GS2025-20

Complex Quaternary geology around Grunthal, south-central Manitoba (parts of NTS 62H7)

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In Brief:

- Buried gravel in the Grunthal area was deposited during pre-Holocene ice-margin retreat
- There may have been multiple phases of deposition

Citation:

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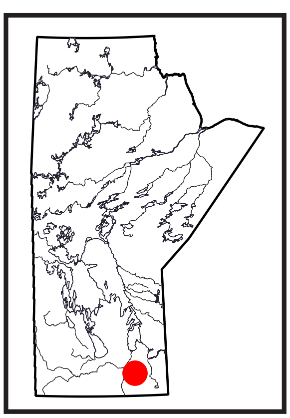

Summary

Herein, the stratigraphy from several representative gravel pits near Grunthal, Manitoba, is described. The subtill ‘buried’ granular-aggregate deposits in the two studied pits were likely deposited as proglacial outwash, at fluctuating distances from the ice margin. Timing of deposition is still questionable, as the granular aggregates were likely deposited during ice-margin retreat in an earlier interstadial and/or interglacial period(s). Current data suggest there is no obvious link between gravel or till composition and provenance, and deposits were likely formed in complex environments by water and ice flowing from the northwest, north and northeast.

Introduction

In south-central Manitoba, near Grunthal (Figure GS2025-20-1), there are significant economic granular-aggregate deposits. These deposits have been mapped as both kame-deltas deposited in proglacial Lake Agassiz (Fenton, 1974; Thorleifson and Matile, 1993) or within an older proglacial lake formed during the penultimate retreat of ice (Matile and Conley, 1979), or as eskers (Matile and Conley, 1979; C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007). Interestingly, the deposits do not have a topographic expression, making it difficult to map the lateral extent of existing deposits, and to predict the location of additional aggregate resources (Gauthier and Rentz, 2024; Marks and Rentz, 2024; Rentz et al., 2024).

According to local aggregate producers around Grunthal, diamict (~0–5 m thick) regionally drapes gravel or sand (~0–30 m thick; C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007). The diamict cover, if interpreted as till, would suggest that the granular-aggregate deposits were formed either under the ice, or were buried by subsequent deposition of sediment by ice; and hence they are older than the Holocene deglaciation. Interestingly, mammal fossils and spruce wood have been extracted below the water level, from an unknown source or sources (Nielsen and Matile, 2002; C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007), which further questions the formation and age(s) of these deposits.

Herein, the stratigraphy from several representative gravel pits near Grunthal is described. The goal is to evaluate whether the buried granular-aggregate deposits are of the same formation and age, and hence whether it’s possible to better map these buried deposits.

Previous work

A Quaternary stratigraphic framework for southeastern Manitoba was initially developed by Fenton (1974). This framework consisted of four laterally discontinuous tills that were identified at surface; initially interpreted to represent one southwest-trending advance of ice from the Quebec–Labrador sector of the Laurentide Ice Sheet (LIS), and three southeast-trending advances and readvances of ice from the Keewatin sector of the LIS during the last glacial period (Fenton, 1974; Teller and Fenton, 1980). Recent stratigraphic study of the Roseau River area, 23 km to the south of Grunthal, confirmed the advance and retreat of ice along the southern margin of the LIS during the last interstadial (Gauthier et al., 2025). There, sands were deposited in both fluvial and shallow ice-marginal lake (glacial Lake Vita) environments, prior to the more significant advance of ice sometime after 30.4 ±2.3 ka. As such, the study area was glaciated at least twice during the last glacial cycle with ice-free conditions during parts of interstadial Marine Isotope Stage 3 (57–29 ka). It should be noted that the above history accounts for just ~11 m of the 70–90 m of Quaternary sediments in the region (Keller and Matile, 2021).

Plausible depositional environments for granular-aggregate deposition

To evaluate whether the buried granular-aggregate deposits near Grunthal are correlative, first, the depositional environment(s) in which they formed in needs to be determined, as well as their

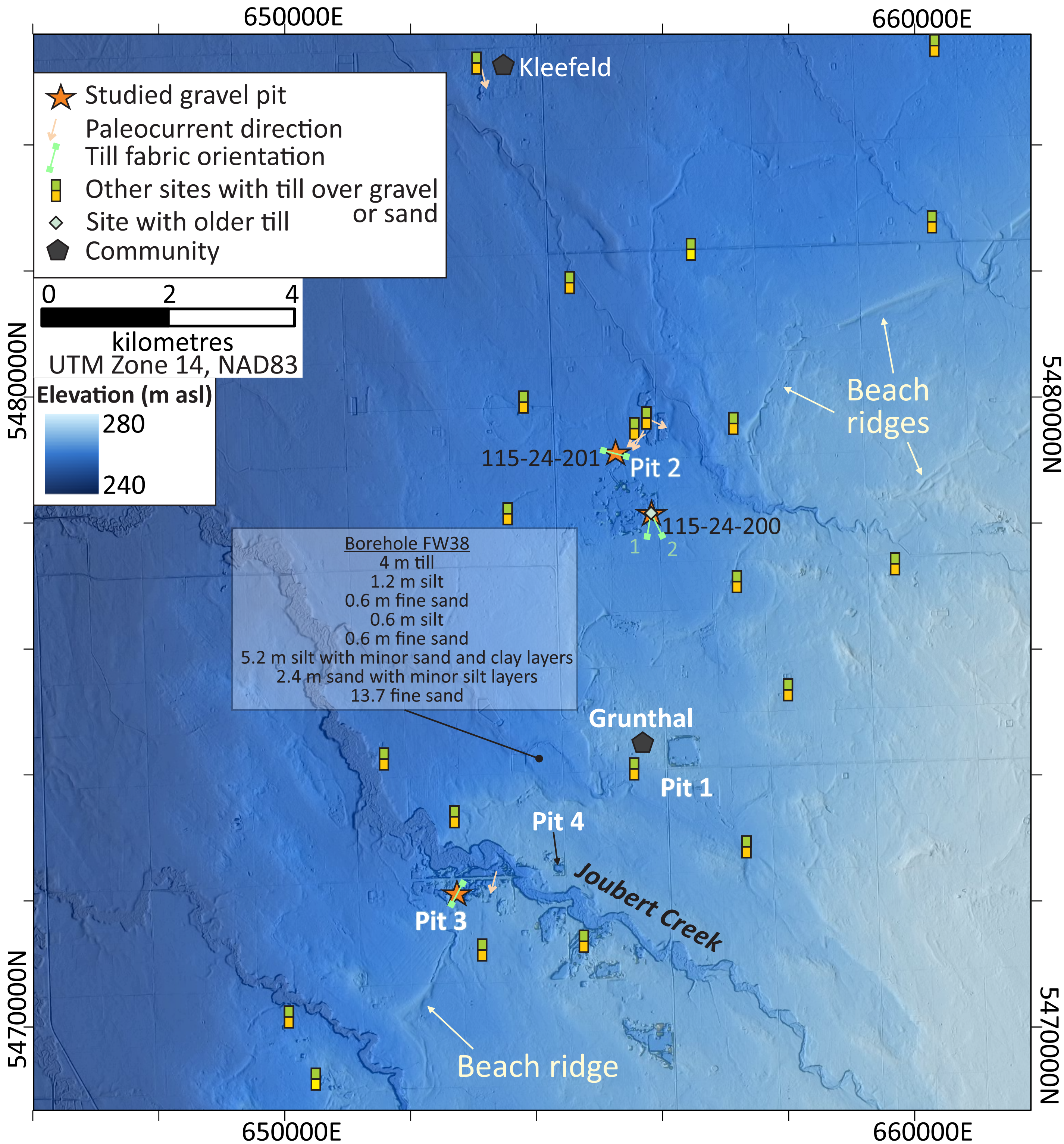

Figure GS2025-20-1: *The area around the town of Grunthal, south-central Manitoba, includes at least eight aggregate pits in deposits that have no topographic relief—only studied pits are labelled. Northeast-trending beach ridges separate the upper sand and till landscape (to the southeast) from the lower glaciolacustrine clay landscape (to the northwest). The background hillshade is derived from light detection and ranging (LiDAR) imagery (Manitoba Government, 2020). Borehole data is from Fenton (1974).*

stratigraphic relationships to other Quaternary sediments. The majority of the granular aggregate in Manitoba is from sediments that were deposited within environments related to the glaciers that crossed the province (James F. MacLaren Limited, 1980). In general, granular-aggregate deposits are formed either in front of a glacier, as proglacial fluvial outwash or proglacial lacustrine sediment, or under the glacier, as subglacial glaciofluvial sediment.

The distance from the ice margin affected the sediment supply and presumably flow rate as well; meaning that deposits with higher proportions of gravel—especially coarser gravel—were likely deposited closer to the ice margin. Geology and sediment provenance also played a factor, as the softer Paleozoic and Mesozoic bedrock breaks down faster into smaller grain sizes than the harder Precambrian shield bedrock (Figure GS2025-20-2).

Study area

The Grunthal area, south-central Manitoba, lies between ~257 and 267 m asl and is situated just east of the low-lying (240 m asl) Red River valley of central Manitoba (Figure GS2025-20-1). The local rise in topography is due to the thickness of Quaternary sediment (40 to 60 m in this poorly studied area; Keller and Matile, 2021) and not bedrock topography. Eight major aggregate pits have no topographic expression (Figure GS2025-20-1), attesting to the buried nature of the deposits. Most of the study area is mapped as till covered by a thin veneer of glaciolacustrine and/or glaciofluvial sediments, or as fine- to medium-grained sand deposited in moderate to shallow levels of glacial Lake Agassiz (Matile, 2004). The study area was glaciated by the Red River ice stream during the end of the last glaciation (Matile and Conley, 1979; Dredge and Cowan, 1989; Patterson, 1997; Harris et al., 2020; Gauthier et al., 2022), and by ice of unknown source at least twice prior to that (Fenton, 1974; Matile et al., 2023a;

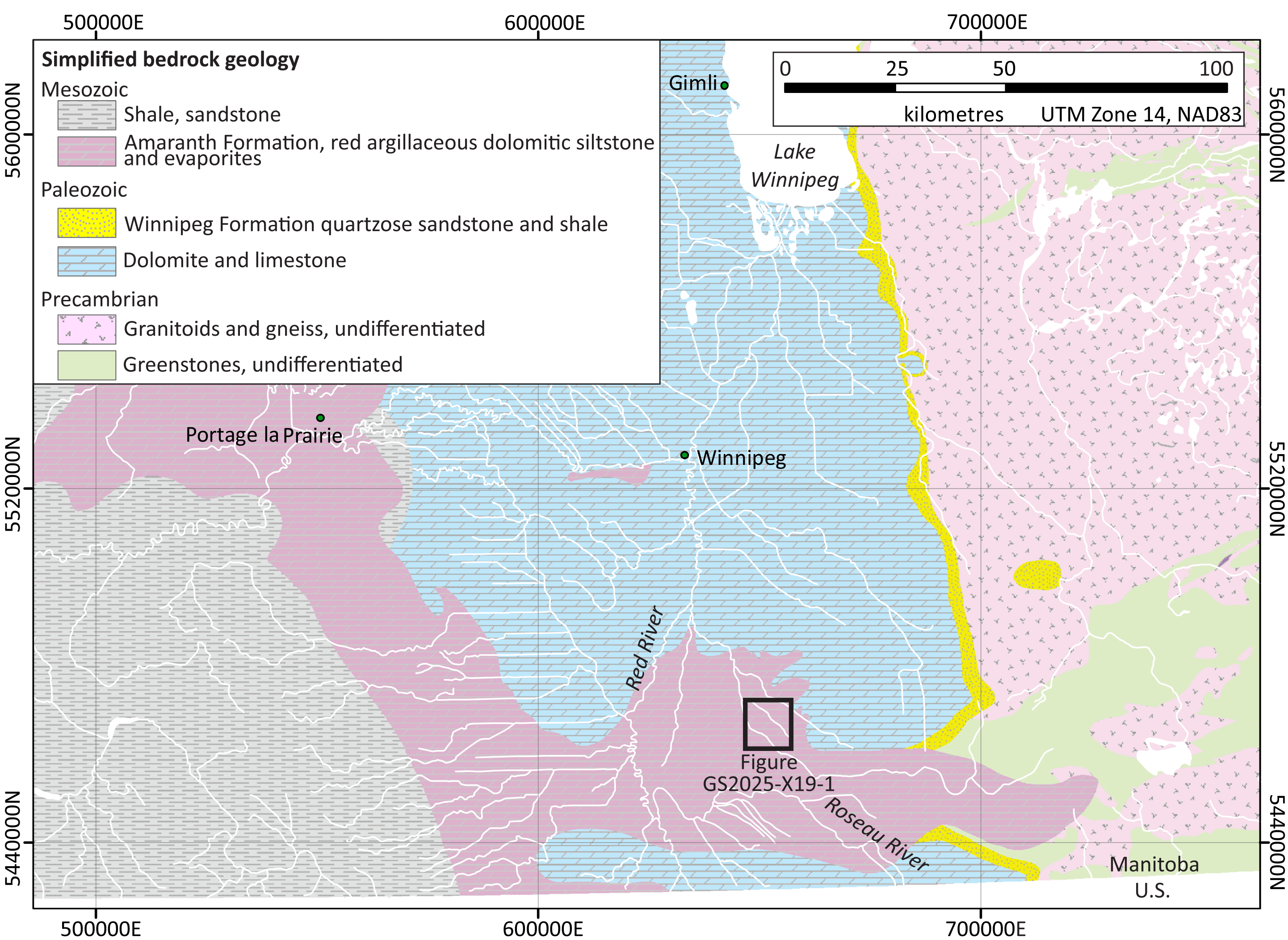

Figure GS2025-20-2: *Regional bedrock geology surrounding the study area (black square), modified from Manitoba Geological Survey (2024).*

Gauthier et al., 2025). The region was then covered by glacial Lake Agassiz, which formed beach ridges at the surface in higher areas and deposited clay in low-lying areas (Figure GS2025-20-1).

Methods

Two active gravel pits, north and southwest of Grunthal, Manitoba, were visited to investigate the Quaternary stratigraphy (pits 2 and 3; Figure GS2025-20-1). Lithofacies were defined based on texture, colour, sedimentary structures, clast content, stratigraphic position and the nature of contacts. Diamict and gravel samples were taken to compare with regional data (Thorleifson and Matile, 1993; Gauthier and Hodder, 2023). Clast-fabric measurements were conducted within the diamicts interpreted as tills, to determine the strain direction, which allows for an interpretation of the orientation of the ice flow that deposited the sediment (Holmes, 1941; Andrews and Smith, 1970). Fabric sites were chosen based on uniformity of diamict, where no sand lenses or discontinuous bedding was present. Clasts were carefully excavated and measured from within a 'box' consisting of three vertical faces of different orientations, over a maximum distance of 30 by 30 by 30 cm. Accepted clasts included in these analyses 1) were free to rotate in the matrix at the time of deposition (not clast supported or close to much larger clasts), 2) were rod-, tabular-rectangle– or wedge-shaped (ratio of the a:b axis was 1.5 or greater), 3) had a plunge of the a-axis less than 60° (average plunge of 18° with a standard deviation of 11°), and 4) had a plunge of the b-axis less than 60° (cf. Holmes, 1941). Clast-fabric data were represented graphically using Rockware® StereoStat v. 1.6.1. Ice-flow interpretations were assigned to the data based on stereonet patterns and rose-diagram patterns, in addition to the eigenvector of the largest eigenvalue or V_1 (Mark, 1974).

Results

Pit 1

The geology at this site is currently inaccessible, covered by colluvium or groundwater. According to a groundwater well record just north of the pit, the area consists of a till blanket (~1.5 m thick) over gravel (Manitoba Environment and Climate Change, unpublished data, 2025). A visit by the Manitoba Geological Survey (MGS) in 1979 noted "till that laterally transitions into or overlays interbedded and faulted fine-grained sand, coarse-grained sand and clay diamict" (site GM096; G.L.D. Matile and G.G. Conley, unpublished field notes associated with Matile and Conley, 1979).

Pit 2

The pit 2 area currently encompasses ~4.6 km^2 with several inactive and active pits (Figure GS2025-20-3). This study has identified four lithofacies at pit 2, ~3.3 km north of Grunthal, Manitoba (Figure GS2025-20-4). It must be noted, however, that the stratigraphic column represents a composite stratigraphy based on multiple exposures; the surface geology changes within as little as 200 m (Gauthier and Rentz, 2025[1]). The lowermost lithofacies (P2-A) is below groundwater. According to the pit operator in 2024, the dredged lithofacies contained ~12–24 m of sand and gravel (Figure GS2025-20-4a, b), with a few patchy 'clay' layers within that contained charcoal and wood. At several sites, P2-A is overlain by gravel or gravel and sand (up to ~2.5 m thick; lithofacies P2-B; Figure GS2025-20-4c, d). The gravel is poorly sorted, matrix to clast supported, and contains 40–90% fine pebble– to cobble-sized clasts in a medium- to very coarse grained sand matrix. Some clasts are striated, indicating a glacial origin. Lithofacies P2-B can be massive, and in one spot contains cross-beds, 0.8–1.0 m thick, that dip 18° to 232° and 26° to 210° (Figure GS2025-20-4c). A 0–2.7 m thick, laminated and overconsolidated diamict (lithofacies P2-C) overlies the gravel (Figure GS2025-20-4d, e). The diamict is light yellow–brown with a clayey–silty sand matrix and 15–20% clasts (Gauthier and Rentz, 2025). The clasts are granule to large cobble sized, sometimes faceted, and dominantly carbonate (74.8 ct. %; Figure GS2025-20-4f).

Lithofacies P2-C is interpreted as a subglacial traction till, based on the consolidated nature, texture, clast shape, clast fabric and lateral continuity (cf. Evans, 2018). A spread-unimodal clast fabric (S_1 = 0.66, n = 32) was measured from lithofacies P2-C and interpreted to have formed by west-northwest or east-southeast flowing ice (286–106°; Figure GS2025-20-4a; Gauthier and Rentz, 2025, Table 7.2). The high carbonate content suggests that ice flow was likely to the east-southeast (106°). The uppermost lithofacies (P2-D) is a 0.15–0.60 m thick sandy gravel to gravelly sand (site 115-24-201; Gauthier and Rentz, 2025).

Interestingly, there are two other diamicts interpreted as till in the pit 2 area at site 115-24-200 (Figure GS2025-20-3; Gauthier and Rentz, 2025). There, an upper (1.5 m thick) grey-brown till with a silty sand matrix and 5% clasts overlies a lower (>0.6 m thick) light olive–brown till with a clayey–sandy silt matrix and 5–10% clasts (Gauthier and Rentz, 2025). Both tills are highly overconsolidated and have a blocky and friable structure with oxidation staining along joints. These tills have measured clast fabrics interpreted to have been formed by ice flowing to the south-southeast (~158°) and south (~189°), respectively, and are relatively less calcareous (65.4–68.4 ct. % carbonate clasts; Gauthier and Rentz, 2025).

Pit 2 area preliminary interpretation

Pit 2 area consists of complex changes in surficial sediments over as little as 200 m (Figure GS2025-20-3). These changes

[1] MGS Data Repository Item DRI2025025, containing the data or other information sources used to compile this report, is available online to download free of charge at https://manitoba.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Business, Mining, Trade and Job Creation, 360-1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

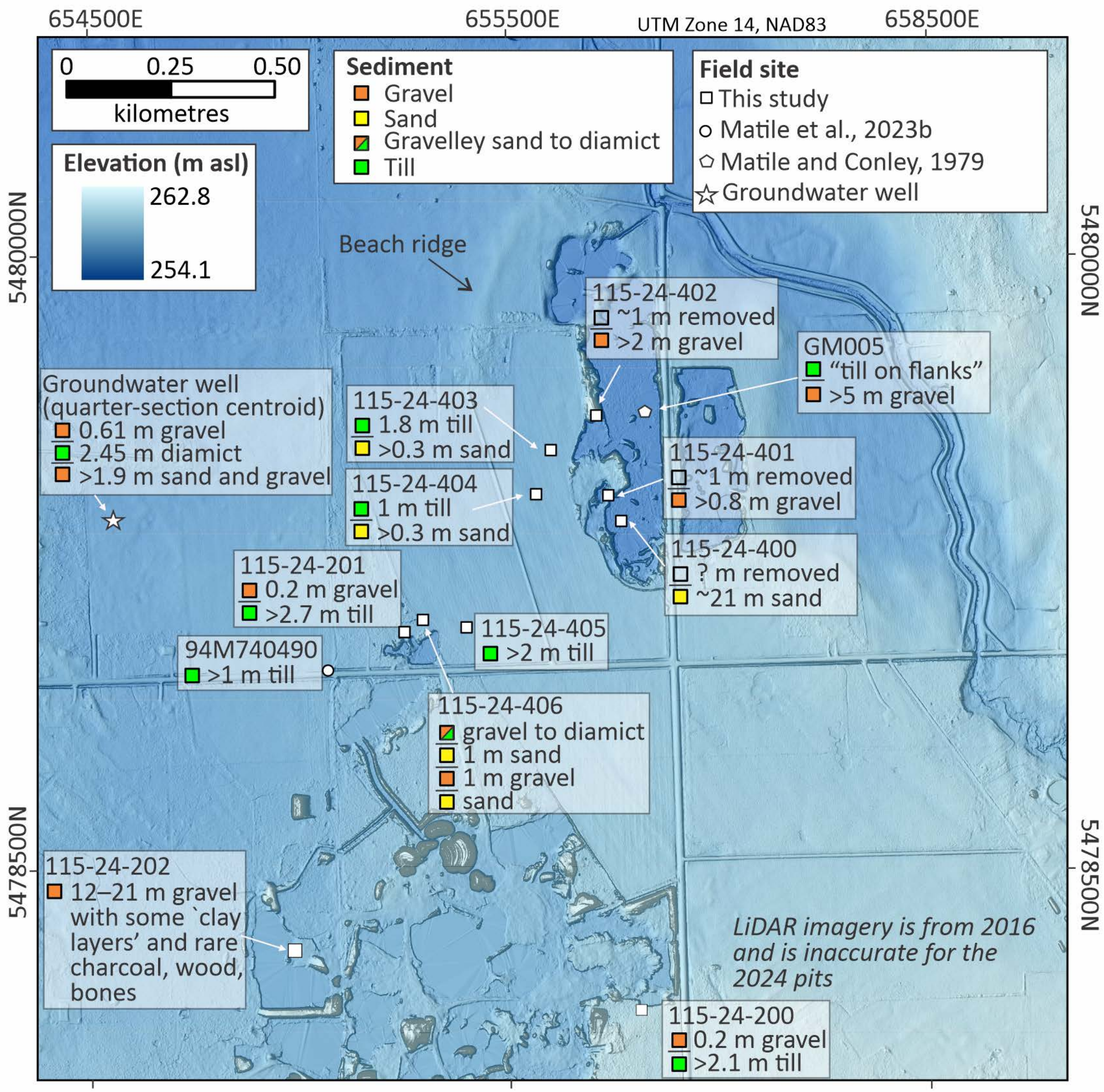

Figure GS2025-20-3: *Pit 2 area, ~3.3 km north of Grunthal, Manitoba, encompasses ~4.6 km^2 with complex surficial geology. Sites shown are from 2024 fieldwork (Gauthier and Rentz, 2025), historical data (Matile and Conley, 1979; Matile et al., 2023b) and groundwater well data (Manitoba Environment and Climate Change, unpublished data, 2025). The background hillshade is derived from light detection and ranging (LiDAR) imagery (Manitoba Government, 2020).*

have no topographic expression, suggesting that while glacial Lake Agassiz modified the surface (planed/denuded) it did not deposit sediments in the area. Instead, the landscape appears to be a patchy fragmented mosaic of whatever sediments were previously deposited. The composition of the pit 2 younger till is similar to that of the underlying gravel, perhaps signifying that the gravel has the same source as the till. In contrast, the paleo–ice-flow directions suggest different source areas for the till and gravel. Clearly, more work is needed to untangle the geological history of this area.

Pit 3

Pit 3, ~3.3 km southwest of Grunthal (Figure GS2025-20-1), was studied in the field in 2022 (sites 115-22-303 and 115-22-304,

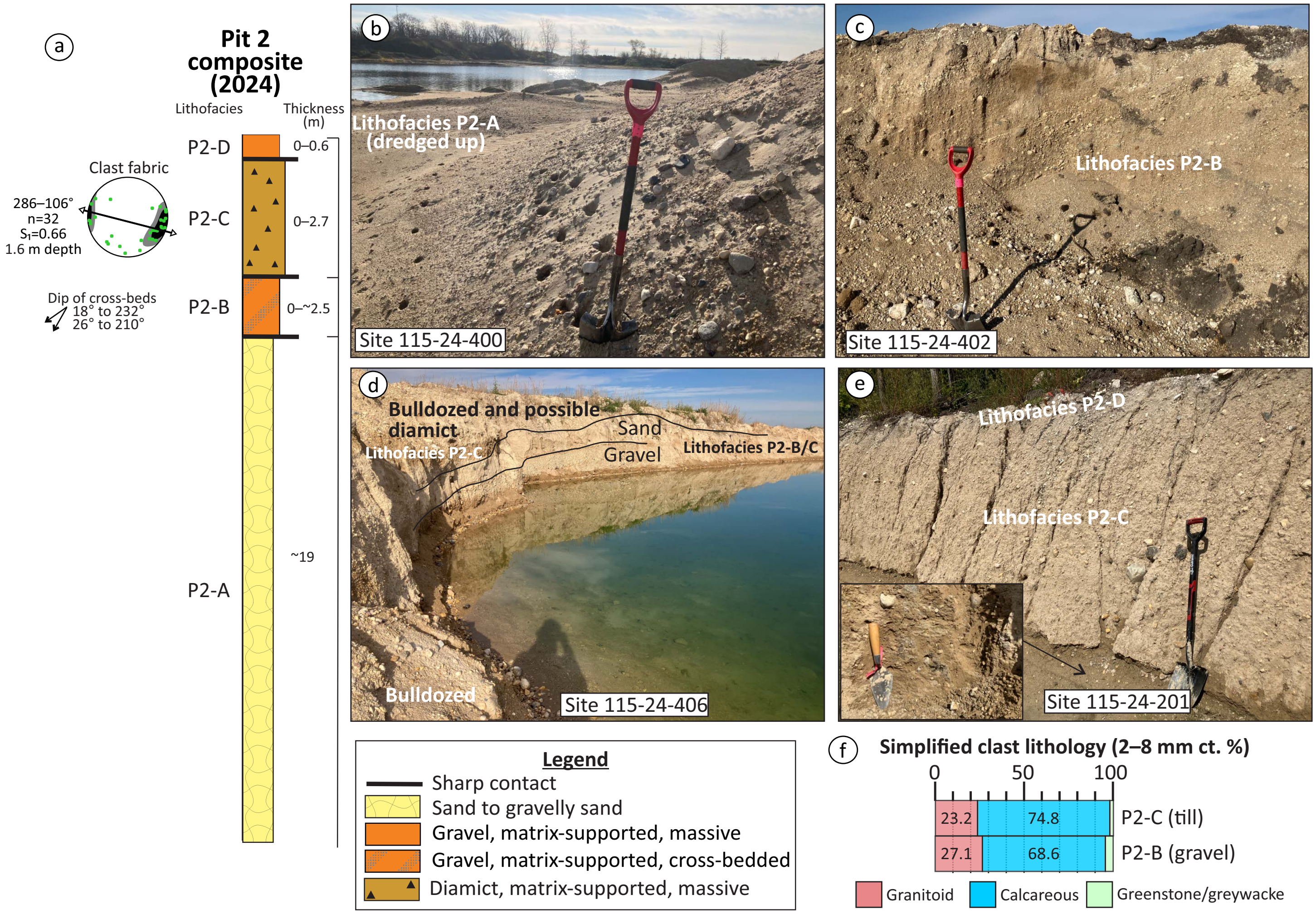

Figure GS2025-20-4: *Stratigraphic section showing the composite lithofacies for the pit 2 area* ***(a)****, which includes sand and gravel* ***(b)****, massive to cross-bedded gravel* ***(c, d)****, a calcareous diamict interpreted as a till* ***(e, f)*** *and a thin sandy gravel to gravelly sand (top of e).*

Gauthier and Hodder, 2023). This study has identified five lithofacies at pit 3 (Figure GS2025-20-5a). The lowermost lithofacies (P3-A) is a clast-supported, poorly sorted, imbricated, horizontal to chaotically bedded gravel, >5 m thick, with a fine-grained sand matrix and 40–60% subrounded to rounded clasts that are granule to large cobble sized (Figure GS2025-20-5b, c). According to the pit operator, lithofacies P3-A has a regionally variable thickness (0–30 m) and sporadically contains megafauna fossils. At the studied site, P3-A is overlain by a sand-filled channel, about 8 m wide and up to 2 m deep (lithofacies P3-B; Figure GS2025-20-5b). The sand is fine to medium grained and has beds 1–10 cm thick that drape the channel structure (Figure GS2025-20-5d). Overlying lithofacies P3-B is 0.3 m of clast-supported, poorly sorted gravel with a fine-grained sand matrix and 60% rounded to subrounded clasts that are granule to large cobble sized (lithofacies P3-C), similar to lithofacies P3-A (Figure GS2025-20-5d). The lower contact of lithofacies P3-C is sharp and undulatory. Preliminary analyses, from just one sample, show that the clasts are derived equally from the Precambrian shield (49%) and Paleozoic carbonate rocks (51%; Figure GS2025-20-5f). There are a few smaller sand-filled channels at similar elevations around the pit, though most of the pit exposes only gravel. A 1.25 m thick, laminated and overconsolidated diamict (lithofacies P3-D) overlies the gravel (Figure GS2025-20-5e). The diamict is light olive-brown with a silty sand matrix and 15% clasts (sample 115-22-304-A01, Gauthier and Hodder, 2023). The clasts are granule to medium pebble sized, sometimes faceted, and more calcareous than those within the underlying gravel (67.1 versus 50.6 ct. %; Figure GS2025-20-5f; Gauthier and Hodder, 2023).

Lithofacies P3-D is interpreted as a subglacial traction till, based on the consolidated nature, texture, clast shape, clast fabric and lateral continuity (cf. Evans, 2018). The lower contact with the gravel and sand is transitional over 0.3 m, indicating erosion and incorporation of the underlying unit into the till. A spread-unimodal clast fabric (S_1 = 0.67, n = 31) was measured from lithofacies P3-D and interpreted to have been formed by south-southwest flowing ice (~209°; Figure GS2025-20-5a; Gauthier and Hodder, 2023). The uppermost lithofacies (P3-E) exposed in the pit is a 0.25 m thick sandy soil that over-

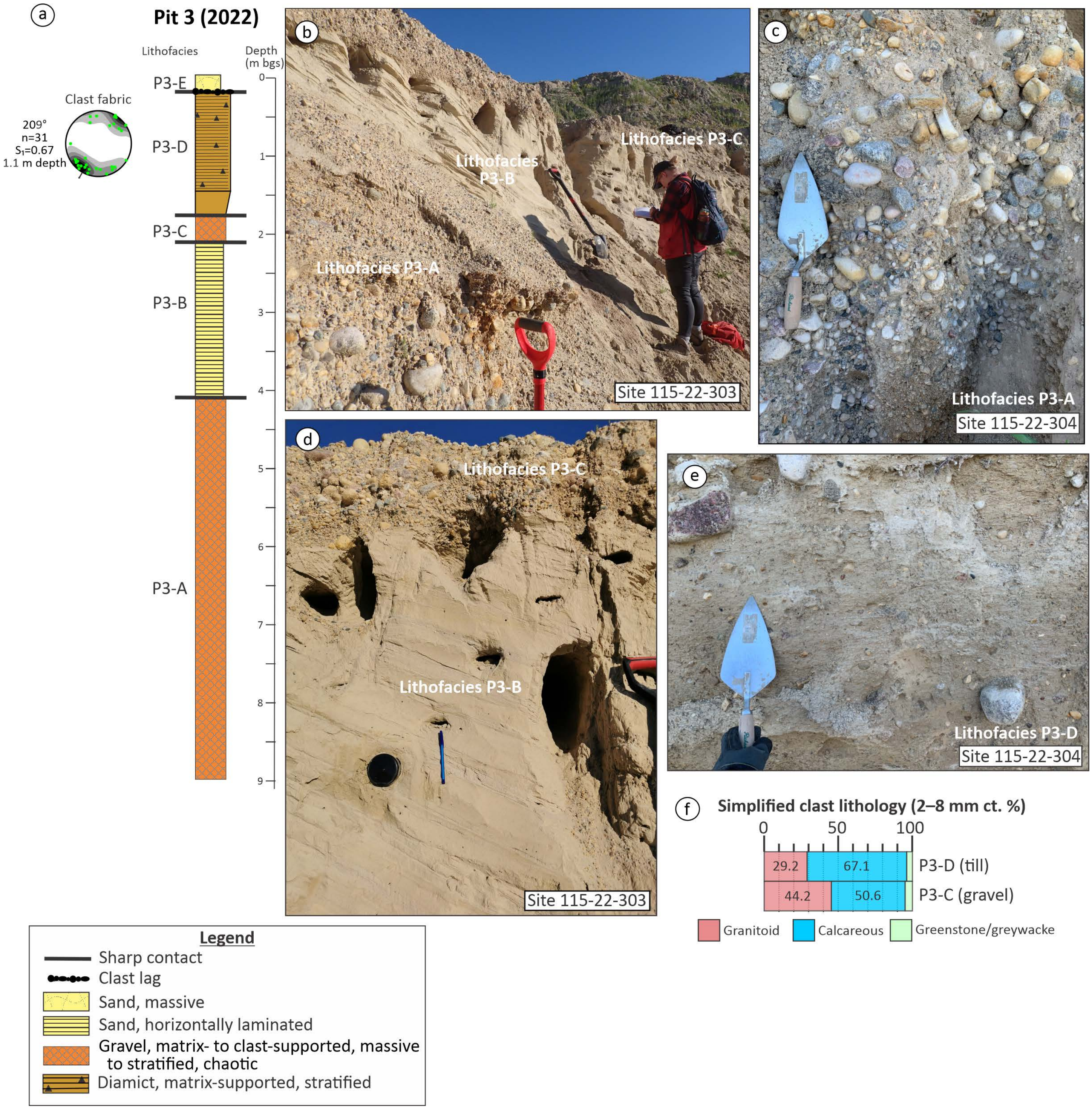

Figure GS2025-20-5: *Stratigraphic section* ***(a)*** *for Pit 3, ~3.3 km southwest of Grunthal, Manitoba, which exposes thick gravels* ***(b–d)****, with a sandy channel fill (b, d). The eastern side of the pit preserves the original surface, where laminated diamict* ***(e)*** *overlies gravel; the diamict is more calcareous than the gravel* ***(f)****. Details are in Gauthier and Hodder (2023, Appendices 1–8, sites 115-22-303 and 115-22-304). Abbreviation: bgs, below ground surface.*

lies a 0.05 m thick layer of clasts that vary from fine-pebble to large-cobble size (Gauthier and Hodder, 2023, Figure 24).

Pit 3 interpretation

The composition of the Pit 3 till is different than that of the underlying gravel. The elevated Precambrian shield clast concentration in the buried gravel suggests the source of this gravel was situated to the east or northeast (cf. Figure GS2025-20-2). The clast-supported, poorly sorted, subangular–subrounded, imbricated, horizontally to chaotically bedded nature of the gravel (sites 115-22-303 and 115-22-305) together with the mixed clast lithologies, requires a glacial source for the gravel. While these near-surface subtill gravels have variably been attributed as esker sediments (C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007) or kame-delta sediments (Fenton, 1974), it is suggested the gravel was likely deposited as proglacial outwash during ice-margin retreat during an earlier interstadial or interglacial period.

Pit 4

The geology at this site is inaccessible, as it is an inactive and partially reclaimed pit. According to a groundwater well record just to the southeast, the area consists of a till plain (~4.0 m thick) over gravel (Manitoba Environment and Climate Change, unpublished data, 2025).

Other sites

A compilation of previous work shows at least seven additional sites in the study area where till overlies gravel or sand (G.L.D. Matile and G.G. Conley, unpublished field notes associated with Matile and Conley, 1979), and one borehole with till overlying >24 m of sorted sediments (Figure GS2025-20-1; Fenton, 1974, FW38). Subtill sediments vary over short distances; dominantly sand to gravelly sand to gravel, well to poorly sorted and clast to matrix supported. Three sites expose crossbeds, with an apparent dip of 16° towards 196° near pit 3 (Figure GS2025-20-6), towards 130° near pit 2 (historical site GM005, Matile and Conley, 1979), and towards 170° near Kleefeld (historical site GM003, Matile and Conley, 1979; Figure GS2025-20-1). An additional borehole, ~7 km east-northeast of Grunthal, encountered 4 m of fine sand over 8.5 m of clay, 1.8 m of till, 2.7 m of silt, 1.5 m of sand and another 7.3 m of till (site FW39, Fenton, 1974). It should be stressed that till does not always overlie the presumably older sorted sediments; they are sometimes at surface in both the Grunthal and Roseau River areas (Gauthier and Hodder, 2023; Gauthier et al., 2025).

Regional boreholes

Two rotosonic boreholes drilled in the 1990s, ~13 km south and ~15 km southeast of Grunthal, encountered 68–70 m of Quaternary sediments overlying bedrock (drillholes Q and R, originally discussed in Thorleifson and Matile [1993] with data and stratigraphy released in Matile et al. [2023a]). These boreholes drilled into approximately four different diamict packages, interpreted as tills, separated by proglacial or nonglacial lacustrine, pond or fluvial sediments. In those two spots, sand was encountered below till at 10.5 and 19 m, respectively, whereas gravel was not encountered. Thus, while the correlation to the Grunthal gravel(s) is uncertain, it's clear the study area has a depositional record that spans multiple glacial-interglacial cycles.

Figure GS2025-20-6: *This aggregate pit wall exposes 4 m of gravelly sand, the lower half of which is cross-bedded (dip indicated by black arrow); situated just east of Pit 3 (Figure GS2025-20-1).*

Discussion

The buried granular-aggregate deposits near Grunthal have variably been attributed as Holocene (Fenton, 1974; Thorleifson and Matile, 1993) or older (Matile and Conley, 1979) kame-delta sediments and/or Late Wisconsin or older esker sediments (Matile and Conley, 1979; C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007). The clast-supported, poorly sorted, subangular–subrounded, imbricated, horizontally to chaotically bedded nature of the gravels, together with the mixed clast lithologies, confirm a glacial source(s) for the gravel. Spatially variable changes in matrix support, sorting and rounding of clasts likely reflects varying distances of deposition from the ice margin, and variable re-entrainment of sediments, allowing for the possibility of multiple granular deposits from different environments of deposition. Any faunal evidence (e.g., C.R. Harington, G.A. Young, A. Telka and G.L.D. Matile, unpublished poster, 2007) favours a proglacial, rather than subglacial, source—unless the fossils are badly weathered and clearly travelled. The more fossils found, the more likely they are to be in situ or near to that.

Timing of deposition is still questionable, as the granular aggregates were likely deposited during ice-margin retreat in an earlier interstadial and/or interglacial period(s).

Provenance of deposits?

As previous work confirms, there are multiple patchy fragmented tills at surface (Fenton, 1974; Teller and Fenton, 1980; Gauthier and Hodder, 2023), and it's unclear how many different near-surface buried granular-aggregate deposits there are. Theoretically, the lower the carbonate clast concentration, the higher likelihood of an eastern or northeastern provenance, where Precambrian rocks outcrop (45–48 km east to northeast of Grunthal; Figure GS2025-20-2; Manitoba Geological Survey, 2024). The clast fabrics measured on tills herein are interpreted to suggest ice flowed to the east-southeast (pit 2, overconsolidated), south-southwest (pit 3) and south-southeast and south (pit 2, very overconsolidated and stained). There is no clear correlation with till-carbonate content, much as reported in Gauthier and Hodder (2023, Figure 7) where surface tills contain between 60.4 and 96.2 ct. % Paleozoic clasts. The five paleocurrent measurements from granular deposits suggest glacial meltwater similarly flowed to the south, southwest and possibly southeast. Interestingly, the gravels where paleocurrent flow was to the southwest (pit 2) do not have the highest Precambrian shield clast concentration measured (31.4 ct. % versus 49.4 ct. % at pit 3). As such, paleocurrent and paleo–ice-flow directional data suggest that both the tills and the gravels contain a mix of compositions, with no obvious correlation to source. As such, the specific source of granular aggregate is still questionable; likely reflecting re-entrainment of previously deposited sediments combined with distally derived sediment by water and ice flowing from the northwest, north and northeast.

Future work

Surficial mapping studies that incorporate new field observations, legacy datasets and high-resolution LiDAR elevation models are needed to better understand the type, genesis and relative age of surface and near-surface sediments. Chronological studies that consider the age(s) of these deposits, such as optical or radiocarbon dating, are also necessary. This will be essential for the discovery of new buried aggregate deposits in the area.

Economic considerations

Granular aggregate is a vital part of Manitoba's economy, as it provides essential materials for the construction and maintenance of Manitoba's infrastructure. With the increasing scarcity of aggregate resources in south-central Manitoba, it is imperative to be able to effectively identify and map the buried extent of shallow-buried aggregate resources. The Grunthal area contains high-quality reserves of granular aggregate of unknown extent. Understanding the geological origin of these known deposits is the first step to be able to effectively identify and map the extent of new granular-aggregate deposits.

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