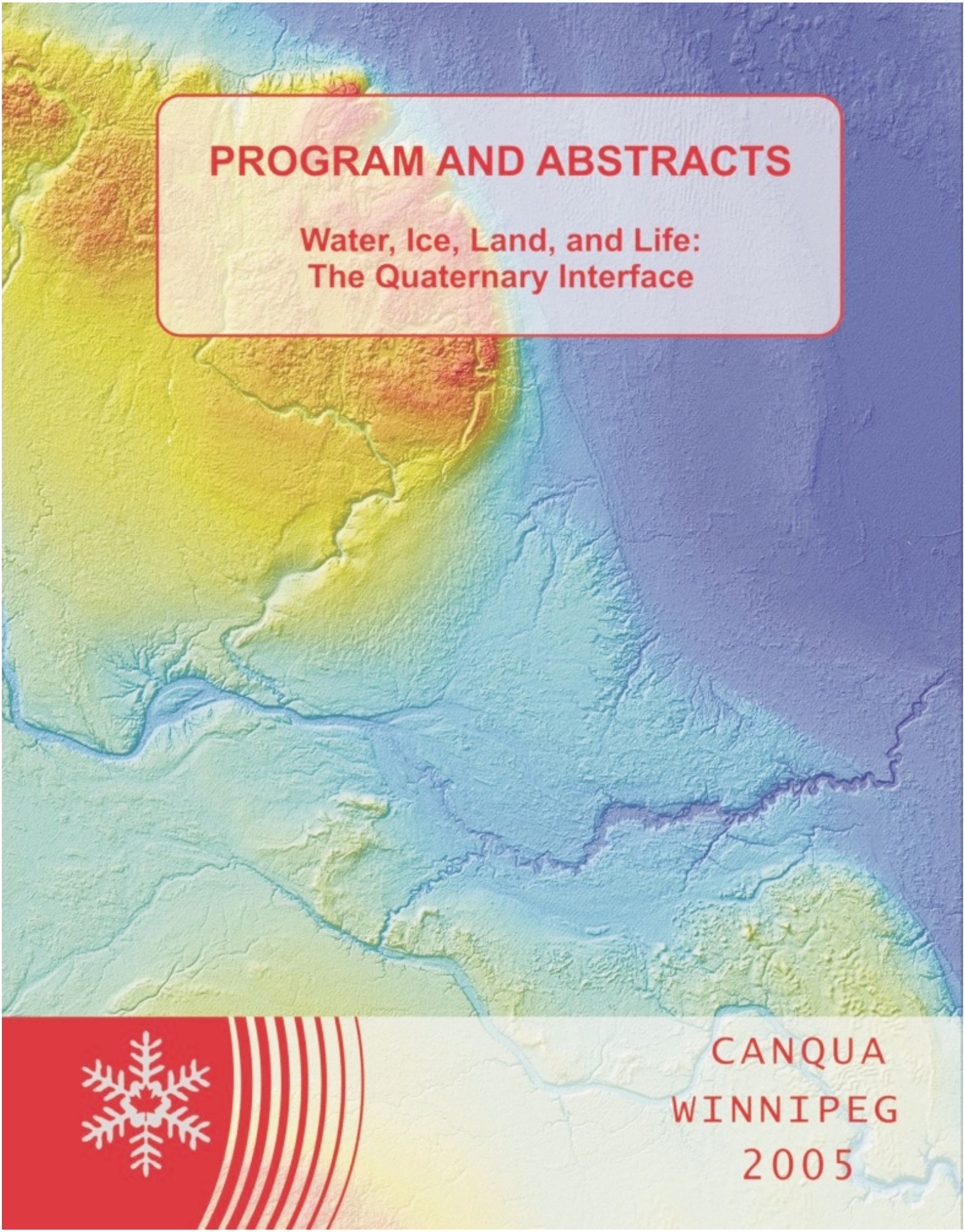
PROGRAM AND ABSTRACTS

Water, Ice, Land, and Life: The Quaternary Interface



CANQUA
WINNIPEG
2005

Canadian Quaternary Association
Association canadienne pour l'étude du Quaternaire

CANQUA 2005 Conference
June 5-8
Winnipeg, Manitoba

PROGRAM AND ABSTRACTS

A MESSAGE FROM THE PREMIER

On behalf of the citizens and government of the Province of Manitoba it is my sincere pleasure to send a warm welcome to all scientists, researchers and students attending the Canadian Quaternary Association 2005 Conference here in Winnipeg.

As climate change and other environmental issues reach the forefront of the public and government agenda, we rely on accepted bodies of scientific knowledge and research. Indeed, the study of the Quaternary period is an imperative contribution to scientific knowledge. Regardless of whether environmental changes are natural or a result of human activity, we can only benefit from a greater understanding of how certain processes, be they hydrological, geological, biological, and so on, brought us to where we are today.

Students and researchers alike are truly fortunate to have this opportunity to gather and discuss the earth's history with colleagues from other disciplines of study. I invite all visitors to take a special exploration of Manitoba's terrain.

Best wishes for a successful conference!

Gary Doer

UNIVERSITY OF MANITOBA | Office of the President

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Welcome to the University of Manitoba

I am pleased to extend, on behalf of the University of Manitoba, a warm welcome to participants to the Canadian Quaternary Association Conference. We are delighted to have been chosen to host the scientific meetings and related events.

Your Conference is the first major scientific conference hosted by the University, since the official naming of the Clayton H. Riddell Faculty of Environment, Earth, and Resources in January of this year. The Faculty is named after Clayton H. Riddell, graduate in geology from the University of Manitoba, who is a leader in Canada's energy sector, and has combined his exploration success with his work with Aboriginal peoples to establish strong working relationships.

The Faculty was established in 2002, and offers graduate and undergraduate degrees in geography, environmental science, geological sciences, as well as Masters and Ph.D. degrees, not only in these disciplines, but also in natural resources management. The theme of your Conference, *Water, Ice, Land, and Life: The Quaternary Interface*, fits well into the research and teaching interests of our new Faculty and related disciplines.

I am also very pleased to note that the Conference will honour Vic Prest, a graduate of the University of Manitoba (B.Sc. and M.Sc.), and a leader in reconstructing the glacial and environmental history of Canada during his illustrious career with the Geological Survey of Canada.

I hope that during the Conference participants will visit much of our University, which was founded in 1877, as the first university in Western Canada. I hope, too, that participants will find time to explore Winnipeg, as it is steeped in old world tradition, charm, and cultural diversity.

Do enjoy the exchanges that will take place in the context of new and long sustained acquaintance and friendship. There will be much to learn at the Conference and much to discover about our University, our City, and the friendly Province of Manitoba.

Emőke J.E. Szathmáry, Ph.D.
President and
Vice-Chancellor

CANQUA 2005 Organizing Committee

Chair, Treasurer	Jim Teller (University of Manitoba)
Technical program	Matt Boyd (Lakehead University) Jim Gardner (University of Manitoba)
Registration	Bill Buhay (University of Winnipeg)
University arrangements	Bill Last (University of Manitoba)
Printing, local information	Bill Rannie (University of Winnipeg)
Fieldtrip coordinator, logo designer	Gaywood Matile (Manitoba Geological Survey)
Webmaster, technical advisor, logo designer	Greg Keller (Manitoba Geological Survey)

Acknowledgments

Generous financial assistance for this conference was provided by the following sponsors:

University of Manitoba

Manitoba Geological Survey

Brandon University

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General Information

FIELD TRIPS

Buses depart 8 AM from Mauro Residence. Pre-meeting field trip returns Saturday (June 4) by dinner time. Post-meeting field trip returns to Winnipeg Airport by 5 PM Friday, June 10 and then proceeds to Mauro Residence. Luggage may be stored at Mauro Residence when registrants are away on field trips before (Friday-Saturday, June 3-4) and after (Thursday-Friday, June 9-10) the meeting.

ORAL AND POSTER SESSIONS

All oral sessions will be held in Rm. **343 Drake Centre**, and all posters will be displayed in Rm. **333 Drake Centre**. Posters should be set up before 3:30 PM on Sunday, June 5, and should remain displayed until 4:30 PM Wednesday.

SPEAKER READY ROOM

A speaker prep room (**539 Drake Centre**) will be available for use during the day, from June 5 to 8. Speakers are strongly advised to test their PowerPoint files on a conference computer before presentation.

POWERPOINT FILE UPLOADING

Speakers must provide Greg Keller with a digital PowerPoint file the day before the presentation. For individuals presenting on Sunday (June 5, Vic Prest Symposium), Greg will be available between 3 and 5 PM on Saturday (June 4) in Room **110 Mauro Hall**. Other times he will be available to copy/ receive PowerPoint files (Rm**. 539 Drake Centre**) are as follows:

(**1**) Sunday (June 5): 10:30 -- 11 AM and 12:20 -- 2 PM

(**2**) Monday (June 6): 10:10 -- 10:40 AM and 12:20 -- 2 PM

(**3**) Tuesday (June 7): 9:50 -- 10:20 AM and 12:20 -- 2 PM

CANQUA GENERAL AND EXECUTIVE MEETINGS

CANQUA executive meeting: Rm. 539 Drake Centre, Sunday (June 5) during the lunch break.

Annual General Meeting: Rm. 343 Drake, Monday (June 6), 5:30 – 7 pm.

Incoming new executive meeting: Rm. 343 Drake Centre, after Annual General meeting.

SESSION SCHEDULE

Sunday, June 5

VIC PREST SYMPOSIUM: GLACIAL HISTORY AND PALEO-ENVIRONMENTAL CHANGE IN GLACIATED NORTH AMERICA

Chairs: S. Wolfe, A. Plouffe, & A. Dallimore
Room: **343 Drake Centre**

8:15 – 8:25	Teller, J.T.	Welcoming address
8:25 – 8:30	Wolfe, S.	Opening remarks (Vic Prest Symposium)
8:30 – 9:10	Clague, J.	**Keynote Address**: THE LAST DAYS OF THE CORDILLERAN ICE SHEET
	1. Glacial History	
9:10 – 9:30	Ferbey, F. & Levson, V.M.	LATE WISCONSINAN ICE-FLOW REVERSALS AT THE BRITISH COLUMBIA COAST MOUNTAIN/INTERIOR PLATEAU TRANSITION: STRATIGRAPHIC, LITHOLOGIC, AND GEOCHEMICAL EVIDENCE
9:30 – 9:50	Spooner, I., Haspel, R. & Osborn, J.	HOLOCENE HISTORY OF BEAR RIVER GLACIER, NORTHERN COAST RANGES, BRITISH COLUMBIA
9:50 – 10:10	Roy, M. & Lamothe, M.	TIMING AND SUCCESSION OF GLACIAL AND NONGLACIAL EVENTS IN THE HUDSON BAY LOWLAND OF MANITOBA, CANADA
10:10 – 10:30	Veillette, J.J.	BOULDER TRACING AND PALIMPSEST ICE FLOWS ON THE GRENVILLE OF CENTRAL QUEBEC
10:30 – 11:00	**BREAK**	
11:00 – 11:20	Stea, R. & Occhietti, S.	INCEPTION AND GROWTH OF THE APPALACHIAN GLACIER COMPLEX
11:20 – 11:40	Catto, N.R., Gosse, J. & Stea, R.	GLACIAL HISTORY OF PRINCE EDWARD ISLAND – REVIEW & ADVANCES
11:40 – 12:00	Bell, T., Liverman, D.G.E., Batterson, M.J., Catto, N., Marich, A. and 4 others	DEGLACIAL ICE DYNAMICS IN NEWFOUNDLAND
12:00 – 1:30	**LUNCH**	

2. Paleogeography

1:30 – 1:50	James, T.S., Hutchinson, I., Barrier, V. & Conway, K.	RELATIVE SEA-LEVEL OBSERVATIONS FROM ISOLATION BASIN CORING AT THE NORTHERN STRAIT OF GEORGIA, BRITISH COLUMBIA
1:50 – 2:10	Murton, J.B. & Bateman, M.D.	PERMAFROST AND GLACIAL HISTORY OF THE TUKTOYAKTUK COASTLANDS, NWT, DURING MARINE ISOTOPE STAGES 3–2
2:10 – 2:30	Wolfe, S.A., Huntley, D.J. & Ollerhead, J.	LATE WISCONSINAN AND EARLY HOLOCENE DUNEFIELDS OF THE SOUTHERN INTERIOR PLAINS, CANADA
2:30 – 2:50	Paulen, R.C. Karrow, P.F. & McClenaghan, M.B.	THE COCHRANE SURGES AND GLACIAL LAKE OJIBWAY IN NORTHEASTERN ONTARIO
2:50 – 3:10	Shaw, J.	GEOMORPHIC EVIDENCE OF POSTGLACIAL TERRESTRIAL ENVIRONMENTS ON ATLANTIC CANADIAN CONTINENTAL SHELVES
3:10 – 3:30	Marich, A.S., Bell, T., Simms, A. & Batterson, M.	GENESIS AND GLACIAL HISTORY OF ROGEN MORAINE ON THE AVALON PENINSULA, NEWFOUNDLAND

3:30 – 5:00 **POSTERS (333 Drake)**

Evening **River Boat Cruise and Dinner** (buses leave from Mauro Residence at 6:00 – 6:15, return about 10:30 PM)

Monday, June 6

VIC PREST SYMPOSIUM (CONT.)

3. Paleoenvironments

8:30 – 8:50	Dallimore, A. & Enkin, R.J.	POST-GLACIAL AND PALEO-ENVIRONMENTAL HISTORY OF THE WEST COAST OF VANCOUVER ISLAND
8:50 – 9:10	Ward, B.C., Telka, A.M., Mathewes, R.W. & Geertsema, M.	A PALEOECOLOGICAL RECORD OF CLIMATIC DETERIORATION FROM MIDDLE TO LATE WISCONSINAN TIME ON THE INTERIOR PLATEAU OF BRITISH COLUMBIA, CANADA
9:10 – 9:30	Dyke, A.S., Savelle, J.M., Hodgson, D.A.	ENVIRONMENTAL HISTORY AND ARCHAEOLOGY ALONG THE NORTHWEST PASSAGE
9:30 – 9:50	Yansa, C.H. & Curry, B.B.	DEGLACIATION CHRONOLOGY AND PALEOENVIRONMENTS OF NORTHEASTERN ILLINOIS, USA
9:50 – 10:20	**BREAK**	

CLIMATE AT THE EDGE

Chairs: J.T. Teller & M. Boyd

10:20 – 11:00	Rutter, N.W.	**Keynote Address:** CLIMATE CHANGE DURING THE LATE QUATERNARY INTERPRETED FROM LOESS-PALEOSOL SEQUENCES FROM EUROPEAN RUSSIA, SIBERIA, CHINA AND THE UNITED STATES
11:00 – 11:20	Pashaie, A.	INVESTIGATION AND N[illegible]URAL DATING OF LOESS PALEOSO[illegible]N SE BASIN OF THE CASPIAN SEA CANCELLED
11:20 – 11:40	Moos, M.T., Laird, K.R. & Cumming, B.F.	PALEOLIMNOLOGICAL INVESTIGATION OF DIATOM SPECIES ASSEMBLAGE IN LAKE 239 (EXPERIMENTAL LAKES AREA, NW ONTARIO) THROUGHOUT THE HOLOCENE
11:40 – 12:00	Evans, C.P., Aitken, A.E. & Walker, E.G.	LATE QUATERNARY GEOARCHAEOLOGICAL INVESTIGATION OF THE ELBOW SAND HILLS, SOUTH-CENTRAL SASKATCHEWAN
12:00 – 2:00	**LUNCH**	

LAKES IN TRANSITION

Chairs: J.T. Teller & W. Last

2:00 – 2:40	Karrow, P.	**Keynote Address**: FOSSILS, CHRONOLOGY, AND LAKES
2:40 – 3:00	Smol, J.P. & Douglas, M.S.V.	FROM CONTROVERSY TO CONSENSUS: TRACKING RECENT CLIMATIC CHANGES USING ARCTIC LAKE SEDIMENTS
3:00 – 3:20	Fishback, L.E.	SEASONAL VARIATION IN FRESHWATER GEOCHEMISTRY ACROSS THE ARCTIC TREELINE NEAR CHURCHILL, MB
3:20 – 3:40	Campbell, J.E.	THE PRESENCE OF PROGLACIAL LAKES IN THE REINDEER LAKE AREA, NORTHEASTERN SASKATCHEWAN
3:40 – 4:00	Spooner, I.S. & Oickle,E.	THE DEVELOPMENT AND APPLICATION OF THERMAL SENSITIVITY MODELS FOR SMALL STRATIFIED LAKES

4:00 – 5:30 **POSTERS (333 Drake)**

5:30 – 7:00 **CANQUA Annual General Meeting** (343 Drake Centre)

Tuesday, June 7

LAKES IN TRANSITION (CONT.)

8:30 – 8:50	Teller, J.T., Murty, T. & Nirupama, N.	A TSUNAMI GENERATED BY THE FINAL DRAINAGE OF GLACIAL LAKE AGASSIZ ~8400 YEARS B.P.
8:50 – 9:10	Breckenridge, A. & Johnson, T.C.	PALEOHYDROLOGY OF LAKE AGASSIZ AND THE UPPER GREAT LAKES FROM 10,700 TO 8,800 CAL YBP [9,500-7,900 ^{14}C YBP]
9:10 – 9:30	McMillan, K., Teller, J.T. & Hugenholtz, C.	NATURE AND SEDIMENTOLOGY OF THE OLDEST AGASSIZ BEACHES ALONG THE MANITOBA ESCARPMENT
9:30 – 9:50	Teller, J.T., Yang, Z. & Boyd, M.	OVERFLOW FROM LAKE AGASSIZ DURING THE YOUNGER DRYAS
9:50 – 10:20	**BREAK**	
10:20 – 10:40	Fisher, T.G., Lowell, T.V., Glover, K. & Hajdas, I.	A NEW DEGLACIAL CHRONOLOGY FOR THE AREA WEST OF THUNDER BAY, ONTARIO, AND ITS IMPLICATIONS FOR A MOORHEAD PHASE EASTERN OUTLET OF GLACIAL LAKE AGASSIZ
10:40 – 11:00	Tarasov, L. & Peltier, W.R.	A CALIBRATED DEGLACIAL CHRONOLOGY FOR NORTH AMERICA: AN INFERRED ARCTIC TRIGGER FOR THE YOUNGER DRYAS
11:00 – 11:20	Yanko-Hombach, V.V.	CONTROVERSY OF NOAH'S FLOOD IN THE BLACK SEA: GEOLOGICAL AND FORAMINIFERAL EVIDENCE FROM THE SHELF
11:20 – 11:40	Chalaturnyk, M., Last, W.M. & Solylo, P.	CARBONATE HARDGROUNDS IN MAARS OF WESTERN VICTORIA, AUSTRALIA: A GLIMPSE AT MODERN LACUSTRINE DOLOMITE FORMATION
11:40 – 1:00	**LUNCH**	

THE ENIGMATIC BED: REFINING OUR UNDERSTANDING OF GLACIER BED PROCESSES AND ICE SHEET DYNAMICS

Chairs: J.-E. Lesemann & T.A. Brennand

1:00 – 1:05		Opening remarks
1:05 – 1:25	Menzies, J.	STRAIN PATHWAYS, TILL MICROSTRUCTURAL ARCHITECTURE – A GENERAL KINEMATIC MODEL
1:25 – 1:45	Lian, O.B. & Hicock, S.R.	TOWARDS UNDERSTANDING SUBGLACIAL THERMAL REGIME AND CHARACTER OF PALEO-ICE-FLOW UNDER PARTS OF THE LAST CORDILLERAN ICE SHEET
1:45– 2:05	Levson, V.M., Ferbey, T. & Demchuck, T.E.	GEOMORPHOLOGY, SEDIMENTOLOGY, ELECTROMAGNETICS AND LIDAR MAPPING OF LOW RELIEF, HIGH ENERGY, SUBGLACIAL CHANNEL DEPOSITS IN NORTHEAST BRITISH COLUMBIA, CANADA
2:05 – 2:25	Sjogren, D.B. & Brennand, T.A.	WHAT CONTROLLED THE DISTRIBUTION AND CHARACTER OF ESKERS IN THE SOUTHWESTERN SECTOR OF THE LAURENTIDE ICE SHEET, ALBERTA, CANADA?
2:25 – 2:45	Flowers, G.E.	THE INFLUENCE OF GLACIER BED PROCESSES ON THE MODELLED DYNAMICS OF VATNAJÖKULL ICE CAP, ICELAND
2:45 – 3:15	**BREAK**	
3:15 – 3:35	Lesemann, J.-E. & Brennand, T.A.	EVALUATING BED CONDITIONS AND MECHANISMS OF RAPID ICE FLOW IN MOUNTAIN-CENTRED ICE SHEETS (CORDILLERAN ICE SHEET), BRITISH COLUMBIA, CANADA
3:35 – 3:55	Brennand, T.A. & Sjogren, D.B.	SUBGLACIAL LANDSYSTEMS IN THE SOUTHERN ROCKY MOUNTAIN TRENCH (BRITISH COLUMBIA, CANADA): TOWARD UNDERSTANDING SUBGLACIAL PROCESSES BENEATH THE CORDILLERAN ICE SHEET
3:55 – 4:15	Shaw, J.	REGIONAL-SCALE FLOW PATTERNS, THE ROCKY MOUNTAINS AND SUBGLACIAL BEDFORMS
4:15 – 5:30	**POSTERS (333 Drake)**	
Evening	**Awards Banquet** – University Club (cash bar 6 – 7, dinner at 7 PM)	

Wednesday, June 8

DROUGHT IN WESTERN CANADA: PROXIES, PALEOCLIMATE OBSERVATIONS AND HUMAN INTERACTIONS

Chairs: S. St. George & D. Sauchyn
Room: **343 Drake Centre**

8:25 – 8:30		Opening remarks
8:30 – 9:10	Woodhouse, C.A., Webb, R.S. & Lukas, J.J.	**Keynote Address**: DROUGHT, TREE RINGS AND WATER RESOURCE MANAGEMENT IN COLORADO
9:10 – 9:30	Beaudoin, A.B.	TRAVELLERS' TALES: NINETEENTH CENTURY OBSERVATIONS AND THE PERCEPTION OF DROUGHT AS ABNORMAL ON THE CANADIAN PRAIRIES
9:30 – 9:50	Rannie, W.F.	WHEN DROUGHT AND DELUGE COINCIDE ON THE PRAIRIES
9:50 – 10:10	Watson, E. & Luckman, B.H.	TREE-RING BASED RECORDS OF PRECIPITATION AND STREAMFLOW IN THE SOUTHERN CANADIAN CORDILLERA
10:10 – 10:30	Meko, D.M.	TREE-RING RECORD OF DROUGHT ON PEACE-ATHABASCA DELTA
10:30 – 11:00	**BREAK**	
11:00 – 11:20	Wolfe, B.B., Hall, R.I., Edwards, T.W.D., Last, W.M., Karst-Riddoch, T.L. & Falcone, M.D.	18TH CENTURY DROUGHT IN THE PEACE-ATHABASCA DELTA, ALBERTA, RECORDED BY LAKE SEDIMENTS AND TREE RINGS
11:20 –11:40	Hall, R.I., Wolfe, B.B., Edwards, T.W.D., Johnston, J.W., and 7 others	LAKE ATHABASCA AND THE LITTLE ICE AGE: SUSTAINED HIGH-WATER STAND DRIVEN BY SNOWMELT-ENHANCED ATHABASCA RIVER DISCHARGE?
11:40 –12:00	Sauchyn, D., Axelson, J., Beriault, A. & Yu, G.	USING TREE-RINGS TO ESTABLISH THE PROBABILITY OF DROUGHT IN THE WESTERN INTERIOR
12:00 – 12:20	Oetelaar, G.A. & Belanger, K.	INDIGENOUS RESPONSES TO THE HYPSITHERMAL: A VIEW FROM THE STAMPEDE SITE IN THE CYPRESS HILLS
12:20 - 1:40	**LUNCH**	

1:40 – 2:00	Michels, A., Laird, K., Thomson, D., Leavitt, P. & Cumming, B.	RECONSTRUCTING DROUGHT REGIMES FROM THREE REGIONS OF THE CANADIAN PRAIRIES DURING THE PAST SIX MILLENNIA
2:00 – 2:20	Buhay, W.M., Babb, J., Bailey, D. & Hemminger, L.	A 1000-YEAR RECONSTRUCTION OF SOUTHERN MANITOBA DROUGHTS
2:20 – 2:40	Bégin, C., Marion, J. & Filion, L.	TREE-RING RESPONSE TO CLIMATE CONDITIONS DURING THE LAST 500 YEARS AT THE TWO ENDS OF THE NORTHERN CANADIAN TREE-LINE
2:40 – 3:00	Girardin, M.P., Tardiff, J., Flannigan, M. & Bergeron, Y.	SYNOPTIC SCALE ATMOSPHERIC CIRCULATION AND FIRE WEATHER CONDITIONS OF THE PAST THREE CENTURIES, BOREAL CANADA
3:00 – 4:30	**POSTERS (333 Drake)**	

POSTERS

VIC PREST SYMPOSIUM: GLACIAL HISTORY AND PALEO-ENVIRONMENTAL CHANGE IN GLACIATED NORTH AMERICA

Campbell, J.E.	SRTM DEM IMAGERY: PREVIOUSLY UNRECOGNIZED REGIONAL-SCALE ICE STREAMS, ICE FLOWS INDICATORS AND GLACIAL LANDFORMS IN SASKATCHEWAN
Carlson, A.E., Jenson, J.W. & Clark, P.U.	FIELD OBSERVATIONS FROM THE TISKILWA TILL, IL AND SKY PILOT TILL, MB OF THE LAURENTIDE ICE SHEET
Dyke, A.S., Giroux, D. & Robertson, L.	VEGETATION HISTORY, GLACIATED NORTH AMERICA
Hodgson, D. & Dyke, A.S.	RAPID ALLEROD AND SLOW YOUNGER DRYAS DEGLACIATION AT NORTHWEST MARGIN OF LAURENTIDE ICE SHEET (NW VICTORIA ISLAND) AND CONTRASTING ICE REGIMES
Kowalchuk, C., Ward, B.C., Plouffe, A., Smith, I.R., Tarplee, M. & Peterson, R.	QUATERNARY GEOLOGY AND STRATIGRAPHY IN THE VICINITY OF ZAMA CITY, BISTCHO LAKE MAP AREA 84M/2, NORTHWEST ALBERTA.
Lewis, C.F.M. & Gareau, P.	AN EMPIRICAL MODEL OF ISOSTATIC ADJUSTMENT FOR THE GREAT LAKES BASIN: THE BASIS FOR RECONSTRUCTING PALEOGEOGRAPHY AND FOR DISCOVERY OF A PHASE OF HYDROLOGIC CLOSURE
Lowell, T.V. & Fisher, T.G.	WHAT IF WE HAD LOOKED FROM SPACE FIRST? USING SRTM DEM DATA TO GENERATE ALTERNATIVE HYPOTHESIS FOR DEGLACIATION OF THE LAURENTIDE ICE SHEET
McGinn, R.A. & Zaniewski, K.	OUTBURST FLOOD IN THE UPPER ROLLING RIVER SPILLWAY, RIDING MOUNTAIN UPLANDS, MANITOBA: A PHYSIOGRAPHIC AND SEDIMENTOLOGICAL APPRAISAL
McMartin, I. & Dredge, L.A.	CONTRASTING GLACIAL LANDSCAPES BENEATH THE KEEWATIN ICE DIVIDE IN THE SCHULTZ LAKE AND WAGER BAY AREAS, CENTRAL NUNAVUT
Miller, A.A.L. & Lewis, C.F.M.	THE ENIGMA OF THE YOUNGER DRYAS: IS THE LABRADOR CURRENT A MISSING LINK?
Trommelen, M. & Levson, V.	QUATERNARY STRATIGRAPHY OF THE WESTERN MARGIN OF THE LAURENTIDE ICE SHEET, NORTHEAST BRITISH COLUMBIA
Waterson, N.J., Lowell, T.V., Fisher, T.G., Glover, K. & Hajdas, I.	THE DEGLACIATION OF THE FORT MCMURRAY AREA, ALBERTA: IMPLICATIONS FOR MELT-WATER DRAINAGE

CLIMATE AT THE EDGE

Dlussky, K.G.	MID-HOLOCENE CLIMATIC CHANGES IN THE SELENGA RIVER BASIN, SIBERIA AND MONGOLIA: REVIEW AND PRELIMINARY RESULTS
Evans, C.P., Aitken, A.E. & Walker, E.G.	A GIS APPROACH TO MODELLING ARCHAEOLOGICAL SITE DISTRIBUTION BY ENVIRONMENTAL ELEMENTS IN THE LAKE DIEFENBAKER REGION, SOUTH-CENTRAL SASKATCHEWAN
Kurek, J. & Cwynar, L.C.	WITHIN LAKE SPATIAL VARIABILITY OF MODERN CHIRONOMID ASSEMBLAGES AND A CHIRONOMID PALEOCLIMATE RECONSTRUCTION FROM WESTERN ALASKA
Pashaie, A.	AN INVESTIGATION ON CLAY MINERAL COMPOSITION OF THE LOESS MATERIALS IN THE SOUTHEASTERN BASIN OF THE CASPIAN SEA CANCELLED
Trindade, M., Bell, T. & Jacobs, J.	DENDROCLIMATOLOGICAL RECONSTRUCTION IN CENTRAL LABRADOR

LAKES IN TRANSITION

Boyd, M.	POSTGLACIAL HISTORY OF THE SOUTHEASTERN ASSINIBOINE DELTA, GLACIAL LAKE AGASSIZ BASIN: ARCHAEOLOGICAL IMPLICATIONS
Brooks, G.R. & Medioli, B.E.	ACOUSTIC PROFILES AND PRELIMINARY INTERPRETATION OF LATE QUATERNARY DEPOSITS WITHIN BASINS OF THE LOWER FRENCH RIVER, ONTARIO
Ginn, F.M., Last, W.M. & Londry, K.	DOLOMITE, MICROBIOTA, AND SALT LAKES OF WESTERN CANADA
Heinrichs, M., Raeder, U. & Müller, J.	CHIRONOMID TROPHIC HISTORY AND TEMPERATURE RECONSTRUCTION FROM A “BIG” (INSENSITIVE?) LAKE
Last, W.M. & Ginn, F.M.	SALTS AND LAMINATED EVAPORITIC CARBONATES: NEW INSIGHT INTO A CENTURY-OLD DILEMMA
Last, W.M. & Morancy, C.K.J.	LITHOSTRATIGRAPHY AND MINERALOGY OF RIVERINE LAKES FROM THE RED RIVER VALLEY OF SOUTHERN MANITOBA AND NORTH DAKOTA
Last, W.M. & Shang, R.Y.	BIG & SALTY: GEOLIMNOLOGY AND PALEOLIMNOLOGY OF SALINE LACUSTRINE GIANTS OF THE GREAT PLAINS
Lewis, C.F.M., Miller, A.A.L., Levac, E., Piper, D.J.W. & Sonnichsen, D.G.	THE OCEANIC ROUTING AND IMPACT OF THE FINAL OUTBURST FLOODS OF GLACIAL LAKE AGASSIZ-OJIBWAY TO HUDSON BAY, 7.6 - 7.7 ^{14}C KA
Yang, Z. & Teller, J.T.	ISOSTATIC REBOUND AND THE HISTORY OF LAKE OF THE WOODS

Yang, Z., Teller, J.T., McMillan, K., Kling, H., Boyd, M., Buhay, W. & Telka, A.	POST-GLACIAL HISTORY OF WEST HAWK LAKE, A METEORITE IMPACT CRATER, MANITOBA, CANADA: A MULTI-PROXY APPROACH

THE ENIGMATIC BED: REFINING OUR UNDERSTANDING OF GLACIER BED PROCESSES AND ICE SHEET DYNAMICS

Ayers, K.L. & Brennand, T.A.	UNDULATING TERRAIN, A NEW SUBGLACIAL BEDFORM ON THE SOUTHEASTERN PLAINS, CANADA
Fortier, G.F., Smith, R.C., Sjogren, D.B. & Neudorf, C.	MODELING AND INTERPRETATION OF GLACIOTECTONIZED SEDIMENT IN SOUTHERN CENTRAL ALBERTA: INTERGRATING GIS, GEOPHYSICS AND GEOMORPHOLOGY CANCELLED

GENERAL POSTER SESSION

Boivin, A.	RELATIONS ENTRE L'ÉVOLUTION DES ÎLOTS DE PERGÉLISOL CÔTIERS ET LES CONDITIONS CLIMATIQUES : CAS DE L'ÎLE NUE DE MINGAN, NORD DU GOLFE DU SAINT-LAURENT, QUÉBEC, CANADA
Wilson, G.C., Levson, V.M. & Allen, D.M.	A COMPARATIVE ANALYSIS OF QUATERNARY STRATIGRAPHY USING 2.5-D SURFACE MODELING AND COASTAL FIELD OBSERVATIONS
Ferbey, F., Church, A., Bednarski, J., Hickin, A.S., Demchuk, T.E., Kerr, B., Levson, V.M., Smith, I.R. & Trommelen, M.	EFFECTIVE METHODS FOR MAPPING SURFICIAL GEOLOGY AND AGGREGATE POTENTIAL IN BRITISH COLUMBIA'S NORTHEASTERN INTERIOR PLAINS.
Lian, O.B. & Brooks, G.R.	OPTICAL DATING OF BURIED HEARTHS FROM RED RIVER VALLEY, SOUTHERN MANITOBA, CANADA
Paulen, R.C., Beadoin, A.B. & Pawlowicz, J.G.	AN INTERSTADIAL SITE IN THE BIRCH MOUNTAINS, NORTH-CENTRAL ALBERTA
Puterbough, J., Catto, N.R., Velichko, A.A., Matishov, G.G., Morozova, V.P., and 6 others	PROGRESSIVE SHIFTS IN INTERGLACIAL CLIMATES, DON RIVER BASIN- SEA OF AZOV, RUSSIA
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ABSTRACTS

UNDULATING TERRAIN, A NEW SUBGLACIAL BEDFORM ON THE SOUTHEASTERN PLAINS, CANADA

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Digital Elevation Models (DEMs) and Landsat images of the Southeastern Plains reveal at least five fields of undulating terrain. This landscape consists of fields of subparallel ridges separated by depressions, ranging in relief from 2 to 30 m, and with intracrest spacing typically greater than 1 km. Each undulating terrain field is located on a regional slope or at a topographic step within broad subglacial landsystem tracts. Although a conspicuous feature on DEMs and Landsat images, undulating terrain of this scale has not been identified in previous research on the Southeastern Canadian Plains. This paper describes the composition of undulating terrain spanning the Qu'Appelle and Pembina valleys and abutting the Assiniboine valley. Formative processes are inferred from morpho-sedimentary relationships and landform associations.

Exposures reveal highly variable ridge compositions including massive diamicton, deformed sand and gravel, stacked and folded shale and diamicton, and fractured horizontally-bedded shale. Substrate deformation is consistent with a glaciotectonic origin for the sediments within some ridges; however, structural measurements indicate that the deforming force acted at an oblique angle to the ridge axes. Therefore, glaciotectonism was not the sole formative agent of the undulating terrain observed today. A glaciotectonic origin is also inconsistent with ridge formation in truncated, horizontally-bedded and fractured shale.

A subglacial origin is inferred from the facts that (i) undulating terrain is superimposed on megascale lineations, and (ii) smaller flutings, eskers and subglacial channels are superimposed on undulating terrain. An erosional origin is inferred from the facts that (i) some ridges are composed entirely of horizontally-bedded shale (truncated at the land surface) and (ii) ridge composition differs between and within tracts of undulating terrain. Erosion by broadly channelized subglacial meltwater flows is consistent with the morpho-sedimentary characteristics of undulating terrain and the landform associations observed. The nascent glaciotectonic or bedrock structures may have provided favourable preconditions for the development of undulating terrain at each locality.

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TRAVELLERS' TALES: NINETEENTH CENTURY OBSERVATIONS AND THE PERCEPTION OF DROUGHT AS ABNORMAL ON THE CANADIAN PRAIRIES

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During the mid to late nineteenth century several well-known EuroCanadian expeditions traversed the Canadian prairies, a landscape that had been home to Aboriginal people for at least 10,000 years. Influential participants (especially Palliser, Hind, and Macoun) wrote about their experiences and drew conclusions based on comparatively brief acquaintance with the area. Although Palliser expressed some doubts about the viability of the southern Canadian prairies, considering much of the area to be "comparatively useless", Hind and, especially, Macoun painted a roseate and optimistic picture of an agricultural hinterland for eastern Canada. Central to Macoun's view was his conviction that the landscape was generally well-watered, and that drought was infrequent and would not interfere with agricultural development. These perspectives influenced subsequent advertising campaigns that encouraged permanent settlement, especially in the late nineteenth century and until after WWI. Proxy climate data, notably tree-ring records, however, show that, far from being infrequent, droughts are regular occurrences in this region. Significantly, these records show several droughts of greater intensity than those experienced in the late nineteenth century. Longer-term (millennial scale) proxy records also show intervals of long-lasting climatic aridity. Rather, it is prolonged high-moisture intervals that are the rare occurrence. Ironically, the instrumental data from Medicine Hat show a sustained run (at least six) of years with substantial moisture inputs spanning the end of the nineteenth century. These resulted in bumper crop years, especially 1905, and no doubt helped to consolidate the optimistic outlook on the region. Subsequently, the precipitation pattern returned to one of high year-to-year variability. Yet, even as late as the 1960s, historians were still writing about drought as an aberrant event on the prairies. I suggest that we consider drought as the norm on the Canadian prairies, and interpret history and archaeology in the light of this perspective.

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TREE-RING RESPONSE TO CLIMATE CONDITIONS DURING THE LAST 500 YEARS AT THE TWO ENDS OF THE NORTHERN CANADIAN TREE-LINE

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Spruce trees growing at high latitudes, close to the tree-line, are sensitive to changes of environmental conditions. Because of this sensitivity, tree-ring series from such marginal trees are commonly used to reconstruct past climatic variations through transfer function procedures. Here we present tree-ring chronologies representative of the two ends of the northern Canadian tree-line and their respective climatic significance. The objectives are to compare the amplitude and the synchronicity of the climatic signature of the last 500 years recorded in tree-ring sequences and determine how biological processes that control growth form genesis should be taken into account when long-term climate fluctuations are reconstructed.

The western tree-line site is located on the south shore of Eskimo Lakes (69° 08' N, 132° 13' W) 48 km southeast of Tuktoyaktuk (NWT) while the eastern site is on Boniface River (57° 44' N, 76° 04' W) on the eastern cost of Hudson Bay, 145 km southeast of Inukjuak (Québec). At the two sites living and subfossil trees were used to build the tree-ring chronology. In both cases response function analysis indicate that high frequency variations in radial growth are positively controlled by July temperatures. At the western tree-line site however, the negative impact of summer temperatures during the previous year suggest that moisture stress can play a non-negligible role for tree growth at these latitudes.

The exposition of tree stems to harsh winter conditions lead to complex, multi-stem growth forms in response to severe deflation conditions. The impact of the development of such growth forms on tree-ring series can result in a misinterpretation of northern tree-ring series if it is not taken into account. The dendro-architectural analysis of more than 400 black spruce trees at the eastern tree-line site has shown that mid- and long-term major changes in tree-ring patterns reflect the dynamics of growth form development. Periods of apical stem degradation and stem substitution are clearly recorded in ring width pattern at the collar level. It then appears that low frequency variations in northern tree-ring series should be interpreted cautiously. If the year-to-year variability of radial growth is controlled primarily by summer temperatures, variations of winter conditions, particularly snow cover, which control the vegetative structure of subarctic trees, will play a major role on the long-term radial growth.

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DEGLACIAL ICE DYNAMICS IN NEWFOUNDLAND

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A review of Newfoundland Geological Survey and Geological Survey of Canada mapping and the academic literature is employed to produce a 'Glacial Map', and accompanying geographic information system database of features related to the last (Wisconsinan) Newfoundland Ice Cap. Information that constrains deglacial ice flow and ice marginal history is emphasized. The following features are included: meltwater channels, eskers, moraines, drumlins, flutings, crag and tails, roche moutonnées, ice-dammed lakes, and glaciomarine deltas. The glacial landform database is spatially integrated with a striation database, a revised surficial geology database, and a radiocarbon database to produce a synthesis of the last deglaciation in Newfoundland. This work builds on previous maps and reviews dating back to 1883, including contributions by Vic Prest and major mapping and synthesis by Doug Grant. Our presentation will describe the first results of this ongoing initiative.

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RELATIONS ENTRE L'ÉVOLUTION DES ÎLOTS DE PERGÉLISOL CÔTIERS ET LES CONDITIONS CLIMATIQUES : CAS DE L'ÎLE NUE DE MINGAN, NORD DU GOLFE DU SAINT-LAURENT, QUÉBEC, CANADA

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Il y a du pergélisol dans le sol organique de l'île Nue de Mingan et des formes périglaciaires alors que la température moyenne annuelle de l'air de la région est de 1 °C et que la limite méridionale du pergélisol actif dans l'hémisphère nord est normalement sise au nord de l'isotherme annuelle de l'air de - 1 °C. Pour pouvoir comprendre la présence et la variation du pergélisol à ces latitudes et altitudes inhabituelles, on analyse : les caractéristiques du sol organique; les différentes composantes climatiques; l'évolution du milieu biophysique, principalement de la végétation, et des formes périglaciaires associées (paléogéographie et paléobiogéographie holocènes).

La combinaison de certaines caractéristiques biophysiques et climatiques retrouvées à l'île Nue de Mingan permettrait la persistance du gel dans le sol, révélant que la température moyenne annuelle de l'air ne conditionne pas à elle seule la présence du pergélisol. L'île Nue de Mingan est un site d'étude exceptionnel car elle permet d'observer l'évolution d'un îlot de pergélisol depuis les dernières décennies et de constater sa détérioration. Cette variabilité du pergélisol pourrait être un indice concernant les changements climatiques dans le golfe du Saint-Laurent ou encore un reliquat d'une période plus froide.

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POSTGLACIAL HISTORY OF THE SOUTHEASTERN ASSINIBOINE DELTA, GLACIAL LAKE AGASSIZ BASIN: ARCHAEOLOGICAL IMPLICATIONS

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The Assiniboine Delta, located in south-central Manitoba, is the largest of several Pleistocene meltwater deltas in the glacial Lake Agassiz basin. Archaeological reconnaissance over the past 30 years has revealed a relatively dense concentration of Paleoindian (especially Plano) sites within the delta margins, suggesting that it was a 'central place' shortly after deglaciation. However, uncertainties in the history of water level fluctuations of glacial Lake Agassiz between ~10.8 and 9.4 ka BP, and the depth and complexity of sedimentary deposits on the Assiniboine Delta, have hindered interpretation of the early archaeological record in this region. In 2003, a new coring program was initiated in the southeastern portion of the delta (Rossendale area) in order to contextualize known Paleoindian sites within the larger history of glacial Lake Agassiz and late-glacial ecosystem dynamics.

In this region, much of the upper 13+ m of sediment accumulation is characterized by multiple cycles of sandy rhythmites interbedded with massive to laminated silt. These sediments were deposited rapidly by traction or turbidity currents, and record the construction of the Assiniboine fan-delta during the deep-water Lockhart phase of glacial Lake Agassiz (>10.8 ka BP). Shortly before ~10 ka BP, fluvial incision into deltaic deposits occurred locally at the Rossendale gully site in response to the regression of glacial Lake Agassiz during the Moorhead phase. Plant macrofossils deposited in the gully by ~10 ka BP provide the first information on early postglacial plant colonization of the distal Assiniboine delta. These data suggest initial establishment of *Scorpidium scorpioides*, *Potamogeton* spp., *Scirpus* spp., and other wetland plants, followed by colonization of uplands by a *Picea-Populus* assemblage. Importantly, because the gully is located in a protected depression behind the Campbell beach, evidence of paludification from aquatic macrophytes suggests that glacial Lake Agassiz rose to a Campbell level during the early Emerson phase (~10 ka BP). Furthermore, no evidence exists for a post-Lockhart rise in Lake Agassiz above the Upper Campbell beach. If Agassiz stood at the Campbell level during the early Emerson phase, then drainage through the southern outlet may have been possible at this time.

Several archaeological implications are suggested by these data: (1) much of the Assiniboine Delta was available for human occupation beginning shortly after 10.8 ka BP (early Moorhead phase); (2) vegetation colonization of the delta probably occurred between ~10.8 and 10 ka BP, resulting in a low ratio of fluted to Plano Paleoindian sites; (3) although Lake Agassiz was nearly abiotic, isolated wetlands on the margins of this proglacial lake were productive and probably able to sustain small prey populations; (4) Paleoindian sites above the Upper Campbell beach are probably in primary context and have not been redeposited by transgression of Lake Agassiz during the Emerson phase (~10 – 9.4 ka BP); and (5) because the bulk of sediment comprising the Assiniboine fan-delta was deposited during the Lockhart phase (>10.8 ka BP), Paleoindian sites should be visible in many upland settings.

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PALEOHYDROLOGY OF LAKE AGASSIZ AND THE UPPER GREAT LAKES FROM 10,700 TO 8,800 CAL YBP [9,500-7,900 ^{14}C YBP]

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Late glacial ostracode and bivalve records from Lakes Huron and Michigan are characterized by extreme δ^{18}O variations, ranging from values that reflect a source that is primarily glacial in origin (~–20 ‰ PDB) to much heavier values characteristic of a regional meteoric source (~–5 ‰ PDB). In contrast, a co-eval record from benthic ostracodes (*Candona subtriangulata*) from a varve sequence in Lake Superior is consistently depleted in ^{18}O, ranging from –18 to –22 ‰ PDB, in a manner similar to a record from northern Lake Winnipeg (Agassiz) (Rodrigues and Lewis, 2000. GSC Open File 3470: 791-794).

Age models from cores in Lake Huron and Michigan are re-evaluated to show a strong correlation between a sequence of thick varves and the lowest δ^{18}O values in Lake Superior between 9,400 and 9,000 cal ybp [8.4-8.1 ^{14}C ka] and negative δ^{18}O anomalies in Huron and Michigan. This negative excursion (~15 ‰ in Lake Huron) resulted from anomalously great fluxes of isotopically depleted water from Lake Superior; in Huron this event was previously prescribed to the Late Stanley lowstand (Rea et al., 1994. Can. Jour. Ear. Sci. 31(11): 1586-1605), and in Michigan the event was attributed to Lake Agassiz overflow and labeled 'A2' (Colman et al., 1994. Geology, 22: 547-550). During the 500 years prior to this period, the presence of very high δ^{18}O values in Huron strongly contrast with much lower values in Superior, which suggests Lake Superior overflow circumvented Lake Huron, and discharged through the Pic-White Otter River Valley en route to Glacial Lake Ojibway. Because glaciofluvial deltaic deposits in the Pic River Valley dated around 9,200 cal ybp [8.2 ^{14}C ka] record glacial meltwater flow towards Lake Superior (Bajc et al., 1997. Can. Jour. Ear. Sci. 34(5): 687-698), northern drainage of Lake Superior must have been blocked by ice advance at around 9,400 cal ybp [8.4 ^{14}C ka], rather than by differential uplift of a northern outlet. If this scenario is incorrect and Lake Superior never overflowed via a northern outlet, then the oxygen isotope records from benthic ostracodes in Lakes Superior and Winnipeg (Agassiz) grossly underestimate the average δ^{18}O values of the greater water bodies.

During this entire period, both Lake Agassiz and glacial meltwater discharged into Lake Superior via the Nipigon inlets. Lake Agassiz and glacial meltwater fluxes into Lake Superior diminished to zero between 9,040 and 8,840 cal ybp [~8.1-7.9 ^{14}C ka].

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SUBGLACIAL LANDSYSTEMS IN THE SOUTHERN ROCKY MOUNTAIN TRENCH (BRITISH COLUMBIA, CANADA): TOWARD UNDERSTANDING SUBGLACIAL PROCESSES BENEATH THE CORDILLERAN ICE SHEET

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Few studies have directly addressed the processes responsible for forming subglacial landsystems associated with the last (Fraser) glaciation of the Cordilleran Ice Sheet (CIS), yet an understanding of these processes is fundamental to inferring past ice sheet dynamics and thermal regime, and is critical if geologic data is to be used to constrain or test numerical ice sheet models. It has been suggested that the CIS may have been drained by ice streams based on the identification of deformation till, overdeepened basins, whalebacks and rock drumlins. Drumlins are common within the footprint of the Cordilleran Ice Sheet and, based on existing hypotheses, may record persistent ice streams that rode on a deforming bed, or landscape unconformities eroded by enormous meltwater floods (underbursts). Here we test the validity of these hypotheses of subglacial landsystem formation against observations from the southern Rocky Mountain Trench, British Columbia, Canada.

The southern Rocky Mountain Trench is a major NW-SE trending topographic depression, up to 20 km wide and floored by drumlins. Drumlins occur in an *en echelon*, space-filling arrangement along a ~500 km-long tract terminating around Flathead Lake, toward the southern terminus of the Flathead Lobe. Individual drumlins are 0.5-2 km long, 0.1-1 km wide and ~30 m high. They range in morphology from classical inverted teaspoons and spindles with crescentic scours around their upflow noses, to downflow widening forms. Larger drumlins often appear fluted.

We mainly report on drumlin sedimentology from two transects (each ~ 3 km in length) transverse to drumlin long axes. Drumlins are mainly composed of matrix-supported silty-sand diamicton containing up to 40% clasts, or bedrock. Diamictons are either massive, or stratified and interbedded with sand and gravel. Clast fabrics taken at vertical and lateral intervals within diamictic drumlins are highly variable and mainly exhibit spread bimodal to multimodal distributions. While some fabrics show alignment with drumlin long axes, most fabrics show no clear relationship to local drumlin form. Diamicton beds dipping toward the Trench axis, clast fabrics and clast morphological characteristics (orientations of striae and plucked ends on clasts, disposition of keels) suggest that most diamictons result from gravity flow and deformed lodgement processes. In places, diamicton beds are interstratified with sand and gravel and appear to be truncated by the drumlin form. This, in combination with juxtaposed bedrock drumlins, suggests an erosional origin for drumlins in the Trench. Given drumlin morphology and the presence of tunnel channels toward the terminus of the Flathead Lobe, we suggest that the southern Rocky Mountain Trench drumlin tract may record a landscape unconformity eroded by a meltwater underburst.

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ACOUSTIC PROFILES AND PRELIMINARY INTERPRETATION OF LATE QUATERNARY DEPOSITS WITHIN BASINS OF THE LOWER FRENCH RIVER, ONTARIO

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As part of a study investigating the early- to mid-Holocene lake level history of the upper Great Lakes, acoustic profiling of selected basins within the lower French River system, Ontario, was undertaken to: 1) determine if late Pleistocene and Holocene deposits are preserved in the watershed basins, 2) develop an acoustic stratigraphy of the deposits, and 3) identify locations for follow-up coring to investigate the composition and depositional history of the deposits. The profiling was conducted between June 8 and 16, 2004 at seven locations, all situated west of Eighteen Mile Island. Data was collected using a Knudsen 320M™ high-resolution sub-bottom profiler coupled with low (3.5-7.0 kHz) and high (200 kHz) frequency transducers mounted on a 16 ft aluminum boat. Seven acoustic facies are identified in the profiles of the basins. Interpretation of the facies and correlation between basins is preliminary. Facies I is stratigraphically oldest and is composed of weak to well-defined, decimeter-scale bedded deposits that probably represent glaciolacustrine deposits aggraded in glacial Lake Algonquin. Facies II consists of one to three major beds of transparent to weakly internally-bedded deposits. It may have aggraded during a Stanley-Hough low-water stage and could represent a fluvial facies. Facies III generally exhibits moderate to well-defined bedding and is inferred to represent distal glaciolacustrine deposits during a Mattawa high-water stage when the ice front was located well beyond the paleo-shorelines of glacial Lake Algonquin. Facies IV consists of transparent to weakly-bedded deposits. The facies forms the majority of deposits at the sediment-water interface and probably represents Nipissing and post-Nipissing stage gyttja. Facies V is a transparent, channel-infill deposit exhibiting an erosive contact that truncates facies IV and III. Likely consisting of gyttja, the facies is encountered only towards the head of Muskrat Bay and is the stratigraphically youngest deposit in the surveyed basins. The two remaining facies represent bedrock and 'non-bedrock'. The latter is marked by a strong opaque reflector and is hypothesized to delineate the extension of the surface of facies I, or more locally, facies II deposits, where there has been limited penetration of acoustic energy. The acoustic profiling confirms the preservation of late Quaternary deposits within the basins of the lower French River. Based on these results, locations have been identified for coring in spring 2005 to further investigate the composition and chronology of the depositional facies.

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A 1000-YEAR RECONSTRUCTION OF SOUTHERN MANITOBA DROUGHTS

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The way in which organic sediments deposited in lakes accumulate carbon and oxygen is isotopically sensitive to the atmospherically influenced lake environment present at the time of sediment deposition. Consequently, they represent a valuable, unique, and well-calibrated source of past drought/dry period information. In 1999 a 1.56-metre gravity sediment core (core S8) was obtained from the South Basin of Lake Winnipeg (determined to represent the period 950 to 1999 AD) and subsequently divided into one cm intervals (156 in total). After processing, bulk organic carbon isotopic compositions and cellulose oxygen isotopic compositions for the 156 sediment samples were determined using a continuous flow isotope ratio mass spectrometer (University of Winnipeg Isotope Laboratory; *UWIL*). The reconstructed record of droughts matches recorded and historical occurrences of droughts and prolonged dry periods in the Red and Assiniboine River Basins remarkably well. This presentation will quantify the chronology, severity and duration of droughts impacting southern Manitoba over the past 1000 years.

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THE PRESENCE OF PROGLACIAL LAKES IN THE REINDEER LAKE AREA, NORTHEASTERN SASKATCHEWAN

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Recent surficial mapping in the northwestern Reindeer Lake area has identified ice contact deltas, sporadic lacustrine deposits and raised strandlines, such as sand and cobble beaches, terraces and wave-cut notches, indicating that glacial Reindeer Lake and/or glacial Lake Agassiz extended further north and west than previously recognized (Schreiner, 1983; Teller *et al.*, 1983 and Teller and Leverington, 2004). Numerous well-developed beaches, wave-cut notches and terraces are at ~350-355 m asl. Much of the area below ~350 m asl is characterized by outcrop, boulder lags and winnowed till. This elevation is consistent with the previous published water level for glacial Lake Agassiz in the Reindeer Lake area.

Although the majority of the well-developed beaches were formed at or below approximately 350 ±5 m asl, sand and cobble beaches were found on the highlands as high as 420-425 m asl with winnowed till surface above the strandlines, suggesting that the water level was at an even higher elevation at some time. Several moderately well-developed strandlines were also found between 410 and 370 m asl. Ice contact deltas occur at elevations ranging from 370 to 405 m asl. The higher elevation strandlines were not observed in the southern portion of the study area, which is mostly below 410 m asl.

Kaszycki and Way Nee (1990) mapped strandlines at elevations greater than 400 m asl east of Brochet, Manitoba (NTS Map sheet 64F) indicating that this higher water level, proglacial lake also occupied the region to the east of the Reindeer Lake basin. Schreiner (1984) recorded strandlines as high as 420 m asl west-northwest of the area, which he attributed to Glacial Wollaston Lake. Based on their regional extent, these high elevation strandlines suggest the presence of one large proglacial lake rather than smaller precursor glacial lakes, and therefore, are more likely related to glacial Lake Agassiz rather than Glacial Reindeer and Wollaston Lakes. Therefore, it is proposed that the northwest extent of Lake Agassiz around 8,400-8,200 ^{14}C BP was more extensive than previously reported (Schreiner, 1983, 1984; Teller et al, 1983; Teller and Leverington, 2004). Although the amount of glacio-isostatic rebound in this region is unknown, the higher elevation strandlines suggest that the water level may have been higher than previously thought during this stage of Lake Agassiz. These are preliminary observations and ideas and more work in needed to confirm the interpretations.

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SRTM DEM IMAGERY: PREVIOUSLY UNRECOGNIZED REGIONAL-SCALE ICE STREAMS, ICE FLOWS INDICATORS AND GLACIAL LANDFORMS IN SASKATCHEWAN

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A preliminary visual examination of SRTM (Shuttle Radar Topography Imagery Mission) DEM imagery for the province of Saskatchewan has revealed numerous, previously unrecognized landform features related to the LGM and subsequent deglaciation. The preserved ice flow features record ice flow both during the advance and retreat of the Late-Wisconsinan Ice Sheet. Streamlined uplands record the regional ice advance to the southwest. Diverging ice directions, particularly over the southern half of the province relate to ice flow direction changes during deglaciation. The streamline features evident on the DEM reflect changes in flow direction of the thinning ice margin due to topographic controls, flow separation from the body of the ice sheet, and the development of lobes along the ice margin.

Evidence of ice streams, such as on the Athabasca Basin in northern Saskatchewan and east of Prince Albert, are clearly visible on the DEM. The ice streams are interpreted as late stage surges as the ice front retreated north-northeastward. Ice streams have long been suspected to have occurred in Saskatchewan but had not identified north of the ice terminus.

South of the Precambrian Shield, features such as glaciotectonic thrust moraine, end and interlobate moraines, hummocky moraine, meltwater channels and spillways, and lake plains are discernable on the DEM. The origin of several landforms evident on the DEM remain an enigma. Over the Precambrian Shield, where the drift cover is thin and discontinuous, the regional structural trends of the bedrock strongly influence the topography and geomorphic expression of the present day landscape.

This relatively new dataset is a valuable tool for regional surficial geological investigations. When combine with other datasets, it will provide valuable insight with respect to glacial dynamics, the effects of topography and substrate composition on ice flow and meltwater drainage. This, in turn will improve our understanding of the glacial history of the region and the processes which formed our present landscape.

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FIELD OBSERVATIONS FROM THE TISKILWA TILL, IL AND SKY PILOT TILL, MB OF THE LAURENTIDE ICE SHEET

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We present field and laboratory data from extensive bluff exposures of the Tiskilwa Till (TT) of the Lake Michigan Lobe, IL and the Sky Pilot Till (SPT) of the Hudson Bay Lowlands, MB of the Laurentide Ice Sheet. Both tills are massive and homogeneous; exhibit a relatively constant grain size throughout their ~6 m thickness; and overly a more heterogeneous till with a gradational contact ~0.6 to 1 m thick. These heterogeneous tills grade into the underlying sorted sediment, parts of which are incorporated into the overlying till. Both the TT and SPT contain deformed sand inclusions up to 1 m thick. The TT inclusions have occasional balls of TT within the sand that indicate sand deposition post-dated deposition of the surrounding till. The TT has stronger macrofabric eigenvalues than the SPT, and shows relatively constant fabric strength throughout its thickness. In contrast, the SPT fabric strength increases up-section in 2 to 3 m thick increments. Eigenvectors are consistent with regional ice flow directions at both locations. There is an abrupt change in ice flow direction across the boundary between the N45E-oriented SPT and the underlying S45E-oriented till. Eigenvectors then shift up-section in the SPT from N45E to N75E as ice flow shifted more towards the west. The TT eigenvectors migrate up-section from N40E to N60E and back to N40E, probably correlating with the initial thickening and subsequent thinning of the Lake Michigan Lobe. The TT also contains numerous pieces of wood aligned with ice flow. Six dates on the wood are between 31.4 and >49.9 ^{14}C ka. The age distribution of the wood within the section somewhat mimics the eigenvector migration. The deformed sand inclusions and gradational contacts suggest some deformation of till during deposition. The fabric data imply continuous deposition of till at both locations.

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GLACIAL HISTORY OF PRINCE EDWARD ISLAND – REVIEW & ADVANCES

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Investigations building upon the original research of Vic Prest have revealed a complex pattern of glaciation on PEI. At different times during the Quaternary, the island was influenced by glaciation from the northwest (Grenville Province), west (New Brunswick), north (Gulf of St. Lawrence), and south (Nova Scotia), as indicated by the distribution of erratics, diamicton fabric patterns, striations, and ice-thrust features. Locally, differences in orientations between adjacent diamicton fabric patterns, with associated lithologically-distinctive clasts, and striations indicate distinctive ice-flow events. However, differences in fabric orientation commonly convey more information about the mechanisms of till deposition at individual sites than concerning the regional ice flow pattern.

All parts of PEI appear to have been glaciated during OIS 2, and multiple directions of ice flow are recorded at numerous locations. Ice-thrust features in eastern PEI suggest that northward flow from Nova Scotia was followed by southward and eastward flow from the Gulf of St. Lawrence. In western PEI, flows from the west, southwest, northwest, and northeast are recorded.

The distribution of igneous and metamorphic erratics is of particular interest, as recognized by Vic Prest more than 40 years ago. Recent investigations indicate that granite and granodiorite erratics found in Prince County (western PEI) and in western Queen's County appear to originate from Appalachian (northern NS-southwestern NB) sources, compatible with striae and diamicton fabrics indicating flow from the west and southwest. Gniess and anorthosite erratics are also present in Prince County, and could indicate Laurentide ice influence.

The possible Laurentide erratics are restricted to west.central PEI and are not found in mainland Nova Scotia or Cape Breton. A single southeastward-trending Laurentide ice flow event (e.g. Acadian Bay Lobe) would have been unlikely to have deposited erratics only in PEI, unless it was obstructed by Appalachian ice centred over southeastern New Brunswick and Nova Scotia. An additional difficulty is that the possible Laurentide erratics are associated with striae and diamicton fabric patterns indicating southwestward flow, which is incompatible with the southeasterly patterns suggested by recent reconstructions of the Laurentide events during OIS 2. Possible mechanisms for erratic deposition include OIS 4 Laurentide confluent with Appalachian ice buildup; deposition prior to OIS 4; or restriction of Laurentide ice to PEI by Appalachian ice in NB and NS, coupled with diversion of Laurentide flow towards the Laurentide Channel, as first suggested by Vic Prest and Doug Grant. Sedimentological and chronological research, including cosmogenic dating of erratics, is ongoing in an effort to coordinate the glacial history of PEI with that recorded from adjacent NS and NB.

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CARBONATE HARDGROUNDS IN MAARS OF WESTERN VICTORIA, AUSTRALIA: A GLIMPSE AT MODERN LACUSTRINE DOLOMITE FORMATION

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The Western Victorian Plains physiographic province of southern Australia contains the greatest concentration and diversity of salt lakes in the entire Southern Hemisphere. The paleolimnology of many of these basins has received considerable attention because of their excellent high-resolution stratigraphic records, which provide important clues about the past climate and hydrology of Australia. In contrast, the modern sediments in these lakes are less well-studied despite the occurrence of a great spectrum of unusual carbonate and evaporite-precipitating environments.

Lakes Gnotuk, Bullenmerri and Keilambete occupy small, deep craters in the central part of the Volcanic Plains. Modern water levels and brine salinities fluctuate dramatically and even greater fluctuations have been deduced from their offshore stratigraphies.

The modern shoreline and nearshore sediments in these basins are dominated by well-indurated carbonate hardgrounds. These dolostones and limestones show a great variety of textures, fabrics and compositions. Morphologically, they range from flat, featureless to laminated wackestone pavements, with variable polygonal fragmentation, to algal boundstones and microbialites having relief of more than a meter.

The complex climate-driven hydrological changes, coupled with multiple exposure and associated diagenetic effects have created an exceedingly complex petrologic record in these hardgrounds. Although their genesis and diagenesis are complex, there is abundant evidence to support mineral formation by both primary inorganic precipitation and by biologically-induced cementation. Similarly, both transformation (chemical and structural alteration of pre-existing minerals) and neoformation (precipitation directly from pore or lake fluids) processes have been important in creating and diagenetically altering these shoreline carbonates.

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THE LAST DAYS OF THE CORDILLERAN ICE SHEET

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Recent field studies have provided a clearer picture of the pattern and timing of disappearance of the last Cordilleran ice sheet. The ice sheet attained its maximum size 17,500 cal yr BP, but abrupt warming during the Bølling interval (~16,000-14,000 cal yr BP) caused snowline to rise, triggering top-down wasting and rapid frontal retreat. Retreat of the ice sheet across the continental shelf of western British Columbia was particularly rapid, due in part to sea-level rise. By 15,000 cal yr BP, the British Columbia continental shelf was ice-free and the large southern lobes of the ice sheet (Puget, Okanagan, Pond Oreille) terminated north of the International Boundary.

The ice sheet continued to decay late in the Pleistocene as solar insolation increased, transforming the Cordillera into a mosaic of active and stagnant glaciers, ice-free ground, and ice-dammed lakes. Climatic deterioration during the Older Dryas and Younger Dryas chronozones slowed the decay. The southern margin of the ice sheet in Fraser Lowland east of Vancouver and in Howe Sound north of Vancouver advanced several times between 14,000 and 12,000 cal yr BP, and similar advances occurred at the western margin of the ice sheet near Terrace. By 11,000 cal yr BP, the Cordilleran ice sheet was dead, and most glaciers in western Canada were no more extensive than they are today.

The plateaus of central and northern British Columbia were probably freed of ice later than plateaus to the south. Active glaciers persisted in high mountain valleys in British Columbia and Yukon until the end of the Pleistocene, after plateaus had become ice-free. Alpine glaciers responded to Younger Dryas cooling, but the lowering of snowline at that time was too small to trigger resurgence of remnant ice masses on the plateaus.

Considerable north-south asymmetry is evident in the response of glaciers in high mountains to Younger Dryas cooling. Cirque and valley glaciers in the Omineca and Cassiar Mountains in northern British Columbia advanced up to 10 km from cirques onto or against stagnant ice in trunk valleys. In contrast, cirque glaciers in the southern Rocky Mountains advanced no more than 1 km from contemporary glacier margins during the Younger Dryas.

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POST-GLACIAL AND PALEO-ENVIRONMENTAL HISTORY OF THE WEST COAST OF VANCOUVER ISLAND

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Annually laminated sediments in anoxic fjords are potentially ideal paleoclimate recorders, particularly once proxy measurements for atmospheric, oceanographic and sedimentological conditions have been calibrated. On the west coast of Canada, these sediments also record the changing environment as glaciers retreated from this area about 12 ka y BP. In Effingham Inlet, a 40 m core taken from the French ship the Marion Dufresne as part of the international IMAGES/PAGES program, gives evidence of an isolation basin at maximum glacial isostatic rebound and lowest paleo-sea level followed by eustatic sea level rise about 10 ka y BP. The Late Pleistocene record also marks dramatic changes in glacial sedimentary source and transport. Excellent chronological control is provided by complementary yet independent dating methods including radiocarbon dates on both plants and shells, identification of the Mazama Ash, varve counting and paleomagnetic, paleosecular variation correlations in the lower, pro-glacial section of the core which does not contain organic material. Paleoenvironmental evidence from this core provides information on immediate post-glacial conditions along the coast, with implications for the possibility of early human migration routes and refugia.

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LIDAR IMAGERY FOR LANDFORM IDENTIFICATION AND AGGREGATE POTENTIAL MAPPING IN NORTHEAST BRITISH COLUMBIA, CANADA

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Light detection and ranging (LiDAR) DEMs have proven to be an effective tool for mapping surficial features and aggregate potential in northeast British Columbia (BC), where an increase in oil and gas activity has created a high demand for construction aggregate. Northeast BC is characterized by low relief, and by subtle glacial landforms commonly masked by forest cover. For these reasons airphoto interpretation on its own is a somewhat ineffective aggregate exploration technique. The BC Ministry of Energy and Mines, in partnership with EnCana Corporation, began using high resolution LiDAR data to map aggregate potential for portions of NTS map areas 94 I and P. LiDAR DEMs with 10 m and 2 m horizontal resolution and vertical accuracies of up to 30 cm are being utilized. To date, these data have helped in the identification of glacial features and are responsible for numerous recent aggregate exploration successes.

Some of these features are visible in lower resolution data sets such as airphotos and RADARSAT DEMs, while others are visible only in LiDAR DEMs. The latter is particularly true for low-relief features (*i.e.* 1 to 3 m high), which can be masked by vegetation in airphotos, and are often not resolved in RADARSAT DEMs. LiDAR DEMs have also proven to be a useful tool for more detailed aggregate potential mapping of glaciofluvial features that are identifiable but poorly defined in other data sets. The Komie Creek aggregate occurrence (interpreted as an esker complex) is one such example, where there is a sharp contrast in detail between RADARSAT DEMs, airphotos, and LiDAR DEMs. This esker complex is composed of a series of southeast trending ridges, 2 to 8 metres high, up to 150 metres wide and 700 metres long. LiDAR imagery clearly shows numerous discrete ridges, that are trucated by a south flowing creek. In this imagery changes in relief and breaks in slope are well defined. In airphotos, however, very few of the same ridges can be distinguished, and both northwest and southeast extent of the features, and relative relief are poorly defined as they are masked by vegetation. This poster presents a comparison of images from the above three data sets, using landforms interpreted as having a glaciofluvial origin (*e.g.* eskers, kames, and glaciofluvial terraces).

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MID-HOLOCENE CLIMATIC CHANGES IN THE SELENGA RIVER BASIN, SIBERIA AND MONGOLIA: REVIEW AND PRELIMINARY RESULTS

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Environmental changes have always played an important role in migration of ancient peoples, and in determining their way of life. Analysis of mortuary complexes of prehistoric peoples in the Baikal area suggests a hiatus between Kitoi (7.5-6.0 ka BP) and Serovo-Glazkovo (5.5-3.0 ka BP) cultural groups in the Lake Baikal area (Siberia, Russia). Tentatively, climatic changes, either in the immediate vicinity of Lake Baikal or in surrounding populated areas, could have forced the Kitoi groups out of their territories.

The aim of this study is to evaluate Middle Holocene environmental changes in the area of the Lake Baikal, which would have played a critical role in the adaptive response of the Kitoi foragers.

In the 1980s, it was shown that climatic trends in Southern Siberia and Northern Mongolia were opposite during the Middle Holocene. Around Lake Baikal, however, they were less prominent than in surrounding areas. The number of tested sites has increased rapidly over the last two decades. Pollen, diatom, and lake-level data show non-uniformity of climatic trends both in space and time. A comparison of reconstructed trends in temperature and precipitation reveals subregional patterns in climate.

Selenga River is the largest river entering the Lake Baikal. Its basin covers Northern Mongolia and cut mountain ranges of trans-Baikalia (Siberia). High-resolution study of two sand/soil sequences from Mongolian (Yeroo site) and Siberian (Burdukovo site) parts of the Selenga River basin shows similarity in their stratigraphy. Transition from alluvial to aeolian sedimentation is ^{14}C dated back to ca. 7.0 ka BP and shows significant changes in hydrological regime and environment of valleys. Another marker is a thick, moderately developed soil buried in aeolian sand ca. 3.5 ka BP. The soil indicates a period of landscape stability. Several other soils are reported from both of the sites. They provide information on paleotopography, landscapes and biogenic activity during the Holocene.

Our data show significant changes in landscapes and environment during the Middle Holocene in the Selenga River basin. Those changes could be a factor initiated migration of ancient peoples. Drying in Northern Mongolia was quite possibly a factor forcing ancient Mongolian peoples to move northward to wetter areas, thereby displacing the Kitoi foragers occupying those territories.

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VEGETATION HISTORY, GLACIATED NORTH AMERICA

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Here we present biome maps spanning from the last glacial maximum (18 000 years ago) to modern times in 1000 year steps after 14 000 years BP. The maps were recently released as GSC Open File 4682 and can be viewed with interactive databases on our Climate Change Program website http://rcvcc.nrcan.gc.ca/products_e.cfm.

Because the ice sheets during the last glaciation sat in near maximal configurations for a period of about 10 000 years, the vegetation distribution at that time was probably as nearly in equilibrium with its contemporaneous climate as the modern distribution is with the modern climate. Subsequent changes in biome distributions during deglaciation and thereafter reflect the complex interplay of climate forcing and the dynamic constraints that limit plant migration rates. The waning ice sheet configuration was one of the strongest controls of continental climate zones until about 7000 years ago, particularly early in deglaciation. Late deglaciation of the eastern part of the continent delayed attainment of maximum postglacial warmth there. Despite these complexities, regional climate trends through time can be reliably inferred from changing biome distributions. Further analysis of the sensitivity of vegetation to climate change at the biome level would be best facilitated if empirical climate reconstructions were available for the same time interval based on sources other than vegetation history. Nevertheless, because there is evidence of general cooling during the last 3000-5000 years, and longer in places, middle and early Holocene biome distributions and species compositions are reasonable analogues of future equilibrium displacements due to equivalent warming, at least in areas that were long-since deglaciated at these times.

Peak postglacial warmth, although not synchronous across the continent, has been estimated elsewhere to have been mainly in the range of 2-4°C above mid 20th century values. Some estimates of immediate future warming exceed that range. Past biome migration rates in response to rapid regional warming during deglaciation were mainly in the range of 100-200 m per year. If these rates pertain in the future, we might expect biomes to shift by 10-20 km in most regions over the next century.

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ENVIRONMENTAL HISTORY AND ARCHAEOLOGY ALONG THE NORTHWEST PASSAGE

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The Holocene history of sea-ice along the Northwest Passage is of socio-economic interest because of its potential as a shipping lane. Both ends of the NWP reliably become clear of summer sea ice, thus providing access to the North Atlantic and North Pacific. The central parts of the NWP, however, are blocked by perennial sea ice. Building on earlier research along the eastern and western approaches, we are currently attempting to determine whether the central sea-ice plugs were permanent Holocene features, or whether they might have disappeared in warmer intervals.

Current data, based on the remains of >1000 bowhead whales, support the following conclusions: (1) Both eastern and western approaches supported larger early Holocene bowhead populations during summer and fall open water periods than they did historically. (2) Early Holocene bowheads extended far beyond modern ranges. Atlantic whales reached NE Victoria Island and ranged along the east side of McClintock Channel. Pacific whales reached the north end of Prince of Wales Strait between Banks and Victoria islands and ranged eastward to at least SE Victoria Island. (3) Whales failed to enter Viscount Melville Sound throughout the Holocene. (4) Thus the southern branch of the NWP, east and south of Victoria Island, was open during the early Holocene much more commonly than it is today. However, the northern branch (western Parry Channel) appears to have retained its ice plug. (5) After an interval (8-6 ka BP) of ice conditions similar to modern conditions, bowheads re-expanded their ranges from east and west and penetrated eastern McClintock Channel between 5.5 and 3 ka BP. (6) For most of the last 3 ka, conditions have been similar to present. However, bowheads briefly ranged into McClintock Channel about 1 ka BP and abundances increased in Amundsen Gulf about the same time. These conclusions imply that the ice plug in the southern branch is close to its melting threshold, which was exceeded at times during the Holocene, most clearly during the early Holocene, when summer temperatures were about 3°C warmer than mid-20th century temperatures.

Archaeological surveys conducted concurrently support the following conclusions: (1) In Amundsen Gulf and McClintock Channel, Paleoeskimo populations reached maximum levels shortly after first peopling; i.e. 4.5-3.5 ka BP. (2) Populations then crashed to near abandonment in both regions and recovered only weakly thereafter, but most prominently during Dorset time (2.5-0.5 ka). (3) Viscount Melville Sound shores remained unoccupied or very sparsely and intermittently occupied throughout. The early Paleoeskimo population peak correlates in time with the middle Holocene bowhead recurrence, but the suddenness of the subsequent crash lacks a convincing correlative in regional paleoenvironmental records, perhaps largely due to the paucity of records. Either climate forcing or resource overexploitation, or both, may have played the key role.

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A GIS APPROACH TO MODELLING ARCHAEOLOGICAL SITE DISTRIBUTION BY ENVIRONMENTAL ELEMENTS IN THE LAKE DIEFENBAKER REGION, SOUTH-CENTRAL SASKATCHEWAN

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The prairie landscape surrounding Lake Diefenbaker in south-central Saskatchewan was a focal point of prehistoric Great Plains human occupation throughout the Holocene. Documented archival archaeological data indicate that these cultural groups resided in an assortment of environmental settings. The application of Geographical Information Systems (GIS) in this study aims to determine the relationship between the spatial and temporal distribution of archaeological site locations with the environmental elements of the Lake Diefenbaker region. The investigated environmental attributes include the surficial geology, surface hydrology, and topography of the region. The GIS model results indicate the presence of concentrations of cultural remains distributed within certain physiographic elements of the prairie landscape. Prehistoric societies appear to have focused their occupational activities in the broad, deep glacial meltwater spillways and the hummocky aeolian sand dune complexes. These landform assemblages are environmentally complex in nature, exhibiting a broad range of topographic relief and situated in close proximity to permanent freshwater supplies that would contribute an array of resources for exploitation by prehistoric peoples. This is demonstrated by the large quantity of archaeological materials recovered in these areas. Physiographic elements such as the hummocky moraine and the glaciolacustrine and glaciofluvial plains demonstrated low concentrations of recovered cultural remains; the subdued topography and greater distances to water resources may have contributed the limited occupation of these landforms. The utilization of a GIS in this investigation facilitated the examination of the occupation patterns of prehistoric Plains peoples and provides an environmental framework for archaeologists to conduct cultural inventories.

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LATE QUATERNARY GEOARCHAEOLOGICAL INVESTIGATION OF THE ELBOW SAND HILLS, SOUTH-CENTRAL SASKATCHEWAN

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The Elbow Sand Hills in south-central Saskatchewan have been the locus of extensive occupations by prehistoric Plains cultural groups throughout the post-glacial period. The objectives of this geoarchaeological investigation of the Elbow Sand Hills are to identify the extent to which 1) Holocene environmental changes impacted prehistoric peoples' occupation patterns, and 2) geomorphic processes influenced the preservation of archaeological materials on a northern Great Plains landscape. An integrated study of the geomorphology, stratigraphy, sedimentology, and chronology of post-glacial sediments was performed in the sand hills and the adjacent terrain within three primary physiographic elements; aeolian sand dunes, outwash plain, and hummocky moraine. An array of prehistoric cultural groups inhabited these physiographic elements, which are confirmed by the detection of an assortment of cultural remains. Results reveal evidence of post-glacial environmental changes of alternating moist and arid climatic conditions which are preserved in the lithostratigraphy as palaeosol horizons interbedded with aeolian deposits. The occurrence of these stratigraphic units record palaeoenvironmental changes that had substantial influence on human settlement strategies in the region. Prehistoric occupations in the Elbow Sand Hills were most extensive during moist climatic conditions when vegetation stabilized the sand dunes and soil development occurred. These environmental conditions provided humans the opportunity to utilize the sand hills to procure flora and fauna resources, obtain wood supplies, and use the hummocky topography as shelter. Arid climatic events characterized by the deposition of aeolian sediments were intervals when humans abandoned the active sand dunes for other resource abundant localities such as the South Saskatchewan and Qu'Appelle River spillways. This research furthers our understanding on prevailing hypotheses of prehistoric human settlement and migration patterns on the Great Plains.

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EFFECTIVE METHODS FOR MAPPING SURFICIAL GEOLOGY AND AGGREGATE POTENTIAL IN BRITISH COLUMBIA'S NORTHEASTERN INTERIOR PLAINS.

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This presentation summarizes methods that have been employed by the British Columbia Ministry of Energy and Mines (Aggregate Program) and the Geological Survey of Canada to map surficial geology in the Interior Plains of northeast British Columbia. There is a chronic shortage of aggregate material in this part of the province, the centre of BC's rapidly expanding oil and gas industry. The discovery of new aggregate sources provide a much-needed local supply of sand and gravel, reducing construction and maintenance costs of petroleum development roads.

Assessing aggregate potential in the region is challenging due to limited topographic relief, masking of landforms by vegetation, thick cover of silt and clay-rich morainal and glaciolacustrine deposits, and a general lack of glaciofluvial landforms outside of major river valleys and meltwater channel systems. As a result, new and innovative surficial mapping and aggregate exploration methods have been developed. This poster outlines the methods including seismic shot hole and subsurface data, high resolution airborne electromagnetics (EM survey), LiDAR imagery (in partnership with EnCana Corporation), remote sensing, and more traditional methods such as aerial photograph interpretation, drilling and target test pitting (excavations). The program has been very successful with several new aggregate prospects being discovered in the region since the inception of the program in 2003. At least three of these new discoveries have been developed into producing pits.

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LATE WISCONSINAN ICE-FLOW REVERSALS AT THE BRITISH COLUMBIA COAST MOUNTAIN/INTERIOR PLATEAU TRANSITION: STRATIGRAPHIC, LITHOLOGIC, AND GEOCHEMICAL EVIDENCE

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The Coast Mountain/Interior Plateau transition in west-central British Columbia experienced a complex ice-flow history during the Late Wisconsinan Fraser Glaciation. Cross-cutting and superimposition relationships constrain the relative timing of ice-flow events and indicate that a westerly-directed ice-flow event occurred during the glacial maximum. Glaciers flowed west, towards and over the Coast Mountains from the Interior Plateau. This event was preceded and followed by smaller magnitude east to northeast ice-flow events from ice centres in the Coast Mountains. These ice-flow reversals can be explained by the existence of an ice divide in the central interior during the Fraser Glaciation maximum.

Detailed data was collected in the Huckleberry Mine region to investigate the stratigraphic, lithologic, and geochemical record of the ice-flow reversals. Basal tills dominate the Quaternary stratigraphy and multiple till units were distinguished primarily by changes in matrix texture, colour, clast content, and geochemistry. Pebble fabrics in the lower till units show strongly preferred clast orientations that indicate deposition during southeastward to eastward ice-flow events. These data provide stratigraphic evidence of an early, eastward-directed, ice flow event. Deposition during this event is further supported by a striated clast pavement that contains numerous faceted, striated, and glacially streamlined clasts with ice-flow indicators (e.g. rat-tail, smoothed and plucked faces) that suggest valley-parallel ice-flow (to the east-southeast).

Lithology and geochemical data also support ice-flow reversals in the region. Lower till units at a 19 m section contain <5% porphyritic granodiorites. There are no documented outcrops of granodiorite west of this section, but <1 km to the east is a mineralized (Cu+/-Mo) porphyritic granodiorite stock. The general lack of granodiorite clasts in lower till units suggest a western provenance. An increase in granodiorite clasts of up to 27% in the upper tills at this section suggest that westerly flowing ice eroded the stock to the east. Till geochemical data also support this interpretation. Maximum copper values occur in the upper till unit (234 ppm), while the lower two tills have only minor copper concentrations (<20 ppm). Locally developed dispersal trains in the area also record transport of mineralization towards both the east and west. Two westward-directed dispersal trains with copper concentrations >1000 ppm are isolated and distant from the mineralized areas and suggest that there may still be undiscovered bedrock mineralization on Huckleberry Mine property.

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SEASONAL VARIATION IN FRESHWATER GEOCHEMISTRY ACROSS THE ARCTIC TREELINE NEAR CHURCHILL, MB

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Lakes and ponds in the Arctic have been identified as potential climate change indicators but there is limited information available on the freshwater chemistry of these water bodies through time or space. Increasing precipitation coupled with thawing of permafrost will mobilize ions stored in their catchments to be released with runoff into water bodies. These increasing ion concentrations will be magnified by lower water levels due to evaporation under warmer conditions. Given the rates of environmental change expected to occur in the Arctic there is a need for monitoring projects to gauge these changes.

Arctic ponds are defined as water bodies that freeze to the bottom each winter whereas lakes maintain an unfrozen water column during the winter months. Three lakes and three ponds located across the arctic treeline ecotone near Churchill, MB were selected and have been monitored to detail their geochemical responses to present day conditions. A representative pond and lake were sampled through May 2003-November 2004 in each of three general environments found across the arctic treeline; tundra, tundra/forest transition and open spruce forest. Analysis of water samples taken weekly included pH, conductivity, dissolved organic carbon (DOC) and an ICP-MS scan for 37 major, minor and trace cations.

Pond water samples were found to have greater concentrations of DOC and major cations throughout the season than the lakes. The variability of DOC and cations in the pond water columns was attributed to the annual freezing and thawing of the water column and sediments and shorter water residence times. Higher concentrations of Ca, Mg, Na and K in the tundra water bodies are a function of the proximity to the coast and the younger terrain age. Higher concentrations of Al in samples from the open forest upland pond may be indicative of soil development processes occurring in the catchments. Geochemistry of pond water columns varies more significantly throughout the open water season than lakes, often increasing an order of magnitude in concentration throughout the season. Continued long-term monitoring will assist in recording the impacts on northern freshwater ecosystems and assessing trends.

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A NEW DEGLACIAL CHRONOLOGY FOR THE AREA WEST OF THUNDER BAY, ONTARIO, AND ITS IMPLICATIONS FOR A MOORHEAD PHASE EASTERN OUTLET OF GLACIAL LAKE AGASSIZ

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New radiocarbon ages from west of Thunder Bay, Ontario suggests that deglaciation was later than originally supposed. The existing paradigm for eastern drainage from glacial Lake Agassiz is through a variety of spillway channels incised across the sub-continental drainage divide separating the Great Lakes basin from Hudson Bay. The spillway channels are mostly in quite inaccessible regions of northwestern Ontario and their chronology has only been assumed on bulk radiocarbon dates from moraines that cannot be directly traced to the channels. It is the opening of the Kashabowie-Seine channel that has been linked to large discharges of freshwater to the North Atlantic triggering the Younger Dryas cold period. However, this channel is considerably smaller and lacks boulders in comparison to the southern and northwestern outlet channels of Lake Agassiz. Hence, our initial strategy for determining the timing of eastern drainage from Lake Agassiz is mapping and dating sequential ice margin positions along the same drainage divide. Sample locations associated with the Steep Rock and Brule Moraines were from small lakes high in the landscape, above the elevation of isostatically depressed Kashabowie-Seine channel. The general stratigraphy indicates short-lived glaciolacustrine lakes giving way to organically productive lakes. At Third Lake this transition is at 10,000 ± 75 (ETH-28946) above ~200 rhythmites whereas at Crawfish Lake the transition is at 10,190 ± 40 (Beta-195959). These preliminary results indicate that deglaciation of the Kashabowie-Seine channel area was approximately ~800 years later than previously thought, which implies that any drainage eastward from Lake Agassiz through the Kaministikwia-Seine channel is considerably younger than previously supposed. The hypothesis that drainage from Lake Agassiz's eastern outlets caused the Younger Dryas is thus problematic.

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THE INFLUENCE OF GLACIER BED PROCESSES ON THE MODELLED DYNAMICS OF VATNAJÖKULL ICE CAP, ICELAND

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Reconstructions of the geometry, hydraulics and dynamics of ancient ice sheets lean heavily on our current understanding of glaciological processes as gleaned from field, laboratory and modelling investigations of present-day glaciers and ice sheets. In this modelling study we examine the hydrology and dynamics of Vatnajökull ice cap, paying particular attention to the role of basal motion (glacier sliding and bed deformation) in determining the overall ice cap configuration and development. Using coupled models of ice dynamics and hydrology, we simulate the evolving ice cap geometry, mass balance, velocity structure and subglacial water pressures and fluxes through the Little Ice Age and into the future. This time-frame encompasses the maximum extent of the ice-cap in the late Holocene and a possible rapid disintegration of the ice cap over the next several hundred years. A reference climatology is defined based on observed mean temperatures from 1961-1990; historical climate is derived from proxies and direct measurements, while hypothetical future climates are based on general circulation model simulations for specified atmospheric CO_2 concentrations. Basal motion is parameterized as a simple function of basal water pressure and driving stress averaged over an area of ~3 km^2 or 3-10 ice thicknesses.

The result of including a dynamic and coupled hydrology is, most notably, a spatially heterogeneous distribution of basal motion that need not closely correspond to the driving stress. For Vatnajökull, this contributes to a spatially organized sensitivity whereby low-lying outlet glaciers on the southeastern and southern flanks of the ice cap are markedly more responsive to climate than glaciers to the west and north. For a prescribed climate warming rate of 2°C per century, these southern outlets retreat 20-30 km by the year 2200 as compared to ~10 km for the northern outlets. While this sensitivity is partly attributable to the maritime environment and particular glacier hypsometries, simulated mean annual basal velocities for the southern outlets exceed 100 m a^{-1} as compared to 20-50 m a^{-1} for other outlets and are strongly influenced by the distribution of subglacial water. Numerical experiments show that amongst various complexities added to the model (e.g., longitudinal stress parameterizations, geothermal heat sources) the dynamic hydrology makes the greatest contribution to increasing the ice cap sensitivity to climate on this timescale of several hundred years. However, we find that increased water production (melt and rain) in a warming climate has a modest effect on future glacier dynamics in the simulations; any flow enhancement promoted by increased water delivery to the bed is largely offset by the overall reduction in driving stress due to glacier thinning. This suggests that while the overall vigour of the glacier hydrologic cycle will increase in warmer times, its effect on glacier dynamics approaches an effective maximum, which for Vatnajökull is likely similar to its present-day condition.

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MODELING AND INTERPRETATION OF GLACIOTECTONIZED SEDIMENT IN SOUTHERN AND CENTRAL ALBERTA: INTERGRATING GIS, GEOPHYSICS AND GEOMORPHOLOGY

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Large-scale glaciotectonic deformation is the faulting and folding of sediments and bedrock due to the compressional and extensional forces imposed by an ice mass. Large-scale features can be observed with the use of air photos and remote sensing where surface expression has been preserved. However, many deformed areas may not have surface expression because subsequent glacial overriding truncated the features. Our goals are (1) to identify the style of glaciotectonism in the three-dimensional subsurface and (2) to isolate important environmental variables that can be used to predict the presence of glaciotectonized sediment where surface expression is absent or altered.

Initially, we characterize glaciotectonics in a prairie setting using information gained from sedimentary descriptions of two-dimensional exposures and three-dimensional Electrical Resistivity Imaging (ERI). ERI measures the degree to which a material resists the flow of electrical current introduced into the ground. Electrical resistivity is a function of porosity, saturation, material texture, and resistivity of the pore fluids and the solid phase. For these reasons ERI is especially useful in settings dominated by fine-grained sediments that render other shallow geophysical techniques, such as Ground Penetrating Radar (GPR), ineffective. Several sites were selected to perform ERI along the shores of Travers and McGregor reservoirs in southern Alberta where glaciotectonism is prevalent and exposures accessible. These data allow us to extend the interpretation based on the sedimentary data into three dimensions, therefore, linking the form and process. The ability to map deformed structures away from exposures strengthens our ability to develop conceptual models that are the basis for the second stage of the research.

In the second stage of this research we incorporate the information gained from the local sedimentary and geophysical investigations into a regional Geographic Information Systems (GIS) model. The purpose is to create a predictive model for a larger geographical area showing where glaciotectonism is most likely to be present. The model uses multiple variables including data for Quaternary and bedrock geology, and surficial and bedrock topography. This data was selected to investigate the extent to which topography and geology controlled large-scale deformation in central and southern Alberta. The modeling process consists of several steps. First is identifying the relevant variables and to identify the relationships between those attributes. Second is to distinguish between the topographic and geologic characteristics of deformed and undeformed zones in order to determine the likelihood of where glaciotectonism can be expected. Finally, these results are validated with the information gathered from traditional field investigations and ERI data.

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DOLOMITE, MICROBIOTA, AND SALT LAKES OF WESTERN CANADA

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Dolomite formation and dolomitization in the sedimentary realm are subjects of long-standing interest and study. Probably no other mineral or sedimentary rock has attracted as much speculation regarding its origin and genesis as dolomite. For Quaternarists, modern and Holocene dolomite formation seems to elude a clear understanding, and there is still considerable difference of opinion regarding the occurrence and genesis of "modern" and Quaternary dolomite. As we celebrate the 75th anniversary of the first scientific report on Quaternary lacustrine dolomite, it is fitting to summarize our current understanding of the origin and genesis of this intriguing and economically important mineral in the lakes of western Canada. We also use this opportunity to outline our new phase of investigation and examination directed at deciphering the role of microbiota in initiating and controlling Ca-Mg carbonate mineral formation and diagenesis in these lakes.

Western Canada is home to over half of the reported occurrences of modern non-detrital lacustrine dolomite in North America. Nearly all of these are from the saline and hypersaline lakes of the Prairie region of Alberta, Saskatchewan, and Manitoba. Although the precise mechanism(s) by which the dolomite is forming in these lakes remains elusive, there is now overwhelming petrographic and geochemical evidence that most of the fine-grained Ca-Mg carbonate material comprising the lacustrine surficial and Holocene sediment is a true primary precipitate. In Freefight Lake located in southwestern Saskatchewan, and several other deep, saline and meromictic basins, there is evidence that at least some dolomite formation and diagenesis is biologically mediated. It has been shown by various researchers that the production of carbonate particles by some microbes, for example, sulphate-reducing bacteria and cyanobacteria is due to their use of different metabolic pathways of the nitrogen and sulphur cycles. At this point it is not fully understood how these mechanisms induce carbonate precipitation and diagenesis. Our goal in this ongoing research project is to provide insight into the long-standing 'dolomite problem' by examining the role of microbial processes in the formation of carbonates in lakes across a range of environmental conditions. We wish to ascertain if the precipitation is due in part to changes in the water chemistry caused by these metabolic processes (i.e., an increase in alkalinity) and/or by a change in the microbial cells that encourages nucleation and growth of the mineral.

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SYNOPTIC SCALE ATMOSPHERIC CIRCULATION AND FIRE WEATHER CONDITIONS OF THE PAST THREE CENTURIES, BOREAL CANADA

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Many fire history studies across boreal Canada report a general decrease in forest fire frequency since ca. 1850. This work intends to provide empirical evidences for the causes of this shift. Five independent multicentury reconstructions of the July Canadian Drought Code and one reconstruction of mean July to August temperature were developed using a network of 120 well-replicated tree-ring chronologies from 13 species covering the portion of the eastern Boreal Plains to the eastern Boreal Shield of Canada. The reconstructions were performed using 52 time varying reconstruction sub models that explained up to 50% of the regional drought variance during the period 1919-1984. Spatial correlation fields on the six reconstructions and on a rectangular matrix of 90 multicentury tree-ring chronologies revealed that the meridional component of the climate system from central to eastern Canada increased since the mid-19th century. Using 500-hPa geopotential height and wind composites, we interpreted this zonal to meridional transition as a response to an amplification of planetary waves flowing over the eastern North Pacific onto boreal Canada, from approximately 1851 to 1940. Composites with NOAA extended reconstructed SST indicated a coupling between the meridional component and tropical and North Pacific SST for a period covering at least the past 150-years, supporting previous findings of a summertime global ocean-atmosphere-land surface coupling.

This change in the atmospheric circulation over boreal Canada could be a key element toward understanding the observed temporal changes in the forest fire frequency. To decipher long-term variability in fire activity on the Canadian Boreal Shield, the six tree-ring reconstructions were recalibrated against instrumental fire data to develop 229-year reconstructions of annual fire activity on the Boreal Shield. The calibration statistics indicated that up to 45% of the fire activity variance could be accounted for by the six reconstructions. The verification statistics indicated a tendency for the reconstructions to reproduce with confidence both high and relatively low frequency variations in fire activity. The results corroborate with the field fire history studies across boreal Canada by showing a decrease of forest fire activity on the Boreal Shield at ca. 1850 and again during the second half of the 20th century.

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LAKE ATHABASCA AND THE LITTLE ICE AGE: SUSTAINED HIGH-WATER STAND DRIVEN BY SNOWMELT-ENHANCED ATHABASCA RIVER DISCHARGE?

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As part of ongoing efforts aimed at improving knowledge of past hydrology, ecology and climate of the Peace-Athabasca Delta (PAD), northern Alberta (see Wolfe et al., this volume), paleoenvironmental studies have revealed evidence for profound changes in the western shoreline of Lake Athabasca over the past six centuries. Archival maps depict an expansive western embayment dating to AD 1827, followed by receding water levels in the early part of the 20th century evolving to the present landscape consisting of a large open wetland that is frequently flooded. Multi-proxy paleolimnological analyses of sediment cores retrieved from a closed-drainage basin in this former embayment of Lake Athabasca are strongly consistent with the paleohydrologic changes depicted on historical maps. Importantly, our analyses have revealed that high relative abundance of open-drainage indicator diatom taxa persists during the Little Ice Age (~AD 1600 to ~AD 1900), but the site existed as an isolated closed-drainage basin during the Medieval Warm Period (~AD 900-1600) and during most of the past century (since ~1910). A sustained multi-centennial high-water stand of Lake Athabasca may be responsible for the diatom stratigraphy during the Little Ice Age, as well as open-drainage conditions documented at this time in the sediment histories of other centrally-located, low-lying basins in the delta that are susceptible to a rise in Lake Athabasca water level. While an increase in river flood frequency could explain these stratigraphic records, this is inconsistent with low flood frequency during the 1700s reconstructed from the sediments of an oxbow lake near the Peace River or extremely dry conditions inferred from multi-proxy paleolimnological records from an elevated perched basin in the northern Peace sector (see Wolfe et al., this volume). We hypothesize that snowmelt-dominated runoff in the eastern Rockies sustained greater summer discharge in the Peace and Athabasca rivers and higher levels in Lake Athabasca during the Little Ice Age, except at times of rapid glacier advance.

To test this hypothesis, we obtained a sediment core from a shallow pond located in a barrier island complex in the western part of Lake Athabasca. Sediments from the pond are mainly organic with several distinct sandy laminations and beds. The close proximity of the coring site to a washover fan suggests that the sand was derived from the barrier and transported by waves overtopping the barrier and, thus, may provide direct evidence of former high-water stands of Lake Athabasca.

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PRODUCTIVITY AND VEGETATION COMPOSITION OF THE SOUTHERN BOREAL FOREST FROM HIGH-RESOLUTION POLLEN ANALYSES

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Both instrumental records and global climate models suggest that significant changes in a number of climate variables will occur in the western interior of Canada. Predicted effects include a northward shift of the grassland-aspen parkland-southern boreal forest transition zone. These changing climate variables and vegetation shifts will manifest as impacts on the forestry industry as well as generally on the soil, water and vegetation resources of the region. Climate variability in future decades is expected to exceed the extremes of the 20th century, with concurrent changes to forest communities beyond those experienced over this time period. The purpose of this research was to reconstruct the response of the forest ecosystem over a longer time period than is possible using direct observation, from lake sediment records at a high temporal resolution and spanning the past 1200 years. These data will facilitate the hindcasting of productivity changes using forest models. Short sediment cores (up to 1 m long) were collected from three lakes (L02, L03, and NFL) in central Saskatchewan in the aspen parkland-southern boreal forest ecotone. The three lakes are all located in shallow depressions surrounded by forest, and span a gradient from 53° 38' N to 54° 39' N, and from 104° 54' W to 106° 38' W. Radiocarbon and/or lead-210 dating indicate that the lake sediments span approximately 500 years (L02 and L03) and 1200 years (NFL). The sediments were sampled at contiguous 0.5 cm (L02 and L03) or 1 cm (NFL) intervals and the pollen was extracted using standard procedures with an added *Lycopodium* spike. At least 500 pollen and spore grains were counted at each level, and pollen percentages, concentrations, and accumulation rates were calculated. Indirect gradient analysis was used to estimate rates of changes in vegetation communities in the past, and these were related to measured climate variables over the range of the instrumental climate record. Cluster analyses were used to relate modern and paleo pollen assemblages, and estimate forest composition and productivity over the past several hundred years.

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CHIRONOMID TROPHIC HISTORY AND TEMPERATURE RECONSTRUCTION FROM A “BIG” (INSENSITIVE?) LAKE

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Chironomid-based limnological reconstructions are often done on “smaller” lakes cored using hand-operated devices, firstly because the lakes are considered more sensitive to external forcing, secondly because of the great cost or impracticality of obtaining sediment from deep lakes, and thirdly because fewer midges inhabit the profundal zones of large deep lakes. Here, we present the chironomid record from Lake Ammersee, a large (46 km^2) and deep (82.5 m) lake in southeastern Germany, to demonstrate that even “big” lakes have informative chironomid records.

Three different zones were identified in the ca. 12,000 year record. The basal zone was characterised by low abundance of mostly profundal taxa, e.g. *Paracladopelma/Cyphomella*, but with some *Cricotopus*, *Sergentia*, and *Heterotrissocladius*. The second zone, beginning prior to 10 000 cal yr BP, is marked by the appearance of *Micropsectra* and a coincident reduction in *Paracladopelma/Cyphomella*. The cold-stenotherm *Heterotrissocladius* was found to occur coincident with the 8200 cal yr BP cold event. In the third zone, from ~4700 cal yr BP to present day, abundant midge fauna were found, including a significant proportion of littoral taxa, suggesting increased aquatic productivity and nutrient influx, likely due to anthropogenic landscape modification.

Benthic Quality Index values ranged between 3.8 - 4.2, suggesting the lake has always been oligotrophic. Mean-July air temperature estimates range from 9.8 °C at 8200 cal yr BP to 14.3 °C at the core top, consistent with the ostracod $\delta^{18}O_P$-inferred temperature record (Von Grafenstein et al., 1998).

Ammersee shows senstivity to both Holocene climate and disturbance regime changes, despite being a “big” and assumed “insensitive” lake. We suggest that records of past chironomid communities from large Canadian lakes could also provide valuable information on the severity of limnological changes associated with Holocene temperatures and disturbance, thereby improving the accuracy of impact scenarios with possible future environmental change.

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RAPID ALLEROD AND SLOW YOUNGER DRYAS DEGLACIATION AT NORTHWEST MARGIN OF LAURENTIDE ICE SHEET (NW VICTORIA ISLAND) AND CONTRASTING ICE REGIMES

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The northwest margin of the Laurentide Ice Sheet is conventionally placed close to northwest Victoria Island, when the island was abutted by an outlet glacier in Viscount Melville Sound (VMS) and McClure Strait. The last glacial maximum flow pattern for the land is not known here, other than ice overtopped the 640 m high NE/SW spine of the Shaler Mountains. During deglaciation, several markedly different basal processes operated in the area, nevertheless deriving similar calcareous till from subhorizontal, relatively weak Paleozoic sediments under much of the area, and Proterozoic sediments and igneous rocks in the south.

Cold-based ice up to 100 km inland from VMS and 350 m elevation (including the north half of Prince Albert Peninsula) retreated southward, as indicated by marginal drainage channels. Other glacial landforms are rare, except for kames, and ice-contact deltas up to at least 130 m asl (Peel Point) and possibly 180 m southwest of Richard Collinson Inlet (RCI). Retreat was underway by the time of initial marine incursion at *c.* 12 ka ^{14}C BP.

On southern Prince Albert Peninsula, later southward retreat into Prince of Wales Strait and Amundsen Gulf was very different, marked by numerous end moraines and massive (up to 10 km wide) outwash plains typical of more temperate basal ice conditions. Although numerous minor readvances are recorded by massive till belts similar to the Younger Dryas belt on southwest Victoria Island, retreat into Amundsen Gulf was complete by *c.* 11.4 ka ^{14}C BP, i.e. it occurred during the Allerod, and was clearly rapid.

Between these two flow regimes, thick ice in the lee of the Shaler Mountains streamed in several phases downslope into the RCI basin. These flows left highly attenuated drumlins, marginal shear moraines, and several piedmont-form moraines in RCI itself. The associated sea levels indicate that flow continued after deglaciation of the Amundsen Gulf coast to the west, until *c*. 11 ka ^{14}C BP. However, retreat across the Shaler Mountains was again cold based (numerous nested marginal channels) but relatively slow, and was completed by 10.2 ka ^{14}C BP.

Finally, *c.* 10 ka ^{14}C BP, ice streaming from eastern Victoria Island filled VMS (including outer RCI) either as a grounded glacier or ice shelf and rode inland from the present shoreline by up to 10 km.

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LANDSLIDES AND AVALANCHES IN CAPE BRETON ISLAND, NOVA SCOTIA, CANADA

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Landslides and avalanches are common occurrences in Cape Breton Island, particularly within the highly-incised river valleys common to highland regions. Both have resulted in significant environmental impact and injury or loss of life.

Thin-skinned debris flows are common in the Cape Breton Highlands and begin as thin translational slides or slumps which quickly evolve into debris flows. Failure is most common on steep slopes (> 30°) where either highly compacted, impermeable clay-rich till or impermeable weathered bedrock is overlain by highly permeable colluvium. Redirected surface and ground water accumulates at the base of the colluvium producing an effective glide plane for initial translational movement. Complex failures involving rock topple, rotation slip, translational sliding and flow have been recognized throughout the Cape Breton Island; large scale rock slumps (sackung) have also been noted.

Avalanches occur in all highland regions but are best documented in the East Bay Hills. A particularly large avalanche occurred on February 5th, 1856 in which five people were killed and the house they were in was destroyed. This avalanche was preceded by heavy snow and rain which increased snow-water content and led to failure at the base of the snowpack.

A landslide hazard model has been completed for Cape Breton Highlands National Park. Continued hazard documentation and mapping is required to better delineate vulnerable areas. Several methods of highways protection have been attempted in the Cape Breton Highlands. The difficulty of implementation in this terrain and associated costs have resulted in varying degrees of success.

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RELATIVE SEA-LEVEL OBSERVATIONS FROM ISOLATION BASIN CORING AT THE NORTHERN STRAIT OF GEORGIA, BRITISH COLUMBIA

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Recent fieldwork has improved the record of postglacial sea-level change in southern and mid Strait of Georgia (James et al., 2002; Hutchinson et al., 2004), but until now no information was available on sea-level change in the northern Strait of Georgia. Cores from low-elevation isolation basins (lakes and bogs), supplemented with information from marine shells from excavations and exposures, record rapid sea-level fall on Quadra and Cortes islands following deglaciation. The oldest ages on marine shells indicate that the region deglaciated at about 14,500-14,000 calendar years ago (14.5-14 kyr BP). In 500-1000 years sea level fell 90 m from about 150 m to 60 m at 13 kyr BP. In the next 800 years, sea level fell nearly 40 m, to about 22 m elevation at 12.2 kyr BP. Sea-level change is not strongly constrained below about 20 m elevation. However, a core from a marine basin with a sill at 7 m depth indicates uninterrupted marine deposition from about 11.5 kyr BP to the present, suggesting that sea level did not drop below -7 m during this time. If correct, this suggests that sea level dropped another 20-25 m after 12.2 kyr BP, probably within 1-3 kyr, then maintained a level near present-day sea level up to the present.

Crustal uplift was determined by subtracting a far-field relative sea-level curve (Barbados), assumed to approximate global eustatic sea-level change, from the relative sea-level curve. An exponential curve with a decay time of 2-3 kyr fits the later part of the crustal uplift well. The rapid uplift immediately following deglaciation appears to require a second exponential term with a faster decay time and may be indicative of a shallow low-viscosity zone in the mantle. Crustal uplift rates in excess of 10 cm/yr occurred soon after deglaciation, but rapidly decreased to rates less than 1 cm/yr in the early Holocene.

The initial rapid emergence at rates in excess of 10 cm/yr is similar to the inferred sea-level curve for the mid Strait of Georgia. However, the low-stand documented for mid Strait of Georgia appears to be reduced in amplitude and may be completely lacking for the northern Strait of Georgia, perhaps due to differing forebulge effects from the wasting ice sheet. Sea level reached 20 m elevation at the northern Strait of Georgia only about 500 years after the mid Strait of Georgia, indicating rapid deglaciation of the area.

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FOSSILS, CHRONOLOGY, AND LAKES

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Canada is uniquely placed in terms of its geology, but this is poorly represented in Canadian geology curricula and education of its graduates. Lake sediments can provide detailed paleoenvironmental records more relevant to human habitat on the continents. In non-glaciated areas, lake records may span millions of years.

The work of Wagner (marine invertebrates) and Terasmae (plants) in the 1950's established the importance of paleontology in the Quaternary mapping program of the Geological Survey of Canada, and provided unique access to paleoenvironmental history. Quaternary fossils, nearly all extant species, allow direct comparison between present and past environments. Studies of fossils show that glacial lakes were rich with life and assemblages in successive lakes demonstrate the progressive increase in diversity with time and allow biostratigraphic zonation of sediment sequences. Glacial lake sands in a pit near Windsor, Ontario reveal that before 13,000 B.P. life was rich and abundant and suggest our spartan fossil record is caused by lack of preservation.

Varved lake sediments remain an excellent but largely untapped source of detailed paleoenvironmental information in North America. As Hughes in the 1960's and Ridge in the 1990's have shown, Antev's basic work of the 1920's was sound and needs follow-up to amplify glacial lake history. The dating of lake sediments continues to be complicated by various sources of error; in many cases, more careful work by AMS can clarify and revise chronology (e.g. redating at North Bay and on the Champlain Sea generally lowering ages).

There is much potential to pursue in North America on the use of tephra for correlation and cross-checking of radiocarbon dating errors from reservoir effects. Swedish workers have established the great spread of "invisible" tephra in both organic and inorganic (lacustrine) sediments across northern Europe.

Much older lake records from non-glaciated North America include those formed near the limit of glaciation in the Appalachian Mountains of the northeastern United States; several large lakes have been identified and others likely remain to be discovered. Long records have become available from mineral exploration and research holes to depths of hundreds of metres in Utah, California, and Oregon, and long records from tectonic and volcanic basins have been published from many parts of the world. The growing attention to lake histories has been recognized by the establishment of the Limnogeology Division of the Geological Society of America.

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QUATERNARY GEOLOGY AND STRATIGRAPHY IN THE VICINITY OF ZAMA CITY, BISTCHO LAKE MAP AREA 84M/2, NORTHWEST ALBERTA

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Glacial stratigraphy, ice flow history, and geotechnical characteristics are being explored through surficial mapping and examination of glacial sediments in the NTS 84M/2 map area in the vicinity of Zama City, northwest Alberta. This study is part of the ongoing Diamond and Shallow Gas Opportunities project in northeast BC and northwest Alberta, conducted by the BC, Alberta, and Federal geological surveys.

This study includes mapping at a 1:50,000 scale of the NTS 84M/2 map area, which includes the oil and gas operations around Zama City. Till, glaciolacustrine, alluvial, and organic are the four major surficial materials identified during mapping. Till is the most common surficial material and is generally clay rich It is mapped as either a veneer or a blanket, the latter being further subdivided based on surface expression. Glaciolacustrine sediments are also clay rich, and form a thin veneer in low-lying areas. Organic sediments include fibric bog material and water saturated mesic fen material that is commonly mixed with fine grained sediments. Alluvial sediments are also very fine grained, and contain less organics than fen sediments. .

Initial stratigraphic investigations provide evidence of a single Laurentide glaciation, with both advance and retreat phase proglacial lakes forming as ice blocked eastward drainage. Uplands in the northern portion of the map area reflect bedrock topography and are draped by a blanket of till between 1 and 10 metres thick. Lowlands in the south portion of the map area are quite flat and underlain by thick glacial sediments capped by retreat phase glaciolacustrine silt and clay. A thin veneer of diamicton overlying contorted glaciolacustrine sediments provides stratigraphic evidence for a surge into a proglacial lake or the grounding of floating ice.

Issues surrounding development in the area center on aggregate resources, permafrost and the geotechnical properties of the surficial sediments. Glaciofluvial sediments are rare, and as a result, aggregate is in short supply for the oil and gas industry. Most roads are simply surfaced with existing surficial material. Existing gravel supplies are found in two pits exploiting subtill gravels likely deposited in subglacial conduits. This study has revealed a possible additional source of glaciofluvial sediments deposited during deglaciation in association with a meltwater channel. Permafrost is discontinuous in the map area, and typically underlies organic bog sediments, where it is especially vulnerable to melting due to disturbance. Large fens occupy the southeast portion of the map area and overlie glaciolacustrine sediments. Geotechnical investigations of the major surficial material types include measurement of liquid and plastic limits, as well as in-situ measurements of shear strength and compactness. These results will be presented.

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WITHIN LAKE SPATIAL VARIABILITY OF MODERN CHIRONOMID ASSEMBLAGES AND A CHIRONOMID PALEOCLIMATE RECONSTRUCTION FROM WESTERN ALASKA

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St. Michael Island (63° 26.9'N, 162° 06.3'W) is located in Norton Sound, western Alaska, and lies beyond the limits of historic regional glaciations. Therefore, the numerous maar lakes (crater lakes) on this island have the potential to archive long, continuous lake sediment records of environmental variability. Maar lakes are also attractive study sites due to their high lake surface area to catchment area ratio and relative deep morphometry. These attributes permit minimal catchment influence of the sediment record and allow lake sedimentation to continue during the extensive periods of aridity that we know have occurred over much of Beringia during the late Quaternary (last 30 kyrs BP).

A 15.2 m lake sediment record with a minimum basal age of >30 kyr BP was obtained from Zagoskin Lake, southeastern shore of St. Michael Island. Published research on this core includes pollen analysis and loess sediment studies. I have quantitatively reconstructed past temperature trends from this record using a newly developed chironomid (Insecta: Diptera: Chironomidae) paleotemperature model. General patterns in temperature shifts inferred from chironomid community change agree with vegetation zones identified from pollen analysis. Highest temperature estimates occur during the Late-Glacial Holocene transition. Surprisingly, temperature estimates during the Last Glacial Maximum are similar to those of the late Holocene. Greater continentality may account for this, however, changes in lake depth cannot be ruled out as the ultimate cause.

In order to address the effects of lake depth on chironomid taxa/ assemblages I will examine ~110 contemporary chironomid assemblages from four maar lakes located on St. Michael Island. Using taxa-environmental relationships identified with ordination analyses (e.g. PCA, CCA, DCCA), I will be testing the hypothesis of the effect of lake depth on fossil chironomid assemblages. Are chironomid assemblages distributed uniformly within a maar lake? Do certain taxa prefer shallow or deep water? If so, a model can be generated using regression-calibration techniques to infer lake level changes through time.

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SALTS AND LAMINATED EVAPORITIC CARBONATES: NEW INSIGHT INTO A CENTURY-OLD DILEMMA

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Laminated evaporitic carbonates and thick accumulations of salts have posed interesting sedimentological and paleoenvironmental enigmas for over a century. Unlike most of sedimentary geoscience, the present is not a particularly useful key to the past when dealing with this realm of deposition. Indeed, much of our understanding of the sedimentological and geochemical characteristics of the “deep water-deep basin”, “shallow water-shallow basin”, and “shallow water-deep basin” evaporite facies models stems from examination of ancient sedimentary rock sequences rather than the application and study of modern and Holocene examples. The result of this situation is a lack of understanding of paleoenvironmental conditions that is in striking contrast to the importance evaporites and laminated carbonates assume in the interpretation of past climates and basin hydrology. The saline and hypersaline lakes of the Prairie region of western Canada offer considerable insight into this interpretive dilemma.

The modern and Holocene salt lakes of western Canada comprise a spectrum of depositional basins with varying geochemistry and morphology. Deep water-deep basin evaporates and carbonates are represented by modern Freefight, Deadmoose, and Little Manitou lakes. Chappice and Muskiki lakes are end-member examples of shallow water-shallow basin settings. The thick Holocene salt sequences in Ingebright and Ceylon lakes represent deposition from shallow water-deep basin environments. While our sedimentological and geochemical understanding of these basins has advanced considerably, these depositional models are based on very limited knowledge of biological and bio-mediated mineral formation processes. A better knowledge of the specific role that biota play or the conditions in which these organisms are present within each of these models will help with our interpretation of the environmental conditions that the salts and laminated evaporative carbonate minerals represent.

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LITHOSTRATIGRAPHY AND MINERALOGY OF RIVERINE LAKES FROM THE RED RIVER VALLEY OF SOUTHERN MANITOBA AND NORTH DAKOTA

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As a result of a low rate of meander formation for the Red River, a surprisingly small number of channel scar and oxbow lakes occur on the floodplain in the 150 kilometers between the terminus of the river at Lake Winnipeg and the Canada/United States border. The only two such perennial lakes are Lake Louise, located 2 km west of the Red River near Emerson, MB, and Horseshoe Lake, located about a kilometer east of the river near Morris, MB. A third lake included in this study, Salt Lake, is neither an oxbow nor a channel scar basin, and is located 10 km west of the Red River near Grafton, ND. Abundant observational evidence indicates that each of these three lakes receive water from the Red River during major flood events. Lake Louise and Horseshoe Lake were both inundated during the 1997 flood; Salt Lake receives water from the Red River due to back-flooding of the Park River. Thus, the stratigraphy of each of these basins should provide a long-term (several millennia) record of major floods on the Red River.

All three basins are small and shallow but perennial. Lake Louise is an elongate (~2 km x 0.2 km) channel scar basin with a maximum depth of less than 3 meters. Horseshoe Lake is a slightly smaller oxbow lake with a depth of approximately 2 meters. Salt Lake has a more equant shape than the other two basins, however it has a maximum depth of less than one meter. Lake Louise and Horseshoe Lake are both hydrologically closed basins, whereas Salt Lake has an outlet to Park River, which connects to the Red River.

High-resolution bulk mineralogy and detailed evaporite, carbonate, and clay mineralogy of cores taken from these three basins, coupled with particle size, chronological and geochemical analyses provide valuable insight into overall late Holocene lacustrine evolution in this region. However, because of post-depositional sediment mixing in these shallow basins and the fact that there is little difference in composition, grain size, or provenance between flood-derived inorganic sediments versus ‘normal’ lacustrine deposits, the physical, mineralogical, and inorganic geochemical lithostratigraphy of these basins offer little promise for deciphering long-term paleoflood frequency or intensity.

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BIG & SALTY: GEOLIMNOLOGY AND PALEOLIMNOLOGY OF SALINE LACUSTRINE GIANTS OF THE GREAT PLAINS

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The northern Great Plains region of western North America contains millions of saline and hypersaline lakes. Most of these lakes occupy small, shallow basins; many are ephemeral; most have only relatively thin Holocene stratigraphic sequences. However, the region also contains lacustrine “giants”: salt lakes of atypical size, exceptional depth, and/or unusual sediment thickness. Ingebright and Metisko lakes, located in western Saskatchewan and eastern Alberta, contain extraordinary thicknesses of Holocene salts and, together, contain marketable reserves of sodium sulfate nearly equal to all of the rest of North America. Lake Manitoba, at the eastern edge of the Prairies, and the Quill Lake basins, in south-central Saskatchewan, are among the largest saline lakes in North America. Freefight Lake, in southwestern Saskatchewan, is not only the deepest salt lake in the Great Plains of North America but also the most saline perennial lake in Canada.

Knowledge and understanding of the geolimnological processes operating in these basins provide sedimentologists with an unparalleled opportunity to better decipher ancient lacustrine basins. Furthermore, these saline giants offer a tremendous wealth of paleohydrological and paleoenvironmental information that is commonly obscured or more difficult to interpret from smaller lakes of the Prairie region.

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EVALUATING BED CONDITIONS AND MECHANISMS OF RAPID ICE FLOW IN MOUNTAIN-CENTRED ICE SHEETS (CORDILLERAN ICE SHEET), BRITISH COLUMBIA, CANADA

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Zones of rapid ice flow (e.g. ice streams) are increasingly recognized as key components of modern and former ice sheets. Through these zones, large volumes of ice can be evacuated and, in some cases, catastrophic debacles and collapses of major portions of ice sheets can occur. These debacles can potentially lead to rapid sea-level rise and climatic changes. For these reasons, there is an increasing need to better understand mechanisms of rapid ice flow. This can be accomplished by gleaning information from modern and former ice sheets.

In formerly glaciated areas, ice streams are often inferred from extensive swaths of streamlined bedforms (e.g.drumlins and mega-lineations). Such inferences assume that *i)* rapid ice flow results from pervasive deformation of subglacial sediments (till) and *ii)* sediment deformation creates streamlined bedforms. In addition, much of our understanding of the behaviour of former North American ice sheets stems from studies of the Laurentide Ice Sheet, which developed over relatively subdued bed topography. In contrast, the Cordilleran Ice Sheet (CIS) developed over mountainous terrain. It remains unclear if/how this pronounced bed topography played a role in the glaciodynamic behaviour of the CIS by controlling meltwater routing and sediment distribution, thus possibly determining the loci for zones of rapid ice flow. We test assumptions relating to mechanisms of rapid ice flow by reconstructing bed conditions and evaluating the field evidence for rapid ice flow along a portion of the southern margin of the Cordilleran Ice Sheet. Our work is focused along the edge of the Thompson Plateau, British Columbia, Canada where a 120 km long and 60 km wide tract of drumlins may record rapid ice flow.

Along this tract, drumlins are eroded in bedrock, diamicton and diamicton interbedded with sand and gravel. Diamictons are poorly consolidated and contain sand and gravel. Silt and clay appear to have been elutriated from the diamicton matrix and occur either as laminations within the diamictons or as thicker (10s-100s cm) lacustrine sediments deposited in subglacial cavities. Grain flow deposits make-up a portion of the material within and between drumlins. Clast fabric analysis and clast morphological characteristics (keels, striae orientations on clasts, plucked ends) suggest that diamictons result from repeated cycles of deposition and remobilization. This 'hybrid till' records evidence of lodgement, localized deformation in zones of high shear stress ('sticky spots'?) and, melt-out and squeeze-flow in water-filled cavities. Therefore, substrate characteristics suggest spatially complex and transient bed conditions and processes.

Drumlins exhibit crescentic scours, *en echelon* arrangement and preferential development over bedrock steps. They occur in association with tunnel channels eroded into bedrock and sediment and crossing topographic highs. Sediment characteristics, drumlin morphology and regional continuity of landforms are consistent with meltwater underburst erosion. Fast ice flow caused by ice-bed decoupling (enhanced sliding) may result during these underbursts.

This work emphasizes the importance of water storage and release in till genesis and in the formation of streamlined bedforms. In addition, it highlights the need to consider

dissociating processes responsible for substrate characteristics from those responsible for drumlin genesis.

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GEOMORPHOLOGY, SEDIMENTOLOGY, ELECTROMAGNETICS AND LIDAR MAPPING OF LOW RELIEF, HIGH ENERGY, SUBGLACIAL CHANNEL DEPOSITS IN NORTHEAST BRITISH COLUMBIA, CANADA

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Subglacial channel deposits in the forested Boreal Plains of northeast British Columbia are difficult to investigate due to their relative scarcity, subdued relief, and thick cover of glacial sediments. The origins of some high energy, bouldery gravels, such as at the Kotcho glaciofluvial deposit, are particularly enigmatic because the gravels are entirely buried and have virtually no surface expression, even though they are exceptionally coarse and locally occur within a metre of the surface. The Kotcho deposit, located about 130 km east of Fort Nelson in NTS map area 93I/15, is characterized by crudely stratified, poorly sorted, large cobble to boulder gravels interbedded with well stratified, moderately well sorted, sands and pebble gravels. Contrasts in grain size and sorting from bed to bed are large and remarkably sharp and reflect sudden changes in flow energy. Low angle, large scale, trough cross-bedding, cut-and-fill structures, and large clast clusters reflect strongly channelized flows yet the deposit shows little overall relief. The gravels are sharply overlain by a 1-5 m thick diamicton interpreted to be a meltout till. The diamict is moderately dense, silty, matrix-supported, contains both local clasts and distally derived (Shield) erratics, and has thin laminae of sorted silts and very fine sands. The presence of angular, soft siltstone clasts that show little sign of shear precludes a lodgment till origin. The geometry of the Kotcho deposit can not be determined from aerial photographic interpretation of geomorphic data due to the extensive forest cover and subdued relief created by the till blanket. However, other techniques for mapping these features, including airborne electromagnetics (EM) and light detection and ranging (LiDAR) surveys, have proven highly effective. This paper describes application of these techniques at the Kotcho deposits and other areas.

Gravels in the region show a marked contrast in electromagnetic properties, when compared to adjacent glacial sediments, allowing for relatively high resolution mapping using airborne EM. The survey was flown with 100 m line spacing over the Kotcho deposit and 200 m spacing over a larger area (25 km^2). The helicopter RESOLVE multi-frequency EM system was supplemented by two high sensitivity cesium magnetometers and a GPS electronic navigation system. The flat, till covered, Kotcho deposit, which was originally detected only in seismic shot hole logs, was mapped remarkably well by high resistivity in the high frequency (115000 Hz) data, which best reflects the shallow geology. Excavations since confirmed the 3-dimensional geometry of the buried gravels at Kotcho and other gravel bodies identified in the larger survey. LiDAR has also successfully helped identify a number of low relief, glaciofluvial landforms in the region, that were previously obscure using other remote sensing data. LiDAR removes the masking effects of vegetation and enhances geomorphic features that have subtle (<1 m) vertical relief. Results indicate that high resolution EM surveys and LiDAR are effective tools for mapping subglacial channel deposits in northeast BC and in other forested plains with similar geology.

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AN EMPIRICAL MODEL OF ISOSTATIC ADJUSTMENT FOR THE GREAT LAKES BASIN: THE BASIS FOR RECONSTRUCTING PALEOGEOGRAPHY AND FOR DISCOVERY OF A PHASE OF HYDROLOGIC CLOSURE

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The Great Lakes of North America consist of 5 major basins within a 775,000 km^2 area. Except for two highstands which were confluent in three of the basins — the Main Algonquin (about 10.6 ^{14}C ka; 12.8 cal ka) and Nipissing (5 ^{14}C ka; 5.7 cal ka) lakes — paleo-lake shorelines were formed at different ages in different basins. The age and elevation of these differentially uplifted shorelines forms the observational data for reconstructing phases of the former Great Lakes. The challenge for reconstruction is in merging the differentially uplifted strandline information of different ages into an isostatic response surface for a single age that applies to the entire watershed of the Great Lakes. A first approximation of a response surface (e.g. of Algonquin age) for multiple basins has been computed and compiled from existing single-basin strandline data, and a method of computing other response surfaces at prescribed ages has been developed using the well-known assumption that isostatic adjustment in a formerly glaciated area can be described as a function of age using a negative exponential function. A function of the form $Et = Ep\text{-}Ua\ (\exp(t/tau)\text{-}1)$ was selected from the work of W.R. Peltier to describe past elevation *Et* of a site at age *t* cal ka BP where *Ep* = present site elevation, *Ua* = post-Algonquin site uplift interpolated from the Algonquin response surface, and tau = relaxation time of the isostatic adjustment process. Mean relaxation time, computed from a number of transects throughout the region where gradients of two shorelines of different age (generally the Algonquin and Nipissing strandlines) were known, was found to be 3700 ±700 years. The use of an exponential function containing '-1' ensures that a site uplift curve passes through the present elevation of the site.

Response surfaces computed by the new model have enabled the paleogeography of the Great Lakes basin to be reconstructed in a geographic information system (GIS). Essentially, a surface of differential uplift for a selected age was subtracted from a digital elevation model of the present Great Lakes basin to yield the paleo-bathymetry and topography. Shorelines were fitted to the reconstructed elevations of ^{14}C-dated lake-level indicators, and, for overflowing lakes, to basin outlet elevations. The bathymetry of paleo-Lake Erie was adjusted to account for its relatively rapid rate of sediment accumulation.

The new model of isostatic adjustment has facilitated discovery of a phase of hydrologically-closed lakes between 8 and 7 ^{14}C ka. The closed lowstands of Late Lake Stanley and Late Lake Chippewa in Huron and Michigan basins are about 15 and 30 m, respectively, below their lowest possible overflow outlets. Such hydrologic closure arises when evaporative losses exceed inflows by precipitation, runoff, and from groundwater. These climate-driven phases are the subject of current research to evaluate the sensitivity of the Great Lakes system to higher-amplitude, longer-duration change than is presently known from recorded instrumental observations. This sensitivity, derived from an episode of severe paleohydrological drought, provides perspective for estimates of possible future change in Great Lakes levels under global warming.

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THE OCEANIC ROUTING AND IMPACT OF THE FINAL OUTBURST FLOODS OF GLACIAL LAKE AGASSIZ-OJIBWAY TO HUDSON BAY, 7.6-7.7 ^{14}C KA

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The Laurentide Ice Sheet over Hudson Bay dammed Lake Agassiz-Ojibway until about 7.6-7.7 ^{14}C ka, when dam failure occurred, probably by subglacial tunnelling (work of J. Teller, D. Leverington, G. Clarke and A. Dyke), resulting in catastrophic floods to the Atlantic Ocean via Hudson Strait and diversion of its drainage from Ottawa-St. Lawrence Valley. Floodwaters would have entrained calcite-rich carbonate glacial sediment derived from Paleozoic limestones flooring Hudson Bay and Strait. In 1999, D. Barber et al. postulated that these floods had entered the Labrador Sea, and there had inhibited thermohaline circulation (THC) with its incoming warm and saline Atlantic water, to induce climatic cooling that was registered in the isotopic record of Greenland ice. However, work by Hillaire-Marcel et al. in 2001 revealed that Labrador Sea THC began at 7 ^{14}C ka, and thus the routing and impact of Agassiz-Ojibway flooding became unclear.

Discovery of detrital carbonate (DC) beds on Northeast Newfoundland Shelf (NENS), which lies on the trajectory of the southward-flowing Labrador Current, leads to a new hypothesis for the oceanic routing of Agassiz-Ojibway waters. The upper DC layer is dominated by calcite, and contains few planktic foraminifera, suggesting rapid deposition, reduced sea-surface salinities, and/or turbid surface waters. The AMS ^{14}C onset age of DC deposition is 8140+/-150 BP on *N. pachyderma* (planktic foraminifera); available reservoir age corrections (450 to 540 yr for the NW Atlantic Ocean) indicate a ^{14}C age of 7.6-7.7 ka. An AMS date of 8390+/-100 BP on *N. pachyderma* near the end of DC deposition is consistent with sampling flood-entrained older forams and/or incorporation of old dissolved inorganic carbon present in the water column into foram tests during growth, from carbonate sediment originating from the bedrock of Hudson Bay and Strait (where reservoir ages and corrections are 630-710 yr). This DC layer is interpreted as deposition from a flood-driven plume of calcite-bearing sediment particles carried southward from Hudson Strait in the Labrador Current.

A DC layer of the same age from Downing Basin (Grand Bank), and re-interpretation of existing cores collected from SE Baffin Shelf, Saglek Bank and Cartwright Saddle are consistent with this interpretation. Carbonate north of Hudson Strait is deficient in calcite, and the calcite-rich DC content and bed thickness progressively decrease from northern Labrador to southern Newfoundland. Dinocyst concentrations in 3 cores from Cartwright Saddle and the Scotian Shelf show consistent decreased surface temperature and lowered salinity about 7.7 ^{14}C ka.

Overall, the evidence indicates that floodwaters with their suspended load of DC exited Hudson Strait, and were deflected southward over the shelf by the Coriolis effect, and not directly out into the Labrador Sea. The plume was carried south in the Labrador Current over the eastern Canadian and possibly US continental shelves. The colder, reduced-salinity waters were then likely dispersed into the North Atlantic Drift, moving northeastward to slow down THC between Europe and Greenland. This routing supports

the theory of D. Barber et al. that the final Lake Agassiz-Ojibway outburst triggered the 8.2 cal ka cold event.

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OPTICAL DATING OF BURIED HEARTHS FROM RED RIVER VALLEY, SOUTHERN MANITOBA, CANADA

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As part of a study examining stratigraphic evidence of paleofloods of the Red River, Manitoba, the utility of applying luminescence (optical) dating to the mud-dominated alluvial environment was examined. During field reconnaissance, buried features resembling hearths were consistently encountered in the bank exposures along the river. This discovery was important as far as dating was concerned because if the constituent sediment grains had been heated to a high enough temperature, the luminescence "clock" would have been reset. Moreover, in many cases, the hearths contained small charcoal fragments whose calibrated AMS radiocarbon ages could be compared to our optical ages. This poster will be concerned only with the results of our research into dating the hearths.

Optical dating was done by measuring the violet luminescence emitted during infrared excitation of the potassium feldspar fraction in separated fine-silt. Bulk heated sediment extracted from the reddened centre of a buried hearth yielded an optical age (1.4 ± 0.2 ka) that was broadly consistent with its associated radiocarbon age (AD 0.23–1.05 ka), but much better agreement (0.79 ± 0.09 ka) was achieved when small fragments of hard-baked mud (total mass ~0.5 grams) extracted from within the feature were dated separately; hard-baked mud fragments from two other hearths yielded similarly good results. This study shows that optical dating of well-heated alluvium of this type is a viable method of dating floodplain evolution.

Details of our methods, and a more thorough discussion of the results, for both the hearth sediment and the unheated alluvium can be found in Lian and Brooks (2004).

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Reference:

Lian, O.B., and Brooks, G.R. 2004. Optical dating of mud-dominated alluvium and buried hearth-like features from Red River Valley, southern Manitoba, Canada. The Holocene, 14: 570–578.

TOWARDS UNDERSTANDING SUBGLACIAL THERMAL REGIME AND CHARACTER OF PALEO-ICE-FLOW UNDER PARTS OF THE LAST CORDILLERAN ICE SHEET

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Over the last two decades the importance of understanding ancient ice sheet behaviour has been realized with the hope that models developed for the growth, decay, geometry and stability of the last ice sheets can be used to predict the behaviour of present-day Arctic and Antarctic ice masses that influence global sea level and climate. One problem that paleo-ice-sheet modellers face is that there is a paucity of information about how the substrate responded to shear stresses imposed on it by overriding glacial flow. This is because traditional surficial geology maps, and lithostratigraphic studies, rarely give information related to glaciotectonic deformation.

Over the past decade we have conducted detailed glacial geologic studies of subglacial sediment (especially primary till) in regions covered by the last Cordilleran Ice Sheet with the goal of deciphering subglacial processes and thermal regimes. During glacial movement stress is transferred from the ice to the substrate and this often results in diagnostic glaciotectonic structures, stone fabrics, and erosional features that can be measured and compared. These are directly linked to the processes that formed them. In particular, the manner in which subglacial sediment and bedrock are deformed is closely related to the thermal state, sediment rheology, and flow conditions that exist beneath the ice. If ice moved over frozen or well-drained (brittle) substrate, friction is expected to be relatively high. In this case ice flow velocity and ice flux would be minimal, and ice thickness would increase. Conversely, if ice moved over poorly-drained substrate that deformed ductily, ice flow velocity (and ice flux) would be higher and ice thickness would decrease.

In this talk we illustrate this hypothesis with two case studies – one from the southern interior, near one of the Cordilleran Ice Sheet's major spreading centres, and the other from near the south-west fringe of the ice sheet. In our first example our data suggest that even during glacial maximum in a high mountain valley (~1000 m) near the centre of the ice sheet, glaciers flowed rapidly over an unfrozen ductily deforming substrate. Ice flow velocity was, however, likely controlled by localized well-drained "sticky spots". Our second example is from a mountain valley that opens onto lowlands near the south-west fringe of the ice sheet, where we infer that ice flowed more slowly over a relatively well-drained substrate that appears to have experienced mainly brittle deformation.

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WHAT IF WE HAD LOOKED FROM SPACE FIRST? USING SRTM DEM DATA TO GENERATE ALTERNATIVE HYPOTHESIS FOR DEGLACIATION OF THE LAURENTIDE ICE SHEET

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Attempts to understand the role of relic ice sheets in the Earth System depend upon our reconstructions of its behavior and activity. The first efforts to reconstruct the behavior of the Laurentide Ice Sheet involved geomorphic inventory, but were hindered by poor topographic data, by non-uniform coverage and were limited to a ground perspective. Subsequently Quaternary geologists employed chronological approaches coupled with genetic interpretation of sediments to build a stratigraphic framework for the ice sheet. However, this approach is limited because it is dependent on outcrop or subsurface data sets that are unevenly distributed across the relic ice mass, there is an inability to correlate events over distances considerably larger than observational data, and there is an uneven spatial and temporal distribution of suitable chronological samples. We have considerable sampling density for some areas (e.g. near universities or urban centers) but only preliminary insights into other areas. Nevertheless, these data generated from multiple workers have been extensively discussed, debated, refined, and integrated with an emerging understanding of modern ice sheets to develop our current perspective for the dynamics of the Laurentide Ice Sheet. In essence we have built our understanding from a non-uniform data set and scaled-up from modern glaciers to reconstruct a continental ice sheet.

A different approach might be, what if we had started from space, observed any ice sheet signatures evident at that scale and zoomed in? In this way we would consider a large regional area with a uniform geomorphic data set and could apply a uniform interpretation. Would we construct the same ice sheet? Where the two approaches result in a consistent story this exercise provides a confirming independent check. However, those areas where the two approaches result in contrasting stories, a reexamination may be warranted.

The first impression is that southern half of the Laurentide Ice Sheet has a crude symmetry about the headwaters of the Mississippi River. The general elongation of the Great Lakes converges toward the SW whereas the general alignment across the southern Prairie Provinces trends SE focusing on a north-south depression containing Lake Winnipeg. This depression, in the center of the craton, appears to be a major outlet from the core of the ice sheet.

Zooming closer reveals a common landscape assemblage of lineated terrain leading to concentric ridges ringing the lower portions of the landscape. Irregular upland areas (drift and escarpment noses) are commonly bounded on one side by anastomosing channel networks. The concentric ridges are very rarely observed to crosscut each other. These observations suggest that the lobes formed major ice margin positions in an orderly manner while the ice margin ringed topographic highs and that the overall retreat patterns are less dynamic than proposed.

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GENESIS AND GLACIAL HISTORY OF ROGEN MORAINE ON THE AVALON PENINSULA, NEWFOUNDLAND

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Field observation, air photo interpretation, and GIS analysis have allowed for the re-examination of Rogen moraine formation on the Avalon Peninsula, Newfoundland. This presentation provides details of ongoing research which examines the morphology and sedimentology of Rogen moraine in relation to potential formative processes by subglacial deformation or subglacial flooding. The relationship of moraine genesis to the glacial history of the Avalon Peninsula will also be discussed.

Mapping of individual Rogen moraine ridges from aerial photography revealed a complicated pattern of ridge orientations. As a whole, the field of moraine reflects the dominant ice flow direction in the area during glacial maximum, but at larger scales many elements within the field of moraine do not fit this pattern. Individual ridges are commonly transverse to one another within small areas, and groups of moraines may be randomly oriented.

The moraines are composed of a compact stony diamicton, and sedimentary structures included openwork gravel lenses, boulder lines, and silt caps. Clast fabric were poor indicators of glacial flow, and more than half of the 57 measurements were weak, girdle fabrics suggestive of genesis by sediment gravity flow.

Preliminary interpretation of the data sources suggests that the subglacial meltwater hypothesis is not the most likely explanation for the formation of Rogen moraine in the study area. Formation by deformation is being considered, although it is suggested here that the moraines likely formed beneath stagnating ice during overall glacial retreat.

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OUTBURST FLOOD IN THE UPPER ROLLING RIVER SPILLWAY, RIDING MOUNTAIN UPLANDS, MANITOBA: A PHYSIOGRAPHIC AND SEDIMENTOLOGICAL APPRAISAL

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The Upper Rolling River valley represents the eastern segment of a prominent spillway complex that initially drained Glacial Lake Proven, a large supraglacial lake located on the Riding Mountain Uplands. It is speculated that another supraglacial lake located to the northeast of the Upper Rolling River Spillway spilled over the stagnant ice to the southwest. The jokulhlaup-like flows poured into the Upper Rolling River Spillway reversing the flow, backflooding into Glacial Lake Proven and effectively shutting down the primary outlet of the supraglacial lake.

This paper examines the physiography of the Upper Rolling River Spillway and the sedimentary facies exposed in the Upper Rolling River borrow pits and the Scandinavia gravel pit in order to assess the possibility that an outburst flood reversed the late Wisconsinan supraglacial flow in the Upper Rolling River Spillway.

Physiographic, depositional and stratigraphic evidence supports the occurrence of a major late Wisconsinan flooding event in the Upper Rolling River valley. Over two metres of valley fill, an associated Hjulstrom-type delta and paleocurrent indicators suggest that the supraglacial flow was reversed in the Upper Rolling River Spillway system. Whether this event resulted in a significant backflooding into Glacial Lake Proven and the opening of a lower outlet remains speculative.

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CONTRASTING GLACIAL LANDSCAPES BENEATH THE KEEWATIN ICE DIVIDE IN THE SCHULTZ LAKE AND WAGER BAY AREAS, CENTRAL NUNAVUT

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In the summer of 2004, the Geological Survey of Canada (GSC) conducted Quaternary mapping in the Schultz Lake (NTS 66A) and Wager Bay (NTS 56G) map areas in central Nunavut. Both areas were located beneath the Keewatin Ice Divide during the last glaciation. Field work included surficial mapping, regional-scale till sampling, stratigraphic studies, and ice-flow indicator surveys. The objectives are to 1) contribute to a better understanding of the glacial history in an area of thick drift and complex ice flow, and 2) provide a regional framework for mineral exploration, particularly drift prospecting for diamonds. The project is part of GSC's Northern Resources Development Program (http://nrd.nrcan.gc.ca).

In the Schultz Lake area, facetted and striated bedrock surfaces, and palimpsest streamlined landforms record multiple ice flows. An old southeastward flow across the area was followed by a north-northwestward flow, and a late westward ice-streaming event in southern areas. In the Wager Bay area, striations and glacial landforms are less developed. Northern parts of this area experienced flow to the NNW, with late easterly flows into Wager Bay. Flows in the south shifted between southward and southeastward. A central 20-km wide belt of weathered upland terrain has few striae or glacial landforms.

Although both areas lay in the area of the Keewatin Ice Divide, the ice-flow directions, sequences and glacial landscapes are different. At Schultz Lake, the well-developed glacial record, together with numerous signs of older subglacial erosion on bedrock, suggests wet-based conditions during a sequence of ice flow events. The preserved record of opposing ice flows throughout the entire map area as well as paleo-landsurfaces containing remnant landforms are indicative of a transitory ice divide with limited duration. In contrast, the location of the ice divide at Wager Bay seems to have been fairly stable, and the poor development of a glacial landscape throughout the central area suggests an ice regime that was different from Schultz Lake. The limited striation record and the absence of well-formed roches moutonnées in the central belt of the Wager Bay map area, combined with grus and weathering pits on rock surfaces in uplands near the ice divide, suggest limited glacial erosion in this area. Ice in the Wager Bay area could have been cold-based and protective under the stable ice divide.

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NATURE AND SEDIMENTOLOGY OF THE OLDEST AGASSIZ BEACHES ALONG THE MANITOBA ESCARPMENT

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The upper (older) beaches of Lake Agassiz include those of the Herman, Norcross, Tintah, and Campbell stages, and range in age from ~10,900 to 9400 ^{14}C yrs. BP. The upper beaches are of particular interest because they may represent lake levels associated with hydrological events that affected ocean circulation and climate. Dating control is poor along most of these beaches, and many interpretations have been inferred from radiocarbon dates in other areas. Optical luminescence dating is being attempted to assess its applicability.

Recent power augering, ground penetrating radar, mapping, and pit studies in the upper beaches have provided new insight into their formation. Most of these beaches are thin, low relief, and narrow accumulations that parallel the Manitoba Escarpment. Most are more poorly-sorted than modern beaches, with sorting ranging from good to extremely poor. Although stratified, some beaches contain silt to boulder sizes, perhaps reflecting the addition of iceberg-rafted material or a high ratio of sediment supply to wave reworking, with nearby till providing the source. GPR shows that regular shoreface accumulation is common in most beaches; backshore overwash deposits are found behind some beaches—probably from storm events. In most areas beaches overlie till or a boulder lag.

The western shore of Lake Agassiz has some of the best developed beaches in the basin. The maps produced by Warren Upham in the 19th century were at a very large scale, and most of the beaches have never been mapped at a scale smaller than about 1:50,000. In this study, the uppermost beaches within a large area (between ~49º and 49.5º N latitude) of the Agassiz basin were mapped from aerial photographs at a scale of about 1:12,000. These maps were digitized using the ArcView 3.1 GIS package, and supplemented with data from field work and published sources.

Since the time of Upham's work, it has been a common misconception that the named beaches are each represented by one or perhaps a few ridges and relate to a narrow period of time in the lake's history. New mapping shows the vast majority of beaches are discontinuous, and often do not cluster into Herman, Norcross, and Tintah beach-sets. The beaches rise in elevation towards to the north due to postglacial isostatic rebound—for this reason, and because of the small size, multiplicity, and discontinuity, beach correlation is difficult.

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TREE-RING RECORD OF DROUGHT ON PEACE-ATHABASCA DELTA

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The Peace-Athabasca Delta, one the world's largest freshwater deltas, is located at the confluence of the Peace and Athabasca Rivers in northeastern Alberta Province, Canada. Water levels of lakes and watercourses of the Delta are expected to respond to large-scale climate changes, as the contributing watersheds cover more than 280,000 km^2 and include a broad swath of the Canadian Rockies between 52º N and 58º N. A study conducted in 1972 indicated that tree-ring records of white spruce (*Picea glauca*) in the Delta are useful for inferring water-level variations in the summer months. That study resulted in a 158-year reconstruction of Lake Athabasca water level. To extend the tree-ring record spatially and temporally as well as investigate the possible growth-response sensitivity to W. A. C. Bennett Dam -- completed upstream on the Peace River in 1967 -- a new tree-ring study was recently completed. The study included increment cores from a total of 137 *Picea glauca* trees sampled in the summer of 2001 from the immediate region of the Delta. The new data were combined with the 1972 collection for an updated and improved lake-level reconstruction for Lake Athabasca.

Analysis of these data along with pre-existing tree-ring chronologies from the International Tree-Ring Databank (ITRDB) and other sources supports the finding of previous studies that growth of *Picea glauca* along the watercourses in the Delta generally responds positively to rising water levels. The strength of the statistical signal for annual water-level change is weak, but becomes stronger with smoothing over several years. The new reconstruction identifies a period in the late 1800s as the most severe prolonged drought in the last 200 years. Anecdotal written records offer some corroboration of this drought. The 20th century is unusual in a long-term context for high-amplitude multi-decadal variations in tree growth and reconstructed water level. The timing of these more recent fluctuations appears unrelated to building of the W. A. C. Bennett Dam, or in any consistent way to regime shifts in climatic indices popularly associated with drought recurrence in North America.

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STRAIN PATHWAYS, TILL MICROSTRUCTURAL ARCHITECTURE – A GENERAL KINEMATIC MODEL

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Subglacial tills, both terrestrial and subaqueous, cover vast areas of the glaciated continents and continental shelves. These tills exhibit a wide array of deformation structures and fabrics indicative of the environment(s) from which they are derived. It is apparent from examination of till exposures and microscopic study that a complex set of deformation processes have been ongoing during and following till deposition / emplacement. Over the past several years considerable discussion has centred upon the kinematics of subglacial soft bed deformation. To examine till internal architecture, a kinematic model of till is presented in which microstructures and other structural artefacts common in tills are placed within the context of this model. Micromorphology reveals that deposition and/or emplacement of tills is a complex '*tectonic*' process such that lodgement, melt-out and flow tills, as previously defined, do not appear to exist. Therefore, in using micromorphology, a substantial understanding of till deposition / emplacement mechanisms can be obtained that has wide implications for the genesis of tills. The implications for this new understanding of tills, allied to statistical 'typing' of tills, is considerable in terms of till formation, glacial stratigraphy and our understanding of glacial environments in terms of stress histories, porewater transmission, subglacial deformation mechanics, till rheological phase changes, and the timeline of till formation.

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RECONSTRUCTING DROUGHT REGIMES FROM THREE REGIONS OF THE CANADIAN PRAIRIES DURING THE PAST SIX MILLENNIA

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Droughts are a common feature in the northern Great Plains, causing severe environmental, economic, and social impacts. Recent studies from western Canada, covering the past 5,500 years indicate that shifts from one drought regime to another reoccur at a millennial-scale. Knowledge of these major shifts in moisture conditions at multi-decadal through millennial time scales is essential for water-resource availability and land-use management especially in agriculturally important regions like the Canadian prairies. Data to determine drought variability in the prairies is scarce, because of the lack of long instrumental climate records and high-resolution paleoclimatic data.

In this study we investigate the importance of long-term dynamics (multi-decadal to millennial scale variability) in drought conditions during the mid to late Holocene in the Canadian prairies. We used fossil diatom assemblages to reconstruct drought frequency, duration and intensity in three closed-basin lakes from the Canadian Prairies. We selected three lakes with evidence of strong linkages between lake chemistry and historical climate: Chauvin lake (east-central Alberta), Humboldt lake (central Saskatchewan), and Oro lake (south-central Saskatchewan). Sediment cores from the three lakes were extracted using a Livingstone piston corer and the preserved diatom remains were used to track past climatic conditions at an approximately 20-year resolution for Chauvin and Oro lakes, and at an approximately 10-year resolution for Humboldt Lake.

The sediment core records cover the past ~4,800 to ~6,800 cal. years BP. Estimates of changes in lake-water salinity were inferred from a modern-day calibration set. Diatoms from the three lakes oscillate between periods of wetter and drier climatic conditions in varying intensity and frequency. For the past ~3,500 cal. BP climatic conditions can be characterized as being predominantly arid with small intervals of wetter conditions. Before ~3,500 cal. yrs. BP, climate at Humboldt and Oro lakes was still arid, but experienced periods with increased moisture, while at the most western site, Chauvin lake, generally wetter conditions with short intervals of arid climate prevailed. The diatom records clearly indicated that major shifts in moisture regimes on a multi-decadal to centennial-scale are a persistent feature of the prairie lakes, and that these variations are much greater than those experienced over the last century.

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THE ENIGMA OF THE YOUNGER DRYAS: IS THE LABRADOR CURRENT A MISSING LINK?

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Sudden cooling during the Younger Dryas (YD) (11-10 ^{14}C ka) is recognized as a significant example of abrupt climate change. Rapid reduction of North Atlantic thermohaline circulation (THC), diminishment of deepwater production, and slow-down of the global oceanic conveyor system of heat transport to northern latitudes and salinity to other oceans, is believed to be the cause. Models indicate that perturbation in freshwater input to the North Atlantic may be the triggering mechanism. Atmospheric greenhouse gas accumulation increases precipitation, which models show may affect THC, and initiate future abrupt climate change. Study of past events such as the YD, are crucial to refining the knowledge of THC sensitivity.

Slowdown of YD THC is considered to have resulted from rapid releases of freshwater from dammed inland glacial lakes, into the North Atlantic. Until recently it was thought the YD was triggered when drainage from Lake Agassiz switched from southern discharge to the Gulf of Mexico, to routing through the St. Lawrence system. However, recent assessments by J. Teller and others, T. Fisher and others, suggest that the Agassiz eastern outlet was still glaciated at 11 ^{14}C ka. Lake Agassiz then, may have drained catastrophically northwestward, and influenced North Atlantic THC by enhancing Arctic Ocean outflows of sea ice and lower-salinity water to the North Atlantic. S. Occhietti, P. Richard and associates have shown that St. Lawrence Valley deglaciation occurred at 11.1 ^{14}C ka, which then released a large flux from locally impounded upstream lakes, which may have preconditioned North Atlantic surface waters.

Marine proxies for freshwater outflow from northeastern Canada are detrital carbonate (DC) layers, sediment transported in, and deposited from, lower-salinity surface plumes. A. Jennings, J. Andrews and associates recognized an YD-dated DC layer, with a distinct dolomite component, present on the SE Baffin Shelf and Slope. This DC originated from an ice advance out of Cumberland Sound to the SE Baffin Shelf edge. It has also been found at Orphan Knoll, off Newfoundland, implying southward transport by the outer Labrador Current, over the upper continental slope.

Here, we present evidence that YD freshwater influx extended over the shelf, and was more extensive than previously recognized. A 53 cm thick YD-dated DC layer containing equal proportions of dolomite and calcite has been found in a core on Northeast Newfoundland Shelf (NENS), hence the inner branch of the Labrador Current also carried YD DC sediment as far south as Newfoundland.

This flow is inferred to have been substantial, of similar magnitude to the 1.6-5.0 Sv outbursts driven by the final and largest drawdowns of Lake Agassiz-Ojibway, at 7.7 ^{14}C, based on DC thickness and the same benthic foraminiferal responses to both flows at this same site. Flow continued southward, as inferred from the DC at Orphan Knoll, and then probably coalesced with the St. Lawrence outflow. This low-salinity surface water would have been dispersed in the North Atlantic Drift, and advected northeastward to join with Agassiz-driven low-salinity Arctic outflows to the northern North Atlantic, to suppress THC and induce YD cooling.

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PALEOLIMNOLOGICAL INVESTIGATION OF DIATOM SPECIES ASSEMBLAGE IN LAKE 239 (EXPERIMENTAL LAKES AREA, NW ONTARIO) THROUGHOUT THE HOLOCENE

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Diatom assemblages in surface sediments were sampled along three transects in Lake 239, from the Experimental Lakes Area (NW Ontario), and analyzed in order to explore the relationship between modern species distributions and water depth. Approximately 170 diatom species were identified; the species composition varied with sample depth but remained highly similar across all three transects. The main patterns of variation in the diatom assemblages across transects, derived from a detrended correspondence analysis (DCA), showed that assemblages were highly correlated (r = 0.97 to 0.98). Around 8 m the pattern of predominantly benthic composition changed to a planktonic assemblage dominated by *Cyclotella stelligera*. This depth currently corresponds to the depth of 1% light penetration as assessed from extinction coefficient measurements. Diatom species diversity increases with the switch to the near-shore benthic taxa in all three transects. Additionally, there is a large decrease in the ratio of chrysophyte scales to diatoms starting at 8 m. Light transmission data from wet and dry periods over the last 35 years suggests that during dry periods the extent of the littoral zone should change by over 2 m. Hence, we suggest that cores along a transect from 8 to 14 m should provide a highly sensitive location for detailed paleoclimatic study.

The current study utilizes two overlapping 13 m sediment cores, taken from the centre of the lake, which will provide a historical record of changes at the ELA. Diatom assemblages will be enumerated and identified to species level in order to understand diatom community changes throughout the Holocene. Magnetic susceptibility will be carried out on the two overlapping cores to obtain calendar dates, with Carbon 14 dating also carried out on any macrofossils. Three large sand lenses were noted in core 2 occurring in meters 10 and 11, this may be evidence of drier conditions during the time period represented by these sections. The diatom inferred history will be conducted at a resolution of every 8.0 cm throughout the core, with higher resolution from 7700 – 9400 Cal as part of a larger project on Great Lakes climate change in Ontario. This study should provide a better understanding of century-scale climate fluctuations and the occurrence of arid periods in NW Ontario.

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PERMAFROST AND GLACIAL HISTORY OF THE TUKTOYAKTUK COASTLANDS, NWT, DURING MARINE ISOTOPE STAGES 3–2

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Litho- and cryostratigraphic studies of permafrost in the Tuktoyaktuk Coastlands permit the reconstruction of the permafrost and glacial history at the northwest margin of the Laurentide Ice Sheet (LIS). Luminescence and radiocarbon dating of the preglacial Kittigazuit Formation indicates that extensive aeolian dunes and sand sheets accumulated regionally between *c*. 43 and 13 ka, especially after *c*. 30 ka. Aeolian activity was interrupted during Marine Isotope Stage (MIS) 2 by the advance of the LIS, which resulted in glaciotectonic deformation of permafrost beneath its margin and burial of large remnants of the basal ice layer within permafrost. During deglaciation, pressurized meltwater was injected into proglacial permafrost, producing younger bodies of intrusive ground ice that post-date glacial deformation. On the ground surface, aeolian activity during deglaciation switched primarily to sand-sheet aggradation between *c*. 14 and 8 ka due to surface armouring by glacial deposits. Deglacial aeolian activity was repeatedly interrupted by meltwater erosion. As climate warmed at the end of MIS 2, glacigenic debris melted out from the top of the buried basal ice, forming widespread supraglacial melt-out till.

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INDIGENOUS RESPONSES TO THE HYPSITHERMAL: A VIEW FROM THE STAMPEDE SITE IN THE CYPRESS HILLS

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An early-Holocene interval of aridity, variously identified as the Early Holocene Thermal Maximum or Hypsithermal, has been documented in western Canada. Although variable across time and space, the Hypsithermal is generally assumed to have lasted from approximately 9200 to 5000 BP in Alberta. Proxy records derived from a number of paleoenvironmental indicators on the northern Plains suggest an increase in temperature and a decrease in precipitation resulting in lowered water tables, increased salinity in ponds and lakes, expanded grasslands, and increased fire frequency.

The impact of this climatic episode on Indigenous communities has been the subject of debate for over fifty years now. To some archaeologists, the Hypsithermal caused a substantive decrease in the carrying capacity of the grasslands necessitating a total abandonment of the northern Plains. Others envision less drastic responses such as slight changes in the patterned movements and subsistence activities of resident groups. These researchers stress the importance of refugia such as river valleys and spring-fed upland locales where animals and humans have ready access to water and critical resources. Still others argue that the lack of evidence for human occupation on the northern Plains during the Hypsithermal can be attributed to sampling bias, not the abandonment of the region.

The record of human occupation on the northern Plains during the Hypsithermal is admittedly sparse with few sites having components dating to this interval. Recent excavations at the Stampede site, however, have exposed a record of human occupation spanning, at least, the last 8,000 years. This archaeological site, which is located along the north slope of the Cypress Hills in southeastern Alberta, has been the subject of research by a multi-disciplinary team as part of the SCAPE (Study of Cultural Adaptations Within the Prairie Ecozone) project. In this paper, we evaluate Indigenous responses to the Hypsithermal by examining changes in the geomorphology, ecology, and archaeology of this deeply stratified site located within one of the proposed refugia.

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AN INVESTIGATION ON CLAY MINERAL COMPOSITION OF THE LOESS MATERIALS IN THE SOUTHEASTERN BASIN OF THE CASPIAN SEA

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The southeastern Caspian Sea region contains extensive loess deposits in a west to east direction. Beginning with sandy loess hills on the alluvial plains of Atrak-River in the west, deposits alter to a blend of coarse and fine loess on the hill slopes and high plateaus of the Koppeth-Dagh Mountains (1200 m above sea level [masl]); these deposits correspond with arid, semi-arid and semi-humid conditions respectively. In contrast, loess deposits on the north slopes of the Alborz Mountains are restricted to a narrow strip from the Alborz piedmont plains up to 500 masl, within the moist Hirkanian Forest which originally extended from near the sea level up to 2500 masl.

Consequently, soil profiles were studied in an anticlockwise direction, beginning with profile no. 1 in the Ghorogh Forest in the south-west, profile no. 2 in the Minoo-Dasht district in south-east along the north slopes of Alborz Mountains, and profiles number 3 and 4 in the Khorusly and Chatal area in the high plateaus of Koppeth Dagh Mountains. Finally, we studied profiles 5 and 6 in the Maraveh-Tappeh and Hutan villages along the Atrak-River (from northeast to northwest) near the Turkmenistan border. X-ray diffractometry indicates that the dominant clay minerals for profiles 1-6 were illite> chlorite> kaolinite. Smectite (13-15%) in A and B horizons of profiles 3 and 4 (Haploxerolls) on the high plateau of Koppeth-Dagh is possibly a secondary mineral, whereas kaolinite in B- and C-horizons is a primary component of parent materials. Secondary kaolinite increased the total to 25% only in profiles 1 and 2 in the humid Hirkanian Forest, particularly in their respective A horizons of Eutrochrepts and Haplustolls,. Mixed-layer minerals in these profiles are also secondary build-ups. In addition, the existing palygorskite traces in all profiles indicate that the loess deposits in this area were transported from a desert or lagoon, located in west or north west according to the dominant wind directions in this area.

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INVESTIGATION AND NATURAL DATING OF LOESS PALEOSOLS IN SE BASIN OF THE CASPIAN SEA

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The study area (~22,000 km^2) is located in the southeastern part of the Caspian-Sea in Golestan (Hirkanian) Province of Iran. Loess materials cover ~400,000 ha of the area in the high plateaus, on the hills in the north-and northeastern slopes of the Alborz- and Koppet-Dagh Mountains, and also a large part of the plains from southwest to northeast of the province. In addition, large areas are covered with loess outwash plains. Sandy loess hills in the region are oriented in a west-east direction, recording the dominant wind direction in this area. The investigated loess profiles are distributed in six different places from southwest to northeast of the Gorgan-, Atrak- and Ghara-Su rivers. The thickness of the studied scarps is often more than one hundred meters with up to 18 paleosols and 21 loess sedimentation periods and red clay at the base of one of them at the source of Gorgan- River in the northeast.

According to thermoluminescence stratigraphy of loess deposits in the southern Rhine Graben, we believe that the investigated scarp in Ghapan-Village, can be taken as a standard profile for correlation of all studied scarps in this area. In this profile we found 14 paleosols with 21 loess sedimentation periods as follows: at the base of profiles S1-S7 we found 3 stone lines with 2 loess layers between them. We believe that these stone lines could be the basis of the L.G.P. in this area. Also, at the base of profiles S8-S11, we found again another thick stone line. We believe also that this one could be the base of the Eemian Interglacial. Finally, at the foot of the profiles S12-S14 exists another stone line dating to the early Riss-Glaciation period. Under the last stone line we found four loess stratums (QL1-QL4) without any pedogenetical indications. They may belong to the Holstein 1-4.

On the basis of clay mineralogical composition and classification of the paleosols, we suggest the following: during the L.G.M. the climatic conditions were the most variable, with alternations from dry and hot to semi-arid and wet condition; while the climate in Eemian Interglacial was relatively constant-- mostly mild-humid. Climatic conditions during the Riss-Glaciation period was warm and humid with evidence of strong solifluction in the Bt-horizon and carbonate cementation in the C-horizon. Finally, at the base of the profiles we find four different loess-and alluvial layers which are approximately 2 m thick. The climatic condition of the standard profile at present time is semi-arid with 450 mm rainfall and the soils on the top of the hill (500 m above sea level) are typic calcixerolls.

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AN INTERSTADIAL SITE IN THE BIRCH MOUNTAINS, NORTH-CENTRAL ALBERTA

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Auger coring in the Birch Mountains, northwest of Fort McMurray, intersected an 80 centimetre thick organic layer at a depth of 9 m below surface. The site is located south of Jean Lake, immediately north of the drainage divide near the headwaters of the Sputina River. The organic layer is underlain and overlain by till. The underlying till is considerably more consolidated than the overlying till. The organic layer consists of peaty material. It includes coarse (> 3.5 mm) macrofossil fragments, such as wood, bark and moss. Finer fractions contain needle fragments, charcoal and a few seeds. Taxonomic identifications include *Pinus* sp. (wood fragments) and Cyperaceae (seed). Two radiocarbon dates have been obtained from this organic layer: an AMS date of 32,690 ± 340 RCYBP (TO-10545) on a pine wood fragment and a conventional ^{14}C date of > 50,000 RCYBP (BGS 2585) on organic detritus. Middle Wisconsin sites in northern Alberta are rare. The discovery of well-preserved woody organic material between two till units suggests the occurrence of two glacial events in north-central Alberta. The data from this site strengthen the emerging picture of a regionally significant middle Wisconsin nonglacial interval. To date, this is the most northeasterly middle Wisconsin site found in Alberta.

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THE COCHRANE SURGES AND GLACIAL LAKE OJIBWAY IN NORTHEASTERN ONTARIO

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Examinations of varves discovered in the Mattagami River lowlands, deposited in post-Cochrane glacial Lake Ojibway and overlying Cochrane Till near its southern limit in the southeastern Ontario were undoubtedly deposited in post-Cochrane glacial Lake Ojibway following the rapid retreat of the Cochrane ice margin. Varves overlying the Cochrane Till are contemporaneous with the upper sequence of the Barlow Ojibway Formation (Connaught sequence) south of the Cochrane limit elevations of late stage Lake Ojibway water levels. The varves, strandlines and wave-cut benches formed on Cochrane Till allow for refinement of Lake Ojibway water planes and ages of the Cochrane surges in Ontario as well as drainage of Lake Ojibway into the Tyrrell Sea This information, in turn, has broader implications with respect to meltwater drainage induced climatic change and the nature of the rapidly wasting Laurentide Ice Sheet during the early Holocene.

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SURFICIAL GEOLOGY MAPPING OF THE BISTCHO LAKE AREA (NTS 84M), NORTHWEST ALBERTA

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During the summer of 2004, the Alberta Geological Survey (AGS) and the Geological Survey of Canada (GSC) completed the surficial mapping of the Bistcho Lake map area (NTS 84M). This was the second year of a four-year collaborative, multi-disciplinary project created under the GSC's Northern Resource Development Program (NRD Project 4450) with additional support from the Federal-Provincial Targeted Geoscience Initiative (TGI-2).

The study area is situated in the very northwest corner of Alberta, and physiographically is characterized by the Cameron Hills Uplands in the north, and the Fort Nelson Lowlands along the southern margin. Uplands in the northern half of the study area are characterized by extensive peatlands, underlain by shallow discontinuous permafrost. Regions with active thermokarst are distinguished by polygonal patterned ground, irregular ground surfaces and a characteristic patterning of ponds. Permafrost in this region appears to be extremely susceptible to ground disturbance and melting. Lowlands in the southeast are characterized by flat topography and expansive fens developed over glacial Lake Hay sediment. Much of the study area is draped by a thick blanket of clay-rich, clast-poor till. In the northeast, this is overlain by stony carbonate-rich till. Several bedrock outcrops were discovered in the region where previous bedrock topography and drift thickness maps had suggested thick (<250 m) drift cover. Shales of the upper Fort St. John Group (Shaftesbury Formation, Lower to Upper Cretaceous) outcrop north of the hamlet of Zama City and form a bedrock high which divides the drainage between the Hay and Petitot rivers.

Field observations and interpretation of prominently fluted terrain visible on satellite imagery indicate that the Laurentide Ice Sheet initially flowed west and then southwest across the region. During deglaciation, thinning ice became increasingly topographically controlled, as indicated by a dense network of ribbed moraines on top and west of Bootis hill that record an ice lobe wrapping around the north side of Cameron Hills. A second ice lobe retreated east and northeastward down the Hay River valley. In the Fort Nelson Lowland to the south, retreating ice impounded the regional drainage, resulting in the formation of glacial Lake Hay. A thin veneer of glaciolacustrine sediments was deposited along the northern margin of the glacial lake. Iceberg scours and a thin deposit of diamicton (interpreted to be a till) overlying contorted glacial lake sediments indicate that ice readvanced briefly into the glacial lake basin during the latter stages of deglaciation.

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SURFICIAL GEOLOGY MAPPING, SHALLOW GAS, GRANULAR RESOURCES AND DIAMOND POTENTIAL IN NORTHERN BRITISH COLUMBIA AND ALBERTA

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A four-year collaborative and multi-disciplinary project between the Alberta Geological Survey (AGS), the British Columbia Ministry of Energy and Mines (BCMEM) and the Geological Survey of Canada (GSC) was initiated in 2003. The objective of this project is to produce geoscience information in support of exploration for aggregate resources, diamonds, and shallow gas reservoirs in Quaternary/Paleogene (Tertiary) sediments in northwest Alberta and northeast British Columbia. The project was created under the GSC's Northern Development Program with some financial support from the Targeted Geoscience Initiative-2.

Surficial geology maps are being produced for the study area to 1) reconstruct ice-flow history, patterns of deglaciation, and glacial lake history as an aid for mineral exploration, and 2) identify regions with potential granular resources and underlain by permafrost for infrastructure development dominantly related to the oil and gas industries. Preliminary results indicate that the Laurentide Ice Sheet advanced to the west and southwest over the region and that the pattern of retreat was influenced by topography. Glacial Lake Hay developed over a vast region of northwest Alberta and northeast British Columbia following the blocking of the eastward drainage by the retreating ice sheet.

Since the mid 1990's, near the hamlet of Rainbow Lake, Alberta, shallow gas has been extracted from shallow horizons located in unconsolidated sediments. Shallow gas is present in buried porous fluvial and glaciofluvial sediments (sand and gravel) within paleovalleys eroded into producing bedrock horizons. Gas has migrated from the bedrock source into the sediments which are capped by a succession of clayey till and glacial lake deposits. Bedrock topography and drift thickness maps produced by the AGS and the BCMEM are used for the identification of buried valleys and exploration targets for shallow gas reservoirs. Also, these paleovalleys are of interest because they are associated with well site blow-outs, artesian aquifers and seismic interpretation problems. In collaboration with the University of Alberta, a 10 km long seismic survey was conducted across a buried valley identified from a bedrock topography map. In addition, an electrical resistivity survey was conducted along the same survey line. Preliminary interpretation of both datasets indicate the presence of gas at 50 to 100 m

depth within a broad channel incised into bedrock and dominantly infilled by Quaternary sediments.

As part of this project, bulk glacial sediments are collected and processed for kimberlite indicator minerals (KIMs) to evaluate the potential of the region for diamond exploration. In January 2005, the BCMEM reported the presence of KIMs in glaciofluvial sediments from northeast British Columbia including purple pyrope, yellowish eclogitic garnet, Cr-diopside, olivine, ilmenite and spinel. The provenance of these minerals remains to be identified. A number of areas were staked immediately after the report was released.

Granular resources are in high demand in northeast British Columbia for road improvements and for developing new access routes. Important new aggregate sources have been identified in the region using a variety of subsurface data sets (seismic shot-hole, water well, conductor pipe and gamma logs) airborne electro-magnetic surveys, high resolution LiDAR data and surficial geology mapping. The new aggregate resources represent a direct savings to BCMEM of over $15 million to date.

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THE USE OF SURFICIAL MAPPING DATA IN REGIONAL PLANNING

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Surficial mapping has supported mineral exploration and groundwater research in New Brunswick for many decades. The large volume of data that resulted from this mapping, which incorporates soil parent material properties (lithology, granulometry), geochemistry, and sample site characteristics is being utilized in new ways. Advanced computer technology and integrated data management has made it possible to use existing data to produce multipurpose 'surface material' maps that can be utilized in land use planning, hazard mapping, and modeling of forest soil hydrology. One such project uses data obtained from surficial mapping in the general area of the Fundy Model Forest in south-east New Brunswick. This area was selected by Natural Resources Canada for research and management in partnership with different levels of government, industry, university researchers, and private woodlot owners.

The main landforms that we find in this region are relatively thin basal till units that tend to reflect local bedrock geology in terms of texture and lithology. Other landforms present include: alluvial terraces, glacial fluvial and ice-contact deposits (mainly occupying over-deepened river valleys and glacial spillways) and discontinuous disintegration moraine occupying topographic depressions. Areas with significant slopes (greater than 25%) are prone to mass wasting processes and are often covered with colluvium or have exposed bedrock surfaces. These slopes present challenges to agriculture and forestry, and as such, are considered marginal to poor in terms of productivity.

Alluvial, glaciofluvial/ice contact, colluvial, and ablation till deposits are delineated by using a combination of methods including: air photo interpretation, field observations, computer methods (Surfer© 8.0 contouring software), and already existing aggregate data. Basal till units, although comprising one common till sheet, are subdivided on the basis of lithology, texture (granulometry), physiography and colour. Initially units were outlined that are dominated by one lithology (e.g. more than 50% volcanic rocks, more than 50% igneous rocks, or more than 80% sedimentary rocks). Subsequently, specific combinations of lithologies are used to make the maps complete. As a secondary parameter, till matrix texture is used to further subdivide and/or modify units. Although soil parent material texture is described in the field, the matrix texture (sand/silt/clay ratio) is determined in the lab by using a modified hydrometer method; clay and sand percentages in the matrix are plotted for the entire area and large-scale generalizations and patterns identified. The patterns follow geological and terrain boundaries, but are locally modified by glacial dispersion and mixing. In some instances, bedrock or physiographic boundaries, topographical features, and/or variations in till colour are used to complete the picture.

Subsequent to this procedure, compactness (consistency), surface stoniness, depth to contrasting layer (usually the C horizon) and drainage are incorporated into the final maps. The result is a set of 1:50 000 'surface material' maps that comprise the Fundy Model Forest area.

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PROGRESSIVE SHIFTS IN INTERGLACIAL CLIMATES, DON RIVER BASIN- SEA OF AZOV, RUSSIA

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The lower reaches of the Don River have never been disrupted by Quaternary glaciers, and preserve a record of proglacial and interglacial loess sedimentation and soil development extending into the early Pleistocene. Extension of previous research from the Central Russian Plain to the Sea of Azov allows comparison of the record of interglacial soil sediments from the Muchkap (OIS 11?), Likhvin (OIS 9), Kamenka (OIS 7), Mikulino (OIS 5e), and the Holocene events. The soil units, interbedded with loess, provide an excellent indication of climate changes, both along a north-south transect and among interglacial events.

To complete the north-south transect, three exposures along the coast of the Sea of Azov were examined. The exposures are wave-cut bluffs ~25m high extending from the modern soil to early Pleistocene marine sediments. The sequence at the largest exposure, Semibalki, confirms the results from previous studies. The modern soil overlies the ~4m thick Valdai (OIS 2) loess. Below the loess is a well developed soil of the OIS 5e (Mikulino) interglacial. This loess-soil sequence extends to OIS 11, with Likhvin and Muchkap interglacial deposits lying atop the marine sands.

The soil-loess successions show a progressive shift from Mediterranean dominated climate patterns, with warm, dry southwesterly winds, to colder northwesterly and Atlantic-influenced winds. As expected, soil development shows a progression from Mediterranean assemblages along the Sea of Azov, especially in the older interglacials, to soils developed under boreal and taigas forests in the north. However, differences also exist between interglacials: the early interglacials show stronger Mediterranean influences, especially along the Sea of Azov. In contrast, OIS 5e and Holocene successions are dominated by westerly (Atlantic) circulation in the north, and the Sea of Azov successions also show increased effects from westerly and northwesterly (Atlantic) winds in the younger interglacial deposits. These successions parallel results obtain in the Altaisk region of Siberia, where a progressive shift from southerly winds during OIS 5e and OIS 4 to westerly winds during OIS 2 and OIS 1 has been observed. The overall pattern suggests that westerly winds have become progressively more dominant in the Central and Southern Russian Plain, both with respect to soil development and loess deposition, since OIS 11.

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WHOLE-LAKE ALGAL RESPONSES TO POLLEN FLUX IN THE BOREAL FOREST OF NORTHERN SASKATCHEWAN, CANADA

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Pollen is hypothesized to be a nutrient source for primary producers in boreal aquatic systems because algal blooms often coincide with the time of maximum pollen dispersal early in the summer. The results of studies that have examined the deposition of macronutrients by pollen are inconsistent, possibly due to differences in methods used and time of experiment. Therefore, high-pressure liquid chromatographic analysis (HPLC) of sedimentary pigments and analysis of fossil pollen was used to measure whole-lake algal responses to fluctuations in lake pollen receipt over the last 1150 years in a small boreal lake in northern Saskatchewan, Canada. Sedimentary pigment-inferred algal abundance was significantly correlated ($P < 0.05$) with sediment pollen concentrations of *Alnus*, *Betula* and *Pinus* species (r = 0.22-0.49). Among the 51 plant taxa identified in the pollen record, these 3 genera were the main pollen contributors, accounting for 77% of total pollen deposition. *Pinus* (pine) pollen represented 52% of total grain deposition, and was the species that best predicted historical changes in algal abundance. The results presented here suggest that pine pollen influx represents an available nutrient source for phytoplankton growth. My findings also suggest that conifer pollen is an important allochthonous source of nutrients in small boreal lakes and warrants inclusion in lake nutrient budgets.

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WHEN DROUGHT AND DELUGE COINCIDE ON THE PRAIRIES

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The spatial variability of drought on the prairies is clear in the modern instrumental record but is less-easily addressed in studies of pre-instrumental drought incidence which rely on proxy data such tree rings. Although these data are predominantly drawn from the prairie margins, conclusions based on them are frequently extended to much or all of the region. Given the paucity of pre-instrumental data, this extrapolation is understandable but it is important to recognize that even large departures from normal rainfall in one part of the prairies may not reflect conditions in others. This paper describes two very similar droughts, one modern and one historic, in which great disparities occurred between the eastern and western prairies. Other evidence is presented which suggest that the protracted severe drought interval of the mid-1800s identified from tree-rings in the Cypress Hills did not extend to the central and eastern prairies where quite the opposite conditions appear to have prevailed. These examples illustrate the need for caution in extending proxy data from a single region to “the prairies” in general.

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TIMING AND SUCCESSION OF GLACIAL AND NONGLACIAL EVENTS IN THE HUDSON BAY LOWLAND OF MANITOBA, CANADA

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The riverbank sections of the lower Nelson River in the Hudson Bay Lowland of Manitoba show an extensive depositional record consisting of four till units and two pre-Holocene nonglacial deposits. Ice flow directional data and the clast lithological content of tills indicate a complex succession of events involving ice advances from the Keewatin and Labrador-Québec ice divides. The oldest unit, Sundance Till, was deposited by southeastern flowing ice from the Keewatin sector. A paleosol developed on Sundance Till is stratigraphically correlative to a marine-clay unit that is found below the second oldest till unit, Amery Till. Amery till is extensive throughout the study area and was deposited by southwestwardly flowing ice emanating from the Labrador-Québec sector. Amery Till is in turn separated from the two upper till units by an organic-bearing unit, the Nelson River sediments (NRS). Preliminary optically stimulated luminescence (OSL) ages from the NRS assign this unit to the last interglacial. The overlying Long Spruce Till and Sky Pilot Till were deposited by west-northwestward and southwestward ice flows, respectively, thereby suggesting a northward migration of the Labrador-Québec ice divide during the last glacial cycle. The age of the older nonglacial unit, the Limestone River sediments, is currently being dated by OSL. The different number and changes in ice-flow directions recorded in these glacial sequences suggest significant reorganizations in the location of ice divides, which may have been caused by drastic episodes of “draw-down” of the Laurentide Ice Sheet. Here we present till sedimentological data, along with new OSL results on the two nonglacial units, and discuss their implications on the timing and succession of ice flow events.

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CLIMATE CHANGE DURING THE LATE QUATERNARY INTERPRETED FROM LOESS-PALEOSOL SEQUENCES FROM EUROPEAN RUSSIA, SIBERIA, CHINA AND THE UNITED STATES

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Loess-paleosol sequences of the last interglacial-glacial cycle (oxygen isotope stages 2-5) have been examined in European Russia, Siberia, China and the United States. Although loess sources, grain-sizes and unit thicknesses vary significantly in each area, a record of continental climate change can be compared and documented. Correlation of loess units and paleosols across eastern Europe (Russian Plain), Siberia (Kurtak), China (Chinese Loess Plateau) and the United States (Iowa, Nebraska, Arkansas) was facilitated by adequate numbers of radiocarbon and optically stimulated luminescence ages.

In European Russia and China, OIS 5 is represented by pedo complexes in a series of well developed welded soils, resembling Luvisols, whereas in OIS 5 in Kurtak, there are six paleosols, identified as Brunisols and Chernozems with interbedded loess. In the U.S., the Sangamon soils have luvisolic properties, with a more clayey pedogenic texture than modern Luvisols. The cold climate of OIS 4 is represented by varying thicknesses of loess in most areas, with no detectable soil development except in Kurtak, where five to seven weakly developed paleosols are identified within loess. The warming during OIS 3 is evident in all areas investigated by the presence of paleosols. In the Russian Plain, a single, possibly a welded paleosol, is identified in three widely spaced locations and classified as a Regosol and Luvisol in the north, and as a Chernozem in the south. At Kurtak, OIS 3 is represented by two distinct, stacked paleosols, a Brunisol over a Chernozem. In China, OIS 3 consists of a loess bed that is flanked by two weakly developed Chernozems. In the U.S., the well-known Farmdale paleosol, displaying chernozemic properties, developed in loess is equated to OIS 3. In Asia and North America, the loess-paleosol records of OIS 3 indicate both cool and warm periods. The best climate control and timing is in China where there is an early and late warming period separated by a cooling (loess) in OIS 3. In all areas the last cold period (last glacial maximum) OIS 2 is represented by relatively thick loess units. Only in Kurtak, can weakly developed paleosols be identified, both Brunisols and Regosols.

In all areas examined, the timing of climatic variations throughout the last interglacial-glacial period were remarkedly similar. During the last interglacial (OIS 5) most environments supported grassland to forest vegetation, whereas during the last glacial period (OIS 2-4) most areas had high rates of loess or sand deposition, with or without grasslands. Only in the warming of the last glacial period (OIS 3) was there widespread grassland to forest vegetation, but not to the extent that there was during the last interglacial period. The conclusion is reached that the dominating climatic changes that took place during the late Quaternary at least in continental areas of the northern hemisphere were similar.

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USING TREE-RINGS TO ESTABLISH THE PROBABILITY OF DROUGHT IN THE WESTERN INTERIOR

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In the western interior of North America, a subhumid climate extends to high-latitudes in the rainshadow of the western Cordillera. The least annual precipitation and recurring drought occur in the northern Great Plains. Record low precipitation for this region occurred during 2001-03. The return period for drought of this severity and duration can be determined only from paleoclimatic records. Paleolimnologic research on the northern plains has revealed multi-centennial shifts in moisture regime but tree rings are the only climate proxy that enables the detection of short-term moisture deficits (drought).

We have built tree-ring chronologies for 50 sites in the island forests, foothills and boreal forest from eastern Montana, through Alberta and Saskatchewan, and across the southern Northwest Territories. At most of these sites, tree growth is limited by summer soil moisture. Residual index chronologies account for 30-60% of the variance in measured annual and summer precipitation and streamflow. Unexplained variance mostly reflects the tendency for tree-ring widths to underestimate unusually wet conditions. Our interest, however, is primarily in dry conditions and low flows. The tree rings are a particularly good proxy of the timing and duration of drought. At most sites, there is a mid-19 century shift from the dominance of decadal variance (sustained wet and dry conditions) to more interannual variance that characterized the 20th century and the instrumental hydroclimatic record. Thus the 20th century lacked the prolonged droughts of preceding centuries.

This research addresses concerns about impacts of drought in this region and about water supply forecasting based on relatively short instrumental records. From tree rings, we are able to extend hydroclimatic records beyond the decades of instrumental data, although at some sites, the short length of gauge records presents a challenge for calibrating and validating the tree-ring based reconstructions. To apply our proxy records to drought and water supply planning, we have taken a Monte Carlo approach to expressing uncertainty in the tree-ring reconstruction and to estimating probability of drought, annual and seasonal precipitation and streamflow below specific thresholds.

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QUANTITATIVE MODELLING OF SUBGLACIAL BEDFORM FORMATION

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The genesis of streamlined subglacial bedforms such as drumlins, Rogen moraines and flutes has been a hotly debated topic in glacial geomorphology for well over a century. A sound, physics-based explanation for the formation of these landforms has been difficult to formulate because relatively little is known about processes operating at the base of ice sheets. Geological evidence largely points to drumlins being erosional remnants, and the main challenge in understanding their origins lies in identifying the sediment transport processes involved in eroding the glacier bed in a spatially patterned way.

Subglacial erosion bears little resemblance to the fluvial case, as erosion and deposition processes related to the slow, laminar flow of an ice sheet are very different from those occurring in the rapid, turbulent flow of rivers. However, a meltwater drainage system at the base of an ice sheet has the potential to evacuate much larger quantities of sediment than is possible by direct entrainment into, and advection by, the overlying ice sheet. In this presentation, we consider how a subglacial drainage system can erode the bed of an ice sheet in a spatially distributed way which does not leave a channelized imprint on the bed of the ice sheet. We also consider how interactions between glaciofluvial sediment transport, bed topography and the dynamics of the overlying ice can lead to the selective amplification of certain topography wavelengths on the bed and hence to the formation of bedforms. Our approach is to construct a predictive model in which all processes involved are quantified mathematically, and which allows our results to be tested against field observations.

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A 750-YEAR RECORD OF FOREST DISTURBANCE IN SOUTHWEST YUKON, CANADA BASED ON LAKE SEDIMENT RECORDS

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Fire and spruce bark beetles (*Dendroctonus rufipennis)* are major, if not the chief, forms of disturbance in boreal forest ecosystems. It appears that the size, level of tree mortality, and frequency of bark beetle outbreaks may be increasing as of the last few decades, and climate models predict that future conditions may alter fire and outbreak dynamics. Yet we know very little about the influence of bark beetle outbreaks on forest dynamics, historical occurrences of spruce bark beetle infestations, and if outbreaks interact with fire in these systems. A large-scale spruce bark beetle infestation, beginning in the early 1990s, has infested and killed over 300,000 ha of white spruce forest in the Kluane region of the southwest Yukon, Canada. This study tested a new method of reconstructing spruce bark beetle outbreaks using conifer stomata preserved in lake sediments, as massive loads of conifer needles, and thus stomata, into the lake were evident at the site and appeared to be caused by the recent bark beetle infestation. A 96 cm sediment core, representing a 750-year record, was retrieved from a small pothole lake in a presently beetle-infested area of the Kluane region and sectioned at 3 mm intervals. Conifer stomata, microscopic charcoal, conifer pollen, and magnetic susceptibility were analyzed to infer possible interactions between beetle outbreaks, fire, and vegetation. Coinciding peaks in the charcoal and the magnetic susceptibility records were inferred to represent local fires. Fires may have been frequent before 1850 and appear to have occurred roughly at 1500, 1650s, 1750s and 1850s cal AD. If prominent peaks in the stomata record do represent local beetle infestation, these results may indicate that three of the fires were preceded by bark beetle infestations. Furthermore, there is evidence of a mid to late 1300s beetle infestation as well as one likely sometime between the 1940-1960s. The latter corroborates dendrochronological evidence of a bark beetle outbreak at this time in the Kluane region. Means to calibrate stomata peaks in the sediment record with bark beetle outbreaks are not sufficient yet, but this study has clearly shown the potential of these methods to record disturbance events on a local scale and may provide the first evidence of several past bark beetle infestations in the Yukon. It also suggests that major disturbances are relatively frequent (100-150 year cycles) in this region.

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REGIONAL-SCALE FLOW PATTERNS, THE ROCKY MOUNTAINS AND SUBGLACIAL BEDFORMS

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Drumlins and associated bedforms in east-central British Columbia and west-central Alberta record regional-scale flow patterns that are connected across the mountains. Three groups of landforms are noted: 1. Cordilleran west of the mountains, 2. Cordilleran east of the mountains, and 3. Laurentide. Drumlins in all three groups include resistant bedrock - limestone, sandstone and basalt - contradicting drumlin genesis by subglacial deformation. The drumlins are erosional and show a variety of features -transverse and hairpin troughs, crescentic scours, and elongation varying with topographic slope - indicating that the erosion involved vortices in a turbulent fluid. Genesis was by meltwater, not ice or a deforming bed. The absence of distinct moraines at the termini of drumlin fields points to formation by a fluid that continued to transport sediment beyond these termini. This aspect of the drumlin fields is particularly striking along the western front of the Rocky Mountains. Cordilleran drumlins to the west of the mountains are aligned with corresponding drumlins to the east. 'Through valleys' connect these drumlin fields and dissect the Hart Ranges of the Rocky Mountains. These valleys show low gradients, reversed paleocurrent directions indicated by erosional marks and sediment, and steep sides, swept clean of sediment and with waterfalls and few tributary gullies. These characteristics are similar to those of the Finger Lakes, New York. They are interpreted to result from erosion by catastrophic meltwater floods. The formation of an ice rise near the Rocky Mountain divide is thought to have dammed water over the Nechako Plateau in interior British Columbia. Breaching of the seal for this dam caused subglacial meltwater to drain westwards to the Laurentide Ice Sheet. Stratigraphic and morphological evidence shows that the Cordilleran drumlins formed before the Laurentide bedforms. Thus, drainage events from the Cordilleran Ice Sheet may have primed subglacial, meltwater reservoirs prior to immense Laurentide drainage events.

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GEOMORPHIC EVIDENCE OF POSTGLACIAL TERRESTRIAL ENVIRONMENTS ON ATLANTIC CANADIAN CONTINENTAL SHELVES

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Changes in geography of Atlantic Canada since the last glacial maximum (LGM) are grouped into three phases. Early in the first phase (LGM - c. 13 ka) ice streams in shelf-crossing troughs reached the edge of the continental shelves; later in this phase the glacier had ice retreated by calving in deep water. In the second phase (c. 13 ka – c. 10 ka) glaciers were on land, but ice remained on some offshore banks; elsewhere emergent banks formed an archipelago of islands. In phase 3, glaciers had disappeared, and the outer shelf islands were gradually submerging, but elsewhere falling relative sea levels caused emergence. Through time, submergence became pervasive, except in the northern Gulf of St. Lawrence. Multibeam mapping in the past few years has revealed the geomorphic evidence of terrestrial terrains in phase 3. Examples of fluvial, deltaic, and coastal systems are described. Evidence of fluvial systems is rare, with the best example located in Northumberland Strait. Deltas were mainly preserved in the special circumstances of fjords in Newfoundland. The best preserved coastal systems have been found in the Bras d'Or Lakes, an inland sea that was formerly a lake. Analysis of multibeam bathymetric data allows discrimination between fluvial and non-fluvial sea-floor channels.

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WHAT CONTROLLED THE DISTRIBUTION AND CHARACTER OF ESKERS IN THE SOUTHWESTERN SECTOR OF THE LAURENTIDE ICE SHEET, ALBERTA, CANADA?

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Eskers within the footprint of the Laurentide Ice Sheet present an imperfect record of late glacial meltwater flow in R-channels (channels cut up into the ice); their distribution relies both on meltwater and sediment supply. A number of factors may control esker distribution, size, shape and morpho-sedimentary relationships: (1) ice sheet dynamics and patterns of decay (active/stagnant), (2) ice sheet thermal regime (temperate/cold), (3) climate (melting), (4) proglacial/ice marginal lakes or subglacial reservoirs (hydraulic damming/water supply), (5) basal substrate (permeability/sediment supply), (6) bed topography, and (7) antecedent glacial conditions (e.g., tunnel channels). Existing research has described a paucity of eskers in the southwest sector of the Laurentide Ice Sheet and has attributed this paucity to (1) active ice sheet retreat, or (2) preferential development of canals (shallow braided channels) rather than R-channels on deformable beds. In this paper we describe the distribution, size, shape and morpho-sedimentary relationships of eskers in southern Alberta and discuss their implications for late glacial hydrology.

There are approximately 380 eskers in southern Alberta displaying a regionally chaotic pattern, though weak arborescence or subparallel alignment may be present locally. Most eskers are small, less than 5 km long (~90%) and 10 m in height. They occur both in areas with thick till and where the weakly lithified Cretaceous bedrock is exposed at the surface. Approximately 33% of all eskers occur where the fine-grained till is thicker than 3 m. Eskers can be grouped based on their association with lowland tunnel channels. Upland eskers: (1) are typically short (< 8 km), (2) exhibit undulating crestlines, (3) contain deformed sand, gravel and diamicton, (4) occur on thin and thick till substrates, (5) are capped with till, (6) are not connected to large glacial lake basins, and (7) rarely terminate in identifiable fans. Lowland eskers: are typically longer (> 10 km), (2) exhibit undulating crestlines that outline sand and gravel macroforms, (3) lie directly on weak bedrock within tunnel channels, (4) are connected to large glacial lake basins, and (5) terminate in subaqueous fans. Where the largest lowland eskers enter lake basins they become higher and broader as they truncate coarse tunnel channel fans.

Several conclusions can be made from these observations. The regionally chaotic pattern of eskers and the absence of systematic recessional moraines indicate that the hydrologic system recorded by eskers formed under regionally stagnant ice. The presence of eskers on soft bedrock or fine-grained till contradicts the contention that R-channel drainage is precluded on a deformable substrate. The coincidence of large eskers, large lake basins and tunnel channels in lowland sites suggests that esker formation and preservation was facilitated by (1) a ready sediment supply from antecedent tunnel channel fills and fans, (2) hydraulic damming by glacial lakes or reservoirs, and (3) decanting of meltwater from other lake basins. In the upland sites, where a direct linkage with tunnel channels and large lakes is absent, the chaotic distribution and the prevalence of faulting and deformation within eskers suggests: (1) short-lived and unstable R-channels, (2) a limited meltwater supply, (3) chaotic ice stagnation, and (4) limited sediment supply.

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MULTIPLE DRAINAGES OF GLACIAL LAKE MISSOULA ALONG THE CLARK FORK RIVER BELOW MISSOULA, MONTANA, USA

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Ice dams created by the Purcell lobe of the Cordilleran Ice Sheet near the current Idaho/Montana border impounded glacial Lake Missoula, which inundated valleys of northwestern Montana to altitudes up to ~1270 m. The drainage history of glacial Lake Missoula is mostly known by analysis of deposits and landforms outside the lake basin, principally from the channeled scablands of northern Idaho and Washington. Evidence within the lake basin used for arguing that the lake drained multiple times are a few sections of rhythmically bedded glaciolacustrine sand, silt, and clay sequences, most notably the "Ninemile section" of glacial lake silts exposed near the confluence of Ninemile Creek and the Clark Fork River. These glacial Lake Missoula deposits have been interpreted by some to represent 6 and 40 fillings and drainings of glacial Lake Missoula. Recent mapping of unconsolidated deposits revealed catastrophic lake drainage alluvial (flood) deposits beneath the glacial lake silts. The stratigraphic sections and landforms suggest that multiple lake stands reached vastly different altitudes.

Gravelly flood alluvium is interstratified with a few <50 cm-thick beds of laminated silty clay. Imbricated boulder-sized clasts and planar cross-stratified gravel, with set heights of 2 to >35 m, display down-river, and up-tributary paleocurrents, indicating a high-energy, high-volume alluvial environment. Flood alluvium is overlain by glacial lake silts correlative to the Ninemile section. The glacial-lake silt unit is locally overlain by thin (mostly < 2 m) gravel deposits on strath terraces and fans, and alluvium in channels and floodplains.

Landforms within the 0.6–3.5 km-wide alluvial valley are 0.1–0.5 km-wide bedrock channels or alluvial floodplains; strath terraces; upper flats covered by glacial-lake silt, 50–110 m above local base level (albl); streamlined alluvial bars and large-scale dunes, with crests 95–170 m albl; and scabland erosional topography and gulch fills that are 40–270 m albl. The large-scale landforms represent erosion and deposition by catastrophic draining of an early, high stand (~1200 m) glacial Lake Missoula. Most glacial-lake silt, such as at the Ninemile section, was deposited on the earlier high-energy deposits, and must represent one or more later and much lower lake stand(s) (<1000 m?). The upper surfaces of the benches of glacial lake silt are incised by a dendritic network of mostly dry, flat-bottomed valleys. The rolling topography developed on the silt units has been interpreted by some as current ripples. The undisturbed silty strata and valley networks are better interpreted as dry valleys, established and abandoned as the last stand of the lake receded. Scabland erosion related to this draining is restricted to the inner valley of the Clark Fork River.

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FROM CONTROVERSY TO CONSENSUS: TRACKING RECENT CLIMATIC CHANGES USING ARCTIC LAKE SEDIMENTS

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Interest in arctic environments has increased over recent years, largely because potential warming is predicted to be greatest in high-latitude regions. As a result, attention has been directed towards the use of arctic lakes and ponds as monitoring sites and, in particular, the use of diatom-based biomonitoring and paleolimnology to track the onset and magnitude of environmental changes.

In 1994, Douglas, Smol and Blake published in *Science* the first detailed diatom-based paleolimnological assessment of recent environmental change in the High Arctic. This original Douglas et al. (1994) study focused on the paleolimnology of three shallow ponds at Cape Herschel, on east-central Ellesmere Island. The stratigraphic profiles revealed unprecedented environmental shifts beginning ca. 1850 AD, which could be linked to limnological changes associated with climate warming (e.g., less ice, longer growing season, new microhabitats such increased moss substrates, etc.). This study elicited much controversy and repeated scientific challenges.

This presentation will review some of the major challenges posed to the initial Douglas et al. study, and show how these constructive debates have accelerated the study of arctic environmental change. For example, by examining diatom species changes in sites that have received nutrient additions (e.g., from local hamlets or from past Thule whalers), we assessed the influence of nutrients on polar ecosystems. Paleolimnological studies of deeper arctic lakes similarly recorded striking species changes with increases in planktonic taxa, again presumably linked to warmer condition, manifested by decreased ice cover and/or changing thermal stratification patterns. In contrast, paleolimnological profiles from lakes in arctic areas that are believed not to have warmed significantly since the 19th century were relatively complacent.

This year, a compilation of 55 paleolimnological profiles from the circumpolar Arctic, which included 26 co-authors (Smol et al., 2005), concluded that widespread species changes and ecological reorganizations in algal and invertebrate communities have occurred since ~1850 A.D. The remoteness of these sites, coupled with the ecological characteristics of taxa involved, indicate that changes were primarily driven by climate warming through lengthening of the summer growing season and related limnological changes.

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HOLOCENE HISTORY OF BEAR RIVER GLACIER, NORTHERN COAST RANGES, BRITISH COLUMBIA

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Stacked tills and lateral moraines provide a relatively detailed record of Holocene fluctuations of Bear River Glacier, located northwest of Stewart in the northern Coast Ranges of British Columbia. A low, bush-covered lateral moraine distal to a prominent Little Ice Age lateral moraine records an early minor advance, tentatively considered Crowfoot (latest Pleistocene) in age, that extended beyond LIA limits. A Neoglacial chronology emerges from five stacked tills separated by four relatively continuous wood mats, on the north side of Bear River Pass. Radiocarbon-dated wood samples from the lower three wood mats show that advances occurred around 3700, 3450 and 3300 14C BP, respectively. These advances likely correlate to the Tiedemann Advance, documented in the central and southern Coast Ranges. A fourth wood mat, enclosed in till and preserved nearly 100m above Bear River Pass, yields a date of 1040 14C BP. Deposition of the overlying till coincides with the earliest LIA advance of the Bear River Glacier. Since its LIA culmination in the late 19th century, the glacier has retreated dramatically to the south, leaving a basin now filled by Strohn Lake.

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THE DEVELOPMENT AND APPLICATION OF THERMAL SENSITIVITY MODELS FOR SMALL STRATIFIED LAKES

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Though small (< 4 ha.), shallow (< 6m av. depth) dimictic lakes in Nova Scotia comprise significant habitat very little is understood about how climate change will affect the thermal structure of these lakes. As well, the variable internal response of these lakes to past climate change (most notably Younger Dryas cooling) is known but not well understood. In our study we performed detailed lithostratigraphic, morphometric, and thermal analyses over a three year period on two lakes that were similar in almost all respects (volume, area, depth, chemistry etc.) but were morphometrically unique.

Lithostratigraphic records from Canoran Lake (shallow sided, high littoral:pelagic ratio) indicated a strong autochthonous response to post glacial climate change whereas Sandy Lake (steep sided, low littoral: pelagic ratio) exhibited no discernable lithostratigraphic response. Thermal data (2002 – Present) indicated that these two lakes react uniquely and strongly to short duration climate events. For instance, during a low-pressure influx, Sandy Lake exhibited strong metalimnic entrainment and a pronounced downwards displacement of the parent thermocline within a 24 hour period whereas Canoran Lake experienced little change. Wind speed, duration and fetch distance were the same at both lakes. Once spring stratification had developed hypolimnetic temperatures remained nearly constant in Canoran Lake but increased in Sandy Lake in response to each climate event. Our results indicate that morphometry very strongly influences the efficiency of storm related heat transfer. An understanding of variances in the thermal sensitivity of seemingly similar lakes can be used by paleolimnologists to better understand variability in paleoclimate proxies. As well, the thermal sensitivity models based on this data will allow ecologists to better understand how lakes (as habitat) will evolve and are essential to the implementation of species monitoring and conservation programs.

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INCEPTION AND GROWTH OF THE APPALACHIAN GLACIER COMPLEX

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The Appalachian Glacier Complex (AGC) was envisioned by Vic Prest and Doug Grant in 1969 as a series of independent local ice caps over Maritime Canada large enough to deflect or direct Laurentide ice into the Laurentian Channel. Implicit in their theory was that local ice caps were active throughout the Wisconsinan and not merely a deglaciation phenomenon. Glacial mapping, age dating and till provenance work in Maritime Canada since that time has served to reinforce the original Prest-Grant concept. Sections in northern Cape Breton, adjacent to the Laurentian Channel are crucial for the understanding of the development of the AGC. After the last interglacial, these sections record the deposition of colluvium and then Cape Breton Highland-derived tills. The Early Wisconsinan development of local highland glaciers is further evidenced by thick glaciolacustrine sections in the adjacent lowlands created when local glaciers dammed up eastern outlets to the Atlantic Ocean.

The Mid Wisconsinan retreat of glaciers in Maritime Canada is only recorded at the Bay St. Lawrence section on the northern tip of Cape Breton Island. The section reveals glaciomarine sediments with marine shells that were radiocarbon dated at 41,725 and 36,730 (^{14}C yr BP). Shells from the same horizon also provided Mid-Wisconsinan AAR ratios. The sandy glaciomarine horizon was found at 30 m elevation attesting to considerable isostatic depression and thick Early Wisconsinan glaciers in the Gulf. After the deposition of Mid Wisconsinan glaciomarine sediments, colluvium and locally-derived tills were again deposited at the site. The lack of any record of Mid Wisconsinan retreat elsewhere in Maritime Canada suggests that ice remained in the region, cut off from potential Laurentide sources by the calving bay which extended well into the St. Lawrence estuary. Glacial Lake Gayhurst in the southern Appalachians of Québec formed during Mid-Wisconsinan retreat and was impounded by an ice cap over the Appalachians of New England-Maine.

With renewed cooling and positive mass balance during the last glacial maximum remnant ice in the Gulf of St. Lawrence developed into an independent glacier (Escuminac Ice Divide) that converged with a Laurentide ice stream in the Laurentian Channel. The Late Wisconsinan re-growth of local highland glaciers and a Gulf of St. Lawrence ice cap was recapitulated during the Younger Dryas when glaciers left after the Allerød warming advanced as much as 30 km. Nourishment of the AGC throughout the Wisconsinan can be explained by deflection of the jet stream and tracking of intense “nor’easter” type low pressure systems around the Laurentide ice sheet bringing abundant snowfall to the Gulf region.

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A CALIBRATED DEGLACIAL CHRONOLOGY FOR NORTH AMERICA: AN INFERRED ARCTIC TRIGGER FOR THE YOUNGER DRYAS.

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We present some results from a new deglacial ice and meltwater discharge chronology for the North American ice sheet complex using a glacial systems model that includes a 3D thermo-mechanically coupled ice sheet model, a visco-elastic model of glacial isostatic adjustment, and a surface drainage solver. The model is calibrated against a large set of paleo-proxies using a Bayesian methodology. Model calibration indicates that North America was responsible for about half of meltwater pulse 1-a, with order 0.15 Sv or larger (combined meltwater and iceberg flux averaged over 100 years) peak discharges into both the Gulf of Mexico and the combined St. Lawrence/Hudson River region and less than 0.1 Sv into the Arctic Ocean.

The late glacial ice sheet obtained shares a number of features in common with the 1987 Dyke and Prest reconstruction, most notably the existence of a large Keewatin ice dome that dominates the ice complex. This features plays a significant role in our most significant result which concerns discharge into the Arctic Ocean. Subject to the accuracy of the margin chronology employed, the largest total discharge into the Arctic Ocean (mean values of 0.1 to 0.2 Sv across ensembles over a 100 year time-step) occurs during the onset of the Younger Dryas. This is the strongest deglacial discharge into the Western Arctic and is greater than the total reconstructed North American discharge into the Atlantic during Younger Dryas onset. Furthermore, the majority of this discharge is locally sourced with reduction of the Keewatin ice dome being the largest contributor. Given that the only outlet from the Arctic Basin at this time was via Fram Strait into the Greenland-Iceland-Norwegian seas, we hypothesize that this pulse was the trigger for the re-organization of thermohaline circulation that is thought to have been responsible for the Younger Dryas cold interval. Subsequent continuing high-level discharge into the Arctic Ocean during the Younger Dryas may have played a role in sustaining the reduced strength of the Atlantic overturning circulation over the millennial duration of the event. Our results also indicate that a significant revision to the conventionally assumed drainage routing history of Glacial Lake Agassiz requires consideration. In contradistinction with past inferences and subject to the imperfectly constrained ice-margin chronology, we find that the north-west outlet likely dominated much of the early Younger Dryas to Upper Campbell stage (@ 10.6 kyr calendar) drainage of Lake Agassiz.

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DIGITAL SURFICIAL MAPPING AT THE GEOLOGICAL SURVEY OF NEWFOUNDLAND AND LABRADOR

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The Geological Survey of Newfoundland and Labrador has committed to providing surficial mapping in digital formats. All new mapping is produced digitally, and many older maps have been converted to a digital format. 1:250,000 scale coverage for the Island is complete, and approximately 40% of the island is covered at 1:50,000. Only approximately 7% of Labrador is mapped at 1:50,000 but most of these maps are available in digital format.

Previously, hand-drafted maps were scanned and then digitized on screen. A digital transfer scope has now been acquired, which allows direct mapping from aerial photographs into ArcMap software. The result is greater accuracy in boundary definition and considerable time saving in draft map production. Final map production is completed using ArcGIS. Maps are available as paper versions using on-demand printing on a large format plotter, and digitally either as pdf files or various GIS formats. Recent maps integrate shaded relief digital topography as an aid to visualization. Current efforts involve linking map polygons and observation points to databases of field and laboratory data, including field notes, photographs, geochemistry, grain size, and clast fabrics. Such truly digital maps can be viewed in a GIS or on the Internet using web-mapping tools.

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STRATIGRAPHY AND PALEOECOLOGY OF A NEW INTERGLACIAL SITE NEAR THE WESTERN LIMIT OF THE LAURENTIDE ICE SHEET IN NORTHEAST BRITISH COLUMBIA, CANADA

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Thick interglacial peats and organic silts recently discovered under till and fluvial sediments provide a first glimpse of the paleoecology of a vast region in northeastern British Columbia and northwestern Alberta. The site, located about 130 km east of Fort Nelson is the only known interglacial site in an area of more than 50,000 km^2. Conventional radiocarbon analyses on two wood pieces from the organic unit yielded dates of >38 690 (Beta 183832) >40 590 (Beta 183831) radiocarbon years BP. The peat and organic silts underlie a few metres of diamicton and oxidized sands that were initially observed in a borrow pit about 100 m long. Subsequent excavations and drilling at the site revealed peats and organic silts at least 5 m thick under the sands. The diamicton, interpreted to be a till of Laurentide provenance, is massive, matrix supported, dense, and contains striated erratics. It erosionally overlies about 2 m of oxidized, fine to coarse sands and pebbly sands of inferred fluvial origin. Possible ice wedge casts and cryoturbation structures at the top of the sands suggest the development of permafrost prior to the advance of ice over the site. The sands gradationally overlie the organic rich unit.

Plant macrofossils from the base of the organic unit provide evidence of an aquatic environment that is dominated by submergent vegetation including freshwater algae (*Chara/Nitella* type), horned pondweed (*Zannichellia palustris*), pondweed (*Potamogeton pectinatus*, *Potamogeton* spp.), naiad (*Najas flexilis*), and water starwort (*Callitriche hermaphroditica* type). The prevalence of aquatic plants and algae that thrive in alkaline water along with abundant ostracodes and molluscs suggest a deeper alkaline lake or pond existed at that time. A change in depth of the aquatic environment is portrayed in the plant macrofossil evidence from the upper part of the organic unit. Submergent plants that dominated the base of the unit are replaced by abundant emergent and shoreline type plants. Only a few plants of the submergent coontail (*Ceratophyllum demersum*) and pondweed (*Potamogeton* spp.) appear in the upper part of the organic unit indicating shallow water conditions of 0.5 to 1.5 m deep. Emergent plants of spike-rush (*Eleocharis palustris-uniglumis* type), bur-reed (*Sparganium* sp.), mare's-tail (*Hippuris vulgaris*) and water plantain family (Alismataceae) dominate the aquatic floral assemblage. Shoreline plants are equally abundant and include sedges (*Carex* spp.), bulrushes (*Scirpus* spp.) and celery-leaved buttercup (*Ranunculus sceleratus* type). Fossil insect and arthropod evidence supports the plant macrofossil data of an aquatic environment. Invertebrates and arthropods that inhabit freshwater lakes and ponds include many bryozoans (*Cristatella mucedo*), water fleas (*Daphnia*), predaceous diving beetle (Dytiscidae), and water scavenger beetle (Hydrophilidae). Although the environment is predominantly aquatic, the recovery of abundant conifer macrofossils suggests that spruce (*Picea*) was growing locally. The plant and arthropod macrofossils and stratigraphic evidence from this site show that this unit was deposited during an interval of climate as warm as present in the area. The organic unit is tentatively assigned a Sangamonian age based on the infinite radiocarbon dates, stratigraphic position and paleoecological data.

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OVERFLOW FROM LAKE AGASSIZ DURING THE YOUNGER DRYAS

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Two groups of channels in the western Superior basin have been interpreted as carrying catastrophic overflow from Lake Agassiz at various times (the “eastern outlets”). One group of channels lies west of Thunder Bay and leads directly to Lake Superior; another group is to the north and leads into the Lake Nipigon basin and then south into Lake Superior many kms east of Thunder Bay. All Agassiz overflow through these outlets drained east through the Great Lakes, into the St. Lawrence, and into the North Atlantic Ocean. Overflow during the Younger Dryas through channels west of Thunder Bay has been implicated in triggering a change in thermohaline circulation of the ocean and, in turn, in causing abrupt global cooling at this time.

New research and radiocarbon dating in the Thunder Bay region brings this interpretation into question. For example, some of the so-called flood channels constrict in places to very narrow widths, which seems unlikely if there was a catastrophic flood (viz. 0.3 Sv, 9500 km^3 yr^{-1}) through them. As well, unlike other flood channels in the area which carried later overflow bursts from the lake, these channels contain no surface boulders. New radiocarbon dates from the base of lacustrine sequences in this region do not provide support for the interpretation that this area was deglaciated before the end of the Younger Dryas, ~10 ^{14}C ka.

However, by generating paleotopographic maps of the area using a modern DEM adjusted for differential isostatic rebound, superposed on Lake Agassiz lake levels during the Younger Dryas, overflow from Agassiz to the Great Lakes would have occurred between 11-10 ^{14}C ka *if* the LIS had retreated from the Thunder Bay area by then. This modeling also indicates that after the lake had fallen below its highest beaches (Herman, Norcross, Tintah), isostatic rebound would not have allowed overflow to the Superior basin from Lake Agassiz through the channels west of Thunder Bay. Isostatic rebound modeling of channels to the north that lead to Lake Nipigon indicate that overflow there would have occurred at much lower lake levels (Leverington and Teller, 2003).

Perhaps the expected boulders in the channels west of Thunder Bay are buried beneath finer sediment associated with the Marquette ice advance into the eastern part of those channels around 9.9 ^{14}C ka. Perhaps overflow from Lake Agassiz was not catastrophic, so the morphology and bedload in the channels reflects a different (non-catastrophic) type of hydrological event. Perhaps overflow from Lake Agassiz during the Younger Dryas was through the northwestern outlet in northern Saskatchewan into the Clearwater-Athabasca valleys to the Arctic Ocean. The latter requires retreat of the LIS from that area, which is something that all reconstructions to date do not show happened until around 10 ^{14}C ka.

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A TSUNAMI GENERATED BY THE FINAL DRAINAGE OF GLACIAL LAKE AGASSIZ ~8400 YEARS B.P.

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About 8400 yrs B.P. glacial Lake Agassiz drained into the North Atlantic Ocean through Hudson Bay, Hudson Strait, and the Labrador Sea. This outburst discharged ~150,000 km^3 in only 6 months to a year (a flux of ~5 Sv, or 5×10^6 m^3 s^{-1}). Using two different models, one analogous to a submarine earthquake, the other comparable to a submarine landslide, we determined that a tsunami would have been generated by this outburst of Lake Agassiz waters. Both simple analytical models suggest that the tsunami amplitude would have been at least 2 m and probably more like 5-6 m in amplitude; in an extreme case, it could have been up to 10 m. There are fundamental differences between tsunamis generated by under-ocean earthquakes and those resulting from submarine landslides—the Lake Agassiz outburst is most analogous to a submarine landslide. Quake-generated tsunamis have much longer wave lengths and periods and consequently can propagate over trans-oceanic distances. Landslide-generated tsunamis have relatively local effects, at about a scale of 100 km, partly because of the total energy released. Thus, it is very unlikely that the Agassiz tsunami could have traveled as far as the Greenland coast or across the Atlantic Ocean.

Tsunami directivity considerations, as well as the effect of Coriolis force, suggest that the Lake Agassiz tsunami would have significantly impacted the west coast of the Labrador Sea, south of the mouth of Hudson Strait. Deposits related to this event may be found for a distance of 100 km along the coast, 20-50 m above modern sea level along the 8400 yr BP shoreline. As well, this catastrophic event may be recorded in Hudson Strait itself.

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DENDROCLIMATOLOGICAL RECONSTRUCTION IN CENTRAL LABRADOR

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This paper describes the preliminary results of a dendroclimatological reconstruction for the Mealy Mountains of Labrador. It is part of a broader multidisciplinary project investigating highland ecosystem responses to climate variability and change in Labrador. The Mealy Mountains provide habitats for a variety of rare and endangered flora and fauna at their southern limit, and are particularly sensitive to climate variability due to their isolation. An investigation of the effects of past climate can therefore provide a better understanding of the potential effects of climate variability and change on this sensitive ecosystem. The relationship between tree rings and climate is used to obtain paleoclimatic records for the Mealy Mountains.

This study reconstructs temperature data from tree ring measurements. In 2004, a total of 4 tree disks and 19 tree cores were collected at a study site in the central Mealy Mountains. The mean age is 86 years, and the oldest sample collected is 183 years. Growth increments were found to be dominated by the extreme conditions of the elevational limit for these species. We seek to understand the environments in which these trees are growing in relation to the regional climate.

Previous dendroclimatological studies in Central Labrador are based on grouped data sets or ring density measurements, and compare Central and Southern Labrador data with other regional datasets. Here we present a reanalysis of some such data with respect to central Labrador. We infer a regional climate from statistical relationships between climate records from permanent stations in the region, and archived tree ring data from two sites in central Labrador, one of which is in the central Mealy Mountains. The resulting relationships provide the basis for a synthetic temperature time series for the period of the instrumental record, while giving us a better understanding of ecosystem dynamics in highland areas of Labrador. Comparison of this record with those from elsewhere in northern Canada will provide more information on the spatial heterogeneity of climate variations, as has prevailed in recent decades.

Data Source:

Schweingruber, Fritz.. 2000. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #PCGL Cana049. NOAA/NCDC Paleoclimatology Program, Boulder, Colorado, USA. Website: http://www.ncdc.noaa.gov/paleo/treering-wsl.html

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QUATERNARY STRATIGRAPHY OF THE WESTERN MARGIN OF THE LAURENTIDE ICE SHEET, NORTHEAST BRITISH COLUMBIA

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During the summer of 2004, Quaternary geology studies were conducted within the Fort Nelson and Fontas River map areas (NTS 094J/SE and 094I/SW, respectively), in northeast British Columbia. This is the first detailed Quaternary investigation conducted in this area. The study area is situated within the Interior Plain physiographic region, encompassing parts of the Alberta Plateau and the Fort Nelson Lowland. The plateau is dominated by Cretaceous Dunvegan sandstone while the more recessive Fort St. John group shales underlie the lowland. Objectives of this study include production of surficial maps, compilation of stratigraphy and investigation of possible interactions between the Laurentide and Cordilleran Ice Sheets.

Previous work suggests the map area is located near the western extent of the Laurentide Ice Sheet and the eastern extent of the Cordilleran Ice Sheet. The dominant surficial material in the study area is a silty-clay diamict, clast-poor and containing abundant shield-derived felsic igneous and metamorphic clasts. This provides evidence for a Late Wisconsinan glaciation of Laurentide provenance. Preliminary field studies have found minimal grey granitoid, schist or slate clasts within the till. This, combined with the abundance of shield-derived clasts, suggests deposits of Cordilleran provenance have not yet been found in the map area. However, it is recognized that ice interaction can cause dilution of clast provenance, and the presence of Cordilleran till in the map region cannot be ruled out.

Investigations of river sections suggest the Prophet River valley is a re-incised paleovalley that provides new pre-glacial to Holocene stratigraphy, including a pre-Late Wisconsinan site. One site provided radiocarbon dates of > 44 730 and > 45 100 years BP from peat and wood within a massive to laminated clay unit with gradational pods of diamict.

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BOULDER TRACING AND PALIMPSEST ICE FLOWS ON THE GRENVILLE OF CENTRAL QUEBEC

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The Quaternary geology of Grenville Province in Quebec, which occupies nearly a third of the province, was largely neglected by generations of Quaternary scientists. The search for distinctive Proterozoic erratics from the Mistassini Group and from the Chibougamau Formation of central Quebec, was carried out over a 10-year period at selected sites in a 250 000 km^2 area in Grenville Province, that extends from Abitibi to the Manicouagan reservoir in the north, and from the Montreal area to the Baie-Comeau area in the south. The objective of the search was to compare the sequence of shifting ice flows, derived from earlier mapping of striations and landform distribution to the north, with glacial transport data over distances of hundreds of kilometers from the Proterozoic rocks of the Lake Mistassini basin. These rocks, when viewed at a continental scale, constitute a point source that occupy a critical location to map changes in ice flow directions over time. This is due to their position near the central part of the Labrador Sector of the Laurentide Ice Sheet, and to their proximity to a major demarcation line separating opposing former ice flows, toward Hudson Bay to the northwest, and toward St-Lawrence River to the southeast. The glacial transport data and the striation measurements recorded during this study, when analyzed with the glacial lineation obtained from small scale maps, from conventional aerial photographs, and from satellite imagery showing landform orientation indicative of ice movement, show that Mistassini erratics dispersed toward the east-southeast were overprinted by younger ice flows, also carrying Mistassini erratics, toward the west-southwest, and toward the south and southeast. The widespread occurrence of these distinctive erratics, transported hundreds of kilometers away from their original location, cannot be explained over the whole area with the general ice retreat patterns revealed by landform distribution. Their presence requires a sequence of shifting palimpsest ice flows differing in direction by nearly 180º in certain locations. The measurements and observations presented, provide a more complete ice-flow data base than presently available to reconstruct the evolution of the eastern part of the Laurentide Ice Sheet during the Wisconsinan. When added to the results of similar surveys carried out earlier in Abitibi, in the James Bay basin and in the Caniapiscau area of north-central Quebec, the data help to establish the extent of palimpsest ice flows lacking expression in landforms, and the relative chronology of Late Wisconsinan ice flows from Hudson Bay and from north-central Quebec. The results are used to distinguish locally between long-traveled ice-rafted and glacially transported erratics, to assess some current glaciological models of ice sheet reconstructions and to discuss mineral exploration methods applicable in glaciated terrain in this part of Grenville Province.

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CALIBRATED RECONSTRUCTIONS OF VEGETATION HISTORY BASED ON HIGH-RESOLUTION POLLEN RECORDS FROM THE SOUTHERN BOREAL FOREST, SASKATCHEWAN

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High-resolution proxy records are being used increasingly to reconstruct past climate and ecological conditions over time scales beyond those covered by instrumental records and direct observations. Research on the responses of vegetation to climate variability at decadal time scales has demonstrated that parameters such as species ranges and abundances and vegetation community structure are sensitive and responsive over short time periods. Since climate variability in future decades is expected to exceed the extremes observed in the 20th century, however, there is a need to extend the detailed understanding of vegetation response to climate variability over longer time periods. The pollen and spores preserved in a lake sediment record are an incomplete and imperfect representation of the vegetation that produced the record. Transfer functions have been developed to reconstruct climate variables such as mean July temperature from the pollen record, but the effective resolution of the pollen record is still being evaluated. This research is based on two high-resolution data sets: pollen records derived from short sediment cores (up to 1 m long), collected from three lakes (L02, L03, and NFL) in central Saskatchewan in the aspen parkland-southern boreal forest ecotone, and a dendrochronological record from the northern Great Plains and boreal forest region in Saskatchewan. Radiocarbon and/or lead-210 dating indicate that the lake sediments span approximately 500 years (L02 and L03) and 1200 years (NFL). The sediments were sampled at contiguous 0.5 cm (L02 and L03) or 1 cm (NFL) intervals and the pollen was extracted using standard procedures with an added *Lycopodium* spike. At least 500 pollen and spore grains were counted at each level, and pollen percentages, concentrations, and accumulation rates were calculated. From these pollen values, past precipitation was reconstructed using transfer functions and compared with tree-ring based precipitation reconstructions for the northern Great Plains.

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A BLIND COMPARISON OF RADIOCARBON LABS

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A small, blind comparison of 4 different radiocarbon labs was carried out to test reproducibility of radiocarbon results. Lab A utilizes the radiometric method. Labs B, C and D utilize the accelerator method. Two of the accelerator labs have participated in the two most recent international radiocarbon comparisons and the radiometric lab participated in the most recent one. These tests are carried out approximately every four years and send labs, willing to participate, a suite of homogeneous samples that span the range of utility of the radiocarbon method.

This test consisted of duplicate samples being sent to separate labs without the labs knowing they were participating. This usually consisted of fragments of the same twig or the same piece of wood. In two cases it consisted of sending separate macrofossils from the same sample. The results are provocative as there are significant differences between labs. Some examples:

Duplicate analysis by Lab A on a *Picea* sp. (Spruce) branch yielded 19,600±170 and 19,500±170 while Lab C produced an age of 17,290±130

Three separate macrofossils from the same sample were dated, two by Lab C, 17,380±130 and 17,820±140, and one by Lab B, 18,380±100.

A single *Salix* sp. (willow) twig was divided into 4 pieces. Two analyses by Lab D yielded 33,240±230 and 33,140±230. Lab B produced an age of 30,400±480 and Lab C an age of 28,310±280.

A single *Salix* sp. (willow) twig was divided into two pieces. Lab D produced an age of >44,000 while Lab C yielded an age of 24,930±940. A separate analysis by Lab C on a different *Salix* sp. twig from the same sample yielded an age of 33,290±380.

These results will be displayed graphically and discussed. As chronologic control is vital for many aspects of Quaternary studies these results are disturbing. Radiocarbon users are cautioned that results between labs are not always equivalent and correlation could be problematic, especially when dealing with samples that may be at or near the limit of radiocarbon dating. A further, better funded, study on radiocarbon labs is recommended.

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A PALEOECOLOGICAL RECORD OF CLIMATIC DETERIORATION FROM MIDDLE TO LATE WISCONSINAN TIME ON THE INTERIOR PLATEAU OF BRITISH COLUMBIA, CANADA

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The Indianpoint section, 90 km southeast of Prince George, presents a >25 ka record of paleoenvironmental changes from non-glacial Middle Wisconsinan time to just before Late Wisconsin ice from the Cordilleran Ice Sheet overran the site. Detailed plant and insect macrofossil analyses of a 5-6 m thick fine grained unit reveal that it represents a small lake, based on aquatic plants and insects, and taxa indicative of riparian or shoreline environments. This unit appears to be a large rip up clast in the Late Wisconsinan till. A total of 11 radiocarbon ages, all obtained on willow (*Salix*) twigs provide chronological control. Radiocarbon ages of >44 ka (CAMS-96170) and 46.5 ka (CAMS 93938) were obtained near the base. Spruce macrofossils (abundant needles, seeds and seed wings) are only present for a short interval near the base but pollen analysis indicates an open coniferous forest until at least 33 ka with one brief period of reduced spruce, increased *Artemesia* and massive numbers of *Isoletes* spores. Further analyses of samples from the lower portion of the section will be carried out to clarify the record of forest vegetation. The middle portion of the section indicates tundra with willow and minor birch. In the upper 2.5 m of the section, between 24.5 ka (CAMS 93940) and 20.4 ka (CAMS 93939), the vegetation changes to dry shrub tundra, dominated again by willow with minor birch. Most pollen from this interval comes from herbs such as sedges, grasses and *Artemisia*. Also present are characteristic insects such as the weevil *Vitavitus thulius* and the ground beetles *Trichocellus mannerheimi*, *Pteriostichus (Cryobius) nivalis*, and *Amara alpina* that are presently only found in dry tundra habitats. The decrease in the occurrence of willow and birch in the upper 40-50 cm reflects increasingly harsh conditions as glaciers approached the site. An age of 19.9 ka (AA44045) has been obtained on a willow twig 20-30 cm below where the unit is truncated by a Late Wisconsinan till.

The lacustrine unit of the Indianpoint section spans >25 ka and records climatic deterioration associated with the growth of the Cordilleran Ice Sheet during the Late Wisconsinan. The increasingly dry and cold conditions indicated by the macrofossil assemblage likely reflect the growth of ice in the Coast Mountains that would reduce the availability of moisture to the Interior Plateau from Pacific air masses. This is confirmed by reconstruction of the growth of the Cordilleran Ice Sheet during the Late Wisconsinan based on published radiocarbon dates.

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THE DEGLACIATION OF THE FORT MCMURRAY AREA, ALBERTA: IMPLICATIONS FOR MELT-WATER DRAINAGE

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New radiocarbon ages from the Fort McMurray area, Alberta provides insight into deglaciation and possible catastrophic drainage events in the area. Three key sites, spaced some 125 km apart document the retreat of an ice lobe partly sourced in the Lake Athabasca lowland. These, pending additional analysis still in processes, indicate deglaciation was later than originally supposed by Dyke et al., (1987) by approximately 1000 years. Deep Hole Lake south of Fort McMurray on Stony Mountain, indicate moraines in the area formed prior to about 9,820 ± 70 ^{14}C B.P. The same minimum analysis on a moraine north of Fort McMurray across what we informally call the Firebag Moraine, indicates it formed prior to 9,295 ± 70 ^{14}C B.P, and a third site associated with the Cree Lake Moraine indicates that recession occurred prior to 8,975 ± 60 ^{14}C B.P. The geometry of the Firebag Moraine, which includes the Fort Hills, would prevent any meltwater drainage through the Clearwater Spillway, catastrophic or otherwise until about 9,295 ±70 ^{14}C.

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TREE-RING BASED RECORDS OF PRECIPITATION AND STREAMFLOW IN THE SOUTHERN CANADIAN CORDILLERA

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Tree-ring chronologies from select low elevation sites in arid regions of western North America have a demonstrated sensitivity to variations in precipitation amounts. Here we present tree-ring based precipitation reconstructions developed from a network of chronologies (n=53) sampled at sites in interior British Columbia and Alberta. The overall quality and regional representativeness of the reconstructions is assessed through comparisons with independent reconstructions developed previously for the adjacent United States and plains region. The spatial extent and severity of precipitation anomalies are evaluated through an analysis of extreme reconstructed values and through the development of a series of maps that extend back to 1640. These annual maps can be compiled for dry and wet events and are useful for examining historical events from a climatic perspective. The longest widespread drought in the last 350 years occurred from 1917-1941. However, shorter intervals of more severely dry conditions occurred in the early 1720s, 1750s, 1860-70s and the 1890s. We also discuss the use of these moisture sensitive chronologies to evaluate pre-instrumental variations of Bow River streamflow and, when examined in the context of reconstructions of other parameters developed from trees sampled in different environments, to attribute causes of flow variability. Limitations and caveats to interpretation are discussed.

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A COMPARATIVE ANALYSIS OF QUATERNARY STRATIGRAPHY USING 2.5-D SURFACE MODELING AND COASTAL FIELD OBSERVATIONS

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This study provides an assessment of the hydrostratigraphy of the Comox-Merville Aquifer, located on the central-east coast of Vancouver Island, B.C. Primarily used as a domestic groundwater supply for the community of Comox, this aquifer is maintained as a valuable groundwater resource for the Province of British Columbia. Classified as moderately developed and having a low level of vulnerability to surface contamination, the aquifer is considered to be a moderate priority to Provincial groundwater management. As such, further research regarding the subsurface stratigraphy and hydrogeologic regime of the aquifer is warranted.

The Comox-Merville Aquifer occurs within the coastal lowlands and borders the Beaufort Mountain range to the west and the Georgia Strait to the east. The aquifer overlies Upper Cretaceous Nanaimo Group sedimentary bedrock, which includes coal units that are of interest for coalbed gas resource development. Trending northwest-southeast the aquifer spans approximately 150 square kilometers. The urban centres of Courtenay and Campbell River are located to the east and north respectively.

Previous mapping has established the Comox-Merville Aquifer as Late Pleistocene Quadra Sand. This lithostratigraphic unit is widely spread throughout the Georgia Depression and Puget Lowland, and consists of horizontally and cross-stratified, well-sorted sand with minor silt and gravel. Previous provenance and paleocurrent studies have determined that the Quadra Sand was sourced from the Coast Mountains to the northeast and deposited in front of ice advancing south down the Georgia Depression. The unit is time-transgressive and has been dated as older than 29000 C-14 years in northern Georgia Strait and younger than 15000 C-14 years in southern Puget Sound. The Comox-Merville Aquifer is located between these two areas suggesting that it was deposited in an intermediate age between these two times.

As part of this study, 197 domestic-use groundwater wells, including two groundwater observation wells, occurring within the southeastern region of the Comox-Merville Aquifer are being investigated for stratigraphic and hydrogeologic information. These groundwater well logs are standardized using a Simon Fraser University-developed lithology standardization code, and mapped using ViewLog, a 2.5-D subsurface stratigraphic modeling software. In this manner, discreet stratigraphic units logged at each well site are correlated to form surfaces marking the bottom and/or top of two successive stratigraphic units. These surfaces can then be viewed in cross-section, providing a spatial depiction of the aquifer's interpreted subsurface stratigraphy and hydrogeological regime. Field observations of exposures along the southern coast of the aquifer are incorporated into the ViewLog model in order to calibrate the well logs and to evaluate the degree of success by which the model predicts the subsurface stratigraphy when extended to the coastal exposures.

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18TH CENTURY DROUGHT IN THE PEACE-ATHABASCA DELTA, ALBERTA, RECORDED BY LAKE SEDIMENTS AND TREE RINGS

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The Peace-Athabasca Delta (PAD), situated at the confluence of the Peace and Athabasca rivers at the western end of Lake Athabasca in northern Alberta, is one of the world's largest freshwater deltas and is recognized internationally for its ecological, historical and cultural significance. Floods caused by ice-jams on the Peace River are key for replenishing water to high-elevation perched basins in the PAD that provide important wildlife habitat. Concerns over the potential linkage between regulation of the Peace River in 1968 for hydroelectric production and low Peace River discharge between 1968 and 1971 during the filling of the Williston Lake reservoir, absence of a major ice-jam flood event between 1974 and 1996, and low water levels in perched basins during the 1980s and early 1990s have sparked numerous environmental studies largely aimed at restoring water levels in the PAD. Lack of sufficient long-term hydrological records, however, has limited the ability to objectively assess the importance of anthropogenic factors versus natural climatic forcing in regulating hydro-ecological conditions of the PAD.

Here we present results from stable isotope analyses on a tree-ring series from near the headwaters of the Athabasca River and multi-proxy paleolimnological studies of PAD basins that document extremely dry conditions during the 1700s, well beyond that observed in recent decades. Reconstructed relative humidity and mean annual temperature, based on coupled carbon and oxygen isotope analyses of the Athabasca tree-ring record, indicate cold and very dry conditions during the 1700s corresponding to the latter part of the Little Ice Age. Downstream, hydrological expression of this climatic episode is evident from lake sediment derived reconstructions of Peace River flood frequency and perched basin water balance history in the northern Peace sector of the PAD. High-resolution analyses of magnetic susceptibility from an oxbow lake adjacent to a major flood conduit of the Peace River, which provides a record of Peace River flooding, suggests exceptionally low flood frequency during the dry 1700s. Correspondingly, multi-proxy evidence from sediments of "Spruce Island Lake", an elevated perched basin, indicates the driest period of the past 300 years occurred during the 1700s.

Evidence for prominent 18th century drought in the PAD is consistent with tree-ring reconstructions of low streamflow for the North Saskatchewan River and regional glacial advances in the Rocky Mountains illustrating the strong and over-riding historical dependence of western Prairie river discharge on upstream glacier mass balance.

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LATE WISCONSINAN AND EARLY HOLOCENE DUNEFIELDS OF THE SOUTHERN INTERIOR PLAINS, CANADA

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Late Wisconsinan dune activity was investigated within the present-day parkland and boreal forest regions to extend our understanding of the spatial and temporal eolian record in the Canadian southern Interior Plains. Optical ages from stabilized sand dunes are used to document the timing of past activity in central Alberta and southwestern Northwest Territories. The ages, combined with dunefield orientations, glacial retreat and paleo-biome records, provide a chronology of eolian activity and climate for this northernmost part of the North American Great Plains. Between 16 ka and 13 ka, dune activity in central Alberta occurred in an ice-proximal tundra setting between the Laurentide and Cordilleran ice sheets. Predominant dune-forming winds were from the west and northwest, and likely resulted from katabatic flow of off-ice winds. Dune activity continued in this area between 13 and 11 ka within parkland and grassland settings as the Laurentide ice sheet retreated to the northeast. Winds here continued to blow from the west and northwest, and the climate was likely influenced by increasingly dominant Pacific air-masses. Also beginning at 13 ka, dune-forming winds along the margins of the retreating Laurentide ice sheet became influenced by strong anti-cyclonic winds from the southeast, and were maintained until about 9 ka. As the Laurentide ice sheet retreated, these southeasterly winds were replaced by winds from the northwest. Dune activity across the region terminated in a time-transgressive manner from the southwest, at about 12 ka, to the northeast, at about 9 ka, with the establishment of boreal forest vegetation and reduced wind strength.

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DROUGHT, TREE RINGS AND WATER RESOURCE MANAGEMENT IN COLORADO

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The recent drought in western North America has played a major role in reminding water providers and resource managers that droughts are a natural part of the climate, and that understanding the range of natural drought variability is critical for long-term planning. In Colorado, the water year 2002 was of particular concern to water providers as flows were the lowest on record at many gages. The frequency of occurrence of this extreme event could, of course, not be assessed with the length-limited gage records, and this motivated water managers to examine the longer records of hydroclimatic variability provided by proxy data from tree rings. The interest in the information tree-ring records could provide created a window of opportunity for collaborations with a number of water providers, both municipal and rural. Together, we have worked to find ways tree-ring reconstructions of streamflow can be used in planning and decision making. Reconstructions for streamflow have been used by water managers in a variety of ways. In some cases, the extended record of streamflow variability has provided information desired about long-term natural hydroclimatic variability to place 20th century variability into a multi-century context. In other cases, tree-ring reconstructions are being used as input into water system models to assess the reliability of the water supply system under a broader range of conditions than afforded by the gage record alone. Successful partnerships with Colorado water managers appear to have been the result of several factors. These include an awareness of the need for long-term water resource planning, perhaps due to the headwaters of five major rivers being located in Colorado, the allocations of which entail numerous interstate compacts and obligations. Other factors, such as local media interest in the droughts documented in tree-ring records, have been helpful in informing the general public about tree rings and the information they contain.

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ISOSTATIC REBOUND AND THE HISTORY OF LAKE OF THE WOODS

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Lake of the Woods covers nearly 4500 km^2 and is dotted with thousands of islands; it lies on the Precambrian Shield at the junction of Ontario, Manitoba, and Minnesota, within the glacial Lake Agassiz basin. About 11 ^{14}C ka (~13 cal ka B.P.), this region was deglaciated, and deep waters of Lake Agassiz expanded over Lake of the Woods (LoW); projections of Agassiz paleoshorelines indicate that water over LoW was nearly 200 m deep at this time. Although the postglacial sedimentary record in this lake has not been studied, computer modeling of differential isostatic rebound allows us to map the changing extent and bathymetry of LoW during its history, and predict future changes.

Isostatic adjustment during the Lake Agassiz and Holocene stages of LoW were calculated using a modern DEM adjusted by: (1) isobase data derived from Lake Agassiz beaches prior to 9.0 cal yr B.P. (~8.1 ^{14}C ka) and (2) modeled isostatic rebound trend analysis after 9.0 cal yr B.P. Just after the end of the early deep stage of LoW, when Lake Agassiz waters fell below the level of the LoW basin (~9.0 cal yr B.P.), only the northernmost part of the basin contained water. Since then, differential rebound has resulted in increasing water depth and lake extent. In the first 3000 years of independence from Lake Agassiz, the lake transgressed >50 km to the south, expanding its area from 858 to 2857 km^2, and more than doubling in volume. Continued differential rebound after 6.0 cal yr B.P. (~5.2 ^{14}C ka) has further expanded the lake, although today it is deepening by only a few cm per century at the southern end.

In addition, climate change in the Holocene probably played a role in lake level fluctuations. Based on our calculation of a modern hydrological budget for LoW, reducing runoff and precipitation by 65% and increasing evaporation from the lake by 40% would end overflow and cause the level of the lake to fall below the outlets at Kenora. Because this climate change is comparable to that recorded during the mid-Holocene warming across the region, it is likely that the area covered by the lake at this time would have been less than that determined from differential isostatic rebound alone, and the lake may have been quite shallow and small.

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POST-GLACIAL HISTORY OF WEST HAWK LAKE, A METEORITE IMPACT CRATER, MANITOBA, CANADA: A MULTI-PROXY APPROACH

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West Hawk Lake (WHL) is a small, 111-m-deep, steep-sided meteorite impact crater in SE Manitoba with ~70 m of sediment over Precambrian bedrock. Five cores were collected from the centre of the lake, the longest being 10.8 m. Age control is provided by AMS ^{14}C, ^{210}Pb, ^{137}Cs dating, and modeling. Sample analyses include bulk and clay mineralogy, major and minor elements, TOC, TC, TN, stable isotopes of C, N and O, pollen, charcoal, algae, and floral and faunal macrofossils.

Below a depth of ~2.8 m, there are ~860 1-cm-thick varves. The 40-60 cm above this are thinly laminated (~180 laminae), and the top is dated at 8791 ^{14}C yrs BP. By adding the 860 varve years to the 8791 ^{14}C BP date (9.9 ka cal), plus a few years for the thin laminae, the age of the base of the core can be taken as ~11 ka cal BP. The varves are related to the Lake Agassiz phase of WHL, and an algae-barren zone in the lowermost 2.2 m of the varved sequence indicates cold lake waters. An end to dolomite in the sequence at ~2.8 m suggests that the influence of Lake Agassiz on the basin was much reduced by this time. Between 8.6-2.4 m, increasing benthic and planktonic algae and depleted $\delta^{13}C_{cell}$ and $\delta^{18}O_{cell}$ indicate a large shallow lake, short water residence time, and a warmer climate. Peaks of some pollen (e.g. *Ambrosia* and *Chenopodiineae)* in the lower 8 m (10.8-2.4 m) record the effects of short-term, cyclical (century- to decadal-scale periodicity) droughts on regional vegetation. Above ~3 m in core 2K, values of Al, Be, Cr, Li, V, K, Sc, Ti, Ca, Mg, and Sr rise rapidly and then slowly decrease by 2.4 m depth, remaining constant until ~1 m depth; $\delta^{13}C$ and $\delta^{15}N$ are relatively high between 3-2.4 m. Changes between 3-2.4 m, including the end to thick varve deposition, suggest increased erosion in the watershed as the level of Lake Agassiz dropped. WHL became independent from Lake Agassiz after 9.9 ka cal BP (~8.8 ^{14}C ka; ~2.4 m in the core). Increased nutrient supply and warmer waters led to higher productivity in the lake. An expanding subaerial region around WHL led to a change in pollen and an increase in drought potential, with increases in charcoal reflecting fires. High amplitude fluctuations in Ni, Co, P, and Mn occur between 2.4-1 m (9.9-4.0 ka cal BP) may be due to variable influxes of runoff and organic input to the lake. Above 1 m (~4 ka cal; 3.7 ^{14}C ka) many elements (Ba, Fe, Y, Zn, S, Cu, Mn, Ni, P, Cd. Co, and Hg) rise, most by a factor of 2 or more; all other elements trend toward much lower values—this is a time when climate in the region was cooling and becoming wetter; at this time there also was a trend to much higher values in TOC, N, $\delta^{13}C$, $\delta^{15}N$, and the C/N ratio and an increase in trees and decrease in herbs.

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CONTROVERSY OF NOAH'S FLOOD IN THE BLACK SEA: GEOLOGICAL AND FORAMINIFERAL EVIDENCE FROM THE SHELF

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This presentation reviews the geological and foraminiferal evidence collected in course of extensive geological and palaeoceanograpic studies of the Black Sea since 1970, largely by eastern scientists, to examine the Noah's Flood Hypothesis proposed by William Ryan and Walter Pitman. According to this hypothesis the Black Sea was a freshwater lake with a level ca 140 m below present during 14.7-10 ky BP. At 7.2 ky BP (initial hypothesis) or 8.4 ky BP (modified hypothesis), the lake was rapidly flooded by Mediterranean waters through the Straits of Bosphorus, forcing the dispersion of early Neolithic people into the interior of Europe, and forming the historical basis for the biblical legend of Noah's Flood.

In the context of the Noah's Flood hypotheses, the time span 28-7 ky BP is emphasized and three crucial points are discussed: (1) level and salinity of the Neoeuxinian lake; (2) re-colonization of the Black Sea by Mediterranean immigrants, and, by implication, sea level and salinity changes due to connection/isolation between adjacent basins; (3) "an alternative" to the Bosphorus connection between adjacent basins.

It is shown that prior the moderately warm Würm Paudorf (Middle Weichselian) Plenigalcial (prior to ca 27 ky BP), there was a brackish Tarkhankutian basin connected with the Sea of Marmara. At the LGM, this connection was lost, and the level of the Tarkhankutian basin dropped to ca -100 m, transforming this basin into a closed Early Neoeuxinian lake. In a warming climate at ca 17 ky BP, a massive water discharge most likely from the Caspian Sea via Manych Outlet increased the level of the Late Neoeuxinian lake to ca -20 m. The latter must have spilled an excess of semi-fresh to brackish water into the Sea of Marmara and from there into the Mediterranean. During the short climate cooling episode occurring at Younger Dryas, the level of the lake dropped from -20 m to -43 m and then rose again to ca -20 m. After ca 10 ky BP, the level of the Black Sea never again dropped below the ca 40 m iosobath, nor exhibited a maximum amplitude of fluctuation greater than ca 20 m. At ca 9.5 ky BP, it reached -20 m again, allowing Mediterranean waters and organisms to enter the Late Neoeuxinian lake. The re-colonization of the Black Sea occurred in an oscillating manner. It was slow at the beginning, becoming most prominent at ca 7.0 ky BP.

The connection between adjacent basins was probably not through the Bosphorus Strait, but via an alternative route, e.g., Izmit Bay - Sapange Lake - Sakarya River. On average, sea level rose gradually but in an oscillating manner to the present level, and perhaps slightly higher, averaging 3 cm per 100 years but certainly not 15 cm per day (almost 55 m per year) as postulated by the Noah's Flood hypothesis. The increase of the sea level by 3 cm per 100 years would not be noticed by the inhabitants and would not have accelerated their dispersion into the interior of Europe, bringing us to the conclusion that "Noah's Flood" in the Black Sea is a contemporary legend.

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DEGLACIATION CHRONOLOGY AND PALEOENVIRONMENTS OF NORTHEASTERN ILLINOIS, USA

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The deglaciation chronology and paleoenvironments of northeastern Illinois are revised in this paper based on recent analyses of lacustrine sediment and fossils from several sites located in Kane County. Our chronology is based on the AMS C-14 dating of terrestrial plant remains. The late-glacial lake sediments were deposited in a number of environments, including numerous ice-walled lakes, an abandoned channel on a fan-delta, and a slackwater lake. At these sites, the sediment is rhythmically bedded, and largely barren of pollen grains, but contains well-preserved ostracodes and plant macrofossils. All three of these fossil proxies are well-preserved in the basal deposits of most kettles in the region.

Our data indicate that interactions between the Huron-Erie Lobe and the Lake Michigan Lobe ceased at about 17,500 14C yr BP during the mid-Livingston Phase. This age marks the end of activity of the Princeton Sublobe of the Lake Michigan Lobe and onset of activity of the Joliet Sublobe. The oldest moraine of this sublobe, the Minooka Moraine, formed by about 16,500 14C yr BP.

Fossils dating from 17,500 to 15,700 14C yr BP were recovered from the ice-walled, proglacial, and slackwater sites. The plant macrofossil assemblage is primarily comprised of tundra species, such as *Dryas integrifolia* (arctic dryad) and *Salix arctica* (arctic willow). This flora, unlike modern arctic tundra, includes a few boreal species, such as *Vaccinum* sp. (blueberry/bilberry), and a few cool-temperate taxa, like *Rorippa* sp. (yellow cress). These plants probably colonized gravel floodplains and their leaves and seeds were washed during floods into nearby proglacial lakes. Eventually, *Picea glauca* (white spruce) came to inhabit the area, later followed by *Picea mariana* (black spruce), and both co-existed for a time with these tundra, boreal and cool-temperate shrubs and herbs. Ostracodes associated with these anamolous environments include *Heterocypris incongruens, Limnocythere friabilis, L. herricki*, and *Cytherissa lacustris* (in order of inferred decreasing salinity).

There is a gap in the fossil record of northeastern Illinois between 15,700 and 14,900 14C yr BP. This period of time is when then the Woodstock Moraine formed, and when rapid retreat likely resulted in large-scale flooding (the Fox River Torrent) in the Elgin-Algonquin area. These floods may have joined the Kankakee Torrent of the Illinois River valley.

At about this time kettle lake records begin. Nelson Lake provides a complete record starting at c. 14,900 14C yr BP. Ostracodes (*C. rawsoni*, *L. herricki*, *Cyclocypris ampla*) from this lake indicate that the paleoenvironment during this time was dry and cold. Plant macrofossils and pollen records beginning at 14,100 14C BP at nearby Mastodon Lake, and 13,900 14C BP at Brewster Creek, indicate that a spruce-sedge parkland persisted in this area until at about 13,600 14C yr BP.

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