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ABSTRACTS

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Paleo-Indian in the Maritimes

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The first colonization of the Maritimes took place between 10,000 and 11,000 B.P. The Indian peoples were part of a native tradition that was widespread throughout North America as the glacial ice retreated. The Paleo-Indian, the first Maritime peoples, were primarily caribou hunters but may have also pursued sea mammals such as the walrus and now extinct land mammals (e.g., mastodon). The Debert site in Nova Scotia (10,600 years B.P.) is the only excavated Paleo-Indian campsite in the Maritimes.

In New Brunswick, four fluted spear points that are diagnostic of the earliest settlement period have been found at Kingsclear, Quaco Head, New Horton Creek and along the Northwest Miramichi River. Other Maritime fluted points have been found at North Tryon, Prince Edward Island and along the Gaspereau River in Nova Scotia. Slightly later projectile points, estimated to be near 9,000 years of age, have been found within the Tracadie River District in northeastern New Brunswick and on Prince Edward Island.

The Paleo-Indian points are made from various materials. The Kingsclear point is crafted from a red and blue-green chert, similar to materials quarried at Munsungun, Maine. The one from Quaco Head is of a dull red chert and the Miramichi specimen is made from white quartz. The stone tools from the Debert site in Nova Scotia are made from locally available chalcedonies.

Applications of Geographic Information Systems in Quaternary geology

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Terrain Sciences Division of the Geological Survey of Canada currently operates two Geographic Information Systems: UNIX version of ARC/INFO on a Sun Sparcstation and ATLAS GIS. ATLAS GIS is a vector base system running under DOS. The system does not have all the capabilities of a full-fledged GIS, but with user friendly interface and low overhead, it is an ideal desktop GIS. ARC/INFO is a powerful analytical tool with both vector and (version 2) raster based capabilities. Terrain Sciences Division is compiling a library of ARC/INFO data sets, available for querry and display by both Mac and PC users, however, all analytical functions will be resident on the Sparcstation.

A Paleogeographic Atlas of Canada, for the period 18,000 to 1,000 years B.P., is being compiled using ARC/INFO GIS. The atlas will consist of a series of "time-slice" maps depicting ice margin positions, glacial lakes, and paleocoastlines, in conjunction with associated pollen sample sites of each period.

Geochemical data sets collected by Terrain Sciences Division can be entered into the info data engine of ARC/INFO, thus permitting the display of geographic location of samples for any area; retrieval and display of sample subsets; and extraction of samples containing specific values and construction of three-dimensional surface plots.

GIS are being used to store and manipulate information on the surficial geology, geomorphology and permafrost conditions in the Mackenzie Valley Corridor. This information will be combined with digital terrain models, borehole stratigraphy, and ground thermal information to produce predictive impact maps of terrain sensitivity to changing climatic conditions.

Glacial dispersion of clast lithologies: Lake George area, New Brunswick

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Dispersal patterns of specific clast lithologies in the 3-8 cm size-fraction of till were investigated over a 532 km^2 area in the Lake George area of southwestern New Brunswick. In the northwest portion of the study area till is underlain by the Pokiok Batholith; granites intruded by small aplite dykes. A sharp diagonal contact separates the granite from greywacke occupying the southeast portion of the study area. Greywacke also occurs outside of the study area, to the north and west of the Pokiok granite. Samples were collected on a 2 km grid from late Wisconsinan age sediments during surficial mapping for the New Brunswick Department of Natural Resources and Energy. Multivariate analysis was performed on 100 till samples.

Southeastward-trending dispersal plumes can be distinguished over distances of 14 km for aplite erratics. The dispersal plumes are elongated towards the southeast and parallel directions of local striae (140°-180°). Clast percentages of granite and greywacke are inversely correlated (r_s =

.7). These observations support a model for lithologic diffusion of glacial load in response to incorporation of these units as the glacier flowed southeastward and south across the area. Along the Saint John River valley, the earliest and most prominent directions are southeastward, which may be indicative of topographic influences on thinner ice. Much of the surficial cover is the result of ablation and glaciofluvial processes associated with later glacial stagnation. Future drift prospecting programs relying on analyses of the clast-size fraction of basal till, will require close sample-spacing and accurate identification of till facies.

ESR dating of tooth enamel at Longola Spring Mound, Zambia

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A single radiation-sensitive ESR signal with g = 2.0018 occurs in well-crystallized carbonate hydroxyapatite, $Ca_5(PO_4)_3(OH,F,CO_3)$, in fossil tooth enamel, but not in modern teeth. For fossil teeth, an ESR age is determined by measuring the equivalent radiation dose (AD) needed to produce the observed ESR signal and the natural, environmental dose rate (ED) experienced by the tooth where it was buried. The age is then given by the ratio, AD/ED. Since the age determined depends on the U uptake history assumed, three dates are normally calculated assuming: (1) early uptake of most U (EU); (2) continuous (linear) U uptake (LU); (3) recent uptake of most U (RU). Generally the LU ages agree best with known ages determined by other methods, but the EU and RU ages are respectively the minimum and maximum ages.

Langola Spring Mound, in Central Zambia, contains artifacts in two horizons. A Late Stone Age collection occurs on the top of the spring mound. Embedded in layer near the base, is a much older layer containing artifacts and bone material. Four ungulate teeth collected from a preliminary excavation in the lower layer were analyzed. EU, LU, and RU ages for all four teeth agree very closely. The teeth range in age from 13 to 70 ka. This suggests that either the layer may be a secondary accumulation, a mixed deposit, or that some of the dates may be erroneous. More excavation and dating are necessary.

Timing and pattern of glacial retreat, east-central Ellesmere Island and northwestern Greenland

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Unlike the coasts of Atlantic Canada, where numerous age determinations on both marine shells and basal organic lake sediments demonstrate deglaciation prior to 12,000, or even 13,000 radiocarbon years ago, along the high latitude coasts of southern Nares Strait (Smith Sound, at 78° to 79°N), the oldest ^{14}C ages bearing on deglaciation are some 3,000 to 4,000 years younger, i.e., between 9,000 and 9,500 radiocarbon years.

Aspartic acid ratios on shells in till above the Holocene limit of marine submergence on both the Ellesmere Island and Greenland sides of Smith Sound are low, ranging from 0.173 (UA-3108) to 0.225 (UA-3107) for *Hiatella arctica*. Also, isoleucine epimerization ratios (*a*lle/Ile) are as low as 0.052 (AAL-1499, total) for *Hiatella arctica* shells in till on top of Cape Herschel, and a single *Mya truncata* shell from this site yielded a finite ^{14}C age of 28,680 ± 230 years (TO-1268). If this value indicates the shell's true age, the date provides a maximum limit for the latest ice advance which scooped up shells from the sea bottom.

The best explanation for: (1) the low amino acid ratios and the young ^{14}C age, (2) the fresh-appearing glacial sculpture in Precambrian granite-family rocks, (3) the late timing of deglaciation along Nares Strait, (4) the fact that the fiord heads became free of glacier ice far later than the outer coasts, and (5) the 135 m of emergence that has occurred at Cape Herschel in the last 9,000 ^{14}C years, is to invoke a significant cover of glacier ice in late Wisconsinan time. The field evidence strongly supports the hypothesis that the Greenland and Innuitian ice sheets coalesced over Kane Basin, a wide and shallow part of Nares Strait, and drained southward to Baffin Bay via an ice stream which filled Smith Sound (greater than 500 m deep and less than 40 km wide). This ice stream would have blocked the marine connection between the Arctic Ocean and Baffin Bay. The change should be reflected in Baffin Bay sediments.

Contribution No. 38 from the Cape Herschel Project, GSC.

Late glacial and post-glacial history of the Tofino area, British Columbia

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Tofino is located on the west coast of Vancouver Island near the limit of Pleistocene glaciation and less than 100 km east of the boundary between the America and Juan de Fuca plates (Cascadia subduction zone - CSZ). Late Quaternary sediments and landforms near Tofino provide insights into the glacial and tectonic history of the region. The area was one of the last in British Columbia to be glaciated during the Late Wisconsinan. Sometime after 16.7 ka, glaciers from the northeast overrode the Tofino lowland and flowed onto the continental shelf. A variety of glacial sediments were deposited and subsequently scoured by these glaciers between 16 ka and 14 ka. During the early stages of deglaciation, glaciomarine sediments were deposited on the isostatically depressed lowland south of Tofino. This period of marine sediment accretion ended with a rapid fall in the level of the sea relative to the land, caused mainly by glacio-isostatic uplift. The presence of *in situ* stumps in the present-day intertidal zone that have yielded radiocarbon ages in the 7-8 ka range indicate that sea level during the early Holocene probably was lower than today. In contrast, there are younger elevated shoreline features near Tofino, which indicate that sea level during the middle and/or late Holocene was higher than at present. This complex pattern of sea level change probably has a strong neotectonic overprint, although the details are not yet clear. Ongoing research is aimed at documenting the effects of large mega-thrust earthquakes in the eastern North Pacific Ocean, particularly along the CSZ. Near-surface, clean sand layers present in fine intertidal sediments near Tofino and elsewhere on Vancouver Island may be products of seismogenic tsunamis.

Glacial-marine events in Maine during the Late Wisconsin deglaciation

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During the last deglaciation the ice margin, receding from its maximum position on the continental shelf, crossed the present position of the Maine coast about 13,500 years ago accompanied by a marine transgression. This condition continued inland for about 100 km at which time rebound exceeded eustatic sea level rise and the ice margin continued to recede above the inland marine limit of the De Geer Sea while the shoreline regressed to a present depth of about 60 m crossing the Maine coast about 12,000 years ago. Subsequently, sea level has risen to its present position.

Current research, aimed at developing a much refined chronostratigraphy of Late Wisconsin age deglacial events in the region, is focused on documenting the chronology, glacier configuration and associated glacial and glacial-marine dynamics. In addition, the closely dated microfossils contained in the emerged late glacial Presumpscot Formation will be analyzed for their oxygen isotopic ratios in order to obtain isotopic signatures for water bodies in the De Geer Sea. In turn, this study will contribute to the tracing of paleo water bodies in the North Atlantic and hence to ocean circulation patterns essential for the interpretation of possible rapid climate changes in the North Atlantic region during the late glacial.

In total this information will add to the data base necessary for determining the relative importance of marine, glacial and climate signals responsible for major environmental changes during the late glacial.

Organic sediment load in modern glaciers, Bylot Island, Northwest Territories

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Intact to deformed masses of young organic sediment comprise an important part of the englacial sediment load in glaciers on the southwest side of Bylot Island, opposite the town of Pond Inlet, N.W.T. Based on physical characteristics and on palynological analyses, these sediments can be placed into one of three groups: (1) A 1 m by 50 cm raft comprising

undeformed mosses and associated tundra vegetation in growth position on cross-stratified pebble gravel and sand was preserved and completely enclosed by ice approximately 30-40 m above the base of Camp glacier (B-7, of glacier inventory area 46201). The sediment was evidently recently incorporated (^{14}C age of 120 + 120 years; GSC-2529), probably by being frozen onto the base of the glacier from outwash in a lateral meltwater channel; (2) One-metre high mounds of putrid-smelling, gyttja-like sediment melted out of a 20 cm(+)-thick, dyke-like sheet along an apparent thrust plane on top of and about 1 km up-ice from the snout of Aktineq glacier. The sediment consisted largely of macerated, unidentifiable organic debris with sparse, degraded pollen and no algal remains, mixed with noncalcareous silt and sand. The deposit is thought to contain mostly bird (probably goose) feces. It has an essentially modern date (150 + 130 years; GSC-5116) and is thought to represent glacially reworked lake-bottom sediment from an ice marginal lake about 6.5 km up ice from the outcrop; (3) Near the snout of Sermilik glacier, we observed several vein-like exposures of organic debris composed of silt, fetid organic matter with sparse, degraded pollen, and abundant remains of the black-coloured algae *Ancylonema nordenskioidii*, which grows preferentially on the glacier's surface. The vein-like occurrences of organic debris are interpreted to be a mixture of wind-blown silt, bird feces and algal detritus, washed or blown into open crevasses in a zone of extensive flow just up-ice from collection sites. The crevasses have closed and are disrupted by thrust faults in the zone of compressive flow near the glacier's snout, where they are marked by differential meltout of organic debris at the glacier's surface and on the sides of a 40 m-deep supraglacial meltwater channel.

Application of glacial geology in the assessment of neotectonics in coastal environments

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Postglacial deformation of bedrock or sediment is often interpreted as evidence of recent earthquake activity and used to extrapolate beyond the historical record of local seismicity. Such deformation is demonstrated by horizontal or vertical offset of striated or polished bedrock surfaces and/or soft-sediment deformation, including: deformed or convoluted laminae, diapirs, clastic dykes, liquefaction or fluidized water-escape structures, rheoplastic structures, large-scale slumping and sediment gravity flows.

However, along coastal regions such deformation may have resulted from previous glacial activity either directly, as dynamic glacitectonic deformation, or indirectly, as sediment loading, permafrost, postglacial isostasy, glacitectonic stress release, or slope instability. Rock masses generally have greater compressional strength than tensile strength and resultant glacitectonic displacements can occur long after initial glacitectonic stress. Saturated sediments, proximal to a grounded glacier, can experience glacigenic expulsions, while slope instability and resultant sediment gravity flow deposits are natural consequences of rising or falling water levels, which in a glacier-ponded environment may be associated with either glacier advance or retreat.

In glaciated areas, initial stresses may be attributed to glacitectonics if deformation structures demonstrate a combination of structural orientation perpendicular to direction of ice advance or retreat, infillings of till and/or glacier-abraded edges on related displacements. Neotectonic deformation is best demonstrated as a major surficial lineament, or as a spatially controlled kineto-stratigraphic unit indicative of a temporal catastrophic event.

Modelling the dynamics of southern Ontario forest during the Little Ice Age

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Southern Ontario pollen diagrams with detail of the last millenium show a decline in beech and a rise in white pine, followed by European disturbance. Oak and other early-successional species form peaks between the beech decline and the pine rise. This succession has been attributed to both the Little Ice Age and prehistoric Iroquoian disturbance for maize horticulture. A comparison of the geographic distribution of different trends in forest succession with the distribution of prehistoric Iroquoian settlements suggests that anthropogenic disturbance is an inadequate explanation.

A computer simulation model of forest dynamics based on FORET (Shugart, **A Theory of Forest Dynamics**, 1984) is coupled with a simple model of pollen dispersal, which translates the biomass figures generated by the forest model into a simulated pollen diagram. The forest model uses growing degree days, drainage, rate of disturbance, and competition to simulate the growth of individual trees on a 1/12 hectare plot. One hundred independent plots are averaged together to simulate a forest.

The simulation results indicate that while anthropogenic disturbance may have locally accelerated the succession, a climatic cooling of 1-2°C is likely to have been the major cause. This estimate of cooling agrees with other available proxy data for the Little Ice Age in northeastern North America.

CANPLOT: a PC-based program for plotting camera-ready pollen diagrams on a laser printer

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CANPLOT is a program for plotting pollen diagrams using a PC and a PostScript laser printer. Features include:

- stratigraphically constrained cluster analysis
- pollen to biomass conversion
- vertical scaling by either depth or interpolated date
- percentage, concentration, or influx diagrams
- the ability to add taxa together to make synthetic taxa
- exaggeration curves for rare taxa
- upright and italic lettering in different pitches
- compact format for data storage
- comments placed at any level in left or right margins
- nine styles of zone boundaries
- bar-graph or sawtooth graph
- up to 250 taxa and 250 levels in a single diagram

It can also be used to plot other stratigraphic data such as diatoms, forams, loss-on-ignition, macrofossils, etc.

The program is written in FORTRAN 77. Compiled with the WATFOR-77 compiler, it requires MS-DOS 2.0 or more recent and 640 K RAM. An average pollen diagram takes about two minutes on an 80286 (AT clone) machine, and an additional minute per page to print on a NEC SilentWriter laser printer.

A companion program, ENTRY, allows easy data entry in the format required for CANPLOT, with elementary input error-checking.

Gravel-dominated tidal flat, Come-By-Chance, Newfoundland: a coastline conditioned by glaciofluvial sedimentation

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The coastline at the head of Come-By-Chance Arm on northern Placentia Bay is characterised by a gravel-dominated tidal flat sequence. The sequence is marked by meandering and anastomosing tidal channels, small washover fans, bank collapse sequences, and sedimentary successions in abandoned channels resembling those of oxbow lakes. The tidal succession is bounded at its seaward margin by a coarse mid-bay bar complex. Present tidal currents along this low-mesotidal to microtidal coast, generally marked by low energy conditions, are not competent to transport large quantities of gravel, except during rare storm events. The gravel was supplied to the arm primarily by glaciofluvial activity during the Late Wisconsinan, originating from the Goobies area to the northeast, and was deposited as an underflow fan delta. Subsequently, Come-By-Chance underwent a period of sea level regression, allowing the coarse fan sediments to be exposed and reworked in the coastal environment. Additional lesser quantities of gravel and sand were reworked from the glaciofluvial deposits and transported short distances by the Come-By-Chance River. At present, a small-scale marine transgression is permitting enhanced reworking of the mid-bay bar complex, and an increase of marine energy levels is apparent in the most recent sediments of the tidal flat succession. The succession thus demonstrates the complexity of sea level history along the Placentia Bay coast, as well as indicating the influence that Late Wisconsinan sedimentation has upon modern coastal processes and coastline evolution in southeastern Newfoundland. Preliminary work suggests that a similar succession may have developed subaqueously in Bull Arm, along the northeastern side of the Come-By-Chance isthmus.

A reappraisal of postglacial uplift, south shore of the St. Lawrence estuary, Québec

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The south shore of the St. Lawrence estuary is a non-conforming area in respect to theoretical models of postglacial isostatic recovery or relative sea-level changes. According to models (Quinlan and Beaumont, 1981, 1982; Peltier, 1987), the area considered should have experienced a rapid submergence tied to the ice sheet withdrawal followed by a continued and progressive isostatic uplift. Proposed a decade ago, the theoretical model of Quinlan and Beaumont fitted well with the existing isostatic curves. There was, however, no data available for the period from 9.5 to 2.5 ka, a gap that has been documented since. Presently, field data from many localities (over one hundred ^{14}C dates) indicate (1) a rapid isostatic recovery (85% of the crustal readjustment had occurred by 9.5 ka); (2) a low sea-level (at least 5 m and possibly 10 m lower than today) occurring between 7 and 6 ka; (3) a re-submergence of 8-10 m between 5.8 and 4 ka, followed by a new uplift or lowering of sea-level. The events which occurred in the period 4 ka to present day are not yet entirely clear and fully understood. However, this interval was characterized first by a period of erosion (Micmac cliff) and then by a period of sedimentation (Mitis terrace, ±6 m a.s.l.), dated circa 2,000 years B.P. The new isostatic curve

or relative sea level changes during the Holocene differ from the predicted models. This type of curve shows that a double transgression-regression event is not exclusive to the St. Lawrence estuary for similar curves exist also for areas in Norway, Greenland and Spitsbergen. Therefore, this curve should be taken into account when drawing of future theoretical models of postglacial isostatic coastal recovery or Holocene fluctuations of relative sea level.

Inundated cultural deposits from Montague Harbour, British Columbia: implications for post-glacial human occupation on the Pacific coast

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A multidisciplinary study of the Montague Harbour basin, Galiano Island, British Columbia, has uncovered evidence of post-glacial sea-level rise and inundated cultural deposits. Evidence for sea-level rise is found in two sediment cores from the lower intertidal zone. The cores contain a depositional sequence of basal clays (Victoria clays?), terrestrial soils, paralic sediments, and marine sands. Cultural deposits recovered from the intertidal zone consist of well-stratified midden deposits, including features, and artifacts diagnostic of Marpole and Locarno cultures of the first millenium B.C., and perhaps earlier. Eleven additional artifacts were recovered from the submarine excavation unit. The stratigraphic integrity of the intertidal deposits suggest the inundation of these deposits was relatively sudden.

The study supports a model of human occupation on now submerged shorelines during the mid Holocene, a period for which is currently underrepresented in the archaeological record, and represents the first attempts to develop methods of excavation and interpretation of inundated cultural deposits on the Pacific Coast. In broader terms, the project may be articulated with the operationalization of the Coastal Migration Theory, which posits the early migrations to the New World along the Pacific coast. Since much evidence of such migrations would now be submerged along the continental shelf, new methods of site survey and interpretation are required to test the theory. It is suggested that investigation of near-shore cultural deposits present a logical beginning to their development.

Coastal subglacial events of two competing lobes, north shore Lake Erie

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Structural and lithologic analyses of drift and interstadial sediments near Bradtville, Ontario, reveal a complex story of subglacial processes and rheologic superposition in the lower 3 m of a 70 m exposure along the shore of a large depositional basin. Two Catfish Creek till members are separated by subglacial channel deposits in two depressions in underlying deformed interstadial sediments (IS).

NW-dipping faults and elongated sand clasts in IS indicate the Huron lobe overrode and deformed IS at the exposure's west end. It buckled IS while depositing Huron-provenance till with NW fabrics at the east end. Conjugate faults, shears, and boudinage in IS indicate superposed flow from the north, when the Erie and Huron lobes met and together flowed southward. At this time subglacial conduits were carved into IS and modified by meltwater erosion which left a stone lag and gravel near the east end. At the west end, a conduit was filled with squeeze flow till whose boulders show signs of rotation in a ductile fluid prior to deposition. N-dipping shears and breccias within flow till show brittle shear superposed on ductile as ice overrode flow till with decreased water content, while N-dipping shears and attenuated silt streaks formed in deformation till above the conduit's east bank where ice/bed contact was continuous. SE-dipping shears in till and IS, and till fabrics, indicate the Erie lobe overcame the Huron and superposed a third force on the sediments. More flow till filled the west conduit, followed by a subglacial stream point bar migrating NE, then by deformation till with a boulder pavement whose clasts rotated freely before final emplacement, while deformation and/or lodgement till covered the rest of the section.

Abundant till deformation by viscous flow and ductile shear under high water pressure infers that ice streaming in the Erie basin could have helped drain the central margin of the Laurentide Ice Sheet.

Heavy mineral dispersal in till: Todd Mountain, New Brunswick

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Drift prospecting surveys in New Brunswick have previously experienced limited success in recognition of dispersal plumes defined by geochemical or mineralogical analyses of tills. A study was undertaken in the Todd Mountain area of central New Brunswick to define possible constraints on glacier dispersal and related prospecting activities. Dispersal patterns for specific heavy minerals in the silt-fine sand size-fraction of till was investigated over a 12 km x 25 km area. Sixty-three sub-samples were obtained from samples previously collected by a Geological Survey of Canada investiga-

tion of regional till geochemistry and considered to represent basal till deposited during the late Wisconsinan. Twelve mineralogies, confirmed by SEM, were selected for study on the basis of local geology and ease of recognition.

Results indicate that in this area of New Brunswick, eastward-trending dispersal plumes can be distinguished only over short distances (<5 km) for rare minerals that are highly characteristic of a specific source (e.g., coticules or zircon grains). When sampled at intervals of 100 m the mineral dispersal patterns more clearly identify nature and orientation of underlying bedrock. Correlations between mineral content and geochemistry are poor and mineralogical relationships are confused. Poor correlations among heavy minerals may be due to glacier mixing of variable source materials which can confuse genetic relationships and obscure correlations, and/or because samples were not uniformly collected from basal till. Some poor chemical correlations may also be due to weathering and hydromorphic dispersal. In this area, prospecting programs utilizing the fine-grained basal till fraction require close sample-spacing and accurate identification of till facies.

Glaciomarine underflow fan sedimentation, Placentia Bay, Avalon Peninsula, Newfoundland

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Glaciomarine underflow fan deposits abut the eastern shore of Placentia Bay. The sequences were formed by several subaqueous fan systems discharging into the bay from lobes of a local ice cap. The largest (63 m high, 1,300 m long) and most sedimentologically complex of these sequences is located at Great Barasway. High density turbidity current flow, slurry flow, viscous grain flow, and debris flow events are represented by diamicton strata, with deposits formed by slurry flow and high density turbidity currents predominating. Dropstones are common throughout the sequence. The high density turbidity current diamictons are characterised by random clast macrofabrics, and by discontinuous pebble and granule monolayers, representing basal traction carpet sedimentation. The moderately sorted slurry flow deposits tend to have moderately oriented macrofabrics, frequently with girdle distributions. Viscous grain flow is responsible for the deposition of moderately sorted sand and sandy diamicton beds. Debris flow deposits, marked by random clast macrofabrics and no internal structures, are rare at the Great Barasway exposure, but dominate some of the smaller fan sequences. The fan sequences generally show transitions from coarser, high-density proximal subaqueous sedimentation at the bases, to more distal deposition from less viscous subaqueous flows in the upper parts of the successions. The overall pattern of sedimentation is indicative of successive retreat by glaciers terminating in Placentia Bay, with sea level a minimum of 70 m above its present elevation.

Paraglacial alpine karst: Small River Glacier, British Columbia

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The evolution of alpine karst during the "paraglacial" phase of deglaciation has received little attention. This highly dynamic environment was studied at Small River Glacier, British Columbia.

During glaciation, erosion of karst produces roches moutoneés interspersed with truncated shafts and cave passages. Hydrologic continuity is maintained between ice and karst, but is dependant on subglacial bedrock topography, ice thickness and basal sediment distribution.

Glacial retreat exposes this surface to a variety of subaerial processes, dominated by seasonally abundant melt-water. In ice-proximal settings, mass-movement and debris-flows are the dominant geomorphic processes and are responsible for redistributing glacial debris into alluvial fans within depressions. Initially active sinks are thus choked, forming intermittent ponds which continue to infill with finer sediments. Completely infilled depressions become graded elements of a fluvial landscape. As the environment becomes more ice-distal, sediment delivery is slowed and vegetation begins to colonize. Seepage and enhanced solution begin to sap sediments and karst drainage is gradually reactivated out of the fluvial system. Subsequent evolution depends upon recharge from the catchment area of the depression. Over a longer time frame, postglacial subareal and subsoil solution produces a more conventional alpine holokarst.

Sea level history of the Gulf of St. Lawrence

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The sea level history of the Gulf of St. Lawrence is both regionally variable and locally complex. Interpretation of a new data set consisting of geomorphic, seismostratigraphic and piston core data is beginning to challenge existing concepts of sea level history within the region.

Terraces of regional extent occur along most of the northeastern margin of the Magdalen Plateau at depths of 110 m and 160 m below present sea level. The smooth surface and low relief of the Magdalen Plateau masks a complex system of basins and channels which are incised to a maximum depth of 160 m and may equate in time to development of the terrace along the plateau margin. The terrace is not observed in the uppermost tills which occur as lobate till sheets emanating from the Cape Breton Channel and Bay of Chaleur. We interpret this to indicate that the terrace predates the last glacial advance in this region.

Sediments infilling bedrock depressions in the Cape Breton Channel from a depth of 119 m comprise organic rich, dark coloured, interbedded silts and sands suggestive of a shallow marine or estuarine system. Stratigraphic evidence suggests that these shallow marine sediments immediately overlie the uppermost (late Wisconsinan) tills. It appears that the Gulf of St. Lawrence records multiple low sea level events including a significant lowering (±100 m) during the Late Wisconsinan glaciation.

Pleistocene stratigraphy and late glacial events in central and northern New Brunswick

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The Pleistocene stratigraphic framework of New Brunswick is best described from sections and cores retrieved from the thick sedimentary infilling of the middle and upper St. John River Valley. At this stage of investigation, the depositional events are all thought to postdate the last interglacial due to the absence of true Sangamonian beds in the area. In the St. John Valley, at least two different till sheets are separated by volumetrically extensive nonglacial coarse and fine-grained sediments which indicate that, at least, regional deglaciation prevailed sometimes during the Wisconsinan. Based on the absence of Precambrian lithological indicators, the Lower till seems to have been deposited by Appalachian ice and might correlate with Chaudière Till of the Eastern Townships of southern Quebec. The upper till is believed to have been emplaced by Laurentide ice as it was flowing in a generally eastward direction. In the vicinity of the Miramichi Highlands, there is widespread evidence for a major weathering event that preceded at least the last glacial advance. Interstadial organic sediments dated at >36 ka were discovered in central New Brunswick, at the Half Moon Pit.

Vertical downwasting of the Late Wisconsinan ice sheets is indicated by the occurrence of late glacial icemarginal and subglacial landforms along the edge of the Miramichi Highlands. Subglacial melt-out till can be seen overlying organic sediments dated at 11.5 ka (Allerod?) in the vicinity of Todd Mountain (central New Brunswick). Local reactivation of ice in late glacial time is thought to represent the Younger Dryas climatic oscillation described elsewhere in the Maritimes. This is thus a critical site for the interpretation of late glacial climatic changes in Eastern Canada.

Quaternary studies and gold exploration in the British Columbia Intermontane Belt

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The Intermontane Belt is a morphogeological region in central British Columbia, occurring between the mountainous Omineca and Coastal belts and is physiographically characterized by rolling hills and basalt plateaus. The study area is till covered and occurs in the eastern part of the Intermontane Belt along the central and northern Quesnel Trough. Research was conducted on the stratigraphy and sedimentology of Quaternary sediments associated with gold-bearing placers in the Cariboo region and a major Cu-Au porphyry deposit in the Mt. Milligan area.

The study area was covered by a generally north-flowing regional ice sheet during the late Wisconsinan. The subdued

relief in this structural and topographic low, combined with relatively easily eroded volcanic and sedimentary bedrock, resulted in deposition of an extensive thick till cover. Stratigraphic and geomorphic evidence shows that depositional patterns were complicated by topographically controlled ice flow during early and late phases of glaciation and by local deposition of thick glaciolacustrine and glaciofluvial sequences. Tills are commonly a few to several metres thick but Quaternary deposits up to 200 m thick occur in buried valleys where deposits from pre-late Wisconsinan events are preserved.

Traditional mineral exploration activities in the study area are hampered by the thick Quaternary cover. Most discoveries to date have occurred in areas of thin surficial cover, the Mt. Milligan area being a notable exception. Similarly, although there are producing shallow Holocene placers in the region (terrace, alluvial fan and colluvial placers), the most productive are sub-till deposits of Pleistocene or Tertiary age. Boulder tracing and soil geochemical sampling programs, combined with a knowledge of the nature of the surficial deposits, are effective drift exploration tools for locating lode sources in areas covered by locally derived basal till and colluvial deposits. These methods are less effective in locating buried placers due the low proportion of fine gold and the resultant nugget effect. Stratigraphic, sedimentologic and geomorphic studies combined with seismic and drilling programs are required to locate deeply buried placer deposits and mineralized bedrock sources.

Foraminiferal test linings in palynological preparations from coastal marshes of Louisiana

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Foraminiferal test linings are commonly observed in palynological preparations and considered evidence of saline environments or simply, foraminiferal production. Few studies, however, have actually addressed the nature of the foraminiferal assemblage present in the palynological preparation. A pilot project has been completed which does examine the "foram-lining" assemblage along a salinity gradient in coastal marshes of the Mississippi Delta plain.

Sediment samples, prepared with conventional palynological treatments (HCl, HF, and acetolysis), were examined from salt, brackish and intermediate marsh zones. Four different morphological forms are recognizable scattered among other palynomorphs on the prepared slides. No discernable patterns are readily evident in the limited data set available, but our analyses suggest that further study is merited. Using data classed by morphology, size and number of chambers, salinity zones can be successfully classified through discriminant analyses (82% correct classification). Comparison of our observations to results of a study of living forams in Mississippi Delta plain marshes (by D.B. Scott, Dalhousie University) also suggests it may be possible to establish a relationship between species and "lining" assemblages within the marsh zones.

The chronology and expression of the Younger Dryas cooling in Atlantic Canada

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Sediment cores have been taken from five small lakes close to the Fundy coast of New Brunswick and the Atlantic coast of Nova Scotia. Loss-on-ignition at 550°C and stratigraphic evidence from these sites show that sediment of the Younger Dryas is more minerogenic than sediment above and below.

Corresponding with this lithologic change is a change in the pollen record. Pollen diagrams from southwest Nova Scotia and Saint John, New Brunswick, both show the same major trends: a decrease in *Picea*, *Quercus*, and Cupressaceae, and an increase in *Alnus crispa* and Cyperaceae. This indicates an expansion of the shrub and herb components at the expense of the arboreal.

Pollen analysis from a site in southern Cape Breton, Nova Scotia, shows a sharp decrease in *Betula* and an increase in *Alnus crispa*, *Artemisia*, Cyperaceae and *Rumex/Oxyria*, indicating an expansion of shrub and herb components at the expense of *Betula*. Future macrofossil studies should determine whether the birch in the pollen record is derived from tree or shrub species.

Macrofossils close to the Younger Dryas boundaries at each of these sites have been used for AMS ^{14}C dating, providing the first accurate chronology of the Younger Dryas in Atlantic Canada. The start of the Younger Dryas at three of these sites, based on the pollen evidence, ranges from 10,560-11,060 years B.P. Loss-on-ignition evidence for this event gives a narrower range of 10,770-11,060 years B.P. These dates are considerably younger than some previously published bulk sediment dates. Dates and pollen diagrams from other sites are still pending.

Late glacial - Holocene history of Harrigan Lake, Saint John County, New Brunswick, based on fossil diatom and sedimentary pigment distribution

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The earliest stage of postglacial development in many north temperate lakes is characterised by an assemblage of small *Fragilaria* species, believed to be indicative of oligotrophic, alkaline, possibly shallow waters, influenced by considerable base cation leaching under a relatively cool climate.

In an 8.89 m sediment core from Harrigan Lake (New Brunswick), six zones were recognised on the basis of diatom, organic matter and pigment data. Zone I, from 8.89-7.80 m, included the Younger Dryas minerogenic zone, dominated by *Fragilaria* spp. Zone II, to 6.45 m, is characterised by a more diverse diatom community dominated by *Cyclotella*, *Navicula*, *Fragilaria* and *Achnanthes*. *Fragilaria* spp. increased dramatically in zone III (6.45-4.00 m), which may correlate in part with the hemlock decline on land. The reappearance of large *Fragilaria* communities during the mid Holocene may indicate some similarity between the mid Holocene and late postglacial limnic environments. Alternatively, many small *Fragilaria* species may tolerate a broader range of environmental conditions than is generally supposed. Clearly, a refinement of knowledge of the ecology of this genus is essential to increased understanding of the late glacial - early Holocene development of north-temperate lakes.

The Late Wisconsinan deglaciation of the Riding Mountain Uplands: the superglacial lake phase

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The Late Wisconsinan deglaciation of the Riding Mountain Uplands was associated with the Lockhart Phase of Glacial Lake Agassiz (11,600-10,800 years B.P.). During the waning of the Falconer advance (post 11,400 years B.P.) a large area of glacial ice stagnated on the Riding Mountain Uplands. Subsequent downwasting generated a drainage network consisting of several superglacial lakes, spillways and meltwater channels. Many of these glacial rivers eroded their ice beds and incised into the substratum. Glaciofluvial sediments were deposited as sandurs eskers and kames. Subaqueous fans were deposited in the superglacial lakes and a major delta was built into the north end of Glacial Lake Hind. During this time an advance of the Valley River Sublobe created the Mears kame moraine.

Following the Marchand advance (11,200 years B.P.), the Assiniboine Lobe built the Oak River, Pipestone Creek, and Arrow Hills kame moraines. Northeastern ice (the Assiniboine Sublobe) retreated from the Rivers - Rapid City end-moraine to the Brookdale position. Further retreat lead to the drainage of Glacial Lake Hind by way of the Assiniboine River into an expanding Glacial Lake Agassiz. Downwasting of the stagnant ice on the uplands continued and the present day entrenched drainage system had developed on the stagnant ice moraine complex by approximately 10,800 years B.P.

Description of post-glacial echinoderm fossiles from marine deposits in New Brunswick

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Invertebrates commonly occur in post-glacial marine sediments that skirt the shoreline of New Brunswick. In addition to the more plentiful remains of clams, snails and barnacles, at least two species of echinoderm have been described, although neither have been well documented. The brittlestar *Ophiura sarsii* Lutken and the common green sea urchin *Strongylocentrotus droebachiensis* Muller are found in marine clays near Saint John. Sea urchin remains have also been described from deposits near Bathurst and Shippegan. In spite of a number of references, only two specimens of sea urchin from the Saint John area can be located, in addition to the recent description from Shippegan. Brittlestar fossils are more numerous, especially from the Sheldon Point deposit in Saint John.

A comprehensive list of Quaternary invertebrates from the Saint John region was published in 1865 by Charles Hartt and other papers have subsequently noted the presence of both *0. sarsii* and *S. droebachiensis*. However, very little has been done to document the occurrence and paleoecology of specimens in any detail. Even though both echinoderms are widely distributed boreal species, they can provide information about the trophic structure of post-glacial communities and with more careful collecting, they have the potential to supply more detailed information concerning water depth and temperature. In modern environments, for example, the disk diameter of *0. sarsii* can be correlated with water depth. Improved documentation of fossil remains of both species is a first step toward enhancing their value in paleoecology.

Fossil Coleoptera from Lismore, Nova Scotia: life before the Younger Dryas

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A Coleoptera assemblage from the late glacial of Nova Scotia suggests that between 11,900 and 10,500 years B.P. conditions in the region resembled the modern boreal forest. Peat samples recovered from the Lismore site on Nova Scotia's north shore contain a small well preserved insect fauna comprised primarily of Carabidae (ground beetles), Staphylinidae (rove beetles) and Byrrhidae (pill beetles) along with lesser numbers of aquatic beetles from the families Hydrophilidae, Dytiscidae and Limnebiidae. Bark beetles (Scolytidae) are also present.

Species include *Elaphrus lapponicus*, *Acidota quadrata*, *Olophrum consimile*, *Olophrum rotundicolle*, *Tachinus tachyporoides* and *Phloeotribus piceae*. All demonstrate transcontinental, boreal distributions and are common components of late glacial and post-glacial insect assemblages in eastern North America.

Recent palynological studies in Nova Scotia and New Brunswick have indicated an event between 11,000 and 10,000 years B.P. equivalent to the Younger Dryas cold interval. At Lismore, the Coleoptera fauna becomes sparse near the top of the section as the sediment becomes sandy. This correlates approximately with the 11,000 year level based on extrapolation between radiocarbon dates. No direct insect evidence is present for a climate cooling related to the Younger Dryas event.

Paleoentomology and the resolution of the Younger Dryas in western Europe and in eastern North America

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The Younger Dryas is a short-lived climatic deterioration, broadly placed between 11 and 10 ka, which is particularly pronounced in the maritime regions of western Europe. Questions about global change have revived interests as to whether this is a regional or global event.

Paleoentomological investigations conducted in western Europe by Coope and co-workers indicate extremely rapid colonisation by thermophilous Coleoptera in warming phases about 13 ka (early Allerød) and 10 ka (early Preboreal). During these phases the Coleoptera indicate warmer conditions than the plants. Discrepancies are suggested to be a result of the rapid pioneering potential of certain beetle species versus many plant species. Beetle faunas and floral assemblages appear to be in closer climatic agreement during the colder episodes and particularly during the Younger Dryas.

Rapid colonisation by boreal Coleoptera is also seen in the postglacial insect faunas of the Great Lakes region of eastern North America. In contrast to western Europe, there is no re-introduction of arctic or subarctic stenotherms, and hence no significant climatic reversal. There is, however, a pronounced "lake effect" in the general time frame corresponding to the Younger Dryas. This is a local, not regional, phenomenon, and is likely due to glacial meltwaters moving through the Great Lakes basins. Fossil insect investigations have now commenced in the Maritimes; perhaps these studies will reveal the amplitude and degree of change along the eastern seaboard of North America.

An update on global change research in Canada: the view from a federal perspective

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The Canadian Global Change Programme (CGCP) is run under the auspices of the Royal Society of Canada (RSC). The present structure of the RSC Programme has evolved from four "Working Groups" and four "Resource Groups" into a series of Standing and Ad hoc Scientific Panels. The Panels are advised by a Canadian Global Change Research Committee with an attached secretariat. Most Quaternary work is, or has, the potential of being related to Proxy Data/Past Global Changes, Long-Term Sites (Observatories), or Remote Sensing, or under Arctic Issues, Critical Zones, or Global Models and Processes. Elements of these programmes will be discussed. The Proxy Data/Past Global Changes Group is aligned along the IGBP recommendation of Stream 1 (last 2,000 years at annual to decadal resolution), and Stream 2 (largely the last interglacial/glacial cycle). Representations have been made to RSC to extend the analysis of past conditions much further back into the geologic record.

The best organised preliminary approach to utilise proxy

data outside GSC has been through "Project CELIA" (the last interglacial in Arctic and sub-Arctic North America). GSC work is concentrated on three Observatory Sites (Ellesmere, MacKenzie and Palliser), on natural hazard and paleoecological "time-slice" maps, and on a "national" paleoecological database. Academic, industry and government researchers interested in Quaternary matters and global change will have to organise broader, multi-disciplinary, approaches to problem-solving in order to optimise diminishing research funds.

Surficial geology of the Nepisiguit Lakes and California Lake areas, Miramichi Highlands, northern New Brunswick

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Surficial mapping (1:50,000 scale) and sampling of B-horizon soil, basal till and 100 pebbles at each of 406 sites on a 2 km grid is ongoing in NTS 21 O/7 & 8. Till is analyzed for Au + 33 elements, and selected base metals.

A till fabric, 264 pebble counts and 486 striae, groove and roche moutonnée measurements indicate an erosive eastward ice movement followed by northeastward and southeastward flowing ice. Lastly, ice flowed in various directions off the Highlands. This is consistent with other areas mapped to the north and south. Periglacial features, suggest that the highest elevations may have been exposed as nunataks during early stages of deglaciation. Granite-boulder erratics from the Mount Elizabeth Intrusive Complex in the center of the area were transported up to 30 km down-ice in an eastnortheast direction. No Canadian Shield erratics have been found.

A Late Wisconsinan homogeneous basal till (<2 m) throughout the area and erratic pebbles in till on the highest elevations suggest that all of the area was glaciated. Till is locally derived. Till thickness increases to the east, as elevations decrease and topography becomes gently rolling. Ablation till and ablation lag over basal till are found in valleys and topographic depressions.

Major rivers and brooks contain glaciofluvial (outwash and ice-contact), and postglacial alluvial deposits. Pre-glacial weathered granite (grus); colluvium and bedrock, dominate in steep valleys and on mountains and ridges.

Late Wisconsinan glaciation on the Atlantic coast of Nova Scotia: evidence from offshore

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About 20 new AMS radiocarbon dates are reported on molluscs from the inner Scotian Shelf off Lunenburg, Emerald Basin and the continental slope south of Halifax. Dates on the inner shelf suggest that the "Late Till" south of Lunenburg is older than 14.5 ka; and that substantial amounts of pre-late Wisconsinan proglacial sediment were preserved from the overriding Late Wisconsinan ice by their position in Rinnentaler on the inner shelf. A 28 ka date on a shell from this area is interpreted as indicating a middle Wisconsinan relative highstand of sea level, perhaps to higher than -27 m. Dates from Emerald Basin show that the base of the La Have Clay on the Scotian Shelf is diachronous and that in Emerald Basin there is a probable acoustic signature to the Younger Dryas cooling event. Although previous dates from Emerald Basin suggest ice retreat at about 18 ka, high rates of sediment supply to the upper slope persisted until about 13.5 ka. Rapid sediment supply ended earlier, at about 16 ka, on the eastern Scotian Slope. On the outer shelf, the oldest date from Late Wisconsinan proglacial sediment is 20 ka .

Applications of Quaternary mapping in New Brunswick

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Quaternary mapping in New Brunswick is presently taking place on a 1:50,000 scale at a slow, but unprecedented rate. The Province's proposed strategy for sustainable development indicates that the need for surficial geological data is essential for proper resource management and landuse planning (urban and rural planning, tourism, resource industries, and health). The relation to mineral exploration is well documented, and the geotechnical properties of surficial materials allow us to use these as construction materials. Increased concern over our drinking water quality, and its protection, has resulted in a greater demand for baseline geological data. The Province is also in the process of establishing regional sanitary landfills. Both bedrock and surficial investigations will ensure that potential damage will be kept to an absolute minimum. More recently the need has arisen to look at surficial and bedrock materials as the parent materials of our forest and agricultural soils. The New Brunswick Forest Site Classification System is an excellent example of applied Quaternary geology.

Coalescence of Newfoundland and Labrador ice - evidence from land and sea, west central Great Northern Peninsula, Newfoundland

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Results of independent land and marine Quaternary projects are combined to determine Late Wisconsinan (?) ice flow history in the area. Early post glacial sea levels reached elevations of about 150 m a.s.l. providing the opportunity to compare raised and submerged glacial geomorphology. Ice flow directions were interpreted on land from bedrock striations and oriented glacial landforms. The earliest ice flowed westward and southwestward from the Long Range Mountains (LRM) to beyond the modern coastline. During glacial retreat ice radiated from numerous valleys on the west side of the LRM, coalescing on the lowlands and flowing into the sea. There is no evidence of Labrador based ice advancing onto this coast.

Data from the seabed include Huntec DTS and 40 in^3 seismic records. A prominent ridge trending northeast-southwest along the west side of the Esquiman Channel that is contiguous with diamicton to the west, and pinches out in the east, is interpreted to be the grounding line of a major Labrador ice stand. Similarly, a grounding line for LRM ice, contiguous with diamicton to the east, is interpreted for a westwardly convex arcing ridge along the east side of the Esquiman Channel. It is suggested that Labrador and Long Range ice formed ice shelves that met somewhere over Esquiman Channel. Labrador ice probably did not advance onto the west coast in this area, possibly because of a calving embayment open to the Laurentian Channel.

Diatom responses to the Younger Dryas climatic cooling in sediments from lakes in southern New Brunswick

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In eastern Canadian lake sediment sequences, the Younger Dryas climatic cooling (ca. 11,000-10,000 years B.P.) is equated with a sharp decrease in organic matter values, a change in sediment colour, and pollen changes consistent with a reversion to a herb/shrub terrestrial flora. At most sites in eastern Canada and elsewhere, these changes appear abruptly, consistent with a rapid onset and end to the Younger Dryas cooling.

Changes in the diatom succession have been determined in a number of sediment cores from lakes in southern New Brunswick. Splan Lake (45°15'15"N 67°19'50"W), Little Lake (45°08'40"N 66°43'00"W) and Long Lake (45°17'N 66°04'W) each show a different sequence of diatom changes through the onset and end of the Younger Dryas cooling. In Splan Lake, the Younger Dryas mineral band is preceded by a *Fragilaria*-dominated community, and followed by a limnic community dominated by *Cyclotella bodanica*. Although the mineral band in Splan Lake is completely free of diatoms, the equivalent sediments in Little Lake show a *Fragilaria* decline immediately before, and redevelopment during the Younger Dryas interval. In Long Lake, sediments with few or no diatoms alternate with intervals containing a fully-developed diatom flora, particularly in the post-Younger Dryas period. To establish the timing and duration of the Younger Dryas cooling in eastern Canada, it is clearly important to separate local from regional features of these sequences.

Interpretation of diatom distribution in Maritime postglacial lake sediments

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Knowledge of the ecology of diatom species and communities (autecology and synecology) is central to the reconstruction of lake ontogeny. Paleolimnology is thus dependent upon the quality of the contemporary ecological data base. Difficulty is encountered, however, where the status of a particular taxon is questionable, and/or a taxon is found in a range of different environments.

Early postglacial communities are often characterised by small *Fragilaria* species believed to represent oligotrophic, alkaline environments with little organic matter, and sand or rock substrata. The general distribution of these communities is possibly related to the leaching of base cations from the abundant supplies of fine glacial materials left by the retreating ice. However, these same communities reappear during the early Holocene in lakes with alkaline catchments. Thus Long Lake and Harrigan Lake, New Brunswick support large mid Holocene *Fragilaria* communities, which decline abruptly about the time of the hemlock decline in New Brunswick. Possible explanations for this pattern are discussed in terms of the ecology of Long Lake, Harrigan Lake and Ashburn Lake, New Brunswick.

Late glacial - early Holocene development of Canoran Lake, Nova Scotia, with reference to the Younger Dryas cooling

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In many formerly glaciated regions, the earliest stages of lake development are characterised by a diatom community dominated by *Fragilaria* species. At some sites, planktonic species begin to appear shortly before the mineral sediments of the Younger Dryas. Subsequent events tend to vary somewhat from one lake to another. However, at most sites, the interface between Younger Dryas mineral sediments and those containing various limnic remains tends to be rather abrupt. This is also true of planktonic community development following the Younger Dryas cooling.

In Canoran Lake, Nova Scotia (44°36'N, 64°34'W), close interval sampling revealed a redevelopment of *Fragilaria* well prior to the deposition of the mineral band generally taken as a marker of the Younger Dryas climatic cooling. Prior to the Younger Dryas, a succession of *Fragilaria* communities developed, dominated first by *Fragilaria construens* v. *binodis*, followed by *F. pinnata* v. *brevistriata* and *F. construens* v. *venter*, *F. construens* v. *construens*, and *F. pinnata* domination immediately prior to the Younger Dryas. Immediately after mineral sediment deposition, *Fragilaria pinnata* peaked again. In Canoran Lake, the manner of redevelopment of the *Fragilaria* community seems consistent with gradual redevelopment of conditions characteristic of the earliest lake environment, i.e., with a gradual onset of the Younger Dryas.

Sedimentology of Quaternary glaciomarine deposits, Springdale - Hall's Bay area, Newfoundland

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Quaternary glaciomarine deposits form a complex sedimentary succession in the Springdale - Hall's Bay area of north-central Newfoundland. Marine incursion, due to isostatic depression, was extensive throughout the Indian Brook and South Brook valleys, reaching at least 10 km inland. Clay was deposited in low energy, distal locations. Dropstones indicative of ice rafting are present throughout the clay strata. The clays were deposited by a combination of suspension settling and sediment gravity flows. Geochemical analyses, including boron and vanadium determinations, indicate deposition in brackish-marine environments. Shells of *Mya arenaria*, *Balanus hameri*, *Macoma balthica*, and *Hiatella arctica* found in life position also indicate a similar brackish depositional environment. A succession of ice-contact deltas, representing the proximal units associated with the marine incursion, and a series of successively lower terraces (indicating isostatic rebound) are also present. Stratified coarse sediment sequences with surfaces ranging from 13 to 75 m above the present sea level were a result of higher sea-level stands. Most of the deposits were formed in ice-contact fan-deltas, but two sites are interpreted as ice-distal fans.

Quaternary geology of New Brunswick: seven years later

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Geological Survey of Canada, Memoir 416, "Quaternary Geology of New Brunswick," by Rampton, Gauthier, Thibault and Seaman, was published in 1984. This volume endeavoured to interpret the results of reconnaissance Quaternary geology mapping carried out intermittently over more than 100 years. The interpretation presented was of a complicated sequence of glacial events during the Late Wisconsinan, due to the interaction of several small, local glaciers. Deglaciation was interpreted as due to the marginal retreat of active ice.

Data collected during the course of detailed mapping projects conducted during the past seven years has confirmed that the sequence of glacial events was indeed complex, in fact, more complex than could ever have been envisioned.

For example, in southwestern New Brunswick 16 different regional ice-flow events have been identified. These appear to relate to the migration of one or more dispersal centres. Chronological relationships indicate that the ice centre shifted position from somewhere to the north, through to the west, and finally to the southwest, probably over coastal Maine. In addition, other ice-flow events are known that may relate to late, local glaciers. In other parts of the province, the glacial record is similarly complex. However, the available data is still insufficient to permit accurate correlation.

Deglaciation, in contrast, was relatively simple. The ice margin retreated to the coastal areas of New Brunswick, presumably by calving into rising marine waters, and then the regional ice mass largely stagnated. Extensive and intricate subglacial drainage systems were formed as the ice mass wasted. While this regional ice mass was disintegrating into a series of remnants occupying topographic depressions, local glaciers may have remained active over highland areas of the province.

Recent bedrock geomorphology of the Niagara Escarpment, Niagara, Ontario

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Within the study area, the Niagara Escarpment is an east-west ridge of rock which acted as an obstacle to advancing Wisconsinan glaciers, a shoreline for short-lived impounded lakes, a high energy section for northward flowing streams and a north facing slope on which a number of mechanical and chemical landscape processes could act. This variety of processes, occurring separately or concurrently, has resulted in a unique landform assemblage with many features representing controversial processes of formation. Sculpted forms with dimension under one meter, to headlands of similar shape and dimension ratios which exist at a scale 100 times greater, are remnant from the last glaciation. The escarpment top exhibits dense karst pavements which deliver water to the subsurface. Pop-ups exist in some quarry areas. The face of the escarpment has numerous waterfalls, springs, caves, collapse zones, zones of freeze/thaw and wet/dry weathering, all of which take advantage of a complex stratigraphy. Work performed along this section of the escarpment has resulted in a clearer understanding of the bedrock geomorphology, the processes which have formed them and the dynamics of the modern systems affecting the escarpment. Two processes which have been accepted as correct for more than fifty years can be debunked within the context of the work performed to date. Waterfall recession does not result from the falling stream undercutting at the base and sapping overlying rocks; and sculpted forms present along the escarpment are not ice molded, but rather the result of subglacial meltwater processes.

Marine geology of Baie des Chaleurs

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Baie des Chaleurs is the fourth largest estuary in eastern Canada, with a total area of 5,670 km^2. The hinterland drains a basin of 25,800 km^2 and receives an annual freshwater discharge of 26 km^3. The bay is a broad shallow basin, mostly <100 m deep but reaching 150 m in the outer bay. It is filled with up to 50 m of Quaternary sediment. Ice-contact sediment, including till, is generally thin or absent, but in the central and outer bay the bedrock troughs contain linear morainal accumulations up to 30 m thick, which may reflect the terminal position of the Gaspé ice dome. In the central and outer bay, 30 m thick glacimarine sediment are commonly dissected by relict ice scours. These glacial sediments have been subject to erosion along the margins and toward the inner part of the bay, where the units are observed to become thinner towards shallower water, and where their surface unconformities and scour relief are smoothed out. This period of erosion is associated with lowered sea levels, during which Holocene terraces and surface lags formed along the margins of the central and outer bay above depths of about 70 m. The inner bay, above depths of about 50 m, has been subaerially exposed and was occupied by a large sandur. The delta was partly fronted by a barrier island formed by reworking of an exposed moraine. Basinal Holocene muds were initially deposited in the deeper waters of the central and outer bay. As sea levels rose they subsequently formed an extensive veneer across the inner bay. The muds show a progression in bedding styles related to the sea level fluctuations, and in thicker sections (up to 35 m) contain prominent gas reflectors.

Late glacial - early postglacial environmental history of south central Newfoundland: evidence from the pollen and geochemical stratigraphy of lake sediments

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Pollen and geochemical analyses have been completed on basal sediments of cores from four ponds along a transect from southern to central Newfoundland, to investigate the timing and pattern of final deglaciation, and the late glacial - early postglacial environmental history of the area.

Basal organic sediments from the ponds yielded dates of, from south to north: 9,710 ± 120; 10,000 ± 120; 11,300 ± 100; and 10,200 ± 240 years B.P. It is suspected that the date of 11,300 years B.P., from the Conne River site, may be too old (Macpherson, 1990), while the remaining dates provide only minimum ages for deglaciation, since organic sedimentation began below the dated levels.

In general, the pollen stratigraphies indicate a succession from a pioneering herb or herb-shrub tundra in the early minerogenic sediments, to a birch-shrub community by about 10,000 years ago. Spruce arrived in the area ca. 8,900 years B.P., and an open spruce woodland was present until ca. 8,100 years B.P. when a closed spruce-fir forest had developed.

The results of the geochemical analysis of the cores complement the evidence from the pollen analysis, with high levels of clastic elements such as Na, Mg, K and Ti in the lower, predominantly inorganic sediments, reflecting high rates of erosion from the barren landscape. The concentrations of these elements gradually decline upwards in the basal sediments, coinciding with the expansion of shrub cover and eventually coniferous forest, representing decreased erosion rates as the soils became more stable.

Glacial processes explain the probable origin and aid in the exploitation of the Fredericton aquifer, Fredericton, New Brunswick

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The Saint John River Valley underwent significant infilling during the Millville / Dungarvon Phase of the late Wisconsinan. The deposition of these glacial sediments in thicknesses of up to 50 m has provided excellent material for groundwater resources. Localized geological settings include permeable Quaternary deposits along the banks of the Saint John River which provide an opportunity for the economical extraction of potable water from those deposits.

The City of Fredericton receives the majority of its supply of water from production wells located near the Saint John River. The intake screens for the wells are positioned in glaciofluvial sands and gravels forming the Fredericton Aquifer. A substantial increase in water demand suggests the need to investigate the capabilities of the aquifer to sustain stresses due to pumping.

A working hypothesis for the geology of the Saint John River Valley at Fredericton has been developed for the application of a computer model for the assessment of the effects of groundwater withdrawal. It is suggested that six geological units are present under the Valley Flat. They include: (A) bedrock; (B) buried sand and gravel channel; (C) lodgement till; (D) glaciofluvial outwash sands and gravels; (E) lacustrine clay/silt; and (F) fluvial sands and gravels. "Snapshots" of groundwater elevations in the aquifer and the Saint John River level support the hypotheses that the recharge to the aquifer occurs mainly via openings in the clay/silt unit, defined as "windows". About two thirds of the recharge is considered to occur from the Saint John River through direct hydraulic connection provided by the defined from windows. The remainder occurs from rainfall and snowmelt with a small amount contributed from the underlying bedrock. The location and extent of these windows need to be confirmed.

Surficial pop-ups as geological indicators of major seismicity in eastern North America

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Pop-ups are surficial, stress-relief structures typically characterized by unbent limbs, and abrupt, elongate hinges. They form in response to high horizontal stress, and are present in both quarries and open fields. In eastern North America they generally occur along, and in proximity to, the St. Lawrence Valley and its southwestward extension through the lower Great Lakes.

Large-scale earthquakes are sub-surface, stress-relief phenomena and have been triggered in unexpected locations in eastern North America. Pop-ups have been recognized in, and near, the epicentral areas of some of the larger ones, including those in Montreal (est m_b = 5.6-6.0), Attica (M = 5.8), Cornwall-Massena (M = 5.9), and the Miramichi region (m_b = 5.7). However, pop-ups are also found in aseismic areas.

Sub-surface earthquakes and surficial pop-ups are both kinematically congruent with the current regional stress field. This, and the presence of pop-ups in several known seismically active areas, suggests that pop-ups may signal areas subject to a greater seismic hazard than estimated exclusively from seismicity data.

Late Wisconsinan stratigraphy, New Sharon and Mercer, Maine

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Quaternary glacigenic deposits exposed along the Sandy River valley in New Sharon and Mercer, Maine, are associated with ice-proximal deposition in a northeast-trending stream valley. Fine-grained sediments represent distal deposits by turbidite deposition, turbid sediment plumes, and associated ice-rafted debris in a proglacial lake. Coarse-grained deposits and stratified diamicton are ice-proximal sediments deposited by gravity flow processes, subaqueous sediment discharge, and fluvial deposition. Massive diamicton was deposited by subaqueous sediment discharge or by basal ice processes.

Kinetostratigraphic data reflect an upsection shift in deformation from a northeast to a northwest source, attributed to Late Wisconsinan sublobes in the Sandy River and Kennebec River valleys. Ice in the Kennebec River valley dammed drainage in the northeast-oriented lower Sandy River valley creating a proglacial lake into which both sublobes deposited and deformed proglacial sediments during the early Late Wisconsinan. Main phase Laurentide ice eventually merged with and overwhelmed the sublobes. The glacigenic sediments were deposited entirely during a single glacial cycle, the Late Wisconsinan.