THE ROUND HEAD THRUST, WESTERN NEWFOUNDLAND: A REACTIVATED BASEMENT NORMAL FAULT AT THE APPALACHIAN STRUCTURAL FRONT [Panel 1 of 2]

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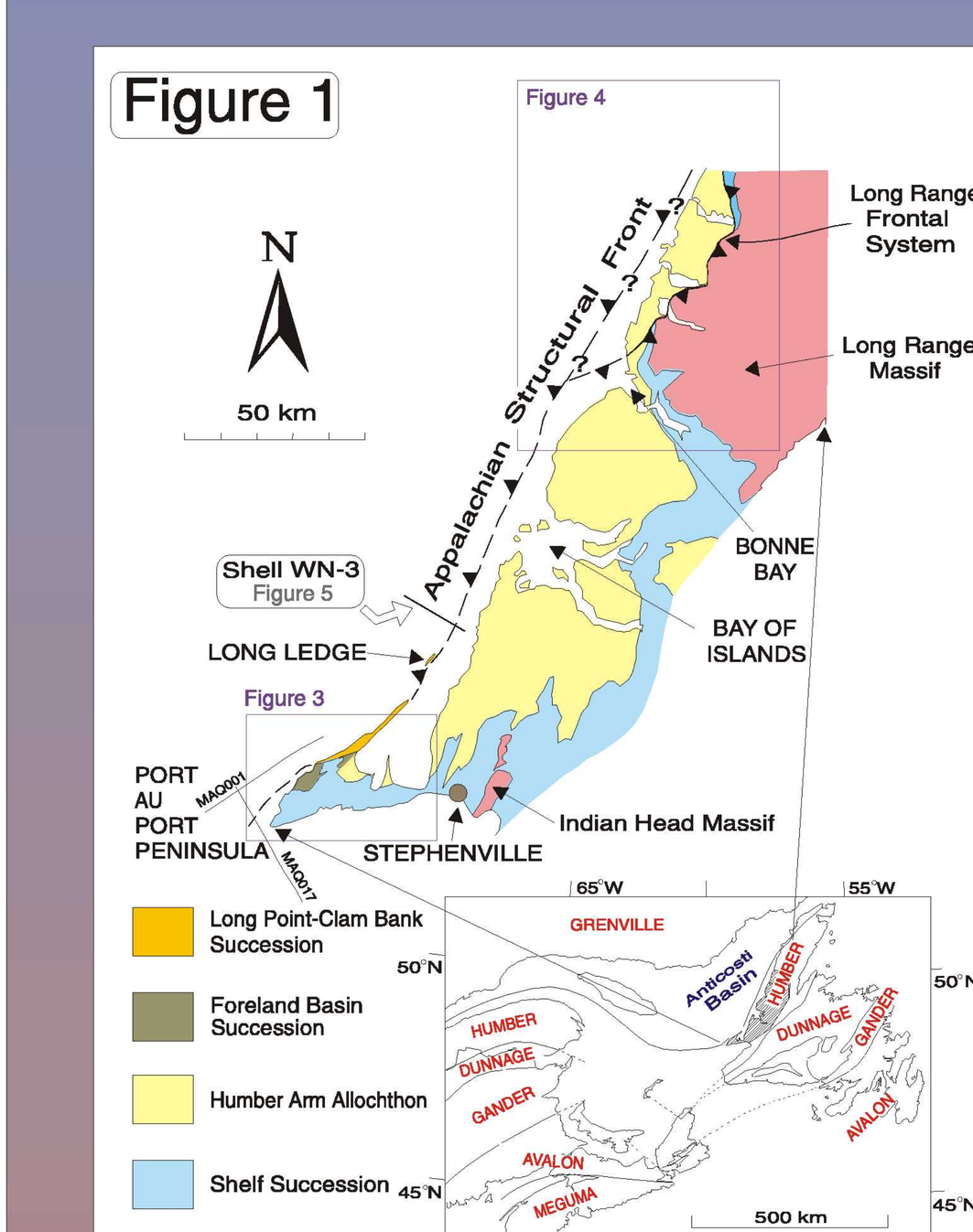


Figure 1: Regional location map for the southern external Humber Zone, western Newfoundland. Inset map at bottom right shows western Newfoundland in the context of tectono-stratigraphic zones of the Canadian Appalachians, as defined by Williams et al. (1988). The Appalachian structural front is principally a submarine feature off the west coast of Newfoundland, but is exposed onland on the Port au Port Peninsula. The locations of more detailed geological maps, shown in figures 3 and 4, are indicated. Also indicated are the locations of critical offshore industry seismic lines, in the public domain.

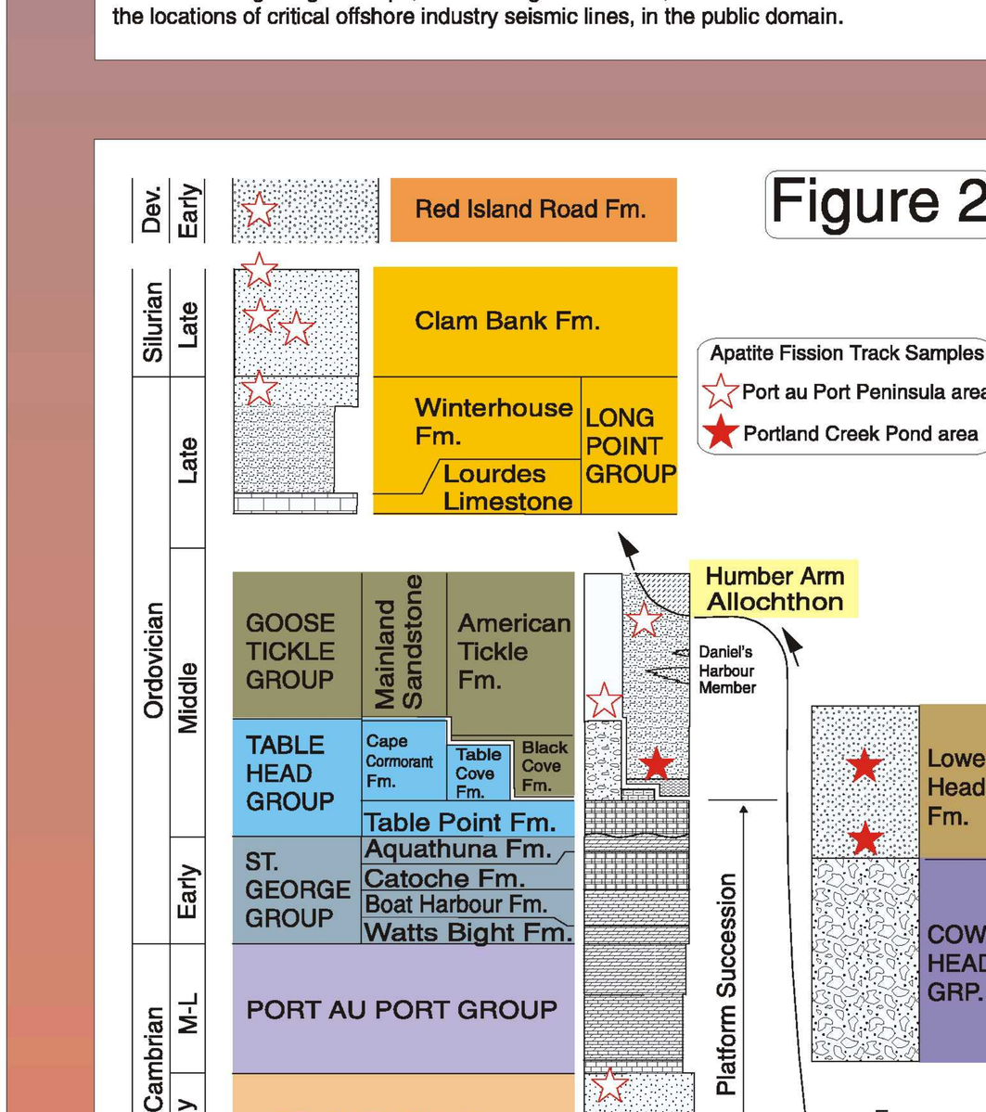


Figure 2: Generalized stratigraphic column for the Port au Port Peninsula and the Bonne Bay-Table Point area, based on James et al. (1988) and Stenzel et al. (1990). Sub-Labrador Group basement may include rift-facies rocks not known from surface exposures. Dominant lithologies are indicated by shading: Dots and small circles, sandstone; dashes, shale; bricks, limestone; diagonal bricks, dolostone; dots and irregular blocks, carbonate conglomerates. Stratigraphic positions of AFT samples indicated by stars (open stars - Port au Port area; filled stars - Bonne Bay-Table Point area).

Introduction and Regional Setting

The Appalachian structural front, western Newfoundland, marks the cratonward boundary of the external Humber zone (Figure 1), which is characterized by Cambro-Ordovician platformal sediments overridden and deformed during early to middle Paleozoic orogenesis (Williams, 1979). The principal periods of deformation include: (1) the Middle Ordovician Taconian Orogeny, which involved initial implacement of ophiolitic complexes onto the former passive margin; (2) the Silurian Salinic Orogeny; (3) the Devonian Acadian Orogeny; and (4) early to middle Carboniferous transpressional and transtensional deformation associated with the Cabot Fault system. Western Newfoundland has recently become the focus of renewed petroleum exploration activity in the wake of reinterpretations of its structural and tectonic setting (Stockmal and Waldron, 1990, 1993; Waldron and Stockmal, 1991, 1994); oil and gas exploration targets include the early Paleozoic platformal succession as well as the overlying Appalachian foreland and successor basins (Figure 2).

Structures associated with the Appalachian structural front include both thin-skinned and thick-skinned thrusts. Thin-skinned deformation is manifested at the structural front by a triangle zone (a blind tectonic wedge). The thin-skinned triangle zone is overridden locally by oblique, thick-skinned, basement-involved thrusts. Stratigraphy preserved in the hanging wall of the best-exposed thick-skinned thrust indicates that the fault developed initially as a normal fault during the earliest stages of orogenesis, and was later reactivated in a reverse sense during late-stage orogenesis.

The nature and age of features preserved at the Appalachian structural front are assessed through numerical inversion of apatite fission track data. This approach allows us to constrain the low-temperature thermal history of the area. Fission tracks in apatite anneal at temperatures between approximately 60° C and 120° C, at normal geological heating rates. This temperature range overlaps the range appropriate for the early generation of liquid hydrocarbons; apatite data therefore provide crucial information for assessing petroleum prospectivity. Here, we focus on two areas at the Appalachian structural front: Port au Port Peninsula (Figures 1 and 3), and the Bonne Bay-Table Point area (Figures 1 and 4).

Port au Port Peninsula

The Appalachian structural front is exposed on Port au Port Peninsula (Figures 1 and 3), where the ESE-directed upper detachment of the thin-skinned triangle zone, the Tea Cove Thrust, is overridden by the NNW-directed, thick-skinned, Round Head Thrust. The geometry of the thin-skinned triangle zone is imaged in offshore industry seismic data, as shown in Figure 5 (Stockmal and Waldron, 1990), where the Humber Arm Allochthon has been tectonically introduced between sediments of the Taconian and the Salinian-Acadian foreland basin successions. The Tea Cove Thrust lies immediately below the Late Ordovician Lourdes Limestone, of the Long Point Group (Figures 2 and 3), as constrained by exposures on Long Ledge (Figure 1).

Figure 6 is a cross section modified after section 'E' in Stockmal and Waldron (1993) on the basis of industry seismic reflection data gathered in 1991 and 1993 (Curtis Evert, Hunt Oil Co., personal communication, 1993). The cross section is constructed where the trace of the thick-skinned Round Head Thrust overrides and deflects the trace of the Tea Cove Thrust. These seismic data also suggest the progressive southwestward development of an imbricate thrust in the footwall of the Round Head Thrust, here termed the St. George Thrust (Figure 6). A minor, more closely spaced en echelon footwall imbricate to the Round Head Thrust is shown in Figure 3 as the Cape Cormorant Thrust.

Figure 7 is a schematic cross section based on offshore industry seismic reflection data in the public domain, and industry seismic data gathered in 1991 (Curtis Evert, personal communication, 1991). It shows the thick-skinned St. George Thrust as a blind thrust, with displacement transfered to the surface along the SE-directed Red Island Thrust. The toe of this thick-skinned triangle zone lies within the Long Point Group (Figure 2). The thin-skinned triangle zone may lie in the hanging wall of the St. George Thrust. Large down-to-the-south normal faults, which bound the south coast of Port au Port Peninsula (Figure 3) and accommodate thick accumulations of Carboniferous strata in St. George's Bay, truncate the Round Head Thrust in Figure 7.

The preserved stratigraphy in the immediate hanging wall of the Round Head Thrust indicates that the fault formed initially as a normal fault, and was later reactivated in a reverse sense (Stenzel et al., 1990; Stockmal and Waldron, 1993; Waldron et al., 1993). The Table Head Group represents initial subsidence in the Taconian foreland basin, following passage of the lithospheric flexural bulge, responsible for the regional unconformity at the top of the St. George Group (Figure 2; Jacobi, 1981; Knight et al., 1991). Shallow marine carbonates of the Table Point Formation are succeeded by a spatially variable package of marine sediments which includes the Cape Cormorant Formation (conglomerate). This extremely proximal conglomerate, which includes blocks ranging up to tens of metres in diameter, is areally restricted on Port au Port Peninsula to within 10 km of the trace of the Round Head Thrust. Clasts within the conglomerate were derived from the underlying platformal succession; their occurence suggests a progressive unroofing of the platform to low in the Port au Port Group (Figure 2).

The Cape Cormorant Conglomerate was therefore derived from a major submarine normal fault scarp to the west or northwest, which exposed at least 1 km of platformal stratigraphy (the Round Head Precursor Fault). This magnitude of throw, coupled with estimates of total platform thickness of ~1.6 km, strongly suggests that the normal fault cut downward into the Grenvillian basement (Stockmal and Waldron, 1993; Waldron et al., 1993; confirmed by recent industry seismic data and drilling). This normal fault may even have been initiated during Early Cambrian rifting and initiation of the Iapetus Ocean. Sediments of the Goose Tickle Group, representing the Taconian foreland basin succession (Figure 2), are significantly thicker on Port au Port Peninsula, in the immediate hanging wall of the Round Head-Cape Cormorant Thrust, than inferred from offshore seismic data. This localized thickening of the Goose Tickle Group further suggests accumulation in a half-graben setting adjacent to the Round Head Precursor Fault, prior to basin inversion at the latest stage of orogenesis.

Apatite fission track sample sites are indicated by open stars on Figure 3, and are projected into cross sections in Figures 6 and 7. Samples were gathered throughout the stratigraphic section (Figure 2) and in the hanging and footwalls of the Tea Cove and Round Head thrusts.

Bonne Bay to Table Point

The external Humber Zone between Bonne Bay and Table Point (Figures 1 and 4) includes thin-skinned slices of the Humber Arm Allochthon (the Lower Head Formation and Cow Head Group; Figure 2), apparently inserted into a low taper triangle zone imaged by offshore seismic data (Curtis Evert, personal communication, 1991). This thin-skinned package has been emplaced above the Cambro-Ordovician platform and a mantle of Taconian foreland basin sediments (the Goose Tickle Group; Figure 4). Seismic reflection data gathered in 1992 by Norcen Energy Resources Ltd. (Figure 8) indicates that the Parsons Pond Thrust is a thick-skinned feature, similar to the Round Head Thrust, which cuts and overrides the thin-skinned package of the Humber Arm Allochthon. Goose Tickle Group sediments, ascribed to the Taconian foreland basin succession, are signtificantly thicker in the immediate hanging wall of the Parsons Pond Thrust, than they are to the north, suggesting accumulation in a half-graben setting similar to that inferred on Port au Port Peninsula. The Parsons Pond Thrust extends into the offshore where it may interact with and override the thin-skinned triangle zone.

Apatite fission track sample locations are shown in Figure 4. Only the Table Point sample is projected into Figure 8; the remaining two samples lie within the imbricated Humber Arm Allochthon which has been eroded across the line of section.

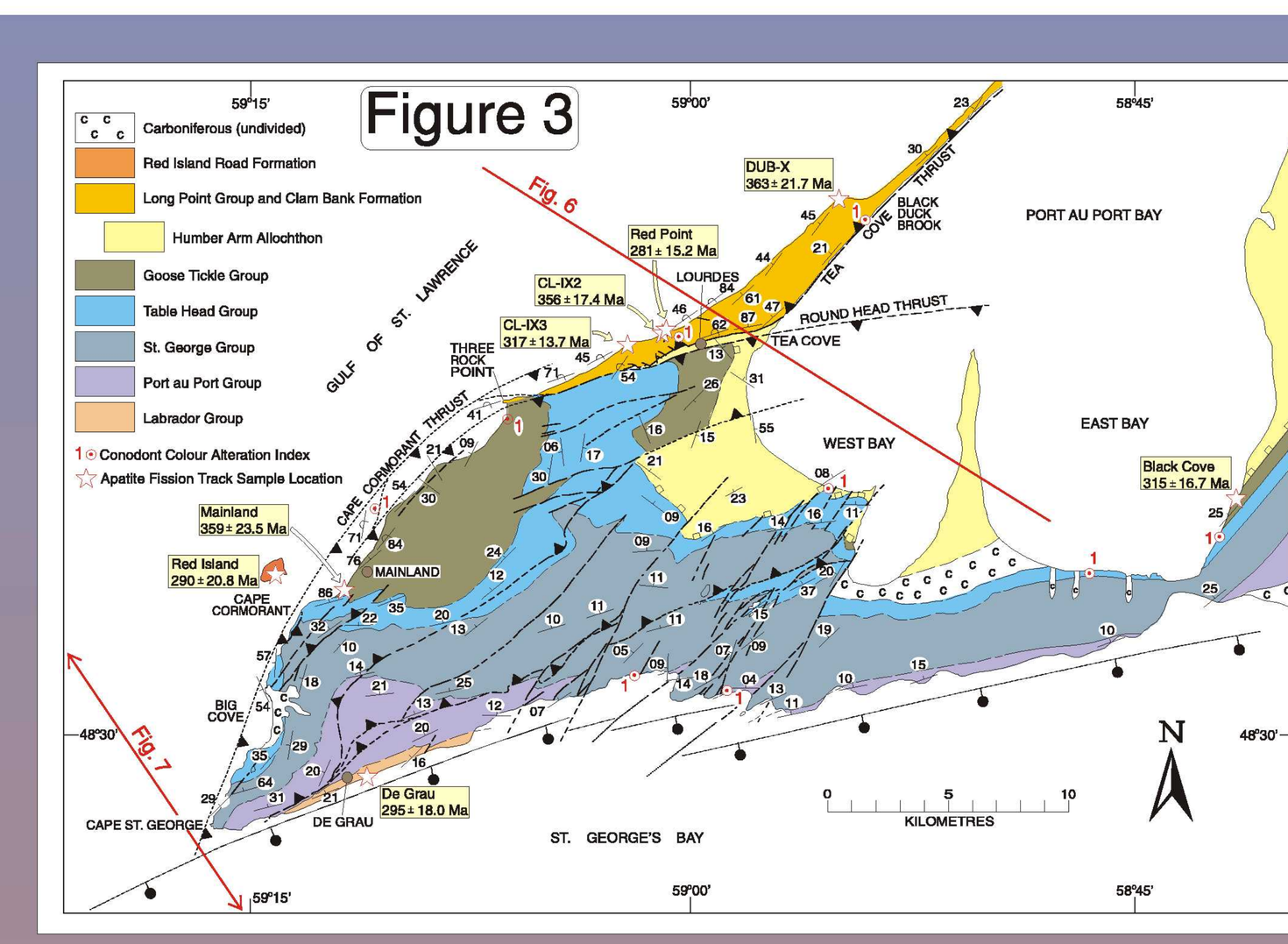


Figure 3: Geological map of Port au Port Peninsula, based on mapping by Waldron and Stockmal (1991) and Stockmal and Waldron (1993). Minor additional details from Manns (1979), Williams (1985), S. Stenzel (personal communication, 1989) , and N. Chow (personal communication, 1990). Locations of cross sections illustrated in figures 6 and 7 are indicated by solid red lines. Apatite fission track sample sites marked by red stars; associated box includes sample name and measured fission track age (plus or minus one standard deviation). Sample sites and measured magnitudes for Conodont Alteration Index (CAI) values indicated by red circle symbols and numbers. The Round Head Thrust and the Cape Cormorant Thrust are considered to form an en echelon linked system.

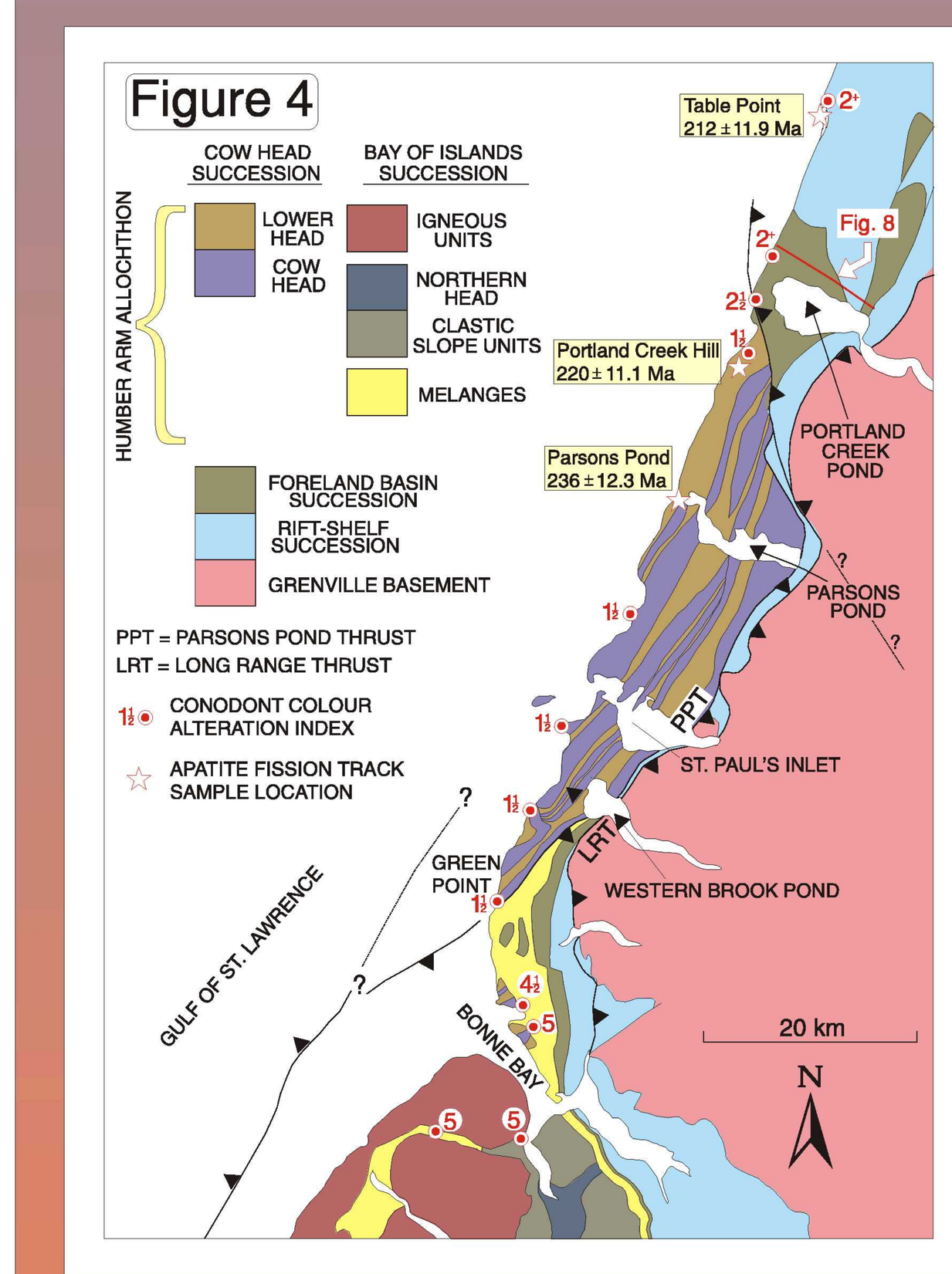
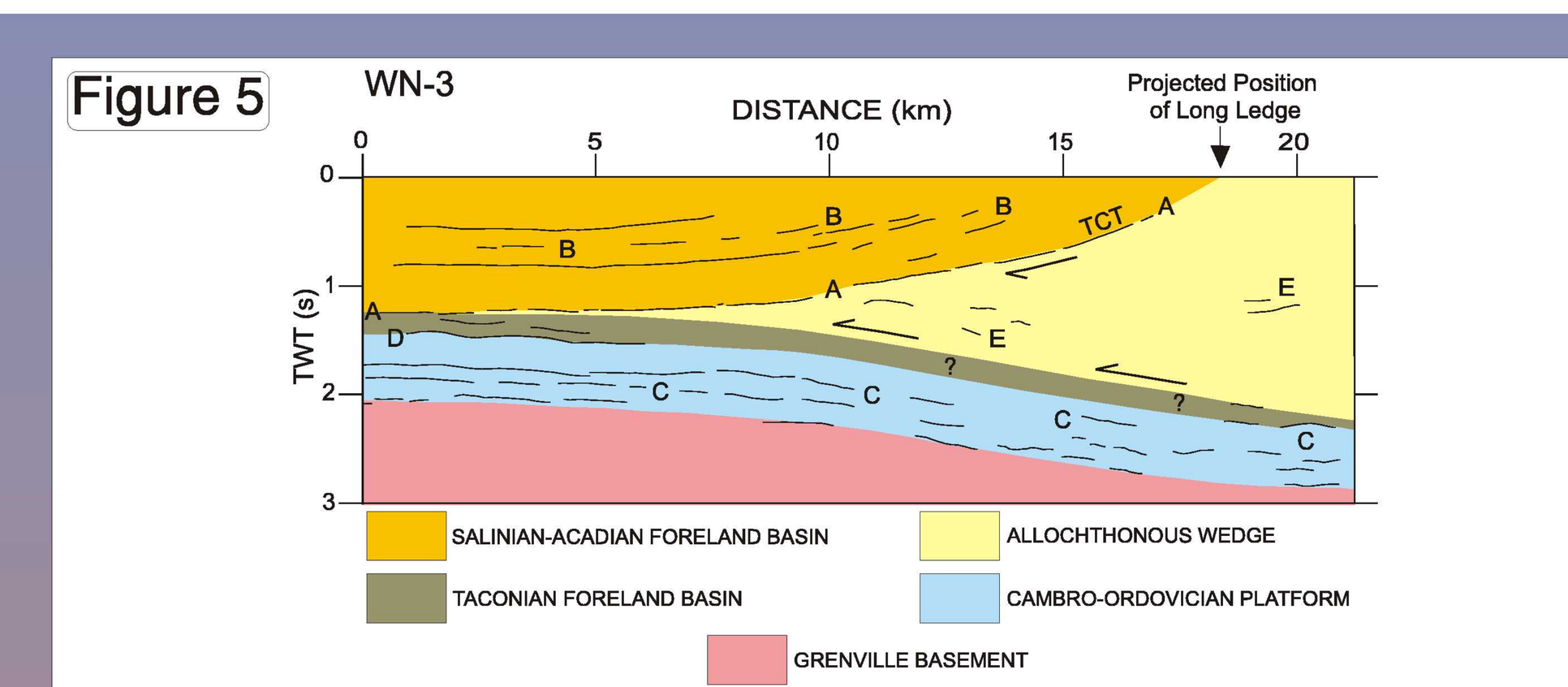
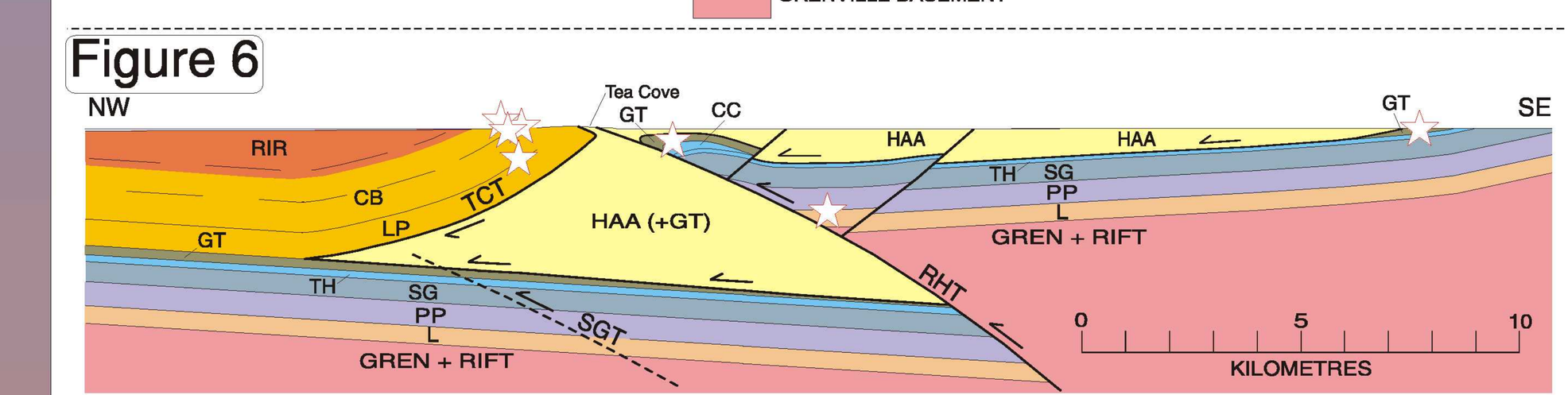
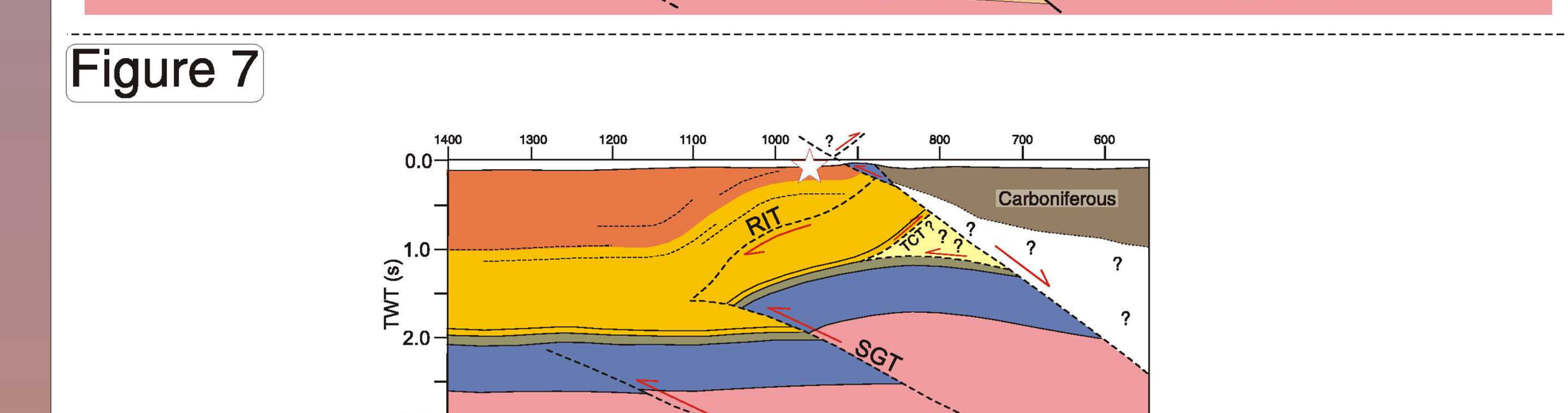


Figure 4: Location map for the Bonne Bay-Table Point area, modified from Williams and Cawood (1989) and Waldron and Stockmal (1994). Seismic line location forming the basis of Figure 8 is indicated by the red dashed line. LRT - Long Range Thrust; PPT - Parsons Pond Thrust. Other symbols as defined in the caption for Figure 3.







Figures 5, 6, and 7: Three cross sections illustrating the change in structural style from north to south on Port au Port Peninsula (all cross sections at the same scale).
Figure 5 is a line-drawing interpretation of offshore industry seismic reflection data in the public domain (Stockmal and Waldron, 1990; location in Figure 1), and clearly shows the nature of the thin-skinned triangle zone to the north. Reflections 'A' mark the Lourdes Limestone (Figure 2), which lies in the immediate hanging wall of the Tea Cove Thrust (TCT; the triangle zone upper detachment). Reflections 'D' and 'C' mark the top of and internal boundaries withn the platformal succession.
Figure 6 is modified after a section by Stockmal and Waldron (1993) showing the thick-skinned nature of the Round Head Thrust (RHT) and its interaction with the Tea Cove Thrust (TCT) near Tea Cove (Figure 3). Projected positions of AFT sample sites indicated by stars. The St. George Thrust (SGT) is shown as an incipient feature. CB - Clam Bank Formation; LP Long Point Group; GT - Goose Tickle Group; CC - Cape Cormorant Formation; TH - Table Head Group; SG - St. George Group; PP - Port au Port Group; L - Labrador Group; HAA - Humber Arm Allochthon.
Figure 7 is a schematic section illustrating the progressive development of the St. George Thrust (SGT) to the south as a blind thrust, with displacement transferred to the orogen-directed Red Island Thrust (RIT). The structurally isolated toe of the thin-skinned triangle zone may be preserved in the hanging wall of the SGT. Large normal faults bounding the Carboniferous St. George's Bay basin have removed the Round Head Thrust-Cape Cormorant Thrust from this line of section.

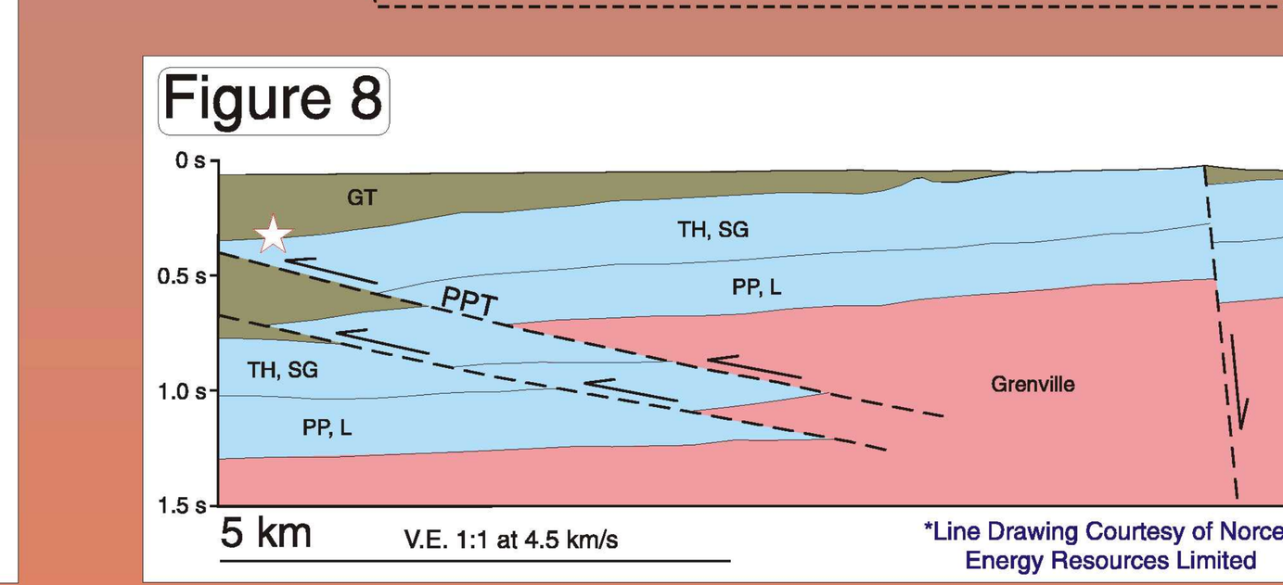


Figure 8: Cross section north of Portland Creek Pond, location shown in Figure 4. Based on line drawing of reflection seismic data, courtesy of Norcen Energy Resources Limited. The Parsons Pond Thrust (PPT) projects into the offshore a few kilometres west of the seismic line, as indicated in Figure 4. The PPT, which strikes oblique to the orogen in general, is a thick-skinned feature which overrides the north end of the Humber Arm Allochthon (Figure 4). The star marks the projected location of the Goose Tickle Group sample at Table Point. GT - Goose Tickle Group; TH - Table Head Group; SG - St. George Group; PP - Port au Port Group; L - Labrador Group. Note scale change in relation to figures 5, 6, and 7.

Inversion of Apatite Fission Track Data

To assess the thermochronology of the Appalachian structural front, we sampled siliciclastic rocks at eleven localities (eight on and adjacent to Port au Port Peninsula, Figure 3, and three in the Bonne Bay-Table Point region, Figure 4) for analysis of fission tracks in detrital apatite. Stratigraphically, the sample sites include Lower Cambrian platformal sediments, Middle Ordovician foreland basin sediments corresponding to the Taconian Orogeny, and Siluro-Devonian foreland basin sediments corresponding to the Salinic and Devonian orogenies (Figure 2).

Apatite fission tracks (AFTs) are produced through the spontaneous fission decay of ^{238}U, which results in zones of linear crystal damage of constant initial length. The density of fission tracks is a measure of the fission track age, whereas the length distribution of confined tracks (wholly within the mineral) provides thermal history information because AFT length reduction (annealing) is a temperature-dependent process. Under most geologically acceptable heating and cooling rates, AFTs anneal over a temperature range of 60-120°C. Therefore, AFT analysis can be very useful for constraining the thermochronology of areas prospective for petroleum.

The complex geological history of western Newfoundland requires that we use an inverse model to fully assess the range of possible time-temperature solutions permitted by the data (Issler and Willet, 1996; Willet, in press; Issler, in press). The inverse model runs a very large number of forward track annealing models which are compared statistically to observed track lengths and fission track ages. Through a constrained random search procedure, the program progressively builds a set of statistically acceptable thermal histories. This approach can indicate which portions of the thermal history are well resolved by the AFT data and which are poorly constrained.

The insert at the top of Figure 9 is a guide to the presentation of AFT inverse model results. The left-hand panel shows: (1) the exponential mean solution for the solution set which statistically fits the measured age and track lengths; (2) envelopes bounding the solution set (the bounds are not solutions themselves); (3) the measured age of the sample (green line); and (4) the partial annealing window for AFTs (~60-120°C for rates considered here). The right-hand panel shows: (5) statistics indicating the number of observed tracks, mean track length, measured and calculated ages, and number of forward models required for convergence; (6) a histogram of measured track lengths; (7) the track length probability distribution function for the exponential mean solution; and (8) the envelopes bounding the distribution functions for all solutions.

The bulk of Figure 9 shows the influence of additional independent constraints on the inversion of the AFT data. These influences are illustrated using the sample Mainland (Figure 3), from the Middle Ordovician Mainland Sandstone (Figure 2), in the hanging wall of the Round Head/Cape Cormorant Thrust. This sample was involved in Appalachian orogenesis and subsequent exhumation, successor basin formation, and re-exhumation. The additional geological constraints include: (1) depositional age (470 Ma); (2) known proximity to an Early Carboniferous (Visean) erosional surface (modelled as 350 Ma; this constraint applies to the Port au Port suite of samples only); (3) maximum temperature constraints from Conodont Alteration Index (CAI) values (observed CAI of 1 at this locality, constraining paleotemperatures to be less than 80°C); and (4) cooling only after 200 Ma (suggested by the regional history of the Carboniferous Maritimes basin). A fifth possible constraint permissible in the inversion program is to place bounds on the maximum geologically reasonable rates for heating and cooling (these would be a function of known environment and history); these bounds are not considered here.

Model 04 for the Mainland Sandstone (Mainland 04, panels a and b, Figure 9), is constrained only by stratigraphic age and proximity to the Visean erosion surface (constraints (1) and (2), above). Model 05 (panels c and d) is similar to Model 04 but is additionally constrainted by the CAI data (constraints (1), (2), and (3), above). Model 07 (panels e and f) includes the cooling only constraints, after 200 Ma (constraints (1) through (4), above). Model 08 (panels g and h) is identical to Model 07, except that individual acceptable solutions are constrained to have a single heating peak between 470 Ma (deposition) and 350 Ma (Visean erosion), and a second single heating peak between 350 Ma and 0 Ma (present-day exposure). The solution sets for models 04, 05, and 08 each include 250 statistically acceptable thermal histories, whereas the solution set for Model 07 includes 500 acceptable thermal histories.

Models 07 and 08, with identical geological constraints, are quite similar, with the mean solution for Model 08 being smoother than that for Model 07 (reflecting the constraint of discrete thermal peaks in Model 08). However, models 04 and 05 are significantly different than models 07 and 08. Imposing independent geological constraints, in the form of maximum temperatures from CAI values, and knowledge regarding the final exhumation history, have sharpened the resolution on the thermal history afforded by the AFT data.

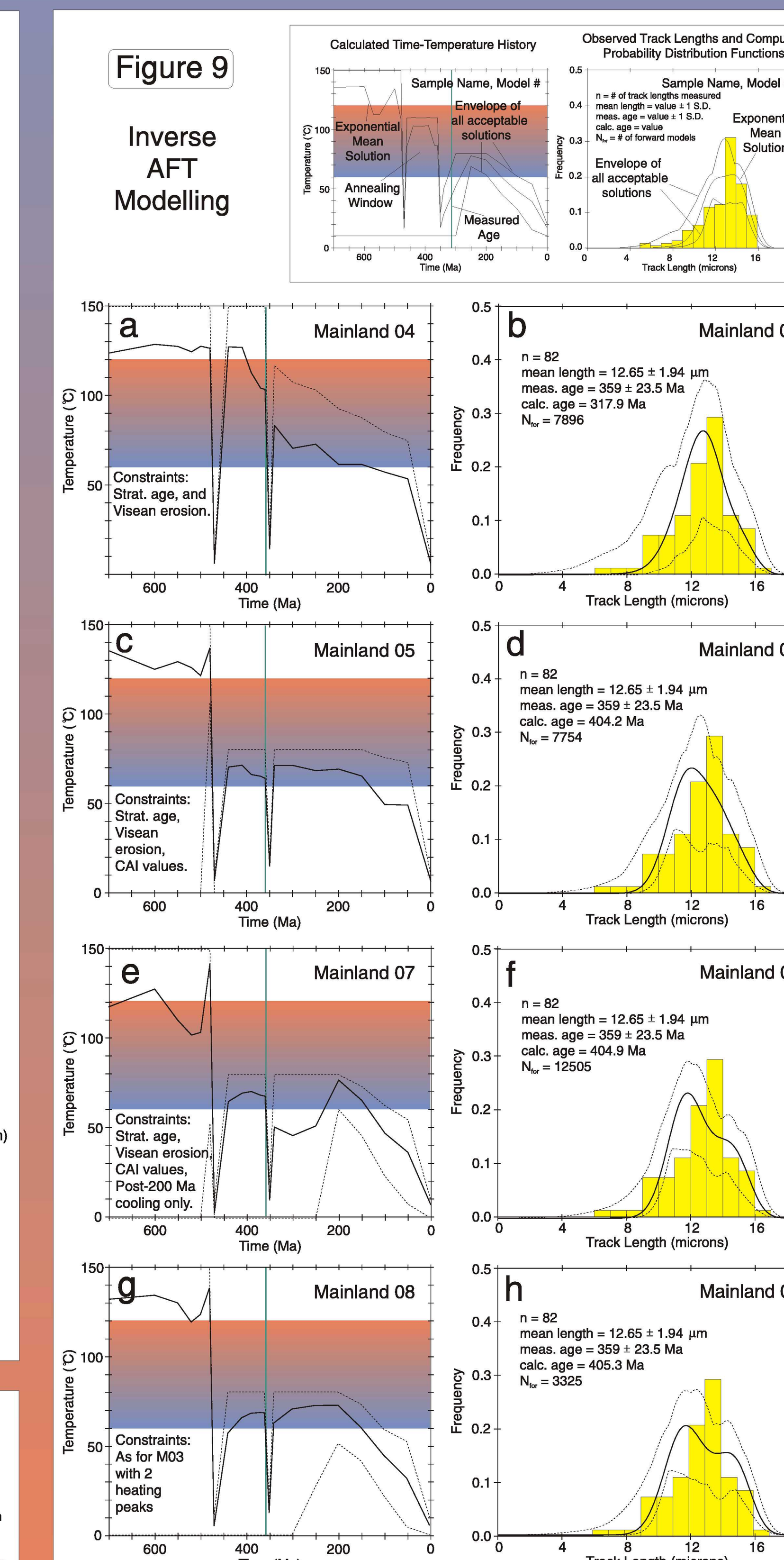


Figure 9: Inversion of apatite fission track data is performed using a computer program which generates a large number of forward track annealing models which are compared statistically to the observed fission track age and length data. The program proceeds using a constrained random search algorithm to produce a subset of statistically acceptable thermal histories. The small insert figures in the upper right corner are keys to the various curves and values in the main figures. The Mainland Sandstone sample (Figures 2 and 3) is used to illustrate the importance of incorporating additional independent geological information in a thermal history interpretation. Panels a and b show inverse model results constrained only by the stratigraphic age of the sample (470 Ma) and known proximity to an Early Carboniferous (Visean) erosion surface (350 Ma; Figure 3). Panels c and d show results which also incorporate maximum temperature constraints derived from Conodont Alteration Index (CAI) values. Panels e and f show results which also include a constraint of cooling only after 200 Ma (known from regional studies of the Maritimes basin). Panels g and h show results with identical constraints to that of panels e and f but allowing for only a single heating-cooling pulse between 470 Ma and 350 Ma, and between 350 Ma and 0 Ma. Although the solutions of the lower three pairs of panels all lie within the bounds of the first solution (Model 04), the additional constraints have sharpened the resolution of the AFT data.

THE ROUND HEAD THRUST, WESTERN NEWFOUNDLAND: A REACTIVATED BASEMENT NORMAL FAULT AT THE APPALACHIAN STRUCTURAL FRONT [Panel 2 of 2]

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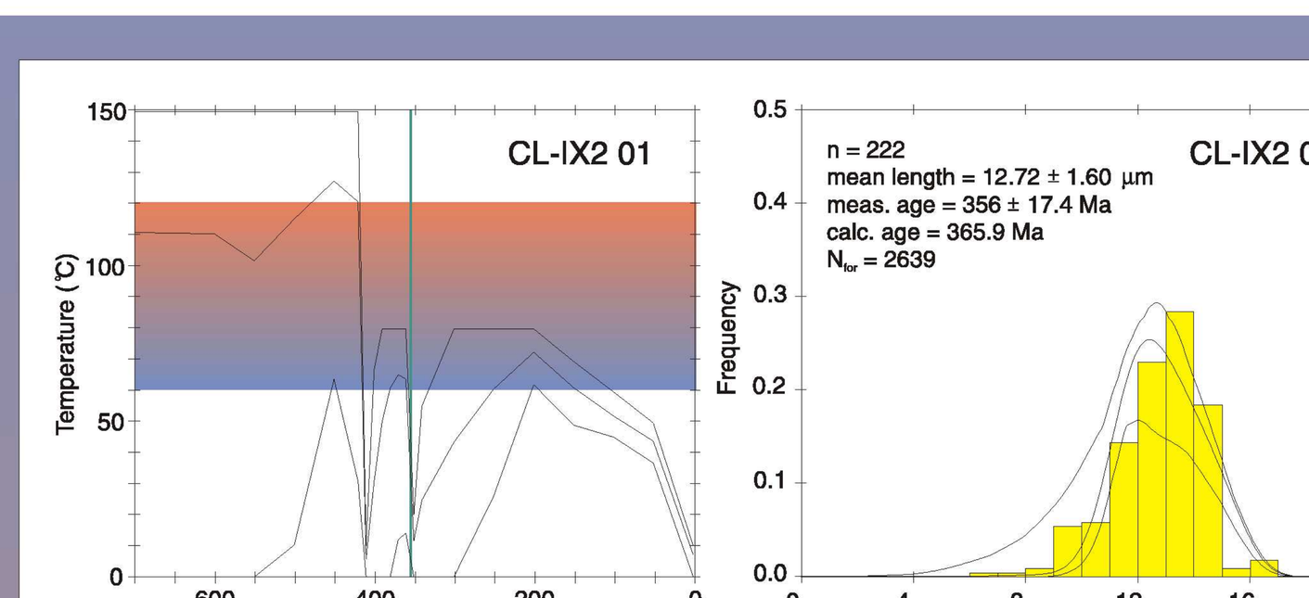
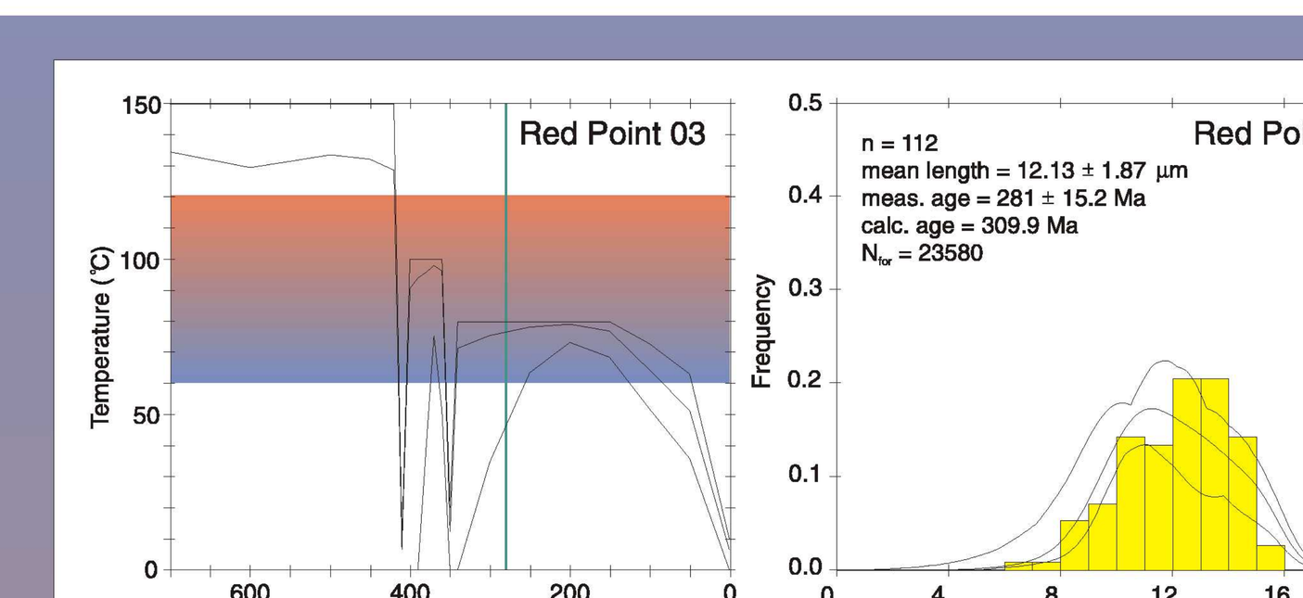
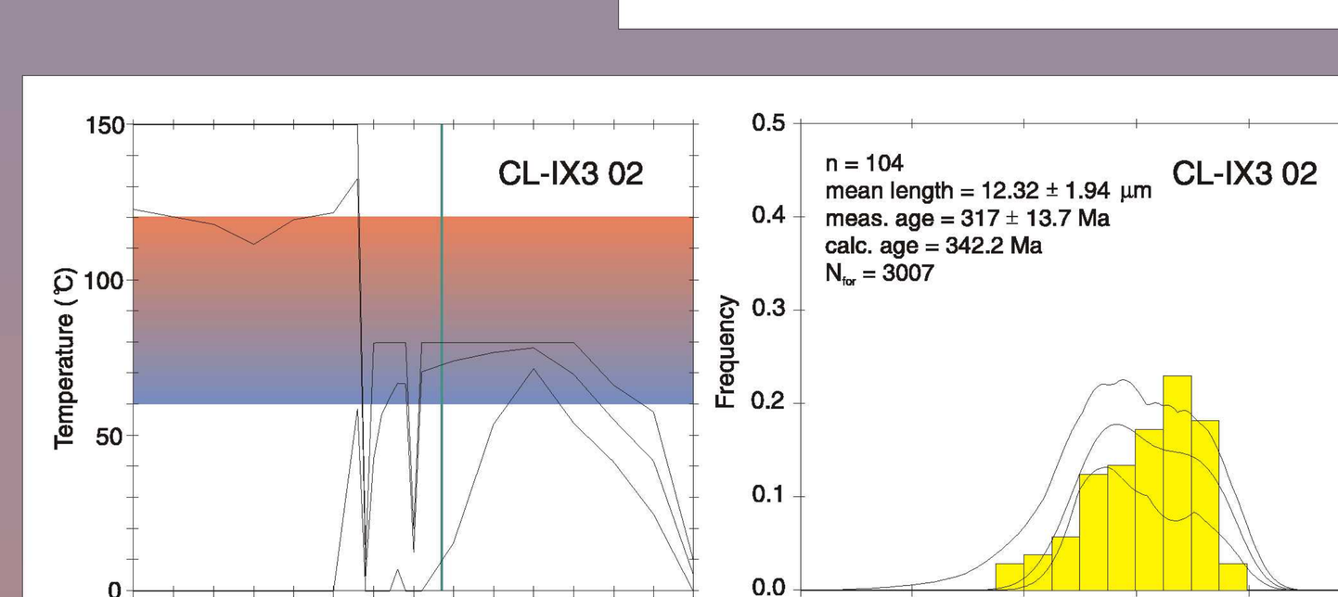






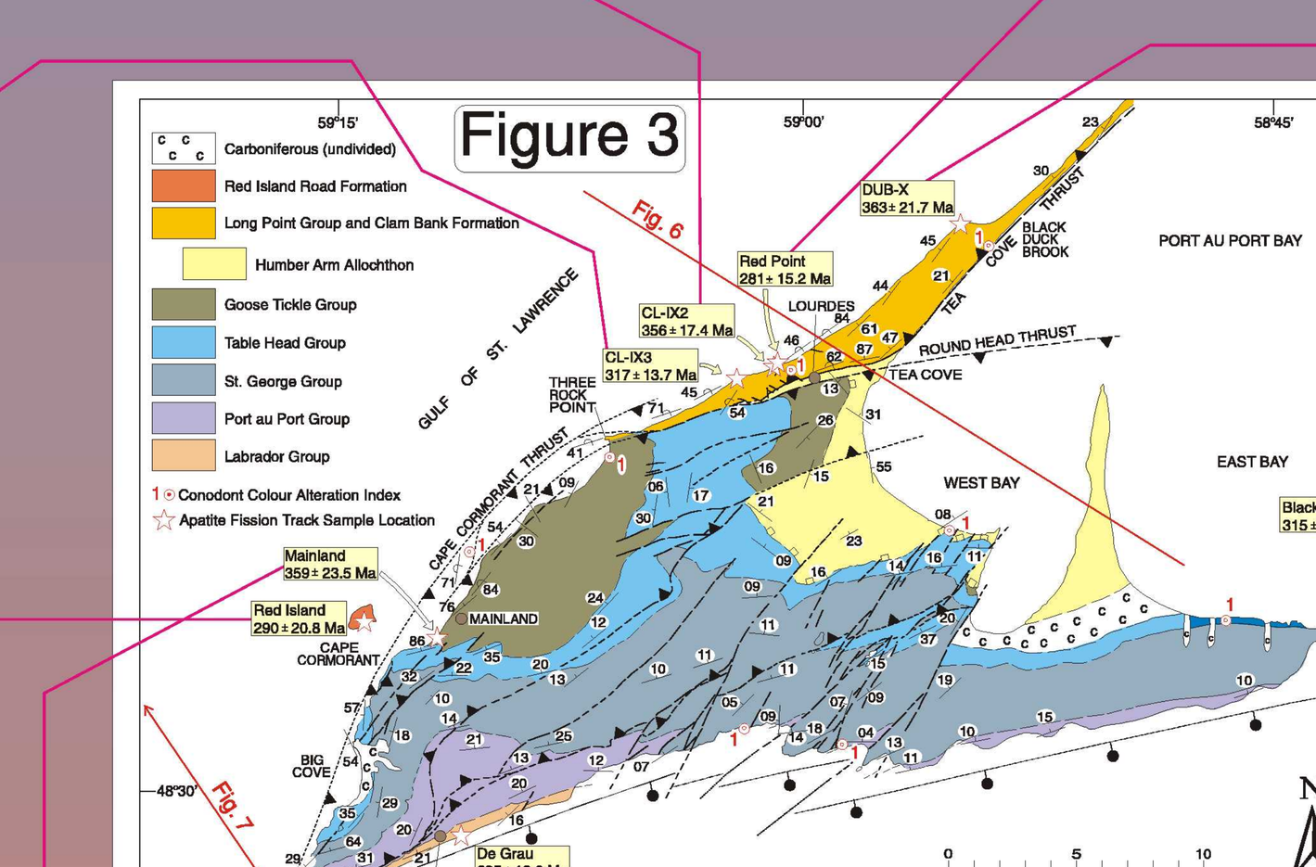
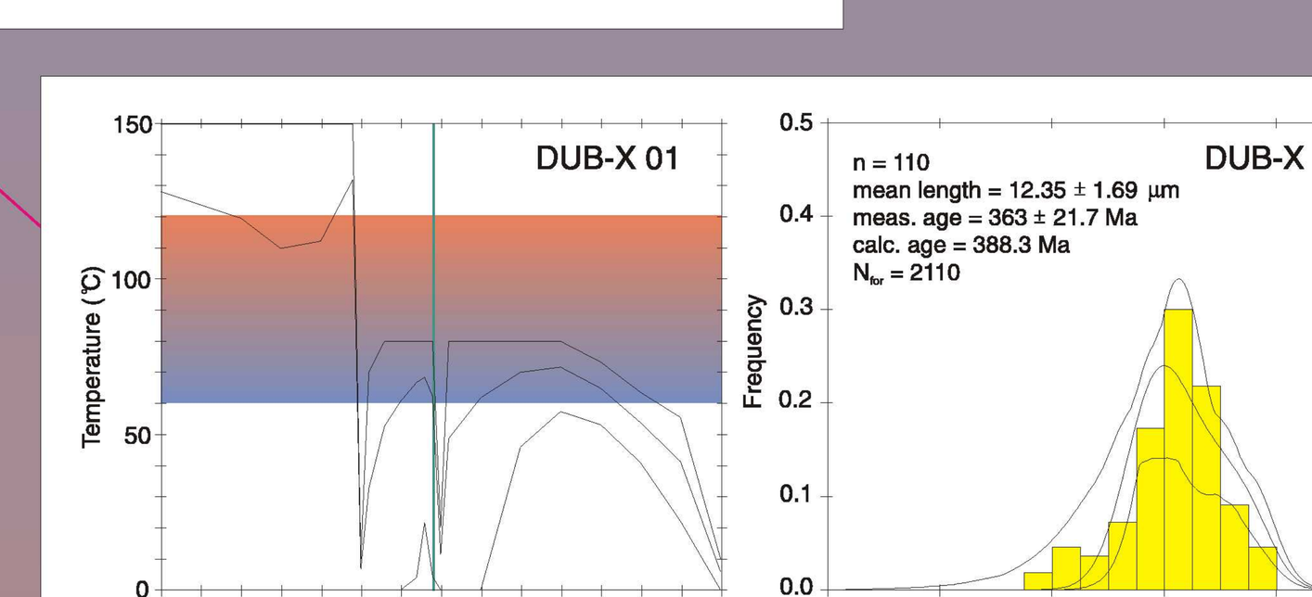
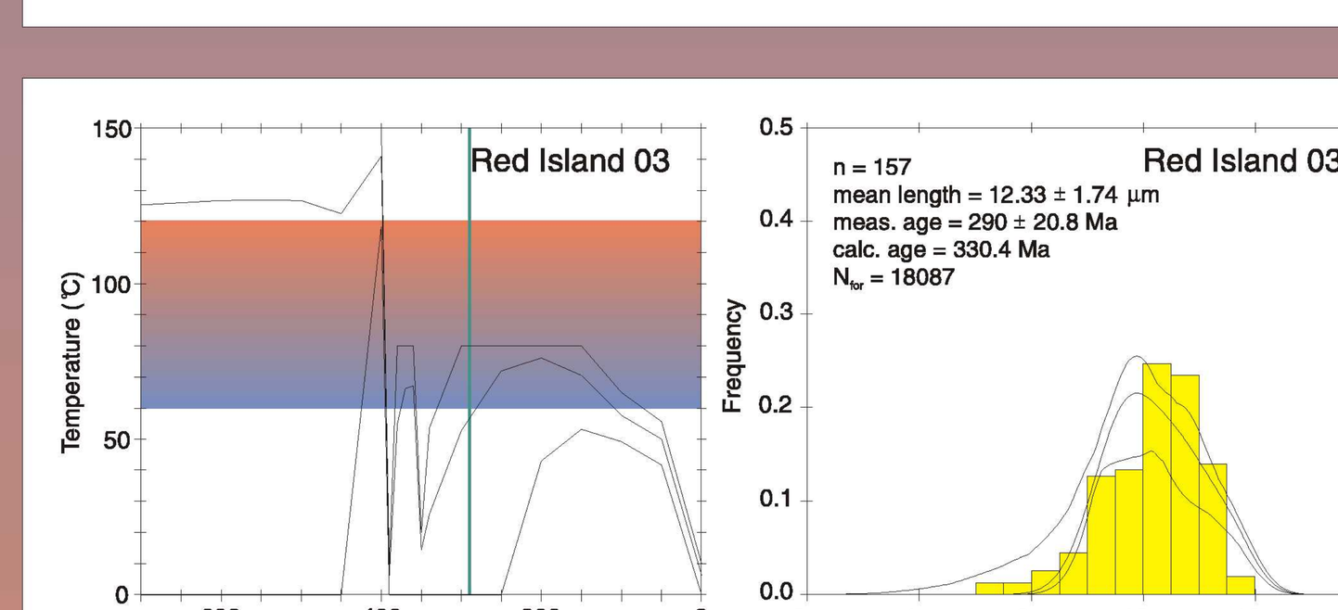
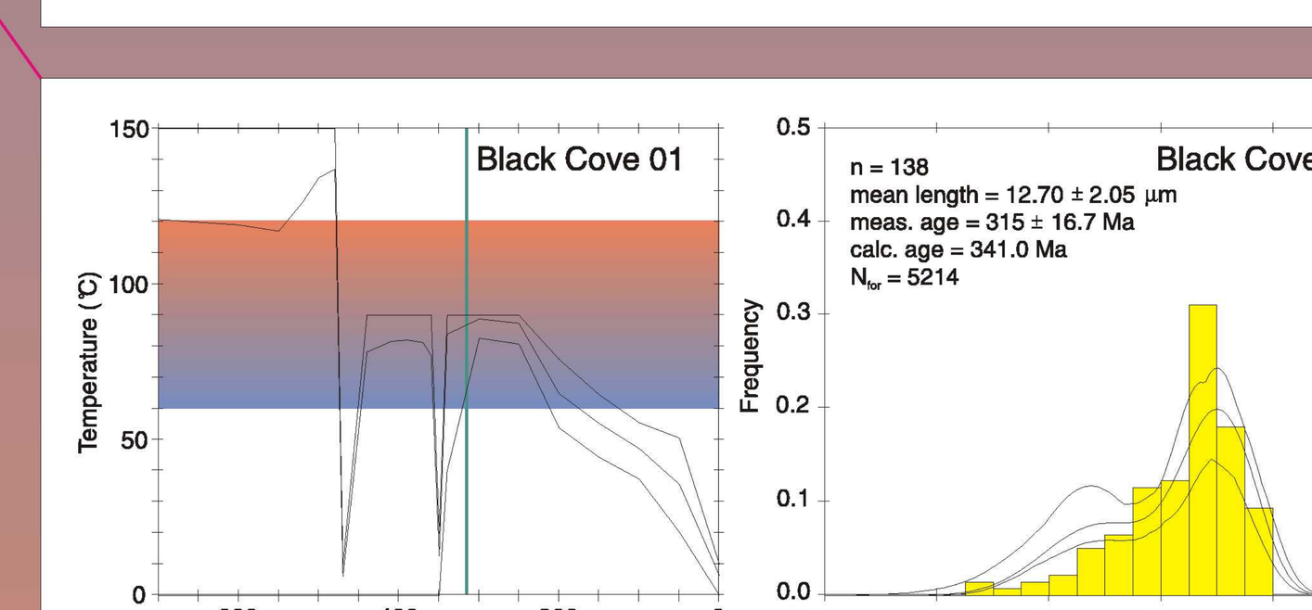
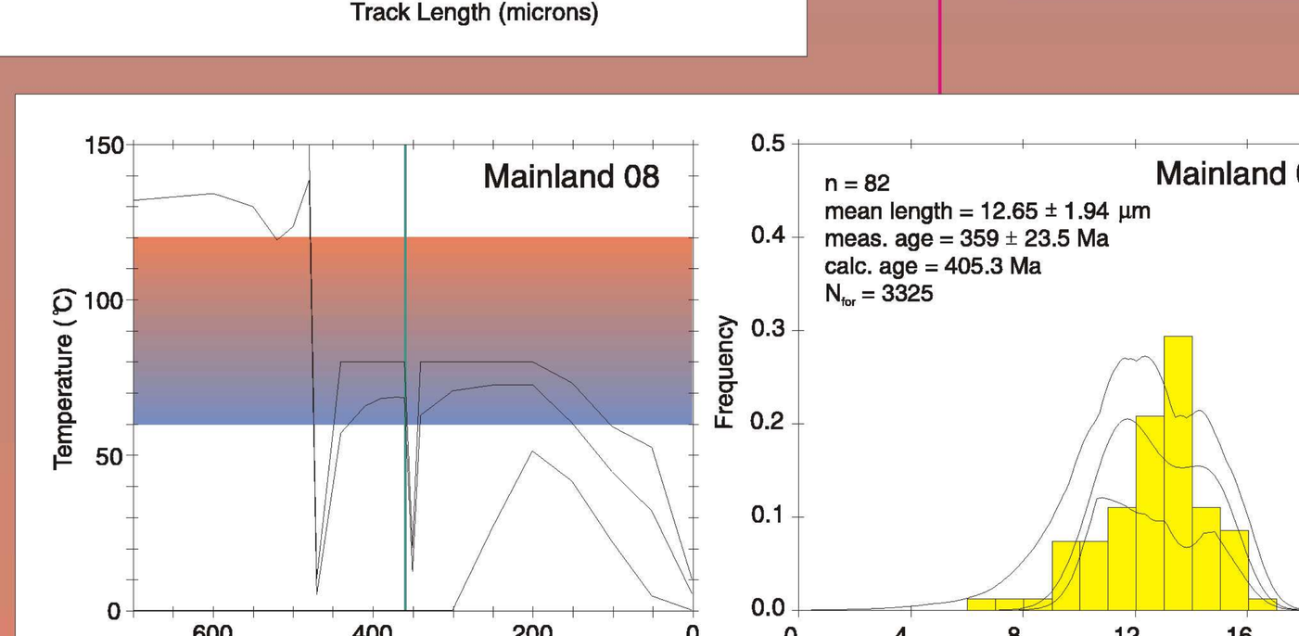


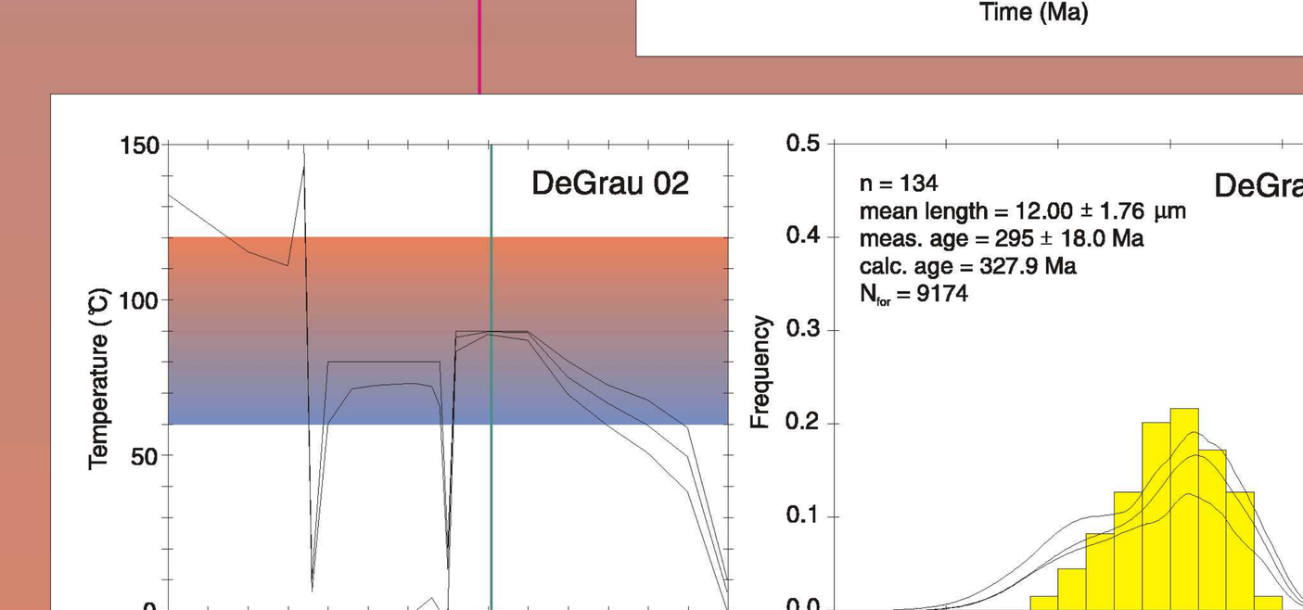
Figure 3: Geological map of Port au Port Peninsula, based on mapping by Waldron and Stockmal (1991) and Stockmal and Waldron (1993). Minor additional details from Manns (1979), Williams (1985), S. Stenzel (personal communication, 1989) , and N. Chow (personal communication, 1990). Locations of cross sections illustrated in Figures 6 and 7 are indicated by solid red lines. Apatite fission track sample sites marked by red stars; associated box includes sample name and measured fission track age (plus or minus one standard deviation). Sample sites and measured magnitudes for Conodont Alteration Index (CAI) values indicated by red circle symbols and numbers. The Round Head Thrust and the Cape Cormorant Thrust are considered to form an en echelon linked system.

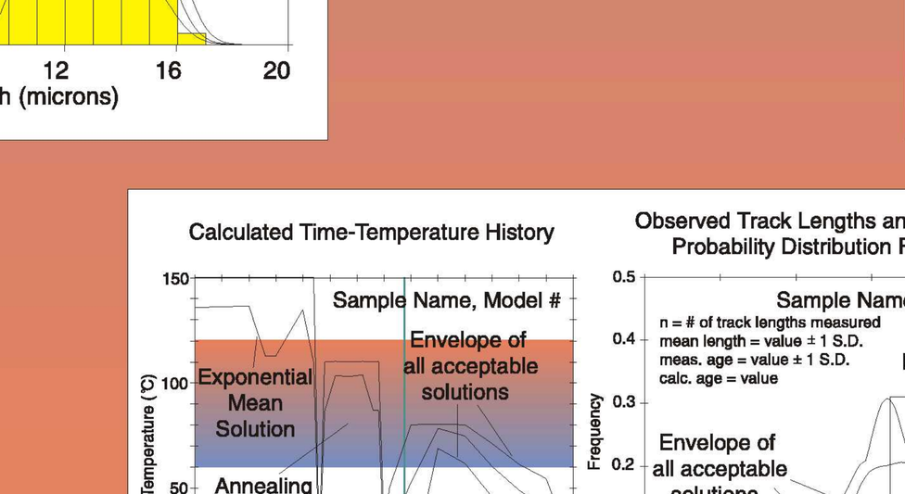












Apatite Fission Track Inversion Results

Port au Port Peninsula

The map of Port au Port Peninsula, Figure 3, is reproduced at left, surrounded by selected inversion results for the eight apatite fission track samples. These results were selected from a number of possible solutions; poster space precludes a more complete discussion of the fission track data.

The fission track samples can be grouped according to structural location with respect to the Round Head Thrust. Samples DeGrau, Mainland, and Black Cove all lie in the hanging wall of the Round Head Thrust, whereas samples DUB-X, Red Point, CL-IX2, CL-IX3, and Red Island all lie in the footwall of this thrust (as well as in the hanging wall of the Tea Cove Thrust). The thermochronologies of these samples are used here to infer the timing of motion of the Round Head Thrust, and to assess the general hydrocarbon prospectivity of the area.

The Conodont Alteration Index (CAI) values of Nowlan and Barnes (1987), as shown in Figures 3 and 4 on both poster panels, are invaluable in constraining the temperature histories of the AFT samples, as noted on panel 1. For the Port au Port Peninsula area, the CAI values suggest that temperatures have never exceeded approximately 80°C. This independent constraint is consistent with the AFT data in most cases, but in a few we require temperatures approximately 10°C warmer.

All samples suggest modest post-depositional, syn-tectonic heating, presumably due to progressive burial in the developing foreland basin. In most cases, however, significant heating into the AFT partial annealing window (i.e., >60°C) is not required by the AFT data for this time interval. This is consistent with modest burial in the foreland basin, and no significant burial by allochthonous thrust sheets. However, most samples suggest a period of greater heating following Visean (early Carboniferous) exposure and subsequent regional Carboniferous sedimentary burial associated with the Maritimes Basin.

The sample of the Clam Bank Formation at Red Point (Figures 2 and 3) cannot be modelled successfully without a period of substantial heating in pre-Visean time. Because annealing of AFTs represents a trade-off of time and temperature, the absolute magnitude of heating cannot be determined, but temperatures clearly in excess of those consistent with the nearby CAI values are required. We suggest that this heating "event" may be due to the release of hot fluids along the Round Head Thrust during reverse-motion reactivation.

Temperatures slightly in excess of those suggested by the CAI data (up to 90°C) are indicated for the samples from DeGrau and Black Cove. These can be successfully modelled with temperature spikes in either pre- or post-Visean time, and could therefore be related to late "Acadian" thick-skinned fault activity, or to Carboniferous normal fault activity related to the St. George's Basin to the immediate south. Alternatively, this slight difference in temperature may reflect inaccuracies in either or both of the CAI and AFT techniques.

Bonne Bay-Table Point

Three AFT samples were gathered in this northern block: two from the footwall of the Parsons Pond Thrust (Parsons Pond and Portland Creek Hill) and one from the hanging wall (Table Point; Figure 4, right). No direct evidence for a Visean erosion surface similar to that to the south exists for this area; therefore we do not impose cooling at 350 Ma in the inversion models. The CAI values for this area are slightly to significantly greater than for the Port au Port area. A CAI value of 1.5 indicates temperatures from 50-90°C, whereas a CAI value of 2 indicates temperatures from 60-140°C (Nowlan and Barnes, 1987). Therefore, total annealing of AFTs (at approximately 120°C) is consistent with a CAI value of 2.

The AFT inversion program was run for all three samples with the constraint of only two discrete heating events (see discussion of Figure 9, panels g and h, poster panel 1), with no constraint on precise timing, to test for the plausibility of pre- and post-Visean events as suggested by the Port au Port sample suite. Both samples from the Parsons Pond Thrust footwall suggest, but do not demand, somewhat greater temperatures in post-Visean times than in pre-Visean times, consistent with results to the south. However, in both cases, successful model convergence was possible only with temperatures slightly higher than suggested by the available CAI data (100°C as opposed to 90°C).

The sample from the hanging wall of the Parsons Pond Thrust, Table Point, was modelled assuming a post-Visean history similar to that suggested by the two samples from the footwall. This exercise indicates post-depositional, syn-deformational temperatures possibly in excess of the total annealing temperature for apatite. Such a thermal history is consistent with burial by allochthonous slices of the Humber Arm Allochthon, followed by tectonic exhumation due to reverse motion on the Parsons Pond Thrust.

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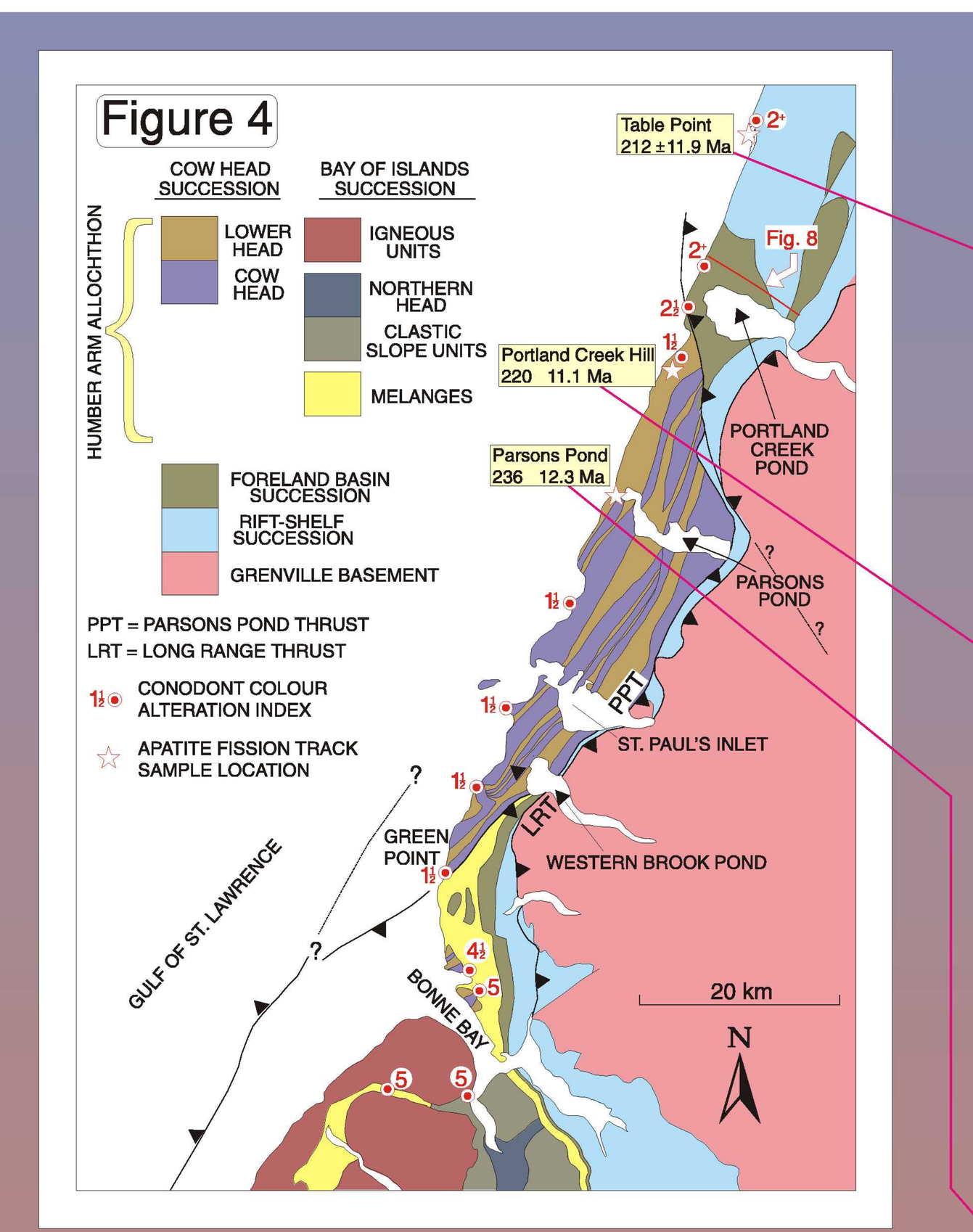
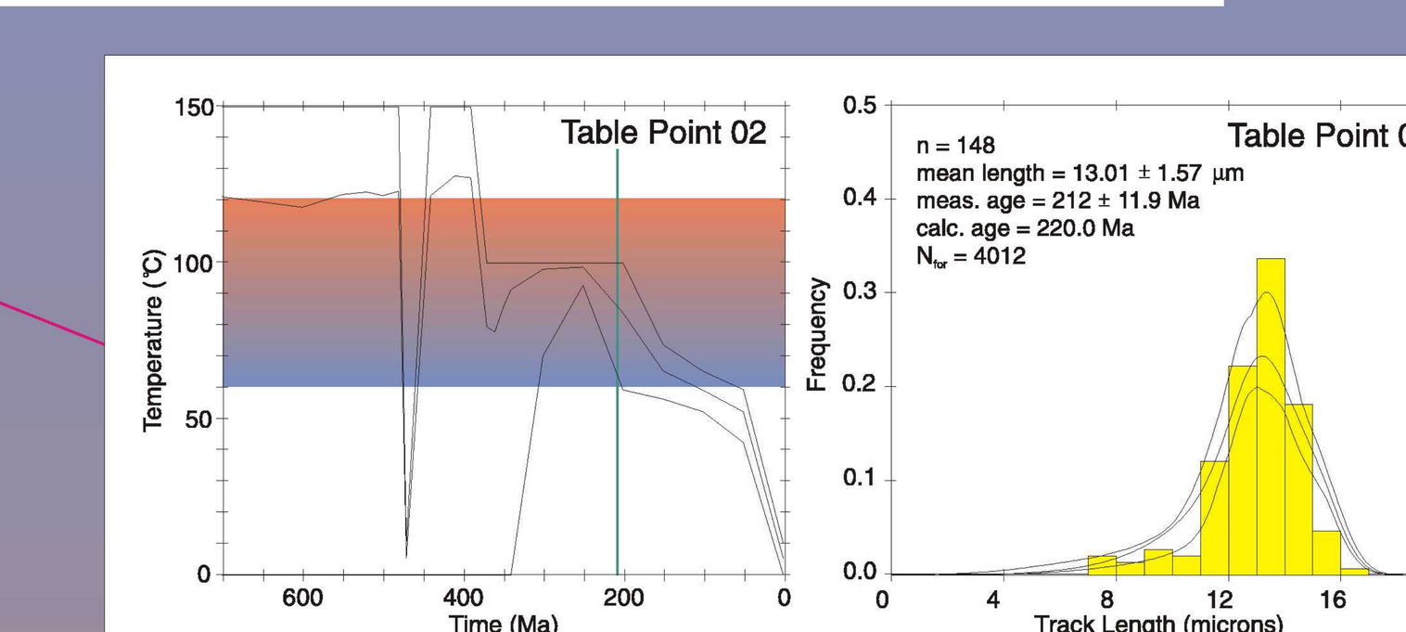
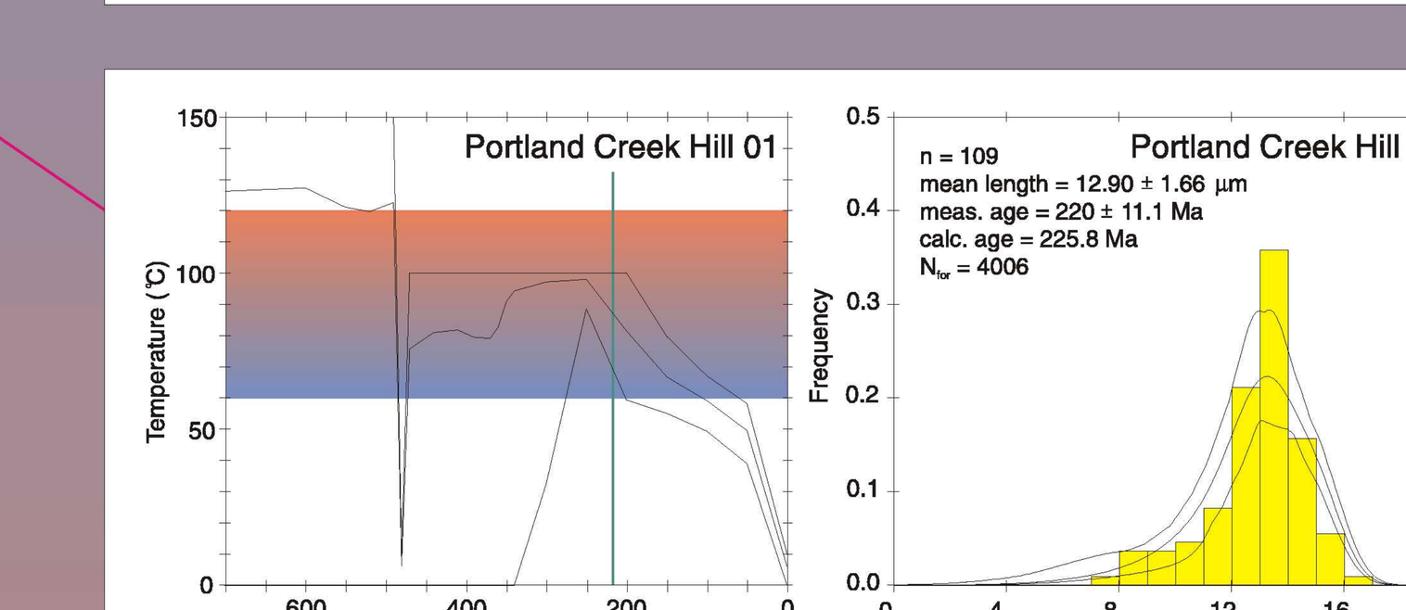
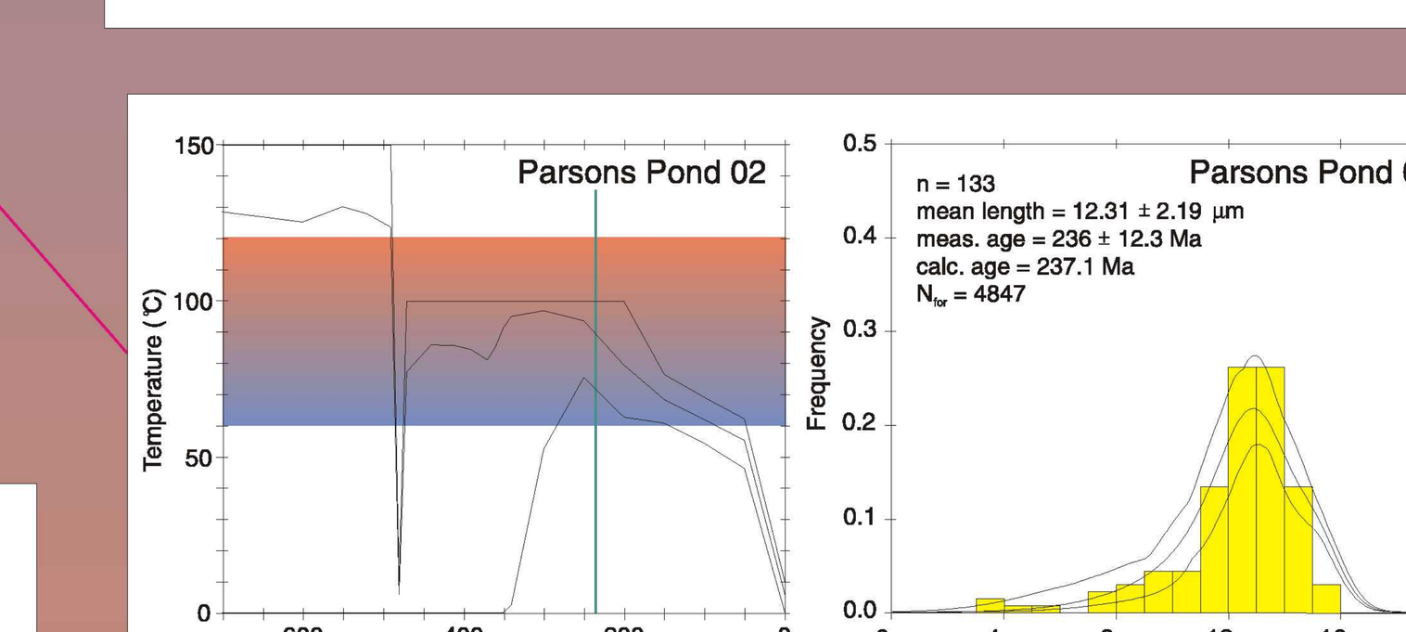


Figure 4: Location map for the Bonne Bay-Table Point area, modified from Williams and Cawood (1989) and Waldron and Stockmal (1994). Seismic line location forming the basis of Figure 8 is indicated by the red dashed line. LRT - Long Range Thrust; PPT - Parsons Pond Thrust. Other symbols as defined in the caption for Figure 3.







Discussion and Conclusions

The Appalachian structural front in western Newfoundland is characterized by both thin-skinned and thick-skinned structures. The thick-skinned structures, in particular the Round Head Thrust and the Parsons Pond Thrust, clearly post-date the thin-skinned structural emplacement on the basis of cross-cutting relationships (the Round Head Thrust overrides the Tea Cove Thrust at Tea Cove; Waldron and Stockmal, 1991). The thick-skinned faults, which involve Grenville-age crystalline basement (Stockmal and Waldron, 1993), can exhibit significant along-strike changes in surface expression, as evidenced by the change in the Round Head Thrust from an emergent geometry along much of its trace to a blind configuration. The existence of the blind thick-skinned tectonic wedge (Figure 7), at the southwest corner of Port au Port Peninsula, was not anticipated by Stockmal and Waldron (1990, 1993). These authors interpreted the seismic expression of the thick-skinned tectonic wedge, observable in 1970s vintage offshore industry data, as the southern extension of the thin-skinned triangle zone which is so well developed to the north (Stockmal and Waldron, 1990; Curtis Evert, Hunt Oil Co., personal communication, 1991, 1992). Therefore, the carbonate platform exposed on Port au Port Peninsula cannot be significantly allochthonous. Seismic data available in the Bonne Bay-Table Point area (Figure 8) indicates that the thick-skinned Parsons Pond Thrust is an emergent feature onshore.

Figure 10 presents a schematic cross section for the Port au Port Peninsula area showing the inferred geometry prior to reactivation of the Round Head Precursor Fault as the Round Head Thrust (the Parsons Pond Thrust prior to reactivation was probably similar). The apatite fission track sample sites are indicated by stars. Inverse modelling of these data, constrained by conodont alteration index values and regional cooling considerations, is consistent with reverse motion occurring on the Round Head Thrust and the Parsons Pond Thrust in late "Acadian" time (middle to late Devonian). Anomalously high temperatures experienced by one sample in the immediate footwall of the Round Head Thrust suggests that hot fluids may have been released during reverse motion. In addition, these data indicate that regional heating due to Carboniferous burial (following exposure or near-exposure of the Port au Port Peninsula area during the Visean) was significantly greater than heating due to sedimentary burial in the Taconian and Salinian-Acadian foreland basin cycles. The inferred timing and the absolute magnitude of the themal peak in both the Port au Port Peninsula and Bonne Bay-Table Point areas is encouraging from a hydrocarbon prospectivity point of view.

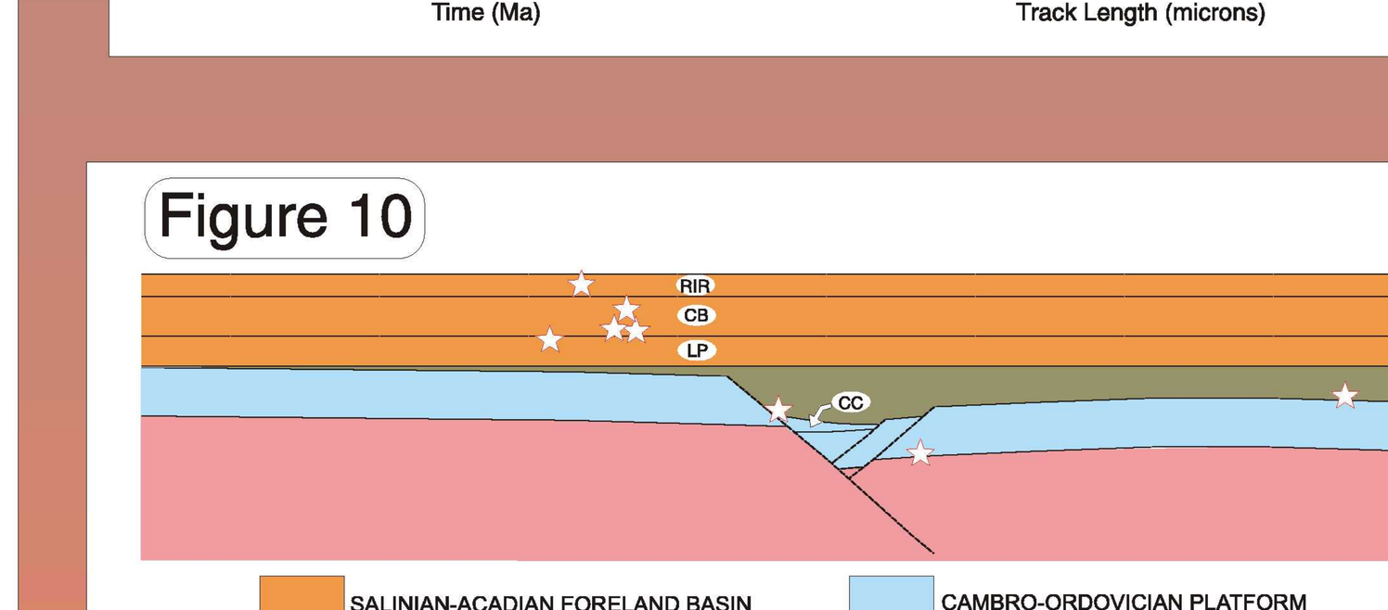


Figure 10: Schematic cross section showing the inferred geometry at Port au Port Peninsula prior to reactivation of the Round Head "Precursor" Fault as the Round Head Thrust; a very similar geometry probably existed prior to reverse motion of the Parsons Pond Thrust to the north. The interpretation of the Round Head Precursor Fault is based on the spatial distribution of the Cape Cormorant Conglomerate (Figure 2) immediately adjacent to the trace of the Round Head Thrust, coupled with identification of clasts within the conglomerate as being derived from the underlying carbonate platform. In addition, the overlying Goose Tickle Group (Taconian foreland basin sediments) are substantially thicker in the hanging wall of the Round Head Thrust than in the footwall (the latter is based on proprietary seismic information). Inversion of the AFT data (sample sites indicated by stars) suggests that post-depositional heating due to sediment burial prior to motion on the Round Head Thrust was modest (in most relatively shallow cases, the sample sites were not heated into the partial annealing window at all). Following emplacement of the Humber Arm Allochthon and subsequent inversion of the Round Head Thrust, post-Visean heating due to Carboniferous burial resulted in a regional thermal peak. Exceptions may indicate short duration, localized heating events, possibly due to release of hot fluids during basement-involved thrusting.

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