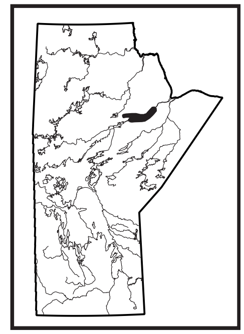
GS-16 Preliminary Quaternary geology in the Gillam area, northeastern Manitoba (parts of NTS 54D5–9, 11, 54C12)

by M.S. Trommelen



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Summary

This report presents a summary of activities related to three weeks of fieldwork undertaken in the road-accessible areas around Gillam, Manitoba, in the summer of 2013. Quaternary geology investigations included site characterization (sedimentology, geomorphology, type and thickness of glacial sediments) and collection of representative till samples for compositional analysis of provenance. Where possible, mainly west of Stephens Lake, ice-flow indicators were collected to augment the current understanding of the regional ice-flow history. Geological observations, sampling of till and/or measurements of ice-flow indicators were recorded at 156 stations along ~200 km of road, which include a number of sections along the Nelson and Limestone rivers. Preliminary findings of this mapping are presented herein.

The Quaternary landscape in the Gillam area is complex. The region preserves a thick stratigraphic record of at least three glacial cycles. Preliminary fieldwork indicates the presence of sandy and clayey-silt tills, with variations in colour, texture and lithology.

In addition to the glacial deposits, the area was inundated by both glacial Lake Agassiz[1] and the Tyrrell Sea during the Holocene. New radiocarbon ages establish that ice readvanced into Lake Agassiz and the Tyrrell Sea during the Holocene, which indicates that drainage of glacial Lake Agassiz, the breakdown of the ice saddle between the Keewatin and Quebec–Labrador sectors of the Laurentide ice sheet, and the incursion of the Tyrrell Sea occurred over a very short duration in the Gillam area—at or near the 8.2 ka cal. (calibrated) BP cooling event. The complex paleoglaciology, details of which have yet to be unravelled, warrants the undertaking of additional field and analytical Quaternary geology studies in the Gillam area.

Introduction

In August 2013, Quaternary geology studies were conducted in northeastern Manitoba, encompassing the road network surrounding the town of Gillam, and extending northeast to the Manitoba Hydro Conawapa camp (NTS 54D7, 8, 9, 11, parts of 54C12; Figure GS-16-1). Additional reconnaissance roadwork, predominately for the purpose of collecting ice-flow indicators was completed between Split Lake and Gillam (NTS 54D5, 6). This report presents a summary of fieldwork activities that included mapping of surficial materials and ice-flow indicators, as well as regional till-sampling surveys.

Surficial geology in the Gillam area was mapped in 1985 at a 1:250 000 scale by Klassen and Netterville (1980). Though released as a Geological Survey of Canada A-series colour map, this map is considered to be reconnaissance-scale because the region was subjected to only limited ground-truthing. Stratigraphy along the Nelson River, prior to building of the Long Spruce and Limestone generating stations, was investigated in greater detail and was the subject of two M.Sc. theses and a field trip guidebook (e.g., Klassen, 1972; Nielsen and Dredge, 1982; Nielsen et al., 1986; Roy, 1998).

Physiography

The study area is located in the northeastern part of Manitoba. Elevation varies from 30–170 m above sea level (asl) with local relief reaching up to 40 m (Figure GS-16-1).

Within the study area, the Nelson River, with Split Lake and Stephens Lake as widened expanses, is the major drainage channel, which flows northeast and eventually drains into Hudson Bay. The study area is dominated by gently sloping, poorly- to moderately-drained topography. Stunted spruce bogs and forests drape most of the region, and surface permafrost is common beneath organic deposits.

Soils are predominately organic cryosols and mesisols developed over glaciomarine parent materials, eutric or dystric brunisols developed on moderately- to well-drained till and glaciolacustrine parent materials, and luvisols, on moderately- to well-drained till or glaciofluvial deposits (Keeyask Hydropower Limited Partnership, 2012).

Bedrock is deeply buried throughout most of the road-accessible area, with the exception of rare limestone outcrops at the Limestone hydroelectric dam and two inaccessible gneissic islands just north of the Long Spruce hydroelectric dam. The closest outcrop encountered along the highway is ~70 km west of the Long Spruce hydroelectric dam, where ditch excavations have removed the overlying glaciolacustrine clays.

[1] For the sake of consistency, the Manitoba Geological Survey has opted to make a universal change from capitalized to noncapitalized for the generic part of lithostructural feature names (formal stratigraphic and biostratigraphic nomenclature being the exceptions).

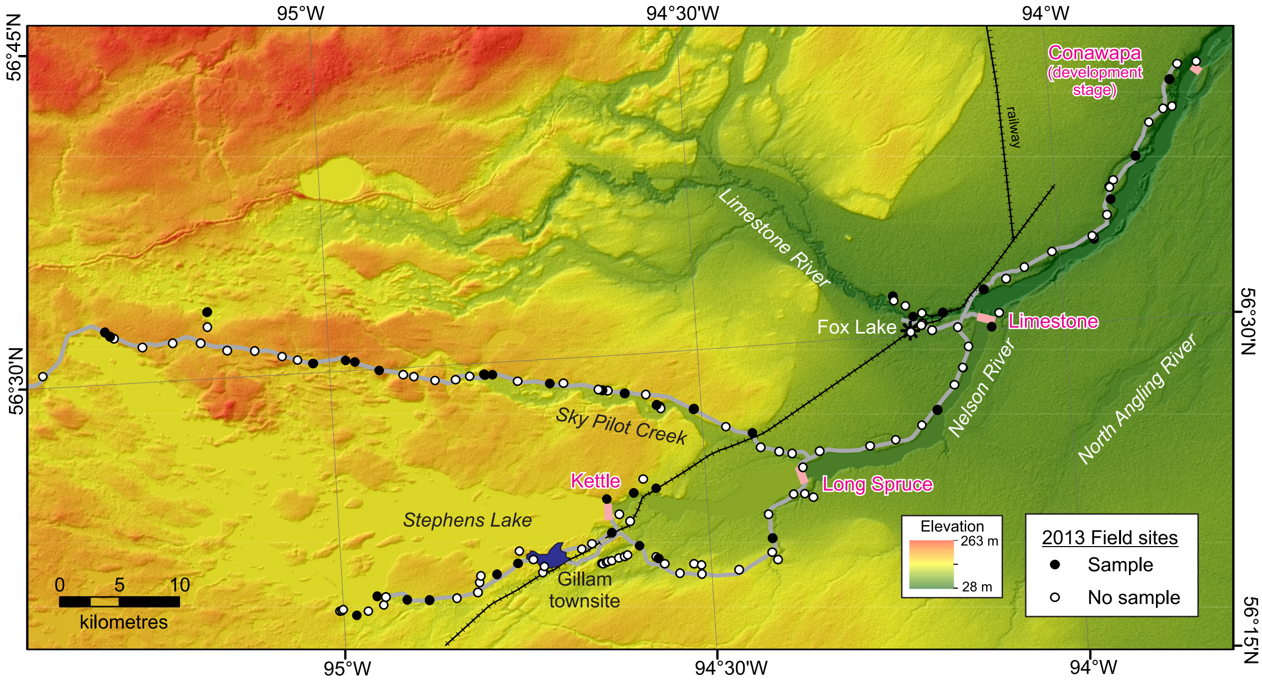

***Figure GS-16-1**: Study area and field sites of 2013 mapping program in northeastern Manitoba. Background hill shade image was generated using a Shuttle Radar Topography Mission digital elevation model (United States Geological Survey, 2002).*

Methods

Road-accessible fieldwork was undertaken during a three-week period in the summer of 2013, based out of Manitoba Hydro accommodations in Gillam. A total of 156 field sites were visited to ground truth surficial geology mapping, collect till samples and identify ice-flow indicators (Figure GS-16-1). Sites were investigated using a shovel and/or an extendable auger (maximum depth of 3 m) provided by Manitoba Hydro. Forty five surface-till samples, each weighing around 2 kg, were collected from C-horizon till throughout the area for geochemical analysis. An additional 18 till samples were collected from subsurface tills found in roadcuts or natural sections. All till samples have been submitted for trace-element geochemistry (>63 µm fraction) and clast lithology (2–80 mm fraction) analysis. Organic matter (i.e., shell, wood) from four sites was submitted to Beta Analytic Inc. (Miami, Florida) to obtain radiocarbon ages, the results of which are presented in MGS Data Repository Item DRI2013004[2]. The orientation of striations, grooves, chattermarks and roches moutonnées were measured at 12 sites (as shown in MGS Data Repository Item DRI2013005[3]).

Results

Example of a stratigraphic section

Stratigraphic sections are numerous in the field area; they can be found along the major river valleys, as well as along the scarps of the deeply-incised meltwater corridors. Some sections along the Nelson River valley have been previously described by Nielsen and Dredge (1982), Nielsen et al. (1986), Roy (1998) and Nielsen (2002b). Most previous work has focused on characterization of pre-Late Wisconsinan stratigraphy. Due to fluctuations in water levels, infrastructure development (dams and generating stations) and accessibility, undocumented sections are present in many areas.

Figure GS-16-2 shows an example of a stratigraphic section visited this summer, which serves to demonstrate the variability of the substrate and range of new information. This site along the Nelson River, located between the Limestone and Conawapa hydroelectric dams, exposes 20 m of till overlain by glaciomarine fossiliferous sand and gravel and capped by a fossiliferous sandy till indicative of an ice readvance into the Tyrrell Sea after 7230 ±40 ^{14}C BP (Figure GS-16-3, sample Beta-356775).

[2] MGS Data Repository Item DRI 2013004, containing the data or other information sources used to compile this report, is available online to download free of charge at http://www2.gov.mb.ca/itm-cal/web/freedownloads.html, or on request from minesinfo@gov.mb.ca or Mineral Resources Library, Manitoba Mineral Resources, 360-1395 Ellice Avenue, Winnipeg, Manitoba, R3G 3P2, Canada.

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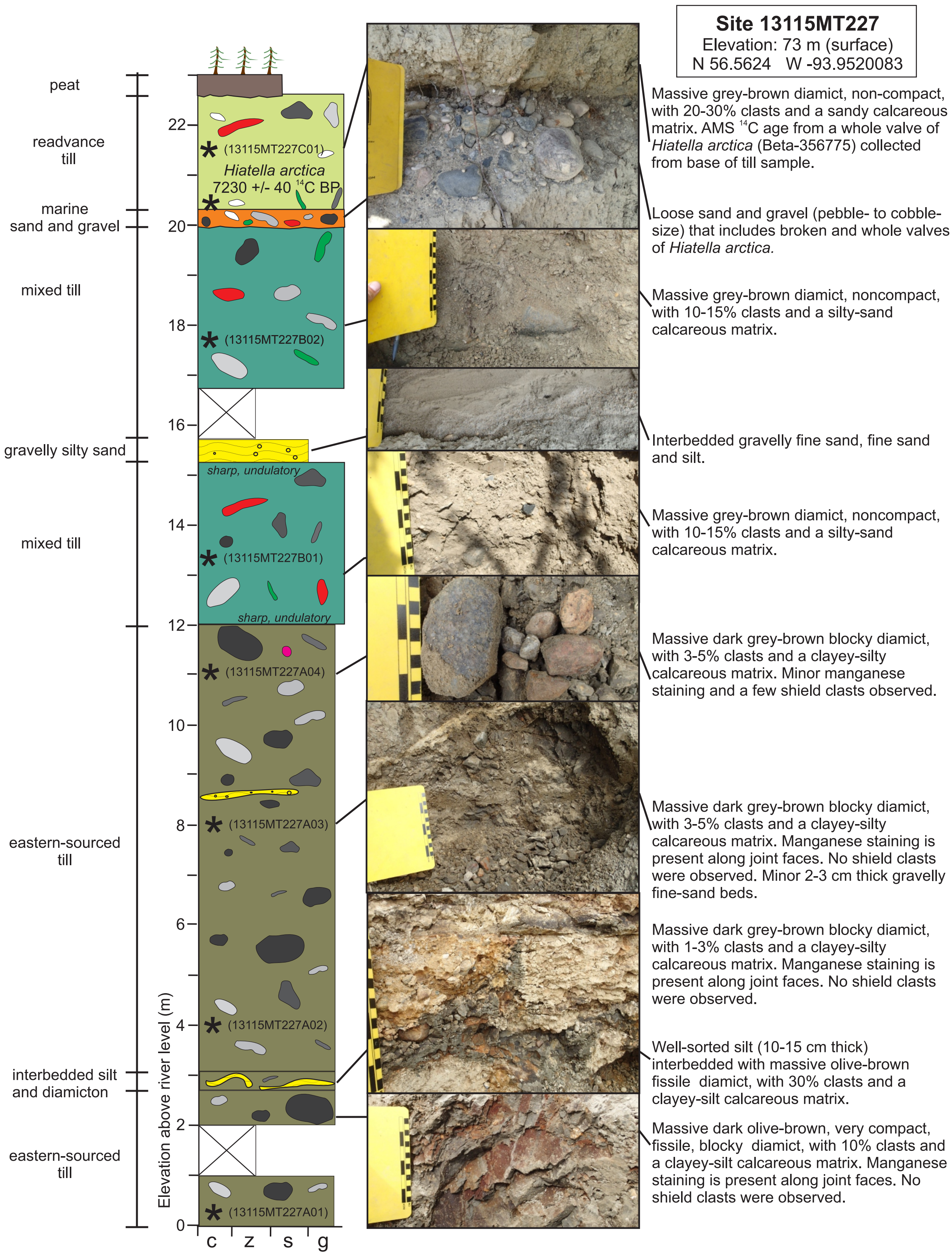

***Figure GS-16-2**: Preliminary stratigraphy of a section along the Nelson River, near Limestone hydroelectric dam (site 13115MT227). Abbreviations: AMS, accelerator mass spectrometry c, clay; g, gravel, s, sand; z, silt.*

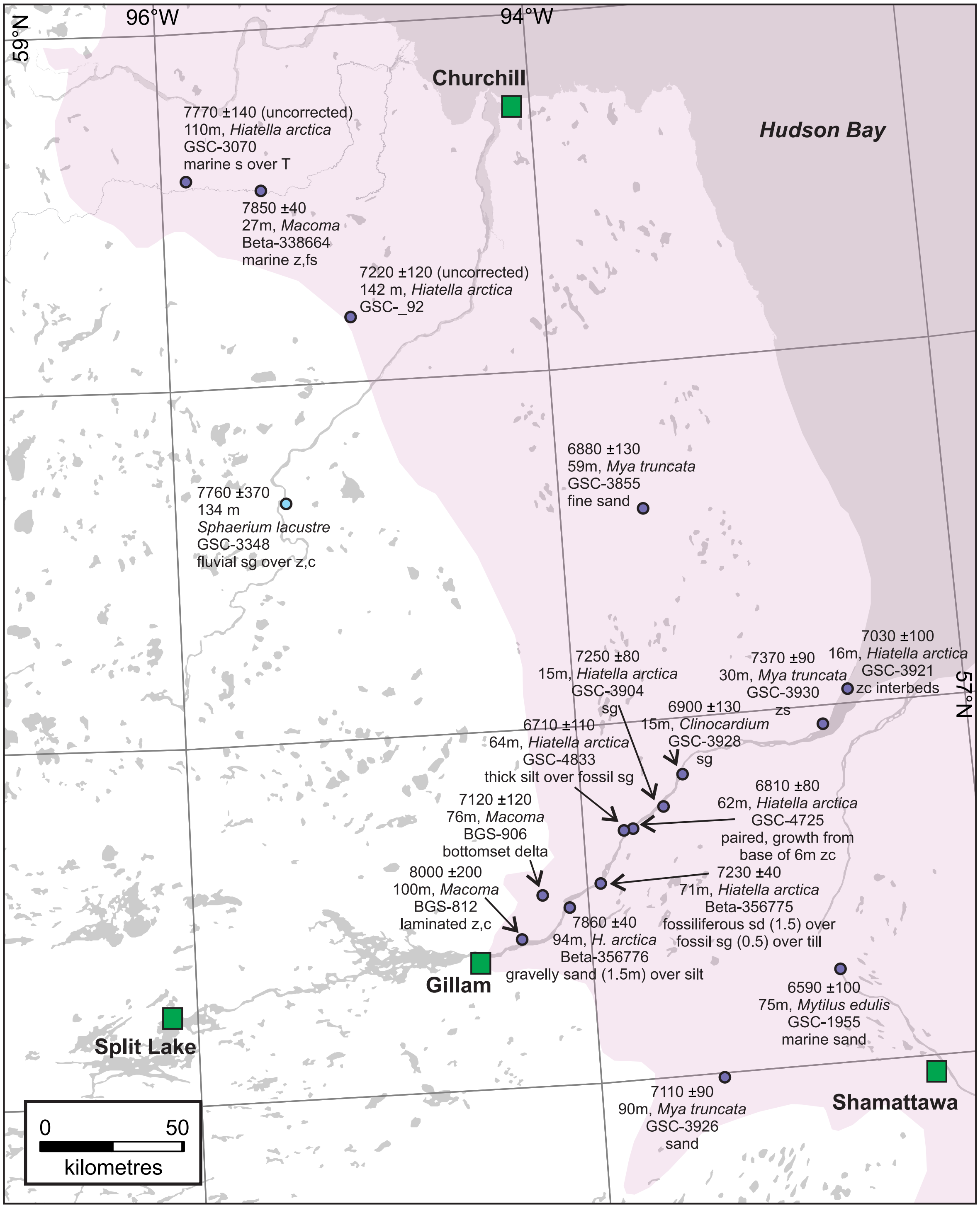

Figure GS-16-3*: Radiocarbon ages pertinent to the deglaciation and subsequent impounding of drainage in northeastern Manitoba. This updated reconstruction of the maximum relative sea level of the Tyrrell Sea (pink) includes two new radiocarbon ages from the 2013 study area (samples Beta-356775 and Beta-356776). The new marine-shell ages have been reservoir-corrected by adding 110 years, as per Coulthard et al. (2010), but correction applied to the previous ages is uncertain. Abbreviations: c, clay, fs, fine sand; s, sand; sd, sandy diamict; sg, sand and gravel; t, till; z, sitl; zc, silty clay; zs, silty sand.*

Radiocarbon ages

Shell and wood material collected at three additional sites returned one modern, one Holocene and one infinite radiocarbon age (DRI2013004). The two new Holocene radiocarbon ages support existing data (Figure GS-16-3). The 7860 ±40 ^{14}C BP (sample Beta-356776) age for the regression of the Tyrrell Sea better constrains a previously reported radiocarbon age of 8000 ±200 ^{14}C BP (sample BGS-812, Nielsen et al., 1986). The younger Holocene radiocarbon age (7230 ±40 ^{14}C BP; Figure GS-16-2, sample Beta-356775) provides important information about the age of fossiliferous sand and gravel deposits along the Nelson River corridor, and constrains a previously unidentified ice readvance to the Holocene.

Surficial geology

Marine sediments (Tyrrell Sea)

Sand and gravel (Tyrrell Sea—shallow water)

Along the road between the Long Spruce and Conawapa hydroelectric dam sites (Figures GS-16-1, -4), matrix- to clast-supported, fossiliferous, horizontally-stratified gravel (Figure GS-16-5a) and well-sorted, horizontally-stratified, fine- to medium-grained sand is present at surface. These sites, situated between 70 and 100 m asl, are attributed to glaciofluvial deposition into a marine setting. At site 13115MT280, an age of 7860 ±40 14C BP (8370 to 8020 cal. years BP; Figure GS-16-3, sample Beta-356776 at 94 m asl) was obtained from paired valves of *Hiatella arctica* (Figure GS-16-5b). These valves were sampled from the base of a gravelly-sand unit (1.5 m thick) that overlies silt. This gravel contains white and pink carbonate, a variety of granitoid and gneissic clasts, quartzite and greywacke clasts. The position of gravel over silt at some sites suggests that gravel may have been deposited during marine regression (lowering of water levels). It is also possible that gravel was deposited by glacial meltwater during an ice readvance into the Tyrrell Sea.

Silt (Tyrrell Sea—deep water)

Laminated silt (Figure GS-16-5c) 0.5 to 5 m thick was encountered at surface east of the Long Spruce hydroelectric dam (Figures GS-16-1, -4), between 97 and 130 m asl. No fossils were encountered in this unit during the 2013 field season, although Nielsen et al. (1986) obtained an age of 8000 ±200 ^{14}C BP from a *Macoma calcarea* valve (Figure GS-16-3, sample BGS-812) enclosed within calcareous silt at 100 m asl, just north of the Long Spruce hydroelectric dam. Interestingly, marine silt is absent within sections, or at surface, below 97 m asl.

Trimlines and marine limit

Numerous beach ridges and trimlines (wave-cut scarps) are present at around 122 m asl (Figure GS-16-4). The maximum marine limit is interpreted as being around 130 m asl, as this is the maximum elevation of trimlines, beach ridges and silt deposition (Nielsen and Dredge, 1982). Shell fragments can be found above this elevation, within till and buried gravel deposits. At two elevations (140 and 169 m asl) at different sites in the field area, sampled shell fragments returned infinite radiocarbon ages (DRI2013004). These shell fragments are interpreted as reworked organic material, transported above marine limit by ice/water that predates the Late Wisconsinan. Nielsen and Dredge (1982) also noted the presence of interglacial shell fragments within several till sheets.

Glaciolacustrine sediments

Silt and clay rhythmites (Figure GS-16-5c), clay (Figure GS-16-5d) and waterlain till were encountered at surface at numerous sites west of the Long Spruce hydroelectric dam (Figures GS-16-1, -4). Glaciolacustrine clay appears to be thick (up to 3.5 m) south of Stephens Lake and thinner (<1 m) to the north. Thin rhythmites were encountered beneath marine silts within some sections along the Nelson River, between the Long Spruce and Limestone hydroelectric dams (Nielsen and Dredge, 1982). Stratigraphic data thus suggests a glacial lake was present (not necessarily synchronous) over most of the study area before transgression of the Tyrrell Sea.

Drainage channels

Nielsen and Dredge (1982) suggested that the drainage of Lake Agassiz began through the large meltwater corridors seen on Figure GS-16-4 along Sky Pilot Creek and the Limestone River. The base of these channels is around 122 m asl and, because this is at marine limit, Nielsen and Dredge (1982) further suggested that drainage was subglacial. Glaciolacustrine clay was noted just southeast of the Gillam townsite at 131 m asl, at 170 m asl 20 km to the northeast and at 144 m asl within the middle of the head of the Sky Pilot corridor. The lack of relationship between elevation and glaciolacustrine deposits suggests that, while there was a drainage phase, it was incomplete and impounding of glacial lakes continued along the ice margin. The western bottom reaches of the Limestone corridors are streamlined (Figure GS-16-6), which supports the idea of an ice readvance after a drainage phase. Contrastingly, a sandy marine delta formed at the mouth of one Limestone River corridor, from which a bottomset valve of *Macoma calcarea* (Figure GS-16-3, sample BGS-906) provided an age of 7120 ±120 ^{14}C ka BP (Nielsen et al., 1986). The top of this delta is flat and draped by a uniform pine forest (Figure GS-16-5e, f).

Hence, the complex geomorphology suggests firstly 1) that ice readvanced or recoupled at the head of the Limestone River corridor and 2) that the corridor mouth was either subaerial or had a large enough subglacial cavity to accommodate marine deltaic deposition that was

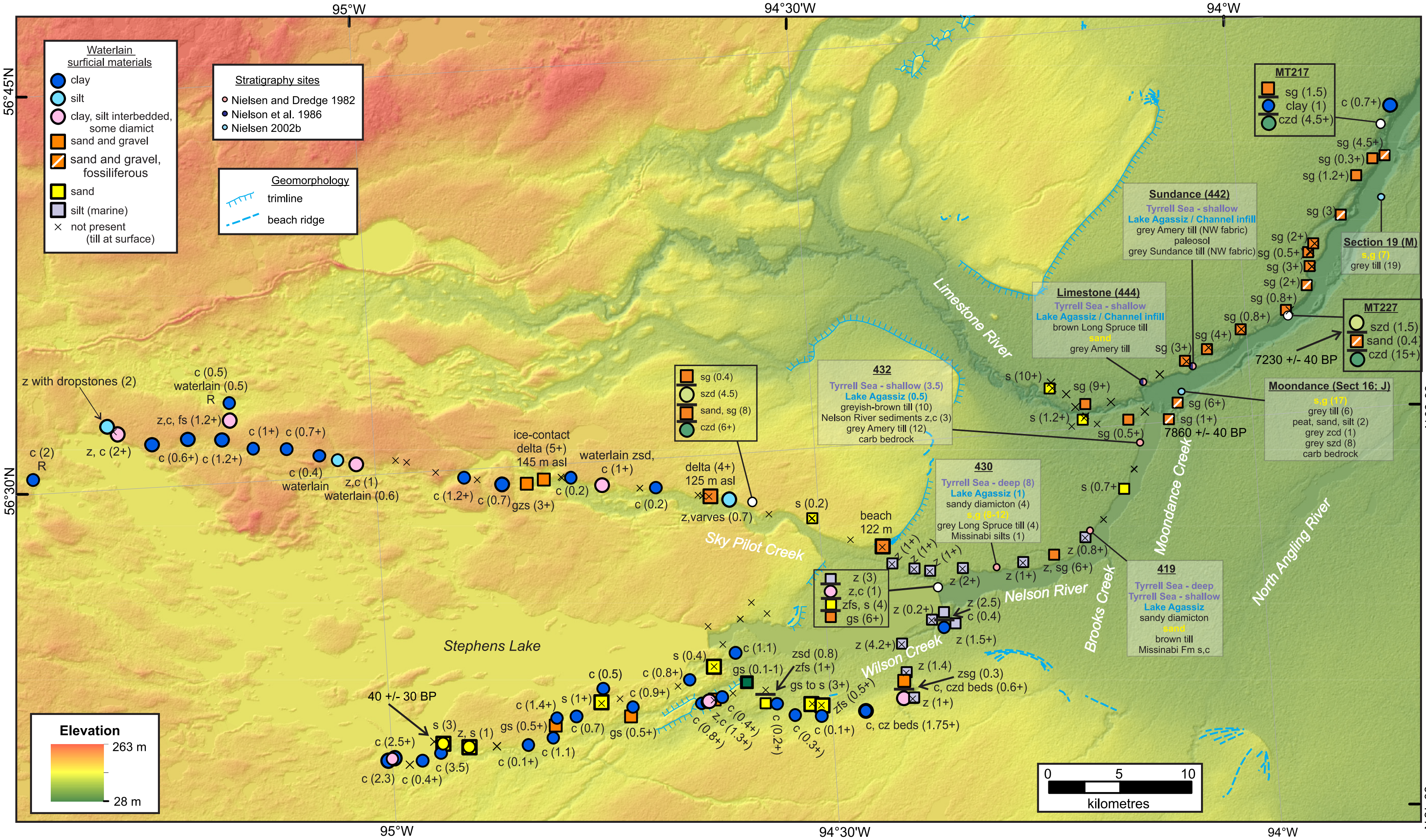

***Figure GS-16-4**: Waterlain surficial materials and associated beach ridges and trimlines in the Gillam area, encountered during fieldwork in the summer of 2013. Numbers within brackets indicate the thickness of sediment at each field site in metres. Background hill shade image was generated using a Shuttle Radar Topography Mission digital elevation model (United States Geological Survey, 2002). Abbreviations: asl, above sea level; c, clay; carb, carbonate; cz, clayey silt; czd, clayey-silt diamict; Fm, formation; fs, fine sand; gs, gravelly sand; gzs, gravelly-silty sand; R, bedrock; s, sand; sg, sand and gravel; szd, sandy-silt diamict; z, silt; zcd, silty-clay diamict; zfs, silty fine sand; zsd, silty-sand diamict, zsg, silty sand and gravel.*

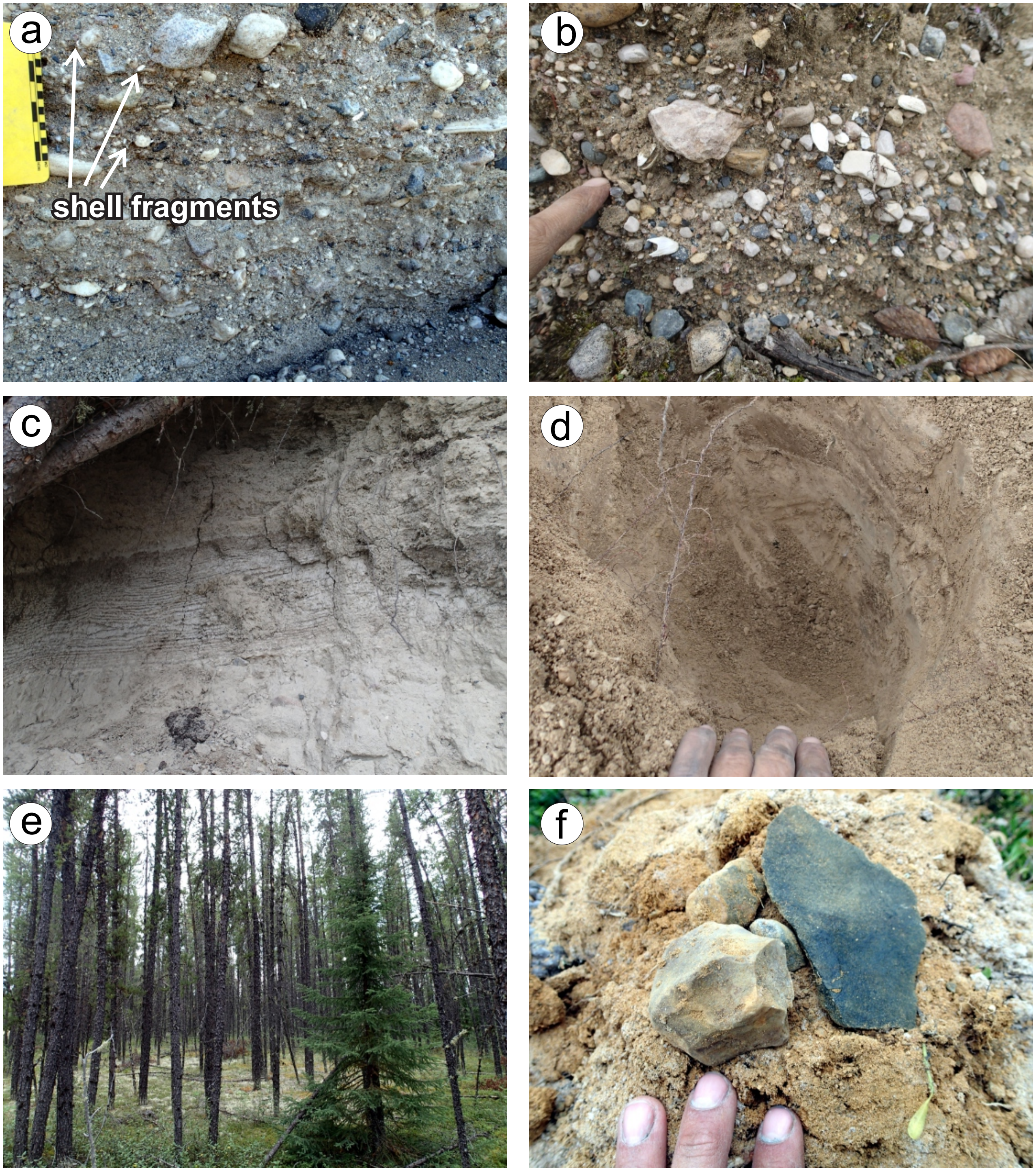

***Figure GS-16-5**: Marine and glaciolacustrine deposits in the study area: **a)** horizontally-stratified, matrix- to clast-supported, pebble- to cobble-sized gravel, with marine-shell fragments, at site 13115MT218; **b)** paired* Hiatella arctica *valves (sample Beta-356776) from within gravelly-sand at site 13115MT280; **c)** blocky marine silts overlying 0.5 m of rhythmically bedded glaciolacustrine silt and clay at site 13115MT273; **d)** massive (or very finely laminated?) glaciolacustrine clay at site 13115MT335; **e)** very well-drained jack pine forest that is growing on the glaciomarine deltaic topset surface along the mouth of the Limestone River meltwater corridor, at site 13115MT236; **f)** well-sorted sand with rare pebble- to cobble-sized clasts from the delta topset beds.*

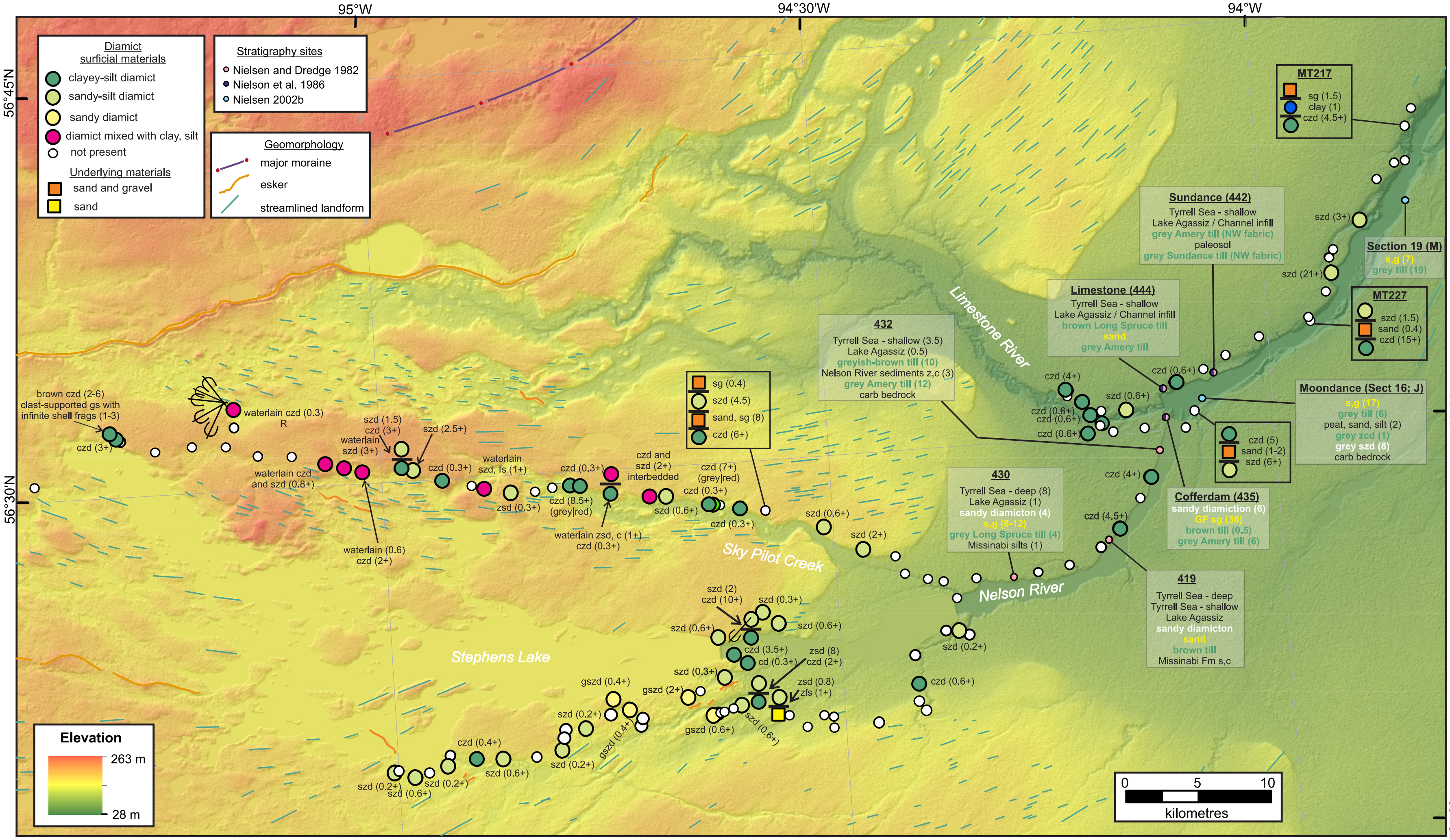

Figure GS-16-6: *Various till types encountered at field sites in the Gillam area in summer 2013. Numbers within brackets indicate the thickness of sediment at each field site in metres. Background hill shade image was generated using a Shuttle Radar Topography Mission digital elevation model (United States Geological Survey, 2002). Abbreviations: c, clay; carb, carbonate; cd, clay diamict; czd, clayey-silt diamict; Fm, formation; fs, fine sand; g, gravel; gs, gravelly sand; gszd, gravelly sandy-silt diamict; s, sand; sg, sand and gravel; szd, sandy-silt diamict; z, silt; zcd, silty-clay diamict; zfs, silty fine sand; zsd, silty-sand diamict.*

not overprinted by streamlining. Secondly, till—and not marine sediment—is present at surface surrounding the glaciofluvial outwash deposits (Figure GS-16-6), even though these sites (86–91 m asl) are below marine limit. Further work is required to determine the detailed glacial history of this area.

‘Henday sediments’

A sandy diamicton, overlying fossiliferous sand and gravel, was noted by Nielsen and Dredge (1982) to be overlain by both glaciolacustrine varves (west of the Long Spruce hydroelectric dam) and marine silt. The fossils within the sand and gravel were presumed to have been reworked from older materials, and these ‘Henday sediments’ were interpreted as sediment deposited subaqueously (outwash and debris flow) into glacial Lake Agassiz from an eastward-retreating ice margin (Nielsen et al., 1986). The new radiocarbon age at section 13115MT227 (Figure GS-16-2) contradicts this view, as it indicates that both the fossiliferous sand and gravel and fossiliferous sandy diamicton are Holocene in age. Furthermore, *Hiatella arctica* is a marine bivalve and its presence requires either a subaerial Tyrrell Sea or an ice saddle at flotation point, which would have allowed for drainage of marine waters westward into the area presumably occupied (or recently vacated) by glacial Lake Agassiz.

The stratigraphy of these surficial units is in need of further revision. The extent and composition of the sandy diamicton needs to be clarified, as does the direction, or directions, of fossiliferous glaciofluvial sand and gravel deposition.

Till

The following is a brief description of tills encountered in the Gillam to Conawapa area, based on stratigraphic and textural observations. Ongoing laboratory analyses will aid to refine the correlation between tills identified during field mapping.

Sandy till

The main surface till, west of the Long Spruce hydroelectric dam, is calcareous and beige, with a silty-sand to sandy-silt matrix (Figure GS-16-1, -6). This diamicton (Figure GS-16-7a) contains 10–25% subangular to subrounded, commonly striated clasts that range from granule to boulder size. Shield-derived clast-types are prominent amongst carbonate (tan, pink and/or fossiliferous) and greywacke clasts. This diamicton is variable in texture, may be weakly stratified (Figure GS-16-7b) and can contain thin pods, lenses and/or beds of moderately-sorted fine sand, clay and brown clayey-silt diamict. This surface diamicton is 1.5–4.5 m thick and overlies gravelly sand, grey-brown clayey-silt till or sand with 1% pebble-sized dropstones.

At one section, just east of the Kettle hydroelectric dam, two striated boulders at the base of the contact with the underlying grey-brown till record ice flow trending 220° (Figure GS-16-1, -6). At surface, this till is associated with streamlined landforms trending 260–270° (Figure GS-16-6). Neilsen and Dredge (1982) carried out six till fabric analyses in this till and, although there was considerable variation, they determined that the average till-fabric orientation was to the west.

Clayey-silt till

Grey (Figure GS-16-7c), grey-brown (Figure GS-16-7d), or brown calcareous till with a clayey-silt matrix occurs at surface or below the sandy till (Figure GS-16-6). This till typically contains 5–15% granule- to cobble-sized clasts that are subrounded to rounded and commonly striated. In section, this till is usually fissile, blocky and exhibits variable degrees of manganese staining. At two sites, 4 m of grey-brown clayey-silt till overlies a red-brown clayey-silt till (Figure GS-16-7e). Multiple samples of clayey-silt till were taken at different elevations from ten sections. The geochemistry and clast lithology of these samples will be used to help determine whether different clayey-silt tills exist, as suggested by the encountered range of moist field-colour types.

Till composition

As indicated above, till lithology varies greatly in the study area. Clast types include

- Paleozoic carbonate rocks (beige, grey, tan, red and/or fossiliferous; Figure GS-16-8a–c) presumably derived from the Hudson platform in the Hudson Bay Lowland (Manitoba Energy and Mines, 1980) and from beneath Hudson Bay (Grant and Sanford, 1988);
- Precambrian granitoid and gneissic rocks (Figure GS-16-8a), metasedimentary rocks, and metavolcanic rocks derived from the Canadian Shield;
- various facies of Omarolluk erratics (also known as Omars)—Proterozoic greywacke with hemispherical voids, pits or unweathered calcareous concretions (Figure GS-16-8a, d)—, which are presumably derived from the Omarolluk formation of the Belcher group in southeastern Hudson Bay (Prest et al., 2000), though they may have been sourced from an area where the Omarolluk formation (or similar) has since been eroded away or is buried by drift;
- red sandstone and mudstone (Figure GS-16-8e), which may be derived from the Loaf formation of the Belcher group and from the Devonian Kenogami River formation of central Hudson Bay; and

Figure GS-16-7: *Various till facies in the Gillam area, including* ***a)*** *and* ***b)*** *silty-sand diamict, which overlies* ***c),*** ***d)*** *and* ***e)*** *clayey-silt diamict.*

- red porphyritic (plagioclase, quartz) Dubawnt supergroup (Peterson, 2006) volcanic rocks (Figure GS-16-8f).

All of the 2013 field samples are being analyzed for clast lithology, to help ascertain the presence of different till types.

Till correlations

In the Hudson Bay Lowland, till stratigraphy has been predominately described based on river sections, with little supporting overland fieldwork. Surface till (Sky Pilot till according to Dredge and McMartin, 2011) descriptions vary with location, but generally describe till as yellowish brown, olive brown or greyish brown, with a silty matrix and total-carbonate content of 26–50%, containing 70–87% carbonate clasts and 4–30% greywacke clasts, which may contain shell fragments and till-fabric orientations that indicate southwestward to westward ice flow (Nielsen and Dredge, 1982; Klassen, 1986; Nielsen et al., 1986; Nielsen, 2001, 2002a,

***Figure GS-16-8**: Till-derived clasts in the study area include **a)**, **b)** and **c)** carbonate rocks; **a)** and **d)** various facies of greywacke with calcareous concretions; **e)** red mudstone and sandstone; **f)** red porphyritic volcanic rocks.*

b; Dredge and McMartin, 2011). Problematically, the underlying Long Spruce till can have similar characteristics. It is described as olive grey, yellowish brown, with a matrix total-carbonate content of 24–50%, containing 70% carbonate clasts and 8–30% greywacke clasts, and with till-fabric orientations that indicate more variable, northwestward, southward, southwestward and/or westward ice flow (Nielsen and Dredge, 1982; Klassen, 1986; Nielsen et al., 1986; Nielsen, 2001, 2002a, b; Dredge and McMartin, 2011). Consequently, while these tills may be stratigraphically distinct where found together in river sections, their descriptions are similar, making the differentiation of individual tills difficult in surficial samples.

Ice flow

New ice-flow measurements were obtained at 12 field sites along or near the road west of the study area

(Figure GS-16-9; DRI2013005). Early, protected chattermarks trend to the northwest (315–322°) and south-southwest (180–205°). Five field sites preserve striations, grooves, chattermarks and several roches moutonnées that document southwestward to west-southwestward ice flow (235–250°). At one site, these crosscut older grooves that trend to 200°. Common fine striations trend between 270 and 275° and are crosscut at eight sites by fine striations that trend between 280 and 320°, located at the top of outcrops.

Preliminary regional glacial history

The regional Hudson Bay Lowland stratigraphy comprises four tills and two non-glacial sequences (Nielsen and Dredge, 1982; Klassen, 1986; Nielsen et al., 1986; Roy, 1998; Nielsen, 2001, 2002b; Dredge and McMartin, 2011). The three uppermost tills have been interpreted as deposited from ice flowing across Hudson Bay (Labradorean ice), whereas the lowermost till was thought to have been deposited by southeastward-flowing ice originating in the Nunavut region, north of Manitoba (Keewatin ice).

As the ice sheet retreated northeastward, the waters of Lake Agassiz continued to rise, for at least 50 years, depositing a thin layer of varved silt and clay in the Nelson River valley (Nielsen and Dredge, 1982). Lake Agassiz drained from the study area around 7760 ±370 ^{14}C ka BP (Figure GS-16-3, sample GSC-3348; Nielsen and Dredge, 1982), as evidenced by a radiocarbon age obtained on freshwater pelecypod shells (*Sphaerium lacustre*) collected from fluvial sand and gravel deposits overlying silt and clay at 134 m asl on the Churchill River, 175 km north of Gillam (Figure GS-16-3). Ice was still present in the study area at that time, as evidenced by the presence of

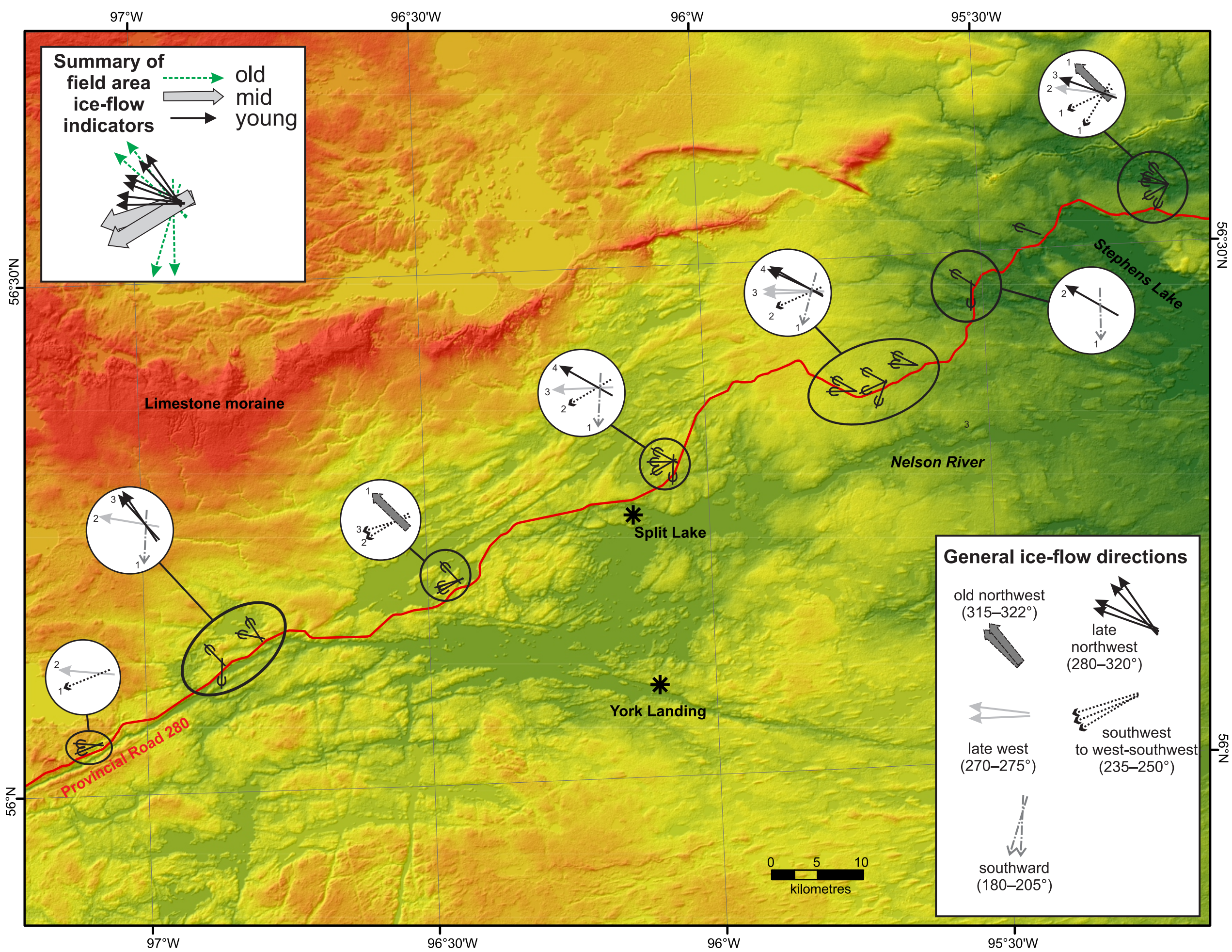

***Figure GS-16-9**: Field-based ice-flow indicator data west of the 2013 study area. Larger circles are a compiled summary of the relative ages (1 = oldest) and trends of ice-flow indicators for a single site or sites in close proximity to each other. The general ice-flow directions provide a key for differentiating between old and young ice flows of similar orientation (upper-left inset). Interpretation of an absolute sequence of ice-flow phases requires additional data for the region. Background hill shade image was generated using a Shuttle Radar Topography Mission digital elevation model (United States Geological Survey, 2002).*

waterlain till and interstratified silt, clay and diamicton beds north of Stephens Lake (Figures GS-16-4, -6*)*.

By 7860 ±40 C ka BP (8370–8020 cal. years BP; Figure GS-16-3, sample Beta-356776 at 94 m asl), the study area was inundated by the Tyrrell Sea. The maximum marine limit was around 130 m asl, and marine silt and fossiliferous sand and gravel were only deposited below 122 m asl. Nielsen and Dredge (1982) suggested that fining-upward transgressive-marine sedimentary sequences are common throughout the Nelson River valley. Marine sediments overlie varved silt and clay at several sites within the Nelson River valley, which suggests the maximum glaciolacustrine limit was achieved before the maximum marine limit. At the same time, the presence of fossiliferous sandy diamicton, deposited over fossiliferous sand and gravel along the Nelson River, indicates ice was still present in the region during the marine transgression. Hence, the drainage of glacial Lake Agassiz, the breakdown of the ice saddle between the Keewatin and Quebec–Labrador sectors of the Laurentide ice sheet, and the incursion of the Tyrrell Sea occurred over a very short, probably overlapping, duration in the Gillam area. This lends support to the idea, presented by Wagner et al. (2013), whereby the collapse of ice in Hudson Bay likely contributed significant meltwater to the 8.2 ka cal. BP cooling event.

Future work

Ongoing surficial geological analysis focuses on tracing lithological indicators from known bedrock source areas, using clast counts and the major- and trace-element geochemical composition of the collected till samples. Results of these analyses

- establish compositional till characteristics and aid investigation of subglacial-transport processes and distances; and
- provide information that can further delimit how the complex ice-flow record affected the strength of sediment erosion, transportation and/or deposition in the area, knowledge of which is pertinent for mineral exploration using till.

Economic considerations

As bedrock outcrops are rare, a thorough understanding of surficial geology is essential for drift prospecting in Manitoba's northern region. Till geochemistry is commonly used in drift-covered regions to help determine the source area for boulder trains, but is more difficult to interpret in palimpsest terrains such as the Gillam area in northwestern Manitoba, which have been modified by more than one ice advance and transport direction. Forthcoming results will provide new constraints to drift exploration in this area. Ongoing surficial geological studies aim to provide a detailed framework for the directions, timing and nature (e.g., erosive or depositional) of major and minor ice-flow events in the region. The outcomes of these studies are geared toward providing mineral-exploration geologists with an up-to-date surficial geology knowledge base and the adequate tools to more accurately locate exploration targets in Manitoba's drift-covered areas.

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