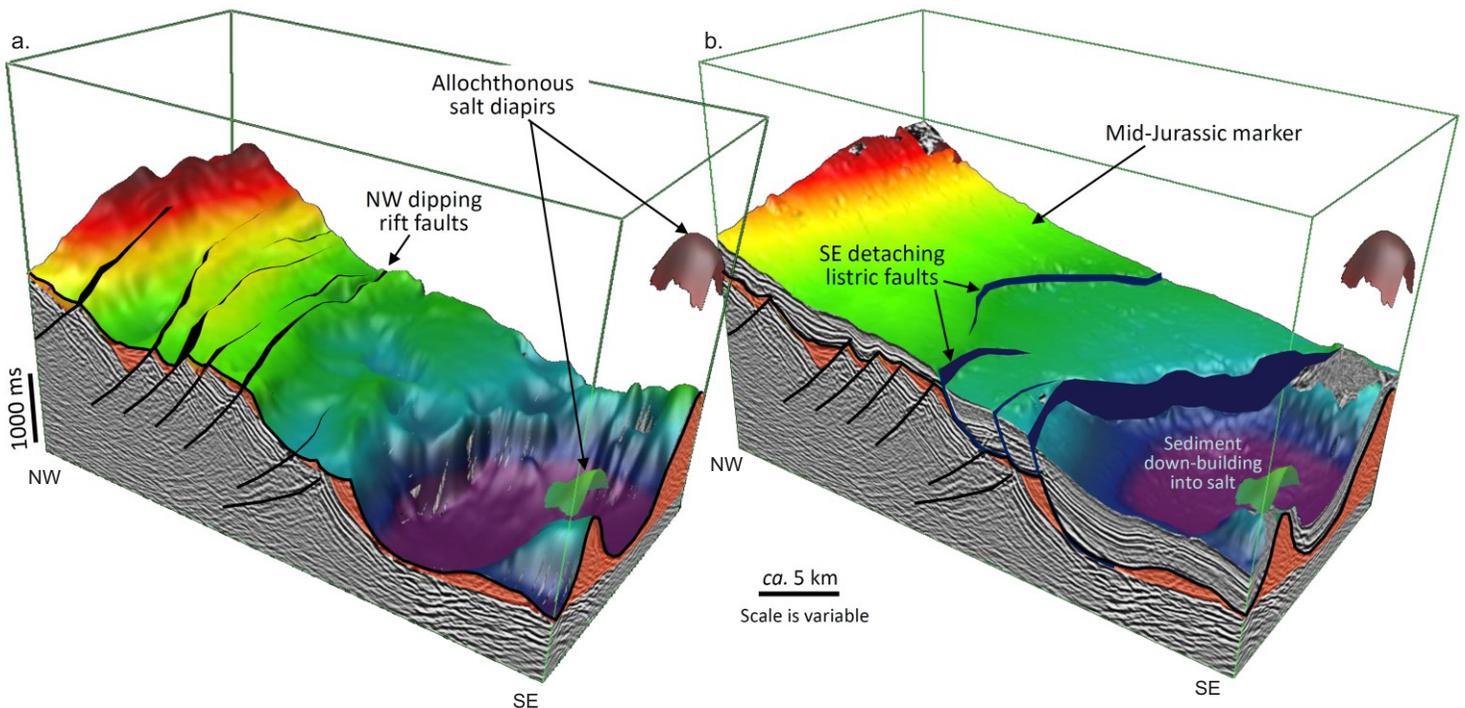


Figure 12 – a) Perspective view sculpted along the top autochthonous salt to primary weld marker, showing the synrift fabric below a thin veneer of autochthonous salt. The landward-dipping (northwest) extensional basement faults are well imaged; b) Perspective view showing a series of seaward dipping 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. See Figure 1a for location.

Jurassic salt canopy in the west (referred to here as the 'Shelburne Canopy') and a series of sutured and reactivated Cretaceous and Paleogene salt sheets to the east (referred to here as the 'SW Sable Canopy' – see also Shimeld 2004; Kendell and Deptuck 2010; and Kendell 2011). It corresponds to the seaward parts of salt subprovince II of Shimeld (2004), whose lateral salt subprovince boundaries cut across the proximal to distal structural provinces described in this study. Despite this subtle difference in classification, much of Shimeld's (2004) description of subprovince II is directly applicable to the DM province of this study.

The landward boundary of the DM province corresponds to a sharp increase in the density of tall salt bodies down-slope of the SD province. The seaward limit of the DM province is the distal edge of the underlying autochthonous salt basin (Figures 11, 13b). Any salt bodies extending beyond its seaward limit (generally salt tongues) are considered part of the outer ECMA province, and are discussed in the corresponding section.

The top of the autochthonous salt layer (or its equivalent primary weld) was interpreted across much of the DM province (Figure 13a). Seismic correlation confidence is variable, particularly in areas with complex salt overhangs. The geometry of minibasin fill was also used as a general guide to mapping this marker. Many of the autochthonous salt highs in Figure 13a form the stocks of overlying salt bodies. The somewhat 'polygonal' distribution of autochthonous salt highs nicely delimits the earliest supra-salt minibasins that loaded the primary salt layer and expelled salt bodies. The halos of thicker salt that rim the earliest minibasins are particularly well imaged in 3D

seismic surveys located on the eastern and western extremities of the DM province. Identification of a base autochthonous salt marker in these areas allows for the generation of autochthonous salt thickness maps that show a general increase in autochthonous salt thickness toward the DM province (see figure 5 of Deptuck 2010).

In contrast to many areas of the SD province, seismic imaging is poor below the autochthonous salt layer over much of the DM province (Figure 10). As such, the structure of the pre-salt succession is hard to evaluate here. The dominant orientation of salt walls in the DM province, however, is SW-NE and SE-NW (Figure 13b). As such, they are commonly parallel and perpendicular to the dominant direction of basement lineaments in the SD and LP provinces, hinting at a potential genetic relationship. In areas with 3D seismic coverage, there is clear evidence that autochthonous salt pillows are preferentially expelled along northeast oriented basement lineaments (Figures 8, 9) and the apparent preferential alignment of salt walls could reflect a similar process during early salt expulsion in the DM province (see also Welsink et al. 1989; Balkwill and Legall 1989; Albertz and Beaumont 2010).

The autochthonous salt basin in the DM province is believed to overlie highly extended continental crust. Distinct lateral offsets are recognized in the landward boundary of the DM province (Figures 1a, 13c). Salt bodies here were dominantly evacuated from a chain of minibasins that define the seaward limit of the SD province, and these minibasins are also offset (e.g. Figure 11). These offsets, combined with the orientation of salt walls, patterns in magnetic data (Oakey and Dehler 2004), the distribution of basement elements

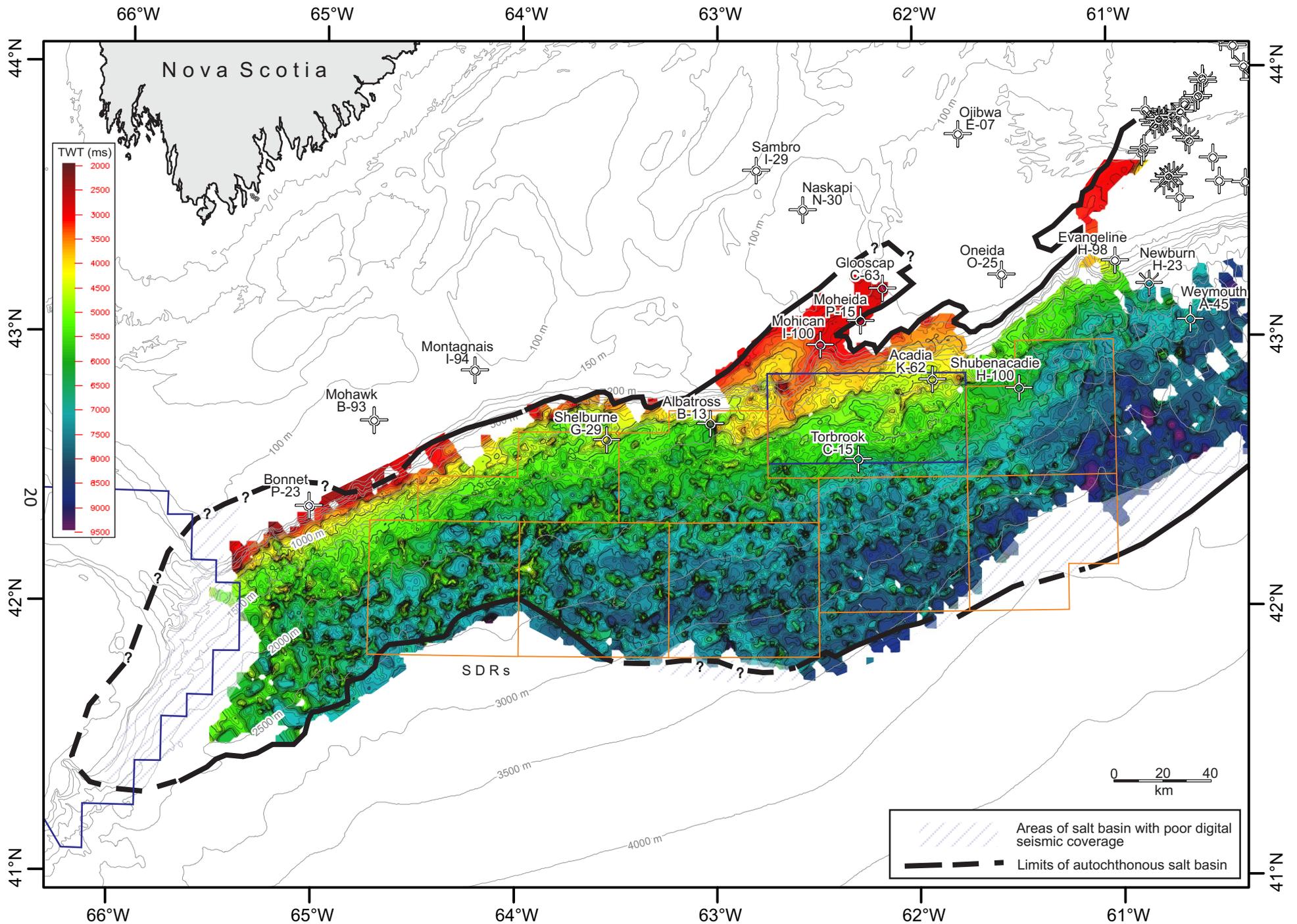


Figure 13a – Gridded time-structure map on the top autochthonous salt surface, correlated along the equivalent primary weld.

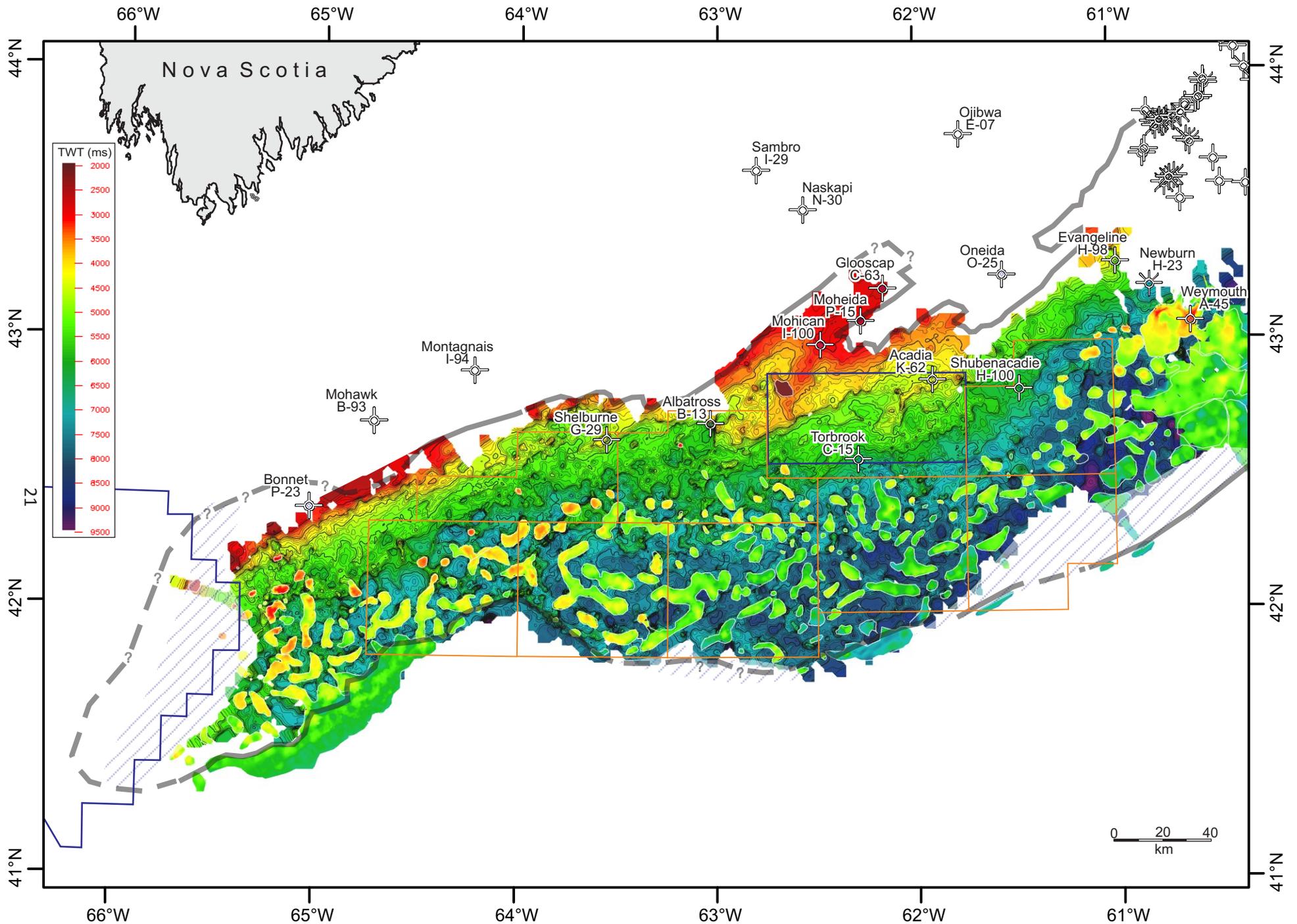


Figure 13b – Gridded time-structure map on the top autochthonous salt surface, overlain by the gridded surface from the top allochthonous salt bodies located predominantly in the ASM province. Autochthonous salt highs produce a polygonal network of minibasins in the DM province, many of which form the stems of overlying salt bodies.

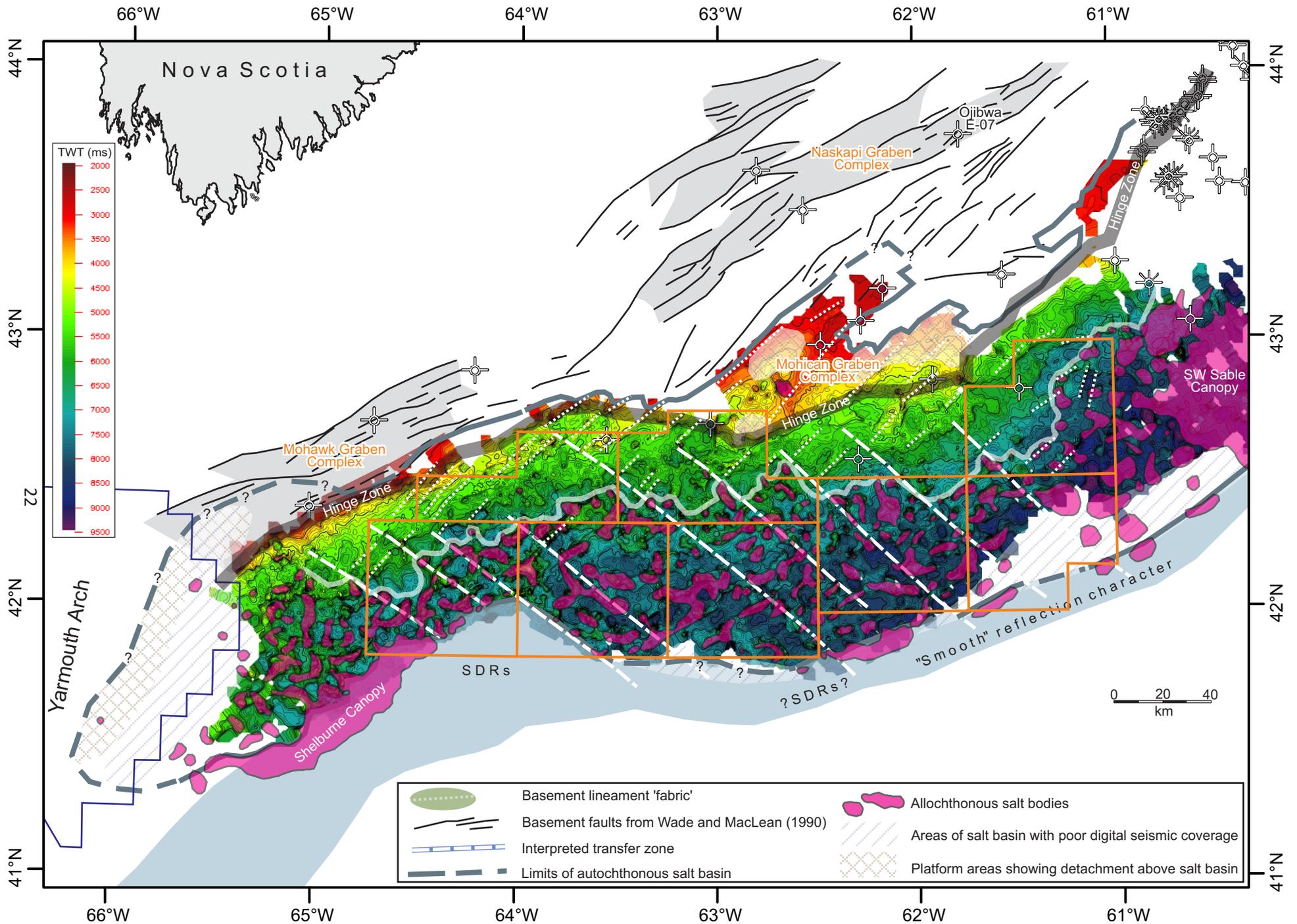


Figure 13c – Annotated map of the top autochthonous salt gridded surface, showing location and orientation of basement lineaments and the interpreted location of transfer faults that appear to offset the landward margin of the DM province.

(in the LP and SD provinces), and variations in synrift fault vergence, in totality, imply the presence of SE-NW oriented right-lateral synrift transfer faults. These transfer faults may have segmented the primary salt basin before, and perhaps during, salt accumulation (Figures 8, 11, 13c, 15b). Their orientation is consistent with the transfer faults proposed by Welsink et al. (1989) and the plate reconstruction proposed by Tankard and Balkwill (1989; their figure 3). Such features, combined with northeast trending basement structures, probably influenced both the expulsion of salt (location, timing, orientation) and its original depositional thickness.

Salt diapirism was presumably initiated during regional extension (rifting), but the majority of the salt expelled from beneath minibasins in the DM province appears to have taken place through passive loading during postrift subsidence (Shimeld 2004; Albertz et al. 2010), starting in the Jurassic and continuing locally into the Paleogene. With the exception of the area of the Mohican Graben Complex, minibasins are generally much broader and longer lived in the DM province than they are in the SD province up-slope. The onset of major salt loading probably took place while the Mohican Formation and its equivalents were deposited in the Early or Middle Jurassic (Wade and MacLean 1990).

The most proximal minibasins appear to have welded out the earliest, with distal minibasins active the longest. This general trend is illustrated nicely near the centre of Figure 16 where minibasins above an Early Eocene marker are thickest. Similarly, the depth of burial of the crests of salt bodies by Cenozoic strata tends to decrease in the seaward direction (i.e. proximal salt bodies are typically buried by greater than

1000 ms of Cenozoic strata, whereas the crests of distal diapirs are generally buried by less than 500 ms of strata TWT). In part this reflects an increase in sedimentation rates in more proximal areas, but it is also consistent with salt in most proximal minibasins welding out first, with continued salt expulsion from more distal minibasins.

Long term narrowing of salt stocks could have been accomplished through passive loading combined with progressive turtle formation (see figure 11 of Albertz et al. 2010) or through shortening of the section to accommodate gravity gliding in the SD province (Deptuck et al. 2009; Deptuck 2010). There is an increased tendency toward contractional structures transitioning from the SD province to the DM province (Figure 17). These structures include detachment folds, fault propagation folds, reverse faults and thrust faults. In some cases the thickest parts of minibasins were inverted (Figure 9), with thrust faults in the basin centre (a structural style that is distinctly different than turtles, which are also recognized). The down-slope contractional response in some areas is quite complex, producing squeezed salt stocks, folds with variably oriented axes, and reverse/thrust faults with variable vergence. These are all believed to be structural products of down-slope shortening that accommodated up-slope extension and gravity gliding in the SD province.

Folding continued above the autochthonous salt layer or its primary weld until the mid to Late Cretaceous, and in some areas into the Early Paleogene. Upslope detachment (SD province) and down-slope shortening (proximal DM province) were therefore highly diachronous. There is also increased influence from the Lower Cretaceous Sable Island Delta towards

Proximal to distal postrift structural provinces of the western Scotian Margin

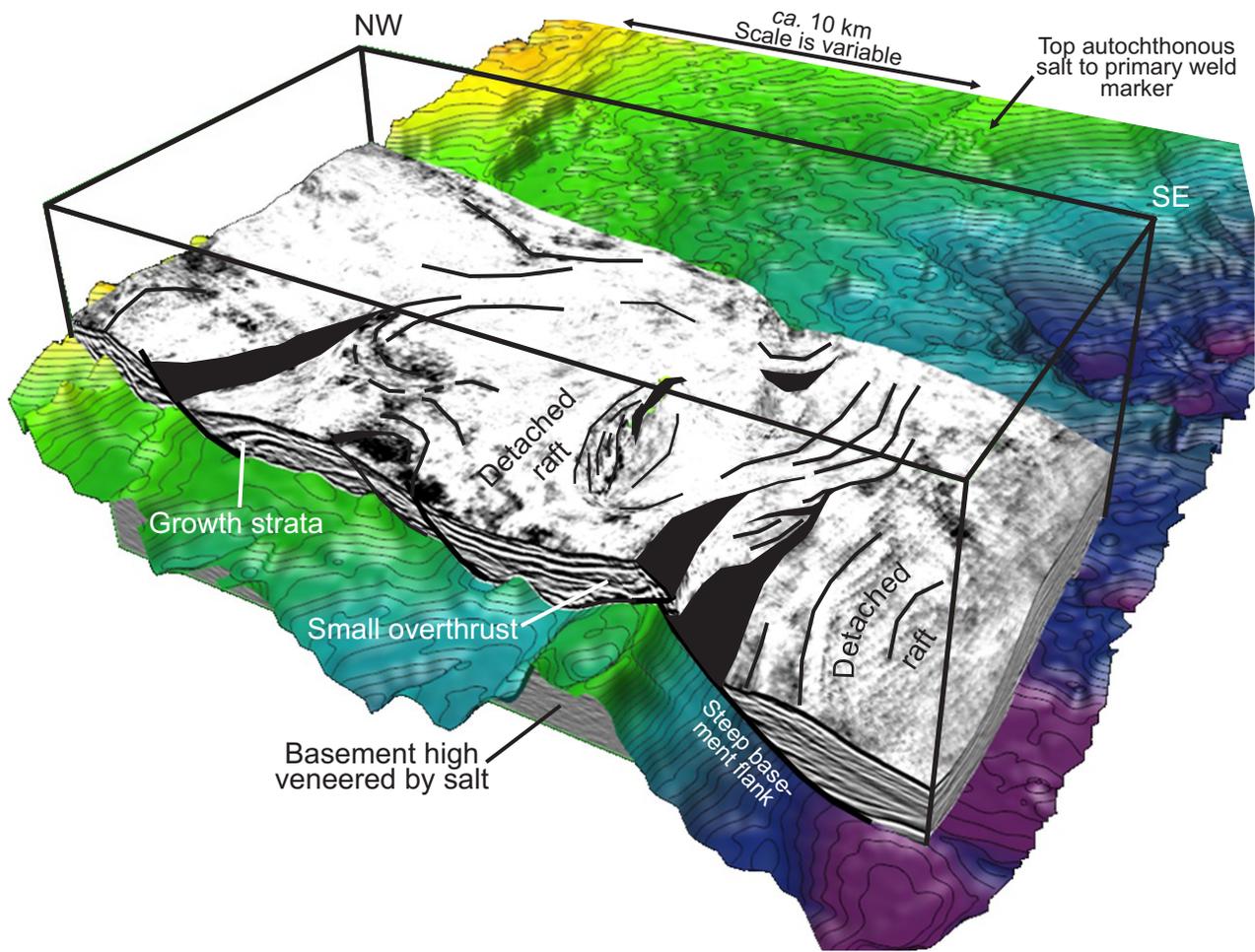


Figure 14 – Rafted blocks detaching above high-relief basement blocks veneered with autochthonous salt.

the northeast, where gravity spreading associated with southward progradation generated a series of down-slope contractional structures that include the Newburn fold-and-thrust belt (Deptuck et al. 2009) penetrated at Newburn H-23 (Figure 1).

It is noteworthy that many salt diapirs also experienced a younger period of rejuvenation when draped strata above diapirs were folded (Shimeld 2004). In the eastern part of the study area this may be explained by a significant landward step in sedimentation starting in the Miocene, during which a prominent contourite drift, up to 1.5 km thick, migrated up the slope above the eastern SD province (Campbell et al. in prep) (Figure 18). The load from this drift may be responsible for squeezing of diapirs directly down-slope from it, where prominent folds developed in the strata above most diapirs.

Area northwest of Shelburne Canopy:

The area northwest of the Shelburne Canopy (corresponding to salt subprovince I of Shimeld 2004) also contains minibasins flanked by elongated salt walls or isolated diapirs. The SD province inboard this region is very narrow or absent, and consequently the transition from the LaHave Platform is very abrupt (as shown in figure 5a of Albertz et al. 2010). This area is treated separately for the time being, because it is unclear whether all of the salt bodies mapped in this region were sourced from the autochthonous salt layer (with the thickest salt abruptly offset in the landward direction from the DM province to the east) or were sourced from an allochthon or inflated salt layer expelled from the Georges Bank area.

Seismic coverage and quality are poor, particularly in the western part of this area where the complexity of allochthonous salt

bodies also appears to increase (see hachured area in Figure 1). Isolated salt diapirs off the eastern flank of the Yarmouth Arch appear to define the western limit of the autochthonous salt basin, where numerous down-to-the-basin (seaward dipping) listric faults are believed to sole out in a primary salt weld. The Jurassic and Cretaceous succession across this region of listric faults is expanded and the succession probably corresponds to the 'Shelburne Delta' comprised of a thick regressive sandstone and shale package that loaded the autochthonous salt basin east of the Yarmouth Arch (Wade and MacLean, 1990, see their figure 5.4). Although poor data coverage makes the link between the region of listric faults (west) and the region of complex diapirs (east) tenuous, it is possible that some of the salt bodies northwest of the Shelburne Canopy formed from reloading of a salt allochthon that was expelled earlier from the Shelburne Delta, in addition to salt bodies that were expelled upwards from the autochthonous salt basin beneath this region. This could explain the extreme difficulty in confidently identifying and mapping the top autochthonous salt surface in this region.

Outer ECMA Province

The East Coast Magnetic Anomaly (ECMA) forms a prominent magnetic lineament along the eastern US margin that continues with a more complex character along southwest Nova Scotia (Klitgord and Schouten 1986; Keen et al. 1990). It splits into two parallel components (Dehler 2010), with an inner component that appears to be more irregular with wide offsets along its landward side, and an outer band that does not appear to show any major offsets (except for an abrupt bend just east of the Shelburne salt canopy), but does show some

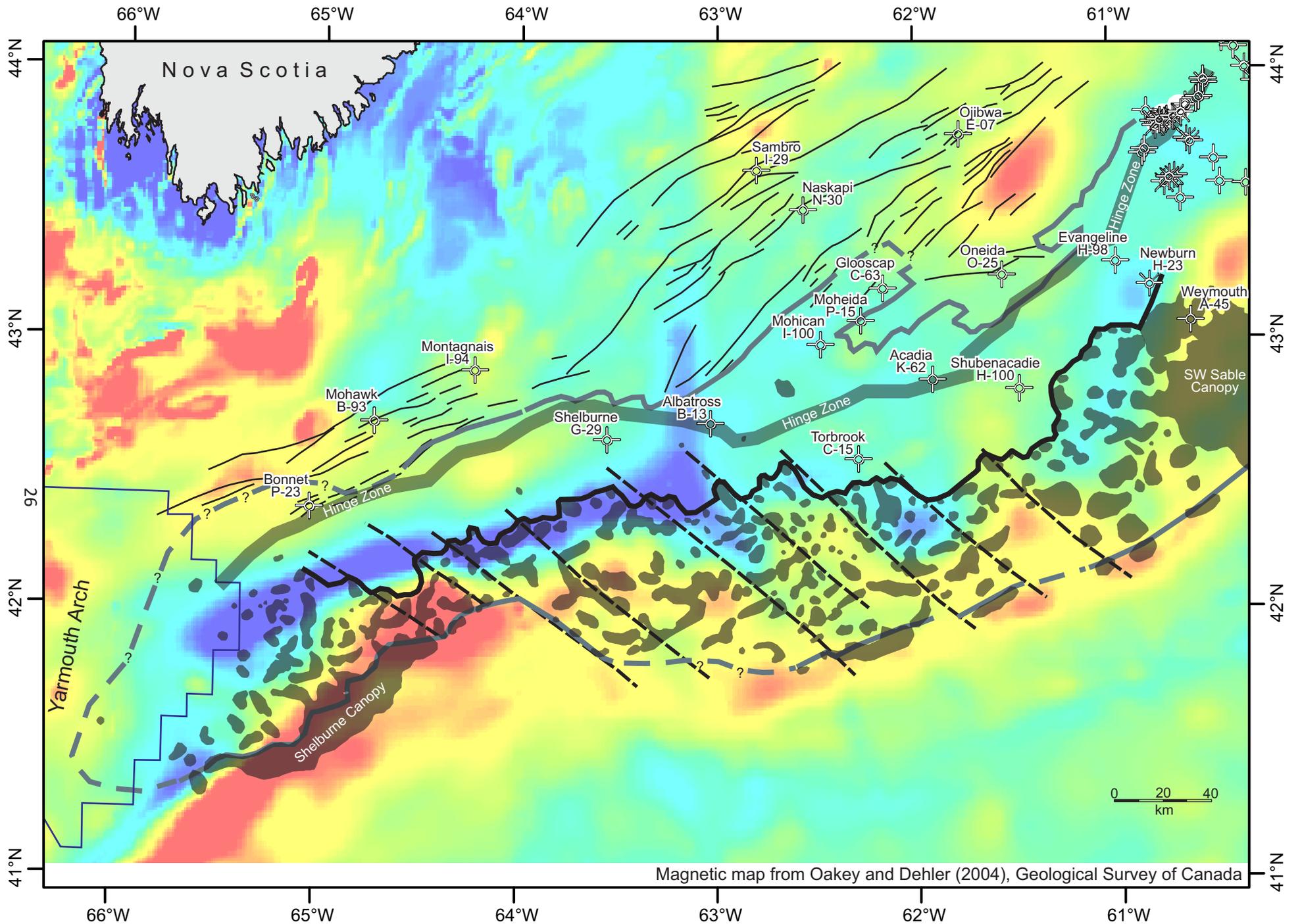


Figure 15a – Magnetic map of western Scotian Margin (from Oakey and Dehler, 2004), overlain by interpreted transfer fault and allochthonous salt bodies. Rift faults and graben complexes from Wade and MacLean (1990).

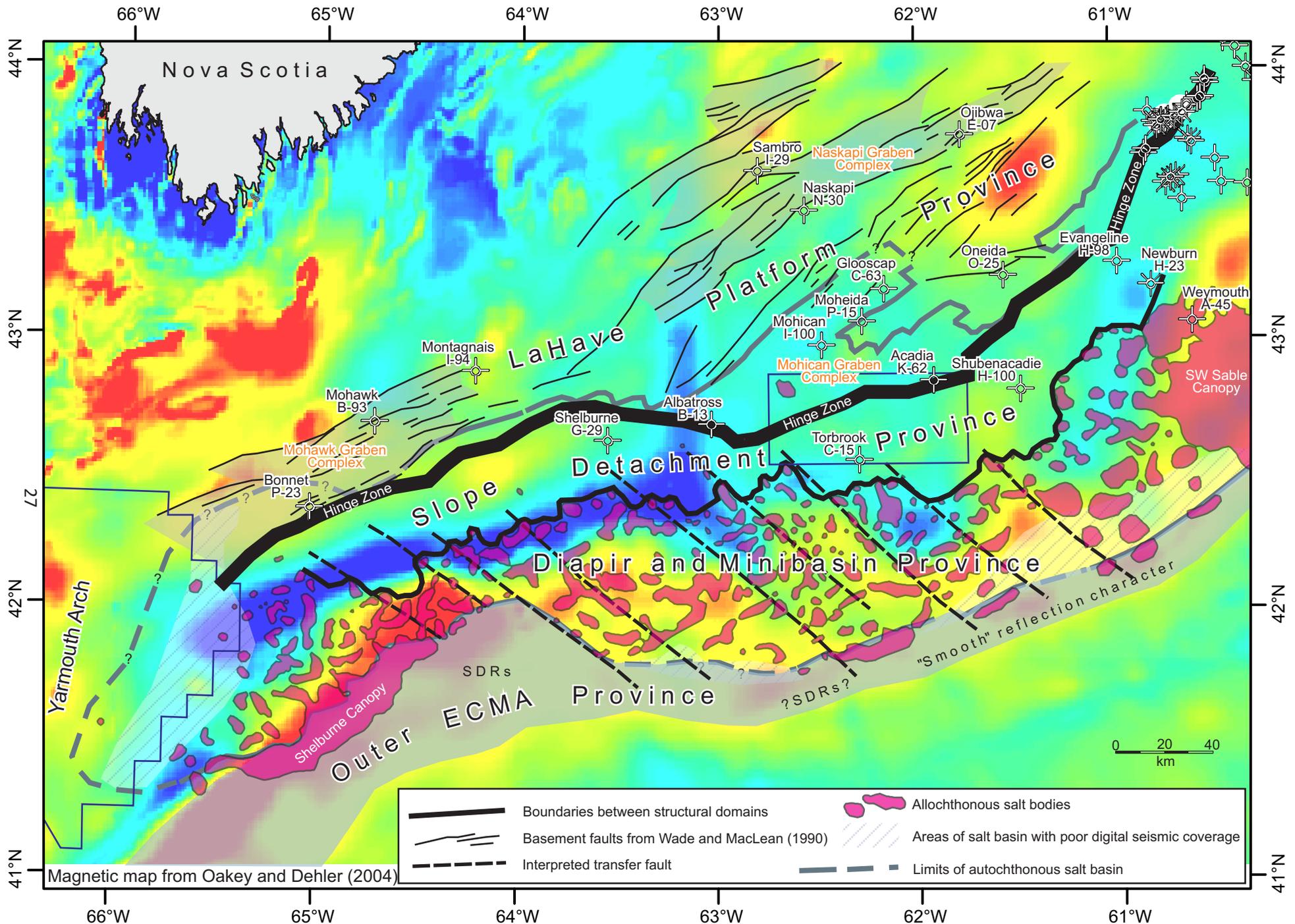


Figure 15b – Magnetic map of the western Scotian Margin (from Oakey and Dehler, 2004), overlain by key structural elements and the four postrift structural provinces described in this study. Note that much of the DM province overlies the inner part of the East Coast Magnetic Anomaly (ECMA), whereas the outer band of the ECMA lies outside the interpreted seaward boundary of the autochthonous salt basin. See text for details.

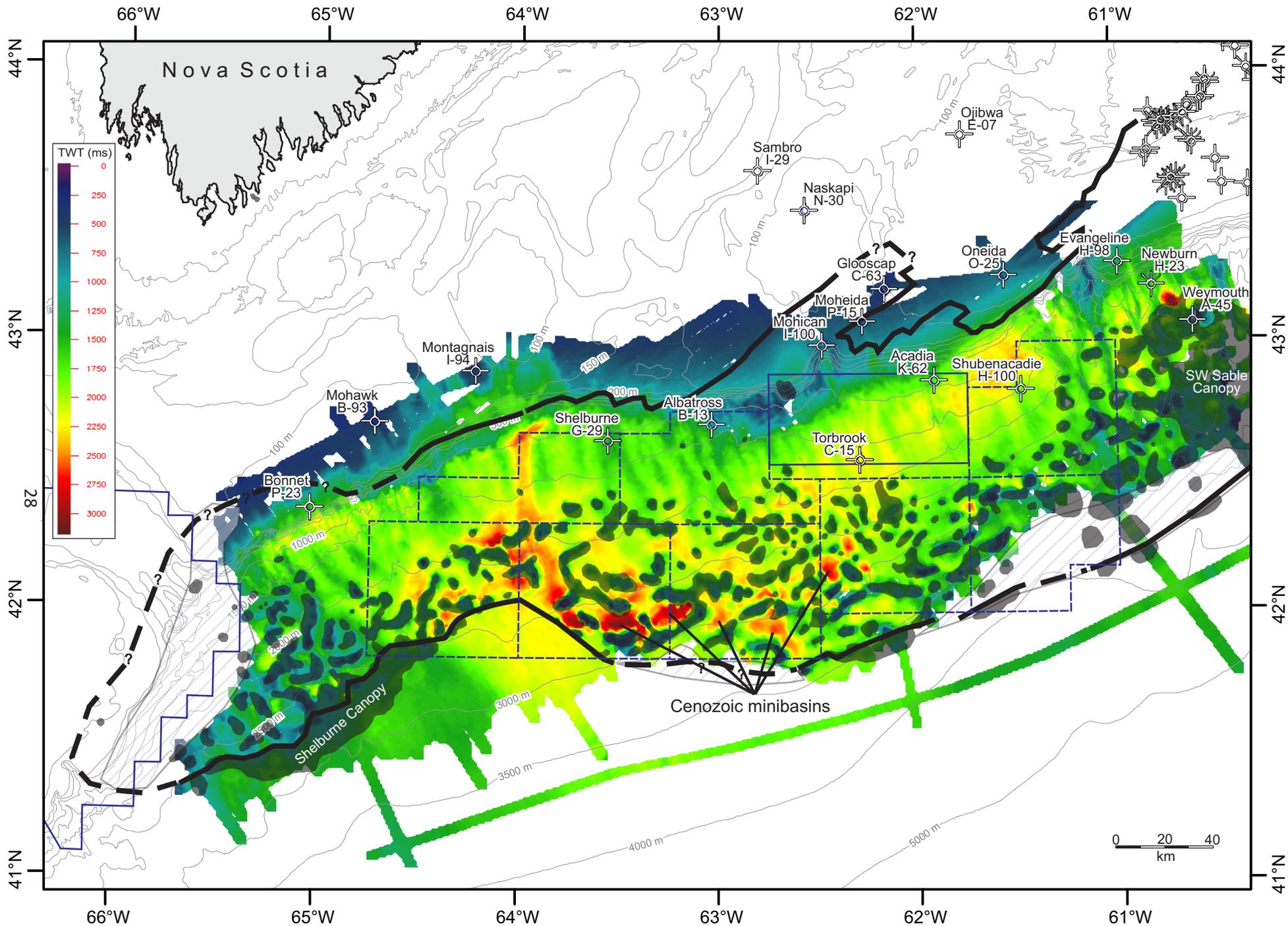


Figure 16 – Time-thickness map between the Early Eocene unconformity and the seafloor (approximately a Cenozoic thickness map, minus the Paleocene). Map shows a clear area of Cenozoic minibasins near the centre of the map.

lateral variations in magnetic intensity (Figure 15a).

It is clear that the autochthonous salt basin, and specifically the DM province, occupies the inner irregular band of the ECMA (Figure 15b). In contrast, the 'outer ECMA province' corresponds to the outer band of the magnetic anomaly found seaward of the DM province and seaward of the primary salt basin. It ranges in width from *ca.* 15 km (east) to 60 km (west), and merges with the full width of the ECMA toward the southwest. The landward boundary of the outer ECMA province closely coincides with the seaward limit of the autochthonous salt basin. The landward parts of the province are commonly overlain by salt tongues towards the east (the "salt overhang trend") and the larger Shelburne Canopy to the west (Figure 15b).

Data coverage across the outer ECMA province is limited in some areas (especially towards the northeast), but there appears to be a lateral trend in the seismic expression of reflective 'basement' rocks below Jurassic strata along this province. In the southwest, where the outer ECMA province is widest, basement rocks correspond to a broad region of seaward-dipping reflections (SDRs) (Keen et al. 1990; Keen and Potter 1995; Shimeld 2004). Towards the northeast, where the outer ECMA province is narrowest, the basement character is still quite reflective, but is dominantly flat-lying with only subtle hints of SDRs.

Regardless of the reflective basement character along the outer ECMA province, its seaward limit appears to coincide with an abrupt increase in basement faulting, rugosity, and relief that takes place near the seaward edge of the ECMA. The ECMA has commonly been used to approximate the boundary between

continental and oceanic crust (Klitgord and Schouten 1986; Keen et al. 1990). Keen et al. (1990) suggested in one scenario that the transition between the smooth and rough areas could correspond to a transition from basaltic rocks extruded above continental rocks (smooth) transitioning into true oceanic crust that underwent extension during and after its formation (rough).

Along the northeast US margin, the anomaly is known to be associated with SDRs (Keen and Potter, 1995) that formed near the end of rifting as a series of subaerial lava flows during a "brief but voluminous" period of extrusion (Jackson et al. 2000) that marks the end of rifting on volcanic margins (see also Larsen et al. 1994). Although there is significant debate about how far to the northeast subaerial volcanism continued along the Scotian Margin (see OETR Association 2011), if the flatter lying reflective character in the narrowest part of the outer ECMA province (inboard the faulted oceanic crust) is a product of *subaerial* volcanism, it implies that the outer parts of western Scotian Margin, and its Moroccan conjugate, were above sea level during earliest break-up. This period of subaerial "seafloor spreading" could have allowed salt, as well as restricted marine source rocks, to have accumulated in a restricted marine basin prior to widespread thermal subsidence of the margin taking place (Jackson et al. 2000; OETR Association 2011).

It is noteworthy that on a few seismic profiles it appears that the autochthonous salt layer can be correlated a short distance *below* the SDRs, supporting the view that the SDRs are younger than the salt, and that their emplacement bisected the original synrift autochthonous salt basin (see OETR Association 2011), at least along the western part of the margin.

Proximal to distal postrift structural provinces of the western Scotian Margin

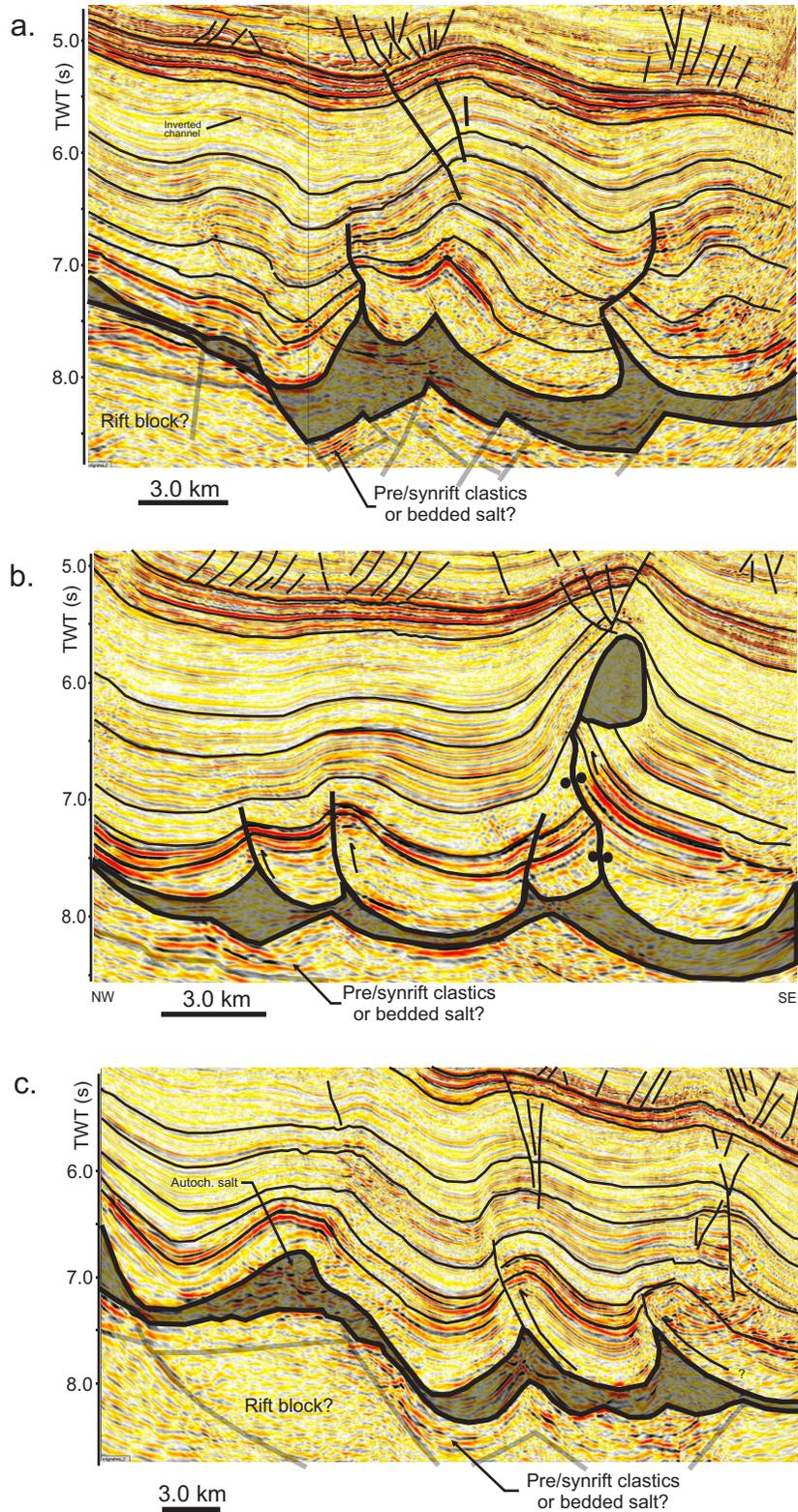


Figure 17 – Three seismic profiles across Jurassic to Cretaceous folds in the landward parts of the DM province in the eastern study area (see Deptuck, 2008).

Discussion and summary

The postrift deformation styles in the four structural provinces defined in this study were probably controlled by variations in the style and magnitude of postrift basement subsidence, preconditioned in part by the distribution of salt in the synrift autochthonous salt basin.

The LP province for the most part formed a stable slowly subsiding continental platform that accommodated up to four km of Jurassic, Cretaceous and Cenozoic strata dominated by non-marine to outer neritic depositional environments. In contrast, the SD province experienced significant asymmetric subsidence causing rifted basement and the overlying autochthonous salt basin to flex and tilt seaward of a prominent postrift hinge zone. The onset of postrift subsidence decoupled the deformation styles above and below the autochthonous salt layer. The widespread thin-skinned detachment (gravity gliding) of cover strata and associated raft tectonics are therefore a product of this seaward tilt. Where imaging allows, the SD province coincides with, and may form a useful proxy for, the area of most rapidly thinning continental crust away from the margin hinge zone. Subsidence in the distal parts of the SD province, where the crust was most attenuated, brought the top of the autochthonous salt basin (that at break-up was presumably close to or just below sea level) down to present day depths greater than 7-8 km, compared to just 3-4 km in the LP province.

In contrast to the SD province, postrift deformation in the DM province was dominated by expulsion of tall salt bodies, and postrift subsidence must have taken place relatively uniformly, such that down-building and passive loading of salt dominated (Albertz et al. 2010).

Tilting of the DM province was probably less important given the limited amount of seaward-leaning salt bodies, and lack of significant salt expulsion beyond the seaward limit of the autochthonous salt basin (see Albertz et al. 2010), perhaps with the exception of the area near the Shelburne Canopy. Some salt presumably flowed seaward from the SD province towards the DM province while the margin subsided, but it is difficult to know the extent to which this happened.

The outer ECMA province, if it corresponds to subaerial volcanics, would define a terrestrial boundary on the seaward side of a newly formed shallow marine basin. It is also possible that the short-term delay in subsidence caused by these subaerial volcanics could have allowed salt to continue accumulating for a short time after break-up (Jackson et al. 2000). However, when this volcanic wedge ultimately subsided below sea level, and true oceanic crust formed, the outer ECMA province ultimately sank 8 to 9 km to its present position. In terms of salt tectonics, the outer ECMA province is a region where localized salt tongues overhang Jurassic and Cretaceous strata in the northeast and a more significant salt canopy (Shelburne Canopy) flowed across Jurassic strata to the southwest (Figures 1, 15b). Emplacement of subaerial volcanics would also have loaded the autochthonous salt layer along the seaward boundary of the DM province as it split the original salt basin.

Why are there so few allochthonous salt bodies in the SD province?

Two end-member scenarios could explain the paucity of tall diapirs and allochthonous salt bodies in the SD province compared to the DM province. Autochthonous salt could have been expelled from the SD province towards the DM

province, thereby increasing the volume of salt and the propensity for diapirism (Scenario 1). This could have been accomplished through sediment loading in the SD province causing salt expulsion (Scenario 1a) or regional tilt of the top salt surface causing autochthonous salt to flow from the SD province to the DM province (Scenario 1b). The latter mechanism is gravitationally driven and does not necessarily require sedimentation so long as salt has enough time to flow (see Albertz et al. 2010).

Alternatively, the lack of tall diapirs over much of the SD province could simply reflect regional variations in the original depositional thickness of autochthonous salt, with more salt originally accumulating in the DM province (Scenario 2). In this scenario, the amount of synrift subsidence combined with offsets along transfer faults (Welsink et al. 1989) would be likely candidates for controlling where the thickest synrift salt could accumulate.

Scenario 1a seems unlikely everywhere except perhaps outboard the Mohican Graben, where Early to Middle Jurassic sediments are thicker, Scenario 1b is more difficult to evaluate and it is possible that some salt flowed seaward from the SD province towards the DM province in the Early Jurassic. This scenario would require an initial period of salt inflation followed later by sediment loading to form the DM province.

The preferred interpretation is that the paucity of allochthonous salt diapirs over much of the SD province reflects the original depositional thickness of autochthonous salt (Scenario 2), with only minor amounts of salt flowing generally only a few km from the seaward most part of the SD province (Figure 19).

In this scenario, the landward limit of the DM province would approximately define the

seaward transition into thicker autochthonous salt. The true transition probably corresponds more closely to the chain of sub-circular minibasins that form just inboard the DM province, from which the most proximal salt bodies appear to have been expelled. The landward limit of the most prominent salt bodies shifts in a stepwise manner from west to east (Figure 13c), and offsets of these basins by synrift transfer faults may ultimately be responsible for this pattern. Within the DM province, segmentation of the autochthonous salt basin along transfer faults, combined with the underlying rugose synrift fabric between transfer faults (rugosity is inferred but not generally observed below the DM province because of poor imaging), could also have influenced the observed orientation of many salt bodies.

Although diapir growth along much of the DM province probably took place during passive loading (Albertz et al. 2010), there is also clear evidence for Jurassic and Cretaceous shortening resulting in fold growth, particularly along the landward parts of the DM province (Deptuck et al. 2009; Deptuck 2010). Increased shortening in the areas immediately down-slope from a region of thin-skinned extension may also have enhanced diapir formation in the DM province.

Finally, increased rift accommodation below the DM province opens up some intriguing opportunities for other synrift to postrift marine deposits to have accumulated, including potential source rocks, but improved seismic imaging below the salt is needed to evaluate this.

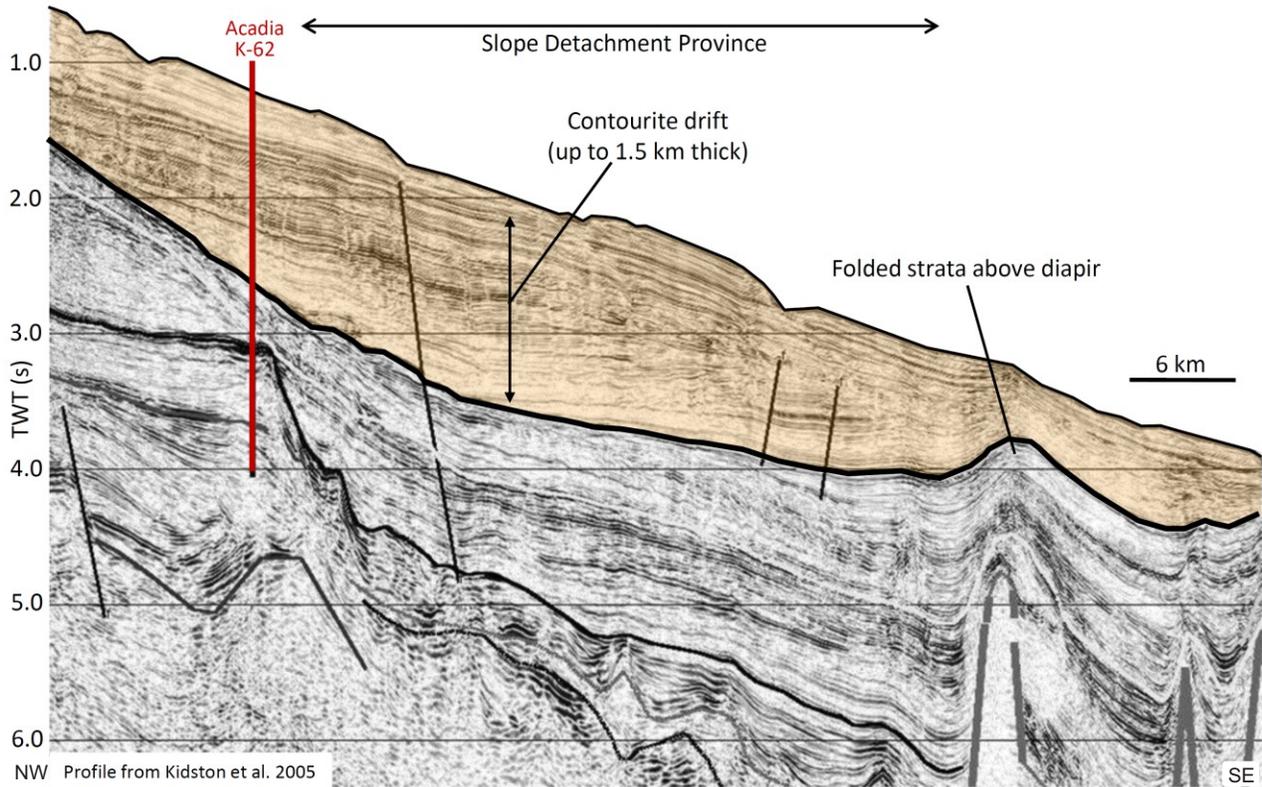


Figure 18 – Northwest- to southeast-oriented profile across a thick contourite drift that is thickest above the SD province. Aggradation of this drift may have prompted down-slope squeezing of pre-existing salt diapirs in the ASM province. Profile from Kidston et al., (2005).

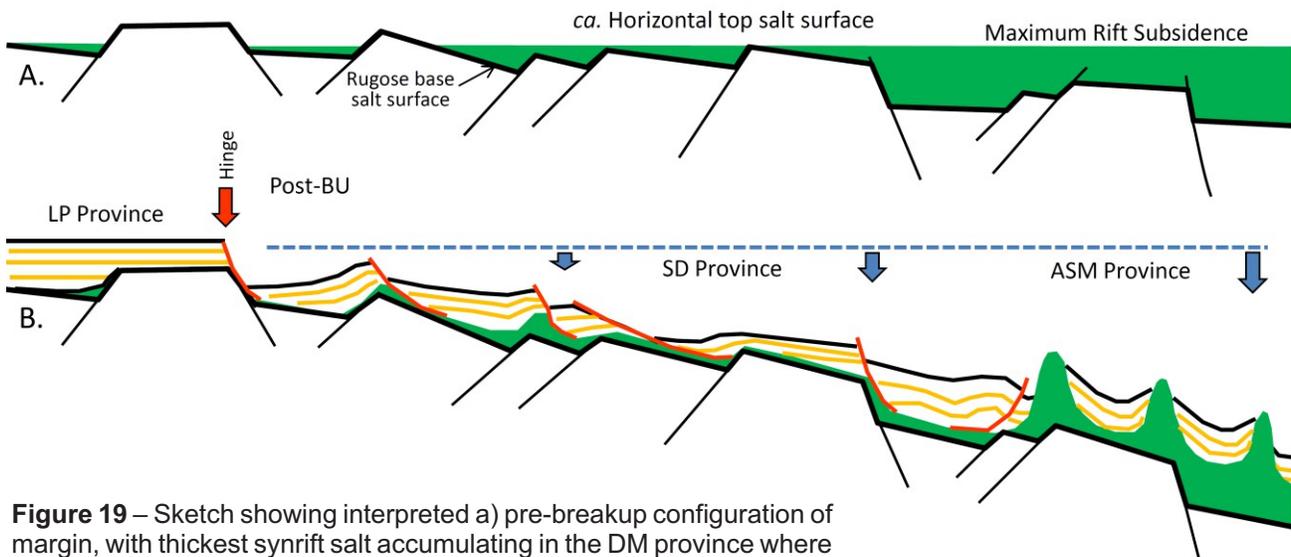


Figure 19 – Sketch showing interpreted a) pre-breakup configuration of margin, with thickest synrift salt accumulating in the DM province where maximum rift subsidence is inferred to have taken place; b) Early postrift configuration with detachment of Jurassic strata in response to hinge zone development and thermal subsidence. SD province was tilted seaward during this time, whereas the DM province may have subsided more uniformly. Contractional structures in the proximal parts of the DM province develop in response to up-slope extension due to gravity gliding.

NS11-1 parcel prospectivity

Parcel descriptions

The acreage in the NS11-1 Call for Bids is a mix of four industry nominated and four non-industry nominated parcels located in deepwater on the western Scotian slope (Figure 1b). The parcels are found in water depths ranging from *ca.* 1440 to 2730 m (Parcel 1), 1745 to 3070 m (Parcel 2), 2050 to 3375 m (Parcel 3), 1760 to 3765 m (Parcel 4), 2570 to 4200 m (Parcel 5), 1120 to 3750 m (Parcel 6), 975 to 2200 m (Parcel 7), and 920 to 1930 m (Parcel 8).

Few wells have been drilled on or near any of the NS11-1 parcels. Shubenacadie H-100 (TDs in Cenomanian strata on the slope) is located just inside Parcel 6. It was spudded by Shell in 1982 and was Nova Scotia's first deepwater test. The primary target was an interpreted lower Tertiary turbidite fan, and the secondary target was a Miocene "bright spot" believed to be a direct hydrocarbon indicator. The well did not encounter any hydrocarbons and the primary target was later determined to be an upper slope erosional remnant composed predominantly of chalks and marls.

Albatross B-13 (TDs in late Middle Jurassic strata of the Abenaki Formation) is located in the northern part of Parcel 7. The primary target was the Jurassic carbonate bank edge. Scattered porosity was observed throughout the Baccaro Member with partial loss of circulation occurring in some intervals. Modest mud-gas peaks were recorded at two intervals, 3434-3440 m and 3012 m, but no hydrocarbon bearing zones were encountered (Kidston et al. 2005). The trap at this location may have been breached by the prominent Early Eocene unconformity, which cuts down to the top of

the carbonate bank at this location (see Figure 6).

Shelburne G-29 (TDs in Upper Jurassic strata on the slope) is located in the northeast corner of Parcel 8. The primary target, an interpreted Upper Cretaceous to Lower Tertiary submarine, was later determined to be an erosional remnant composed predominantly of chalks and marls, similar to what was found in Shubenacadie H-100. The secondary target was an interpreted salt-cored carbonate promontory draped by Middle Jurassic oolitic shelfal limestones (Kidston et al. 2007). A six meter section of Jurassic carbonates was penetrated at the base of the well with oolitic wackestone, but these were likely resedimented from the bank edge to a foreslope setting above what is now believed to be a rift-related northeast-trending basement high (see Figure 13a).

No wells have been drilled on parcels 1 through 5, but Torbrook C-15 (TDs in probable Miocene strata) is located 7.3 km north of Parcel 4. The primary targets in this well were Miocene submarine fans, which were found to be siltstone and claystone dominated.

Potential traps

Parcel 1 straddles the SD, DM and Outer ECMA provinces while Parcels 2 and 5 straddle the DM and Outer ECMA provinces. Parcels 3 and 4 lie almost exclusively above the DM province, while Parcels 6, 7, and 8 straddle the SD and DM provinces. The northern part of Parcel 7 also extends onto the LP province (Figure 1b).

All eight NS11-1 parcels are located, at least in part, above the diapir and minibasin (DM) province on the western Scotian Slope. Most potential hydrocarbon traps here are associated

in some way with structures produced by or adjacent to prominent salt bodies (diapirs, walls or tongues). Multiple potential drilling targets are present in Cenozoic to Jurassic age strata that can generally be grouped into four categories:

a) Structures above salt diapirs: Numerous four-way dip closures are present above salt diapirs in the DM province. They are commonly associated with younger periods of contraction that squeezed salt stocks and folded overlying Cenozoic strata. Some structures show strong evidence for direct hydrocarbon indicators (DHIs) like flat spots, anomalously high amplitude seismic reflections, and gas chimneys. Strong amplitude variations are also present across some fault planes that offset diapir crests.

b) Structures on salt flanks and below small salt overhangs: Numerous potential three-way closures against salt flanks or below small salt overhangs are present within minibasins of the DM province (e.g. right side of Figure 17b; left side of Figure 20b). Some cover areas greater than 25 km² while most are smaller but could have three-way closure at multiple Cretaceous through Cenozoic stratigraphic levels.

c) Structures between salt bodies associated with welded turtles: Structures associated with passive loading and turtle formation have been identified in several parcels. Some of these structures have four-way dip closure areas upwards of 30 km² (e.g. Figure 20a). A unique turtle structure is found in Parcel 4 (Figure 20b) that may have formed after salt tongues from adjacent feeders covered (or partially covered) the underlying minibasin and was later reactivated during deposition of the yellow unit. It is not known why the flanks of the underlying minibasin did not deflate to form a deeper

turtle, but it could indicate that salt below the deeper minibasin still has not welded out.

d) Structures between salt bodies associated with contraction: Numerous structures associated with shortening down-slope from the SD province have been identified in the NS11-1 parcels. In some cases, the entire fill of a minibasin has been inverted, producing structures that can be mistaken for turtles, particularly on profiles oblique to the shortening direction. In Figure 20c, a thrust fault has developed in the basin centre. This configuration probably requires local welding out of the autochthonous salt layer above an angular basement block that then acts as a local buttress. Numerous other contractional structures are recognized in the landward parts of the DM province, including thrust propagation folds, salt cored detachment folds, and reverse faults (Figure 17).

Parts of Parcels 1, 6, 7, and 8 are also located over the slope detachment (SD) province. A number of potential structural and stratigraphic traps are possible here. Most structures are associated with rotation of rafts above the autochthonous salt layer, in some cases influenced by the rugose faulted geometry of the rocks that underlie the salt. The raised edges of Jurassic rafts form angular discordances that are draped by Cretaceous strata. Such structures could form unconformity traps.

Potential stratigraphic traps include Cenozoic turbidites that onlap the steep slope in the SD province or accumulated above a step on the gradient profile (constructed during aggradation of Neogene contourites; see Campbell and Deptuck, In Press). Some of these onlap traps are associated with strong amplitude anomalies that could be DHIs.

Proximal to distal postrift structural provinces of the western Scotian Margin

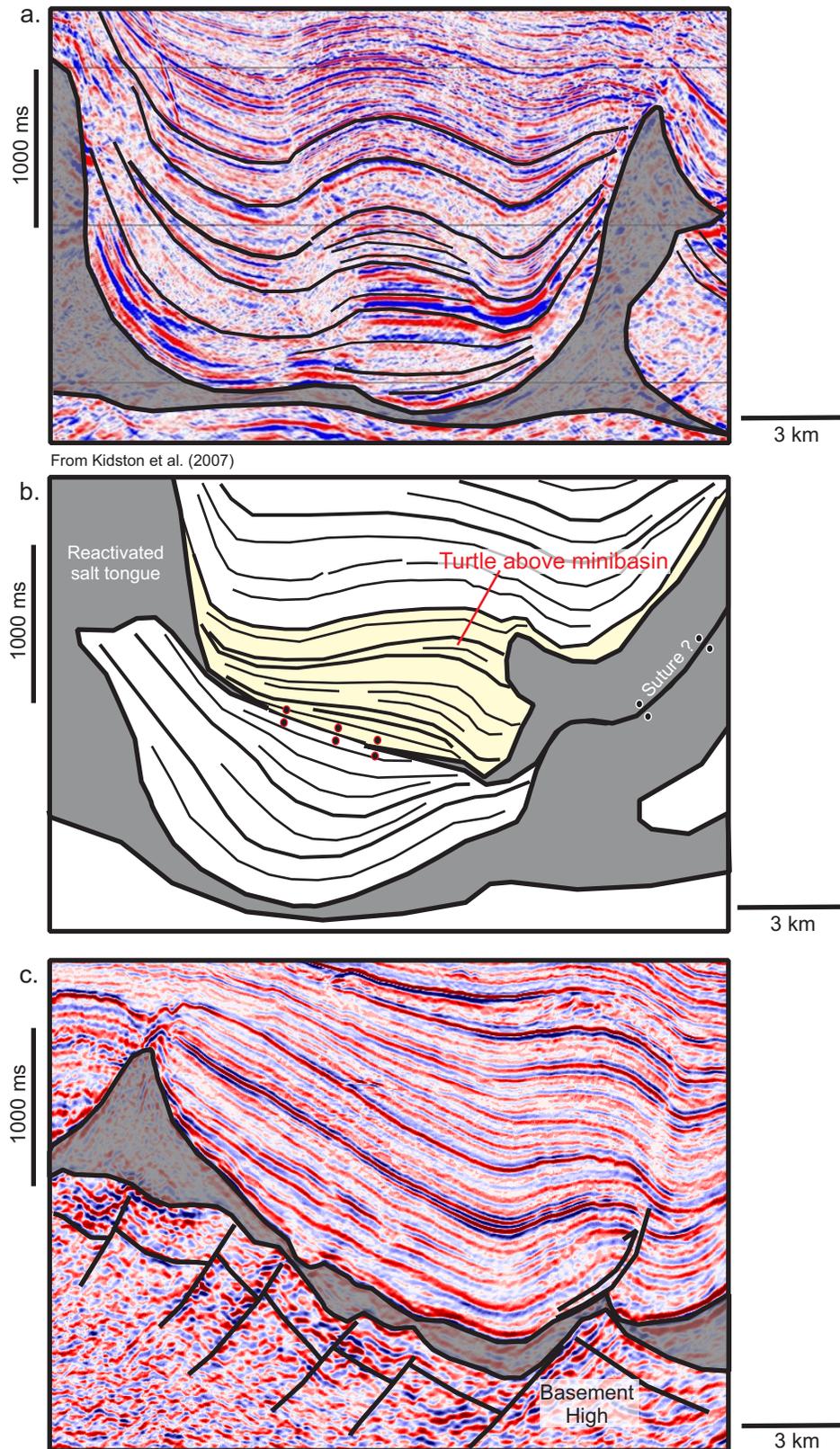


Figure 20 – a) Turtle structure in the DM province (Parcel 3); b) Unique late turtle structure (yellow) perched above a minibasin (Parcel 4); c) Inverted minibasin near the transition of the SD and DM provinces (Parcel 1) formed as shortening accommodated up-slope gravity gliding.

Finally, the landward part of Parcel 7 extends onto the carbonate bank (LP province), where the bank is underlain by the autochthonous salt basin (near Albatross B-13; Figure 1b). Here, the presence of salt, coupled with the proximity of the margin hinge zone, causes a large 1.2 sec (twf) thick section of the carbonate bank to detach and rotate, forming a large potential trap near the mouth of the Mohican Graben Complex.

Potential reservoirs

Evaluating the potential for Jurassic and Cretaceous deepwater reservoirs in the areas of Parcels 1 to 8 is hampered by a number of factors. For example, only one well, Shelburne G-29, tests the Jurassic to mid-Cretaceous deepwater succession on the western Scotian Margin, and this well was drilled on the upper SD province above a prominent basement high (rift block) where the pre-Turonian succession is highly condensed or was eroded. The limited number of well penetrations and poor digital seismic quality and coverage on the outer shelf (LP province) also hinders the study of potential depositional systems that could have supplied sands to the shelf edge. This is compounded by widespread erosion after the Montagnais bolide impact that removed parts of the outer shelf where prograding clinoforms from Cretaceous or Paleocene shelf edge deltas, if they existed, would have been found. Still, a number of observations suggest there are several potential shelf sources for deepwater sands on the western slope that warrant further evaluation.

In the Jurassic, three siliciclastic successions are recognized on the platform that may have periodically delivered sands to the paleo-shelf edge. The Lower to Middle Jurassic Mohican Formation, comprised largely of immature clastics, is found below the Bathonian Scatarie

Member (carbonate). Landward of Parcels 3 and 4, a pre-Scatarie shelf margin is preserved north and west of Acadia K-62. Here, a rapidly thickening progradational clastic wedge is recognized, containing up to 2000 m of Mohican-equivalent strata (Wade and MacLean, 1990). Similarly, localized pre-Scatarie progradational clinoforms are observed near the Albatross B-13 well (below TD) and in the outer parts of the Mohawk Graben Complex (Figures 1a, 21b). Accommodation for these clastic units was provided through salt expulsion at a time when the hinge zone was in the early stages of development.

The Middle to Upper Jurassic Mohawk Formation, comprised of shallow marine siliciclastics, and its time equivalent Mic Mac Formation, comprised of a mix of clastics and carbonates (Given 1977; Wade and MacLean 1990) are known to exist inboard the Jurassic carbonate bank along the western part of the margin. Here, these formations have traditionally been considered the proximal equivalents of the Abenaki Formation that occupies the outer rim of the LaHave Platform. However, there are some indications that the inboard clastic systems periodically breached the carbonate bank. For example, Mohawk B-93 penetrated a 505 m thick texturally mature sand-dominated Upper Jurassic interval, of which 194 m were porous sands averaging 23% porosity (Given 1977). On the outer platform seaward of the Mohawk B-93 well location, an interval of prograding clinoforms is present above the Scatarie marker defining a 150 ms thick (two-way time) forced regressive wedge that was abruptly truncated at the margin hinge zone (Figure 21b). This provides clear evidence that the inboard clastic systems were able, at least locally, to prograde across the carbonate

Proximal to distal postrift structural provinces of the western Scotian Margin

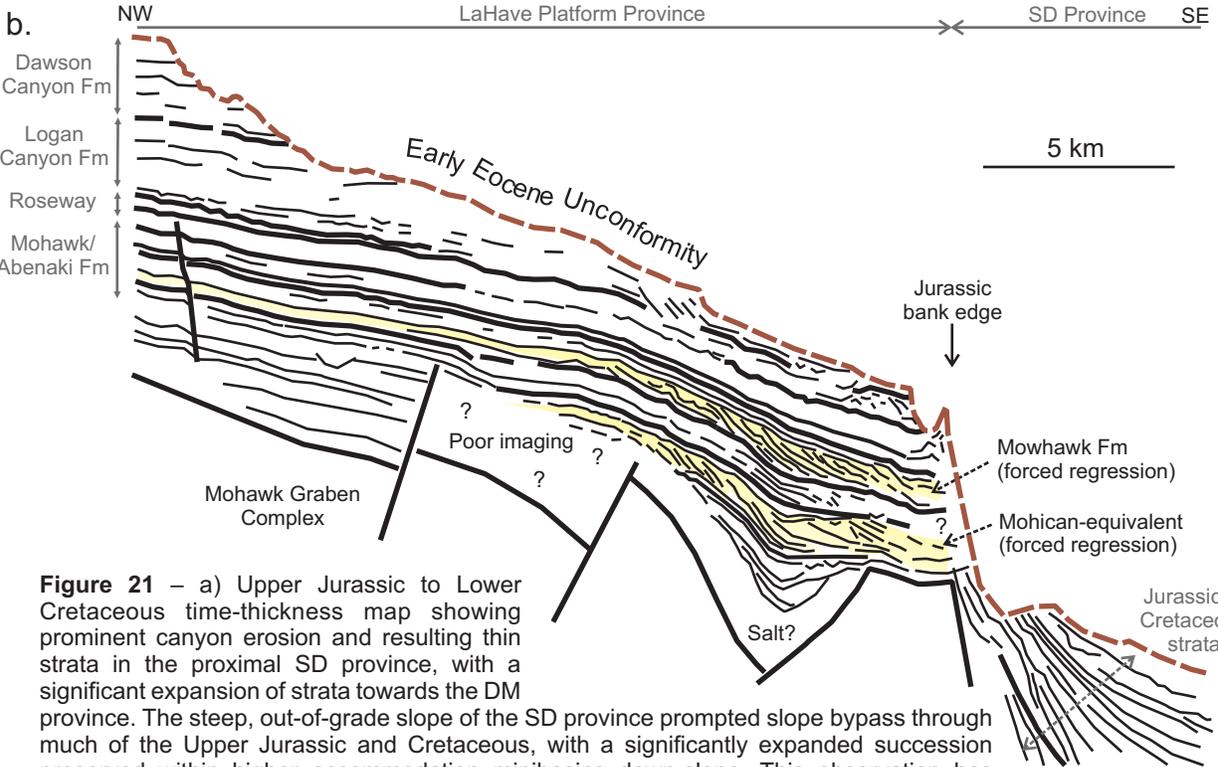
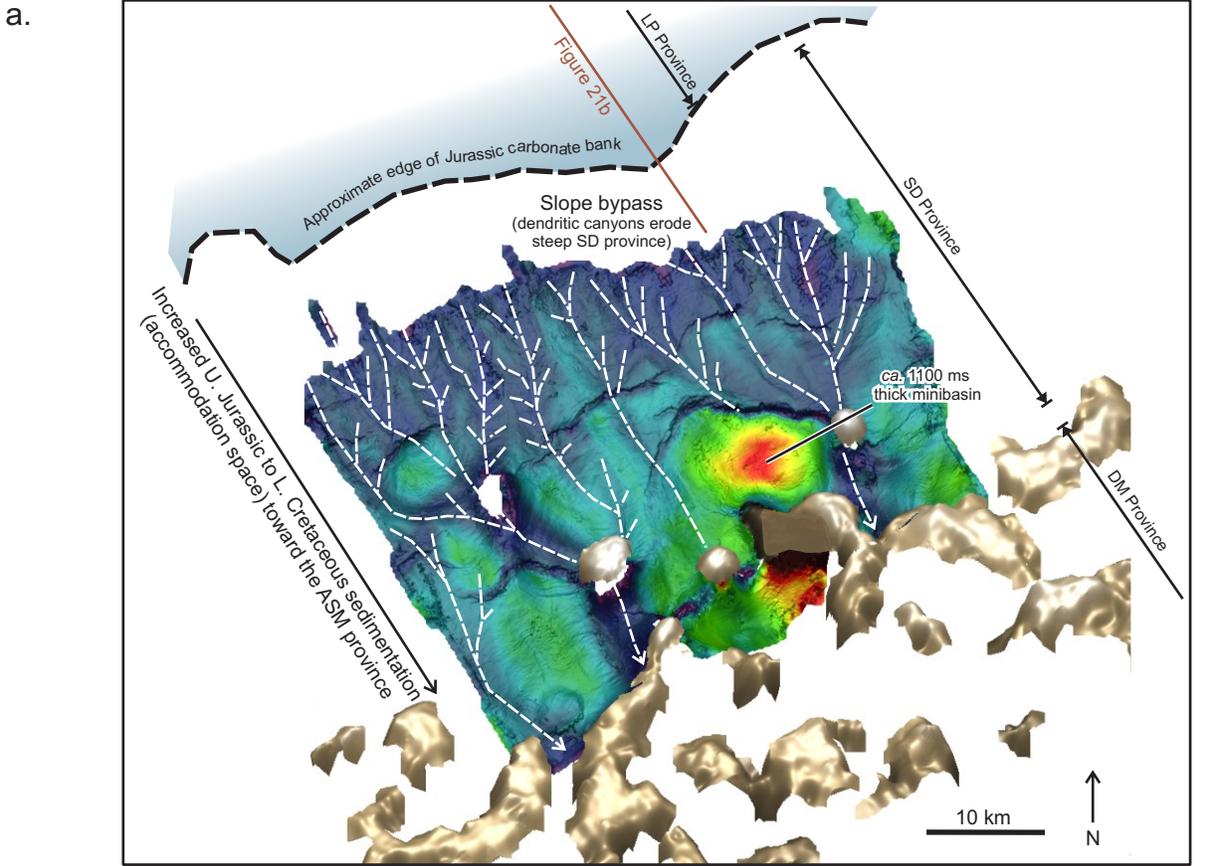


Figure 21 – a) Upper Jurassic to Lower Cretaceous time-thickness map showing prominent canyon erosion and resulting thin strata in the proximal SD province, with a significant expansion of strata towards the DM province. The steep, out-of-grade slope of the SD province prompted slope bypass through much of the Upper Jurassic and Cretaceous, with a significantly expanded succession preserved within higher accommodation minibasins down-slope. This observation has important implications for the presence and style of potential deepwater reservoirs in the SD versus DM provinces; b) Seismic profile line drawing from the outer part of the LaHave Platform seaward of Mohawk B-93, showing two intervals of progradation (interpreted forced regressions) that probably delivered sand to the Jurassic slope.

bank delivering sediment directly to the steep slope that characterizes the SD province.

The distribution of such deposits elsewhere on the margin is not known. Further east, Wade and MacLean (1990) described an unconformity within the Scatarie Member at Acadia K-62 that may be equivalent to the upper prograding clastic wedge in Figure 21b. It is possible that the record of sea level lowstands across much of the low-accommodation LaHave Platform is expressed by thin forced regressive wedges that are preserved only where enough accommodation exists along the outer platform. Elsewhere, lowstands in sea level may be expressed as single disconformable surfaces within the carbonate bank that are difficult to identify on seismic profiles.

In the Cretaceous, deltas on the LaHave Platform may also have delivered sand to the shelf edge. Lower Cretaceous strata (Berriasian to early Aptian) are condensed above the LaHave Platform west of Mohican I-100, where they are largely represented by carbonates with intervening clastics of the Roseway Unit (Wade and MacLean, 1990). However, parcels located furthest east may contain Lower Cretaceous turbidite sand reservoirs sourced from sand-rich deltas along the western Sable Subbasin (Deptuck, 2008). Aggradation and progradation of Logan Canyon to Dawson Canyon formation clastics later in the Cretaceous may also have supplied sands to the edge of the LaHave Platform inboard Parcels 4, 5, and 6. On seismic profiles near Oneida O-25 and Acadia K-62, for example, multiple erosional features (incised valleys?) are recognized in this shelf interval. Further west, however, widespread erosion of this interval along the margin hinge zone makes sand delivery to the shelf edge hard to evaluate (see Figure 6).

Interestingly, several periods of Jurassic and Cretaceous canyon incision are recognized all along the SD province. Though the grade of clastics is not known, they indicate that sediment was periodically transported from the margin hinge zone, down the steep slope, and toward the DM province. Figure 21a shows a dendritic network of canyons cut the steep slope seaward of the hinge zone. Upper Jurassic to Lower Cretaceous strata are thin across this region, but seismic markers diverge down-slope into a significantly expanded section, indicating a transition from sediment bypass to sediment accumulation. Here, well-developed Upper Jurassic to Lower Cretaceous minibasins with up to 2 km of sediment are found in the distal parts of the SD province and into the DM province. Several 'chains' of similar interconnected Jurassic and Cretaceous minibasins are observed all along the margin in front of this bypass slope, and these basins warrant further study to determine their potential for trapping turbidite sands.

Finally, there are several locations along the western margin where Cenozoic strata prograded to or beyond the shelf-edge, with a number of canyons that could have transported sands into deep water. The thickest Cenozoic minibasins are located in the central parts of the DM province in the area of Parcels 1 to 4 (Figure 16), and these basins may have formed the primary sink for Cenozoic turbidite systems.

Source rocks and maturity

According to the Play Fairway Study (OETR Association 2011), there is evidence for a Lower Jurassic oil prone source rock above the autochthonous salt basin along the western half of the margin. This conclusion is based on a number of observations including the analysis of oils found in several piston cores. Petroleum

system modeling indicates that oil expulsion continues today along the southwestern Scotian Slope where the Lower Jurassic section is found at relatively shallow burial depths (compared to the Sable Subbasin region). As such, even young traps, like late Cenozoic strata that were folded above salt diapirs, could be viable plays. The reader is directed to the Play Fairway Study (OETR Association 2011) for a more detailed account of this interpretation.

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Proximal to distal postrift structural provinces of the western Scotian Margin

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