Paris and Galt Moraines, Southern Ontario: Depositional Elements, Paleoglacial Implications, and Hydrogeological Applications

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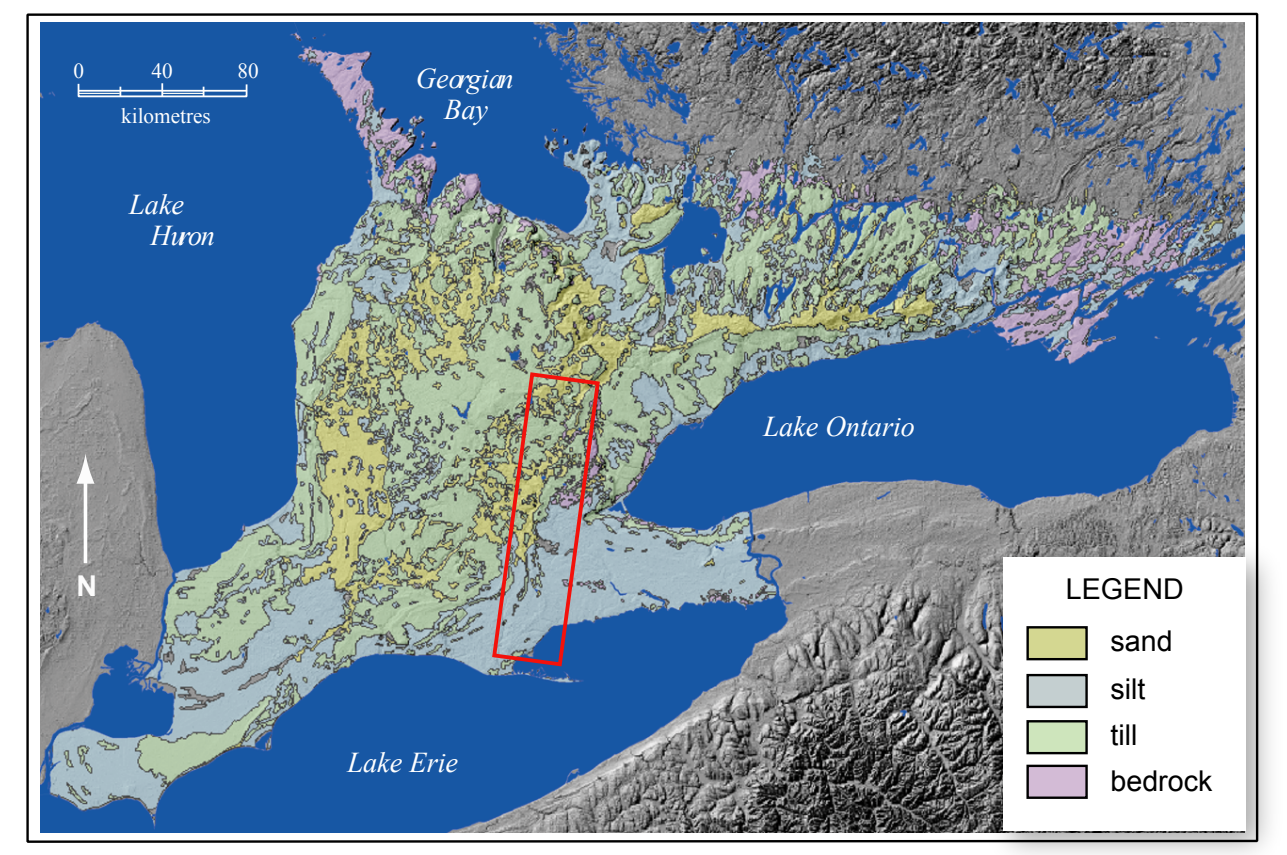

Figure 1. Map of southern Ontario and simplified surficial geology. Extent of the Paris and Galt moraines is indicated by red rectangle. Geology modified from Barnett et al., (1991).

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Abstract

Moraines have been mapped in Southern Ontario for nearly one hundred years (Taylor, 1913), yet their composition and depositional origin remains poorly understood. Moraines in this area have been assigned to one of two classes: i) stratified interlobate moraines and ii) till or recessional moraines. The Paris and Galt moraines were assigned to the till or recessional moraine class (eg. Chapman & Putram, 1943).

The Paris and Galt moraines are 130 km long, are up to 11 km wide, and have relief of 30 m. They evolve from two distinct ridges in the south to a broad hummocky terrain with multiple ridges and secondary landscape elements (kettle depressions, eskers, subaerial fans, channels) northward. These geomorphic changes are mirrored by changes in geology, thickness, and stratigraphy.

Continuous cores from boreholes reveal that the Paris moraine consists of a succession of intercalated gravel and diamicton. Depending on the geographic location, a number of units can underlie the moraine, including bedrock, older till, lacustrine sediment, and glacifluvial gravel. Outcrop data suggest northern and southern parts of the moraine are different. Within the southern mud-rich glacilacustrine basin, large sand and gravel foresets of 10 m height occur at the base of pit exposures. By contrast, horizontally stratified outwash gravel is common in northern pits. Wentworth Till covers a large part of the moraine, it is massive to stratified and is locally interbedded with sand and gravel. Where overlain by the surficial gravel, its upper contact can be loaded.

The moraine strata are interpreted to have been deposited by a fluctuating, retreating ice margin with a highly variable meltwater flux both, spatially and temporally. The narrow, southern moraine ridges may represent more rapid deposition within a glacial lake basin, whereas the northern, broader hummocky terrain is interpreted to have been deposited in a terrestrial environment. The moraine is significant hydrogeologically because the hummocky terrain may enhance recharge to bedrock and sand and gravel aquifers at depth.

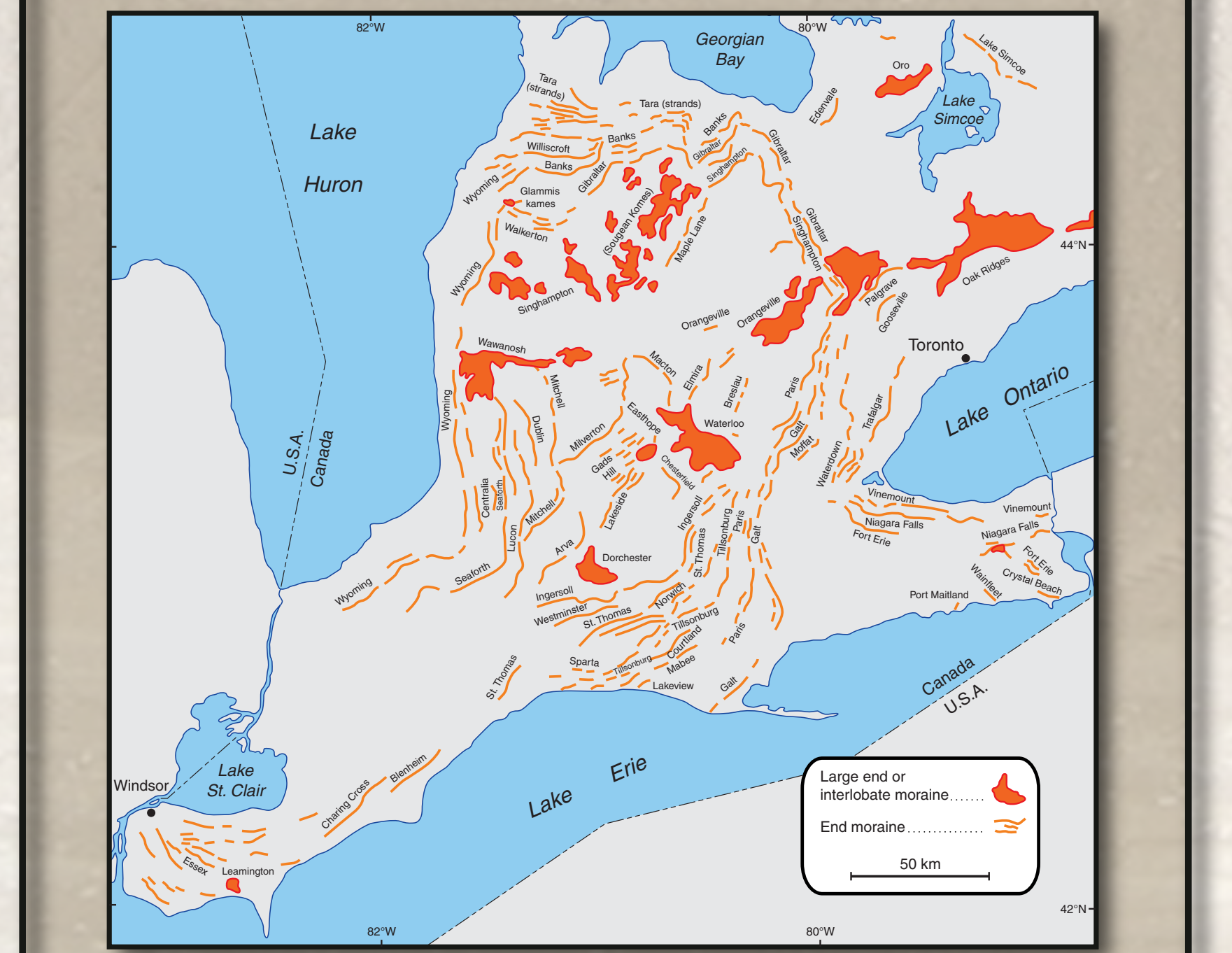


Figure 2. Distribution and extent of moraines in southern Ontario. Larger interlobate moraines have an areal extent of ~ 2500 km². The more linear, till - covered moraines, such as the Paris and Galt moraines, have a cumulative area of > 4200 km². Map is redrawn from Barnett (1992).

Moraine Landscape

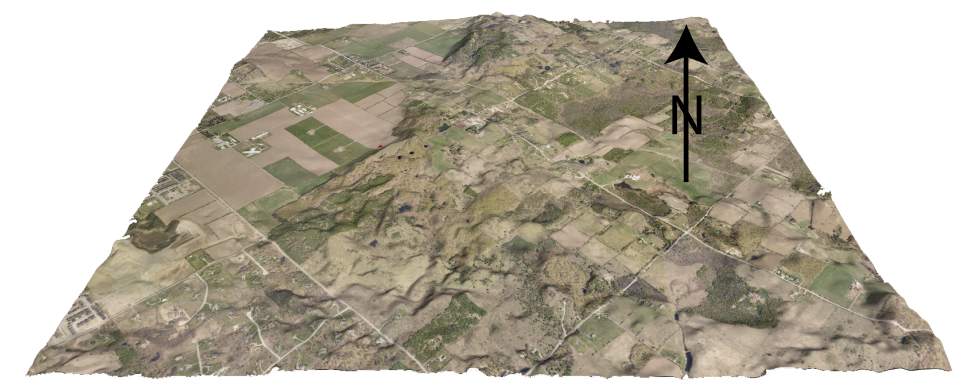


Figure 3. Perspective view toward the north of hummocky terrain in the vicinity of Guelph. Note plain to west, chaotic elevated terrain, and subdued terrain to east.

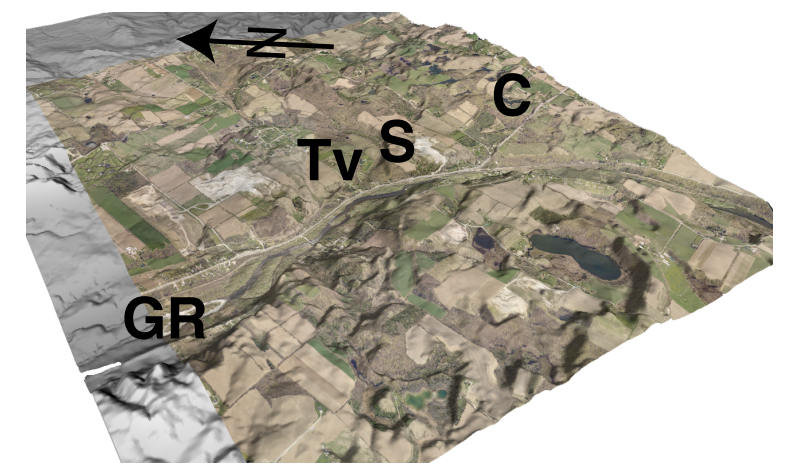


Figure 4. Perspective view toward the southeast of Grand River valley (GR), incised paleo -valley trending eastward (Tv), raised valley shoulders (S), and hummocky terrain (C).

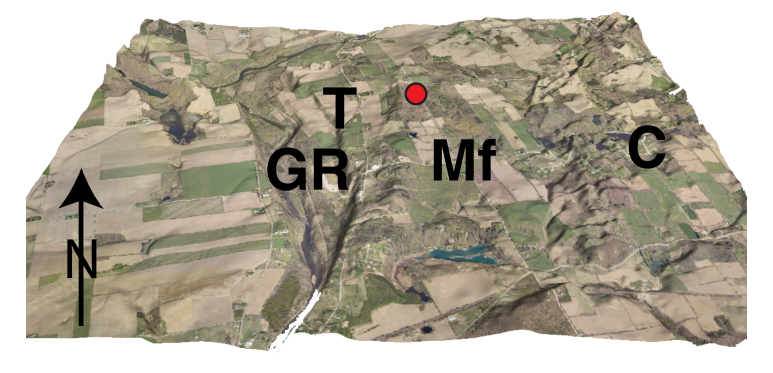


Figure 5. Perspective view toward the north of Grand River valley (GR), valley terraces (T), moraine foreland (Mf), north trending belt of hummocky terrain (C). Note numerous small steep-sided ridge elements within hummocky terrain. Red dot is location of borehole in figure 6.

- There is a need for improved landform analysis of moraine elements.
- Karrow (1968) identified esker and outwash fan sub-elements of moraine.
- Sadura et al., (2007) identified outwash fans; and hill-hole topography.
- Moraine landscape is complex with many sub-elements that have yet to be characterized and explained, for example tunnel valleys.

Moraine Stratigraphy

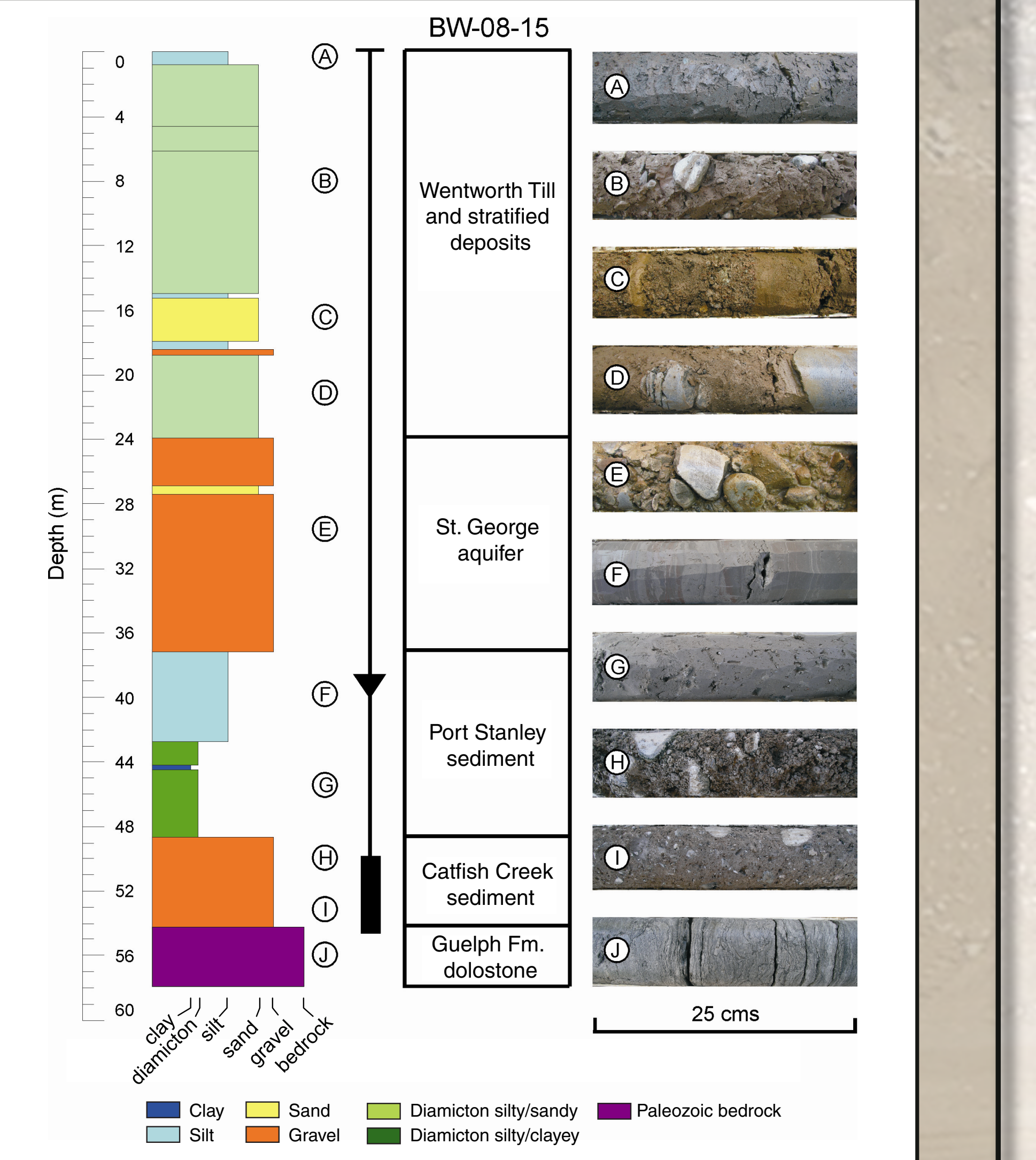


Figure 6. Stratigraphic column for borehole BW-08-15 showing representative photos of sediment facies encountered in the Paris and Galt moraine area. Piezometre location (rectangle) and static water level (arrow) are shown to the right of the sediment log (Bajc, 2007).

- Detailed core logging supported stratigraphic analysis is limited to Cambridge - Oakville area.
- Difficult to fully characterize moraine stratigraphy and composition due to lack of data support.
- Moraine locally overlies Port Stanley Till and a thick succession of coarse-textured sediment.

Moraine Thickness

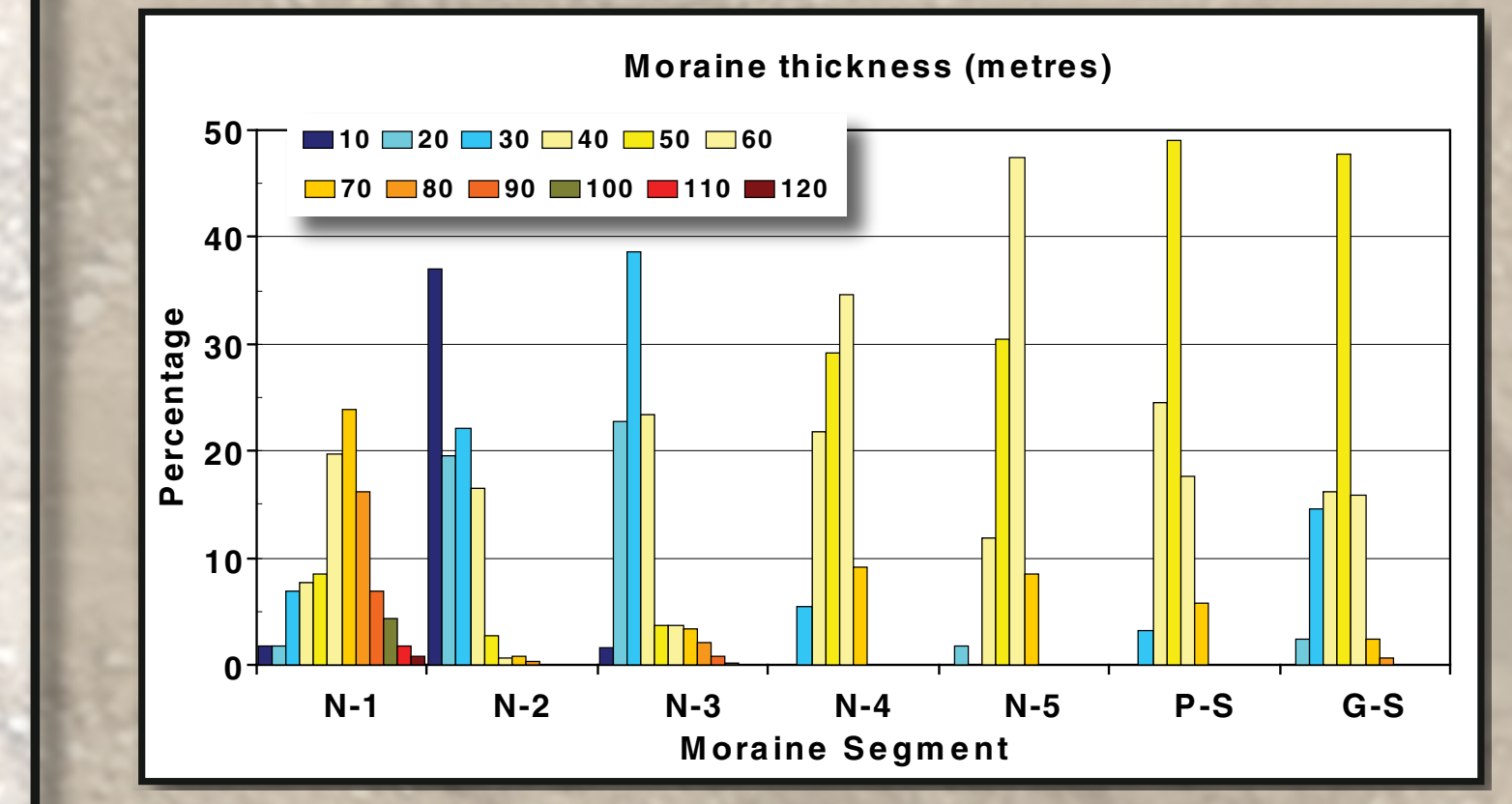


Figure 7. Histograms of moraine thickness grouped by moraine segment. Derived from OGS sediment thickness DEM (1 km grid).

Stratigraphic Composition

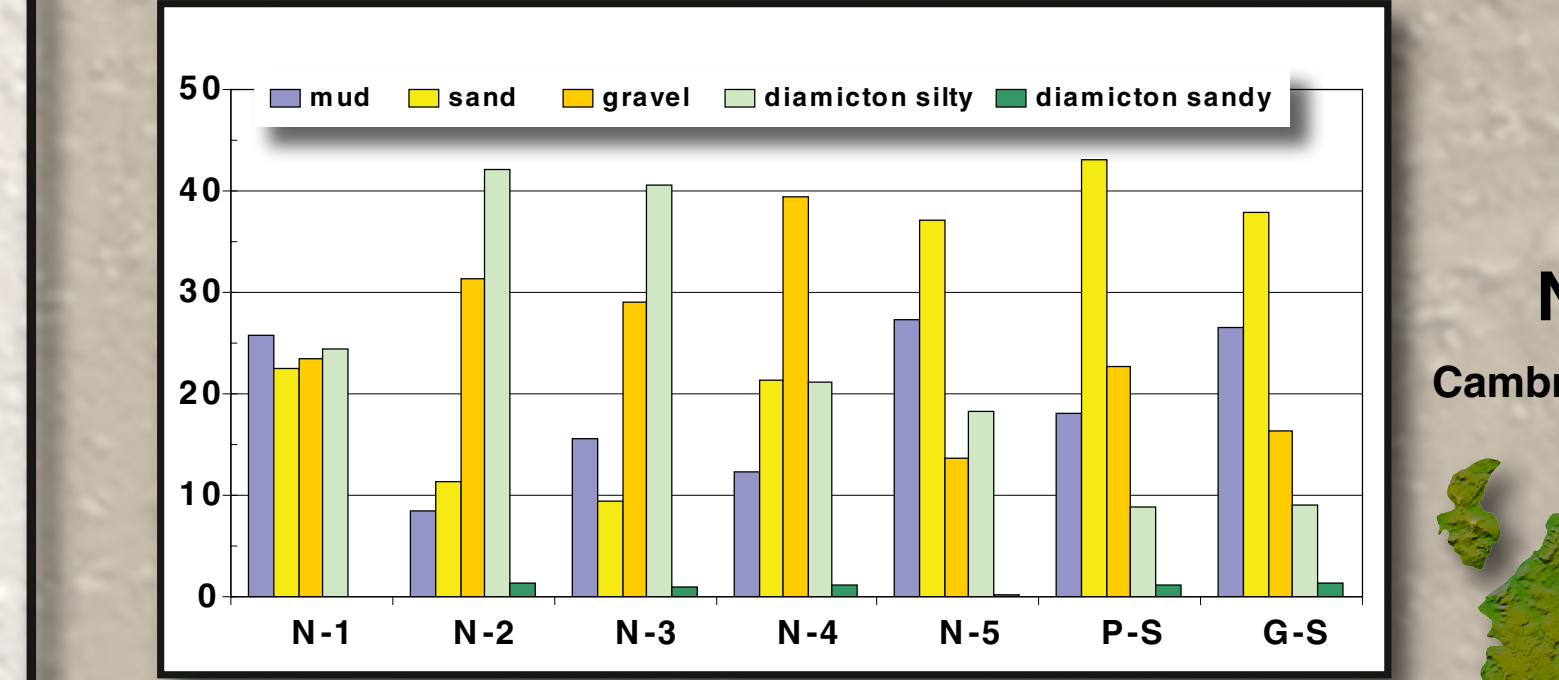


Figure 8. Histogram of sediment composition in MOE waterwell records from within the mapped moraine extent. Data is to bedrock and may include stratigraphy that underlies the moraine. Codes are based on waterwell coding of Russell et al. (1998).

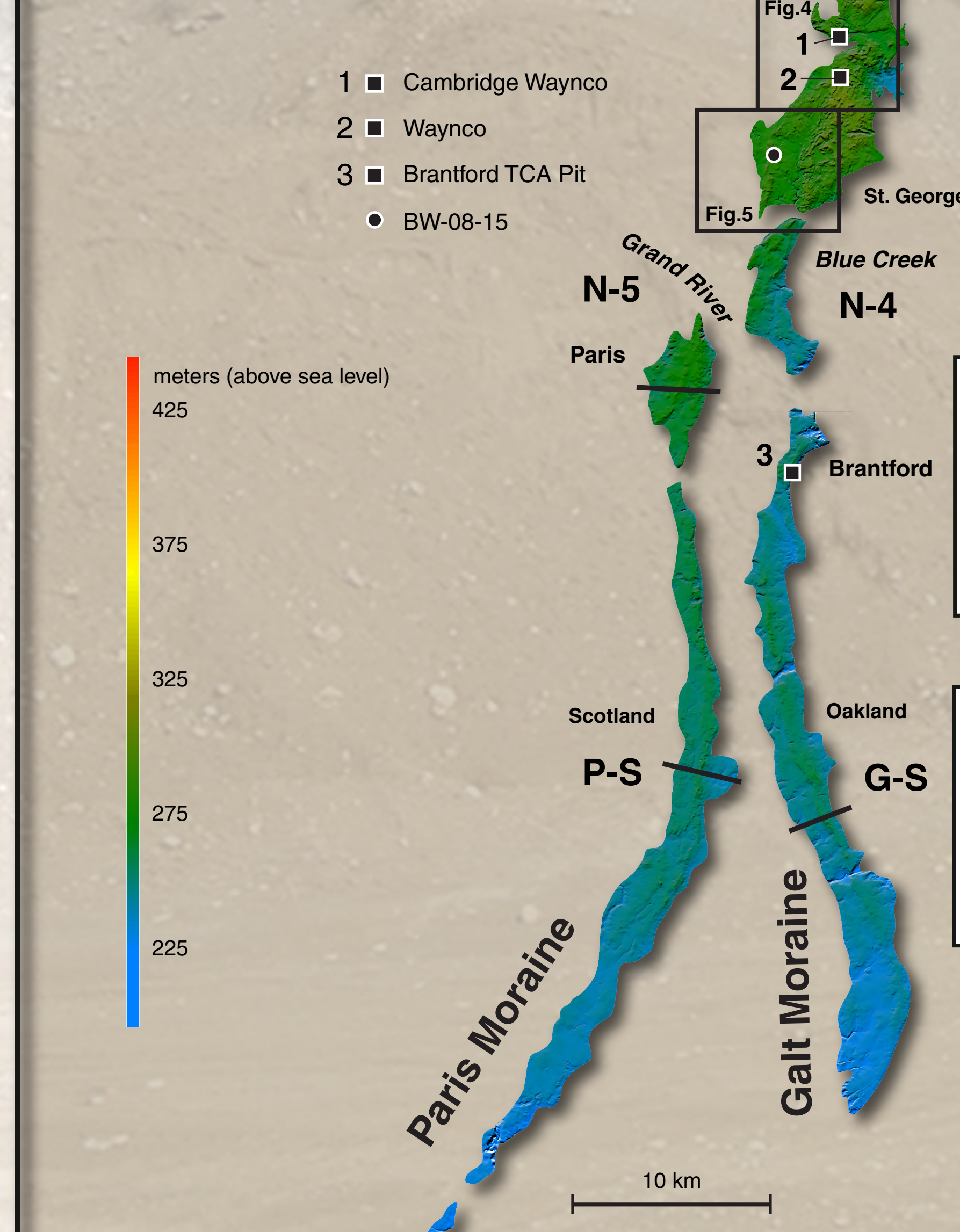


Figure 9. Colour ramp DEM enhancement of the moraine topography. Note change in moraine elevation from north to south. Moraine is segmented into 7 distinct areas by modern and paleo-drainage channels. DEM from Ontario Ministry of Natural Resources.

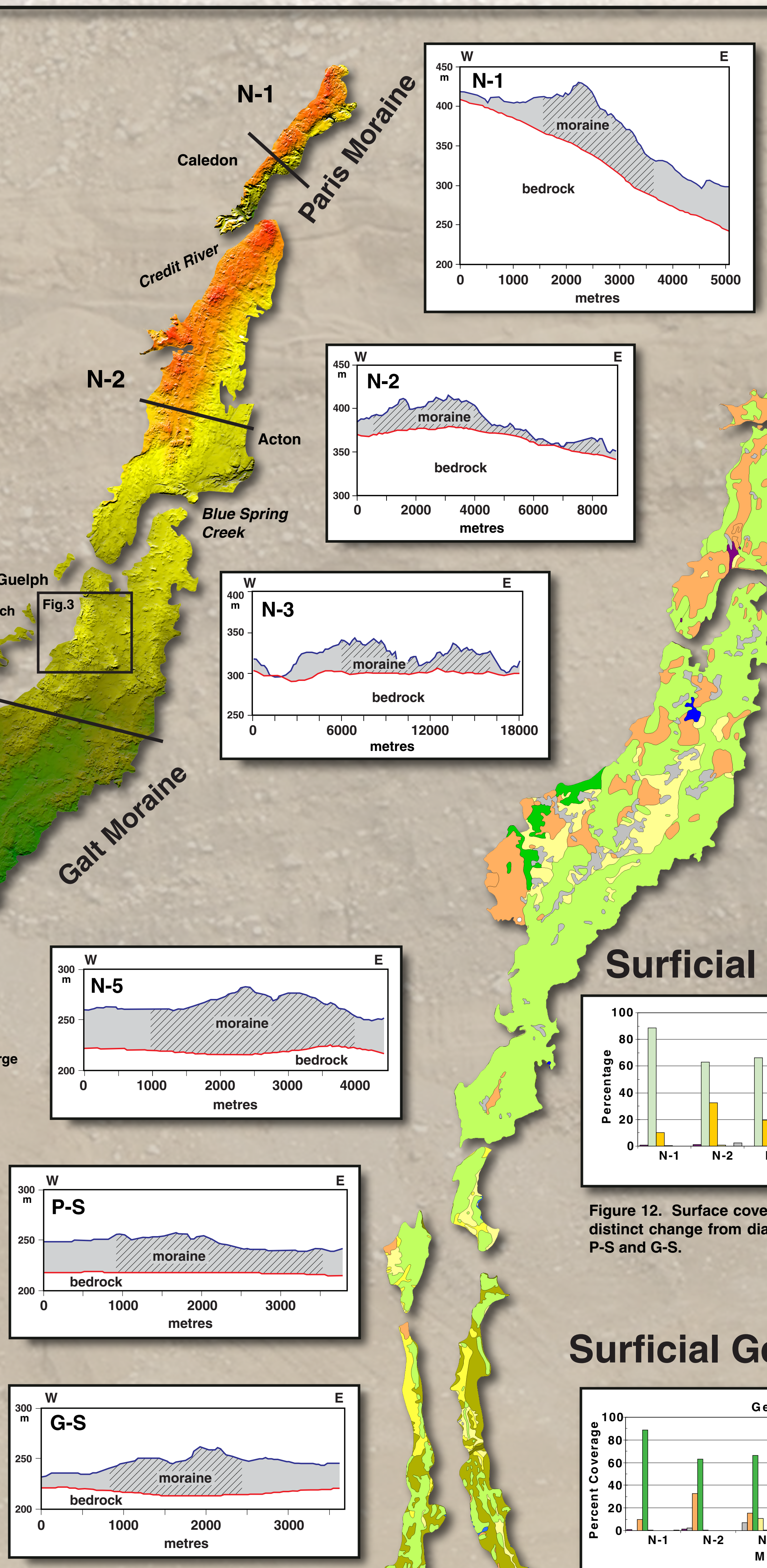


Figure 10. Illustrative cross-sections of the moraine. Note changes in bedrock topography, moraine thickness, morphophology and moraine width.

Figure 11. Surficial geology of the moraine. Note predominance of Wentworth till in northern moraine segments. Geology is simplified from the OGS seamless geology (OGS, 2003).

Surficial Material Type

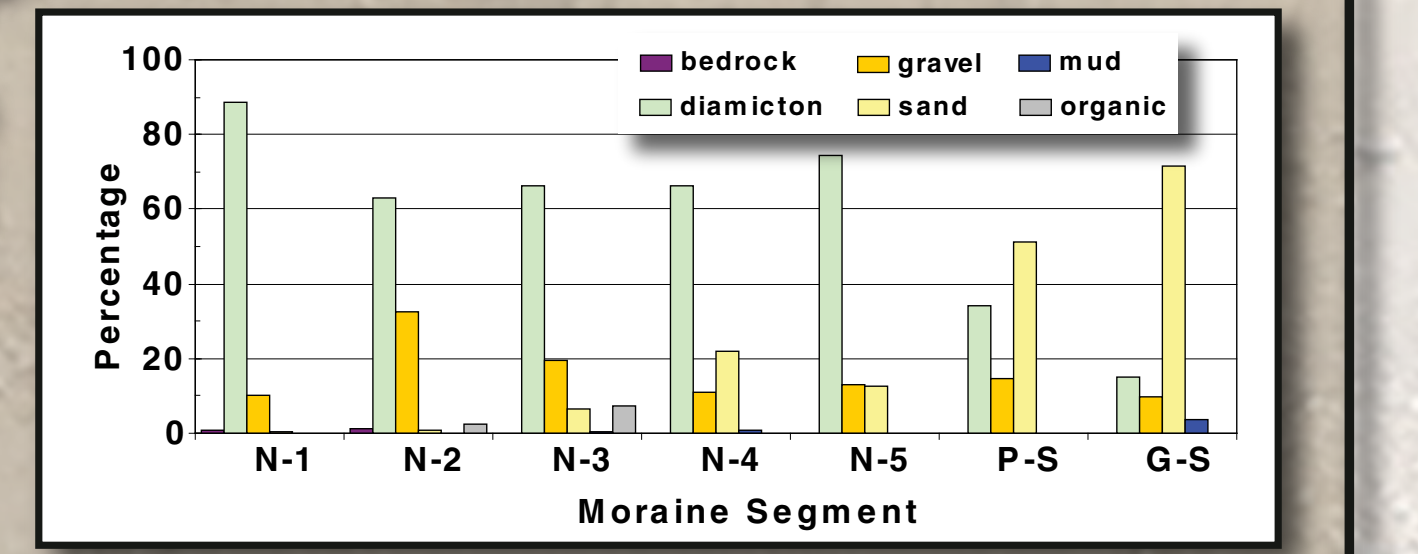


Figure 12. Surface coverage of material type units. Note distinct change from diamicton to sand between N-5 and P-S and G-S.

Surficial Geological Units

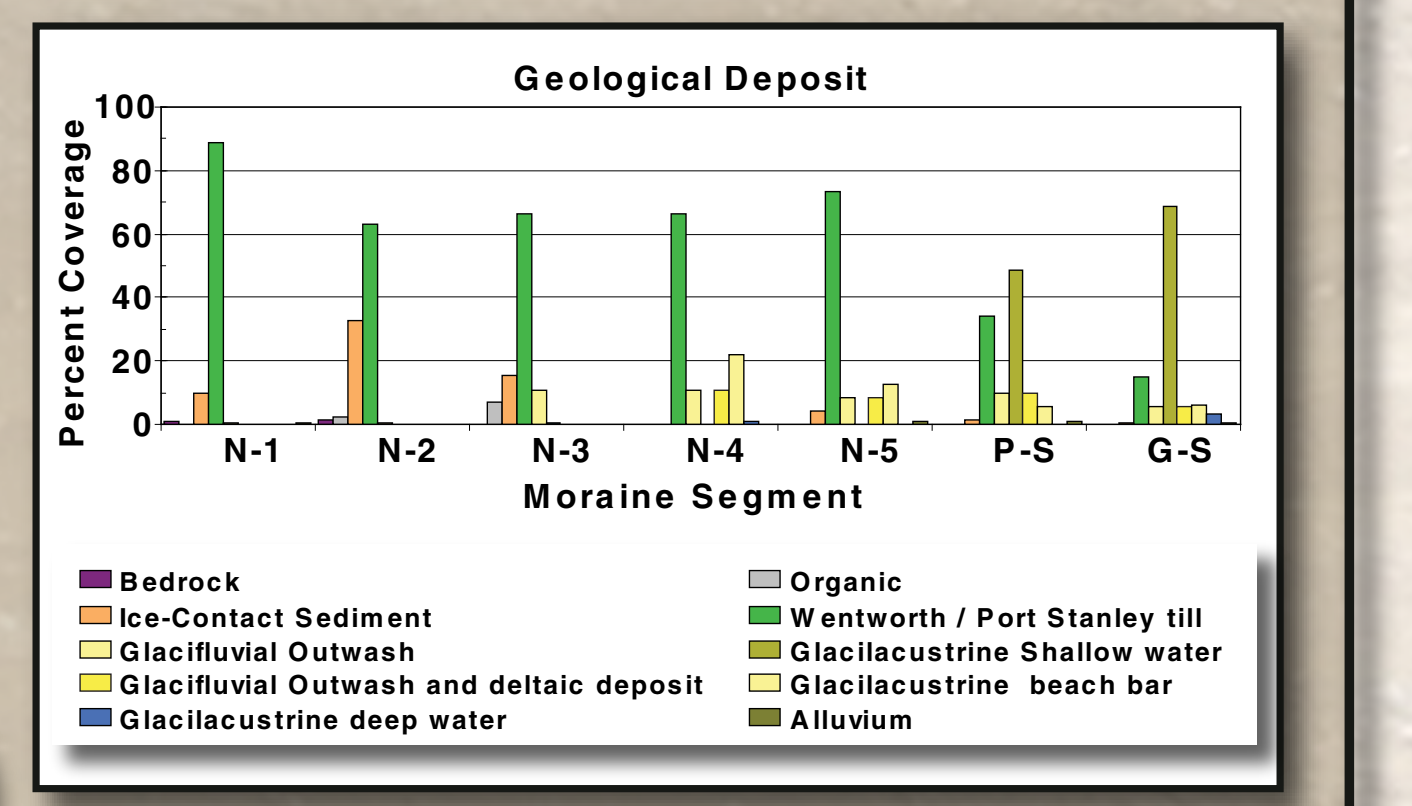
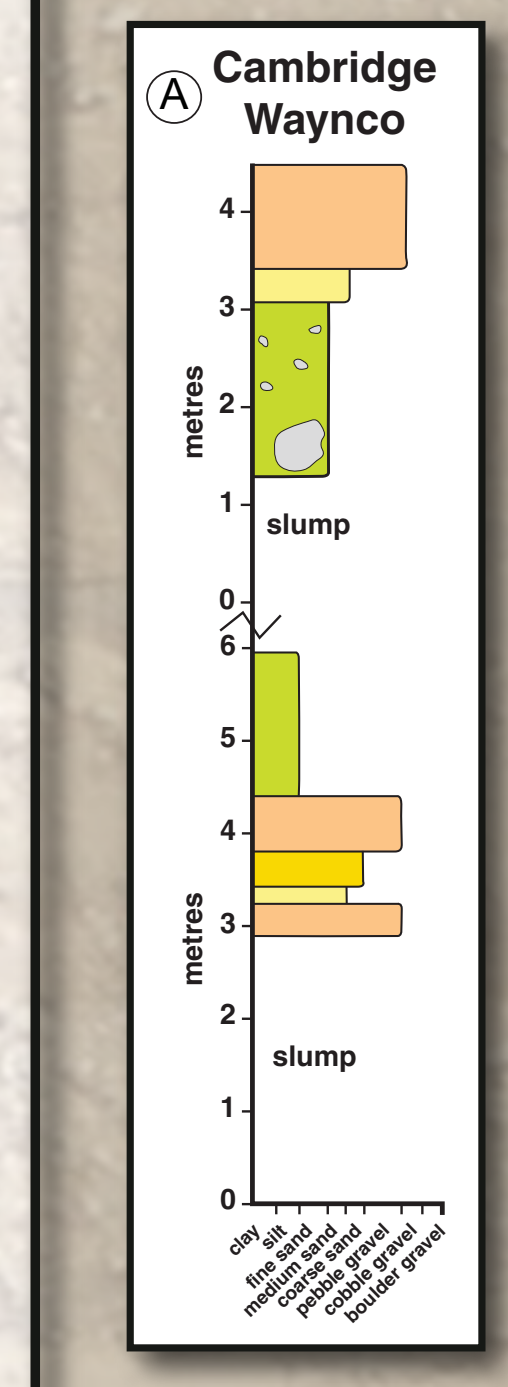


Figure 13. Surface coverage of genetic depositional units. Note change in depositional environment of sand and gravel from north to south from ice-contact stratified sediment to shallow lacustrine. OGS (2003)

Stratigraphic Architecture



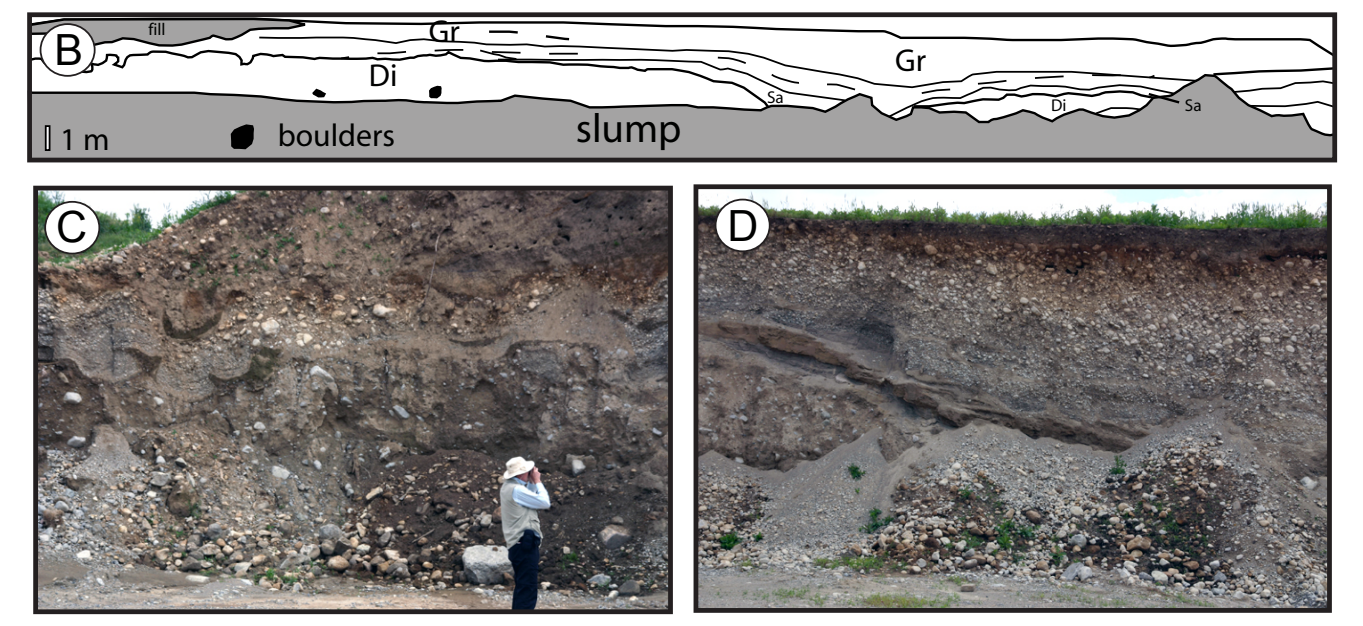
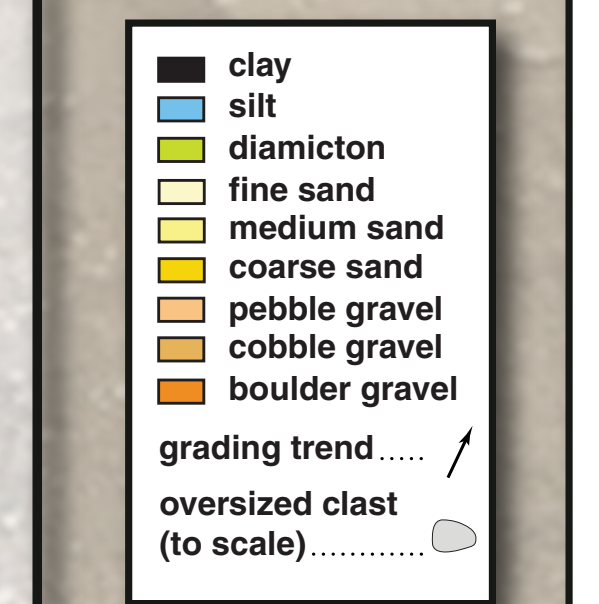


Figure 14. A) Sedimentological log illustrating stacked gravel units (orange) and intervening diamicton (green). B) Line drawing of diamicton - gravel section at top of pit exposure. Note loaded and channelized upper contact of diamicton. C) Loaded upper diamicton contact with gravel. D) Channelized diamicton contact filled and overlain by multiple gravel units.



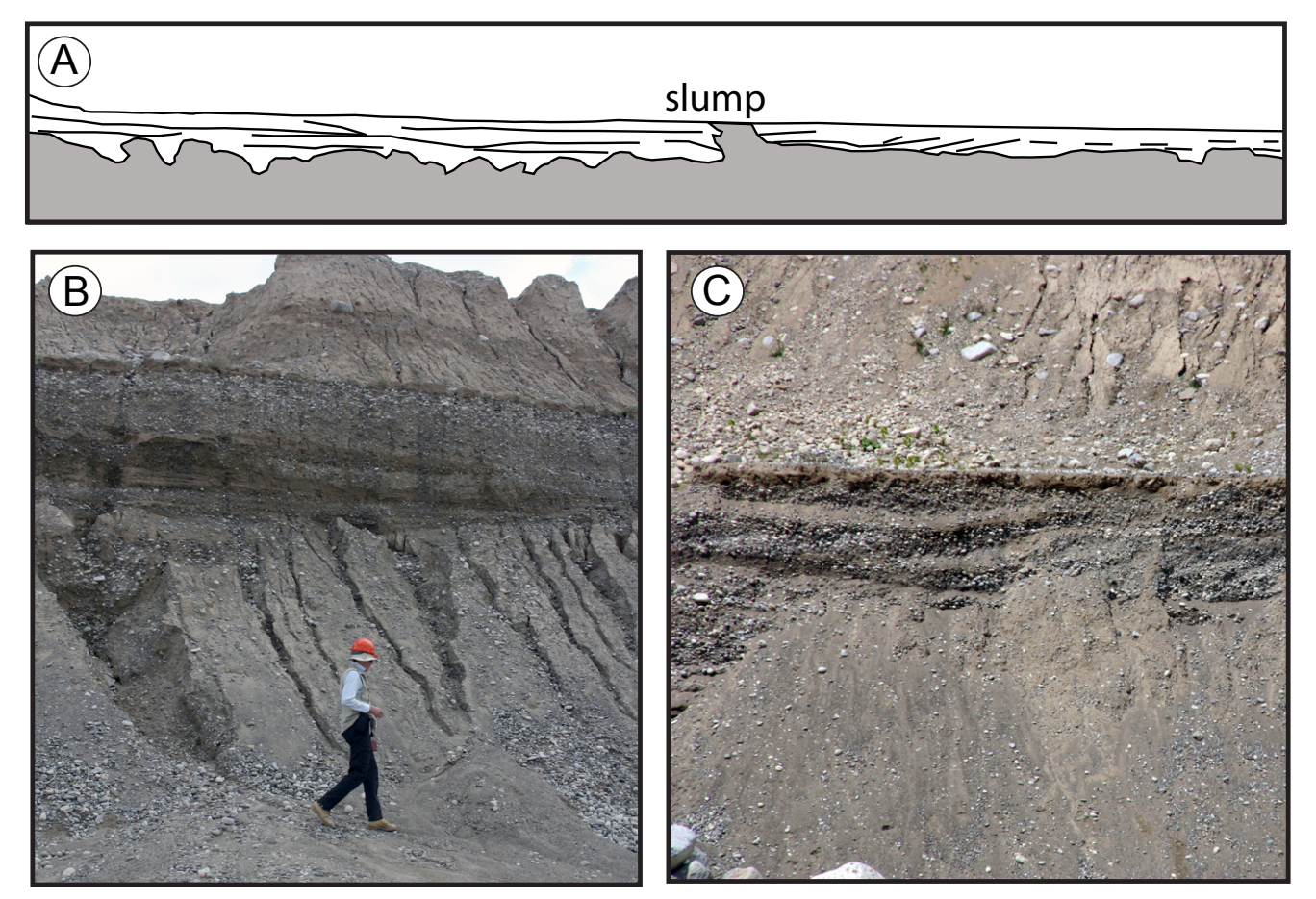
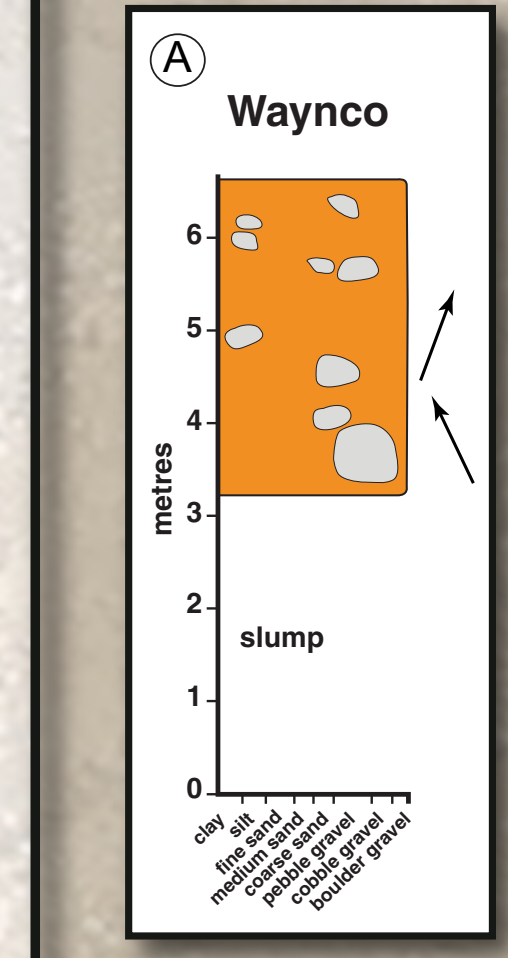


Figure 15. A) Line drawing of gravel beds in basal pit sections. B) Subhorizontal, pebble gravel beds with dune-scale cross-stratification. C) Cross-stratified pebble - cobble gravel.



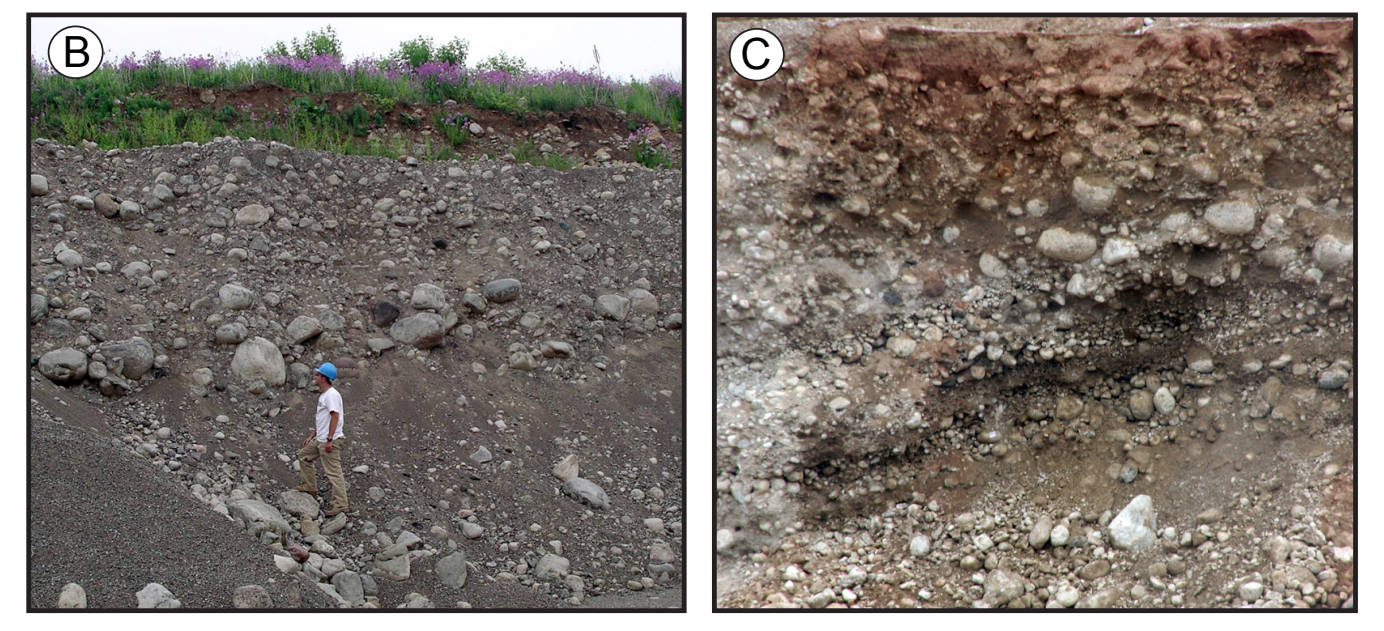
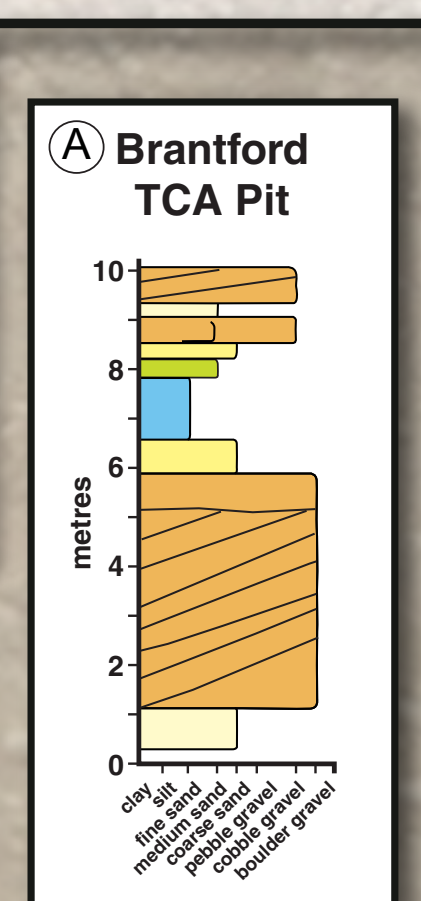


Figure 16. A) Sedimentological log of boulder gravel at Waynco Stuehler site. B) Boulder gravel and series of graded units. Person for scale is 2 m tall. C) Boulder gravel with openwork cobble gravel in forset beds.



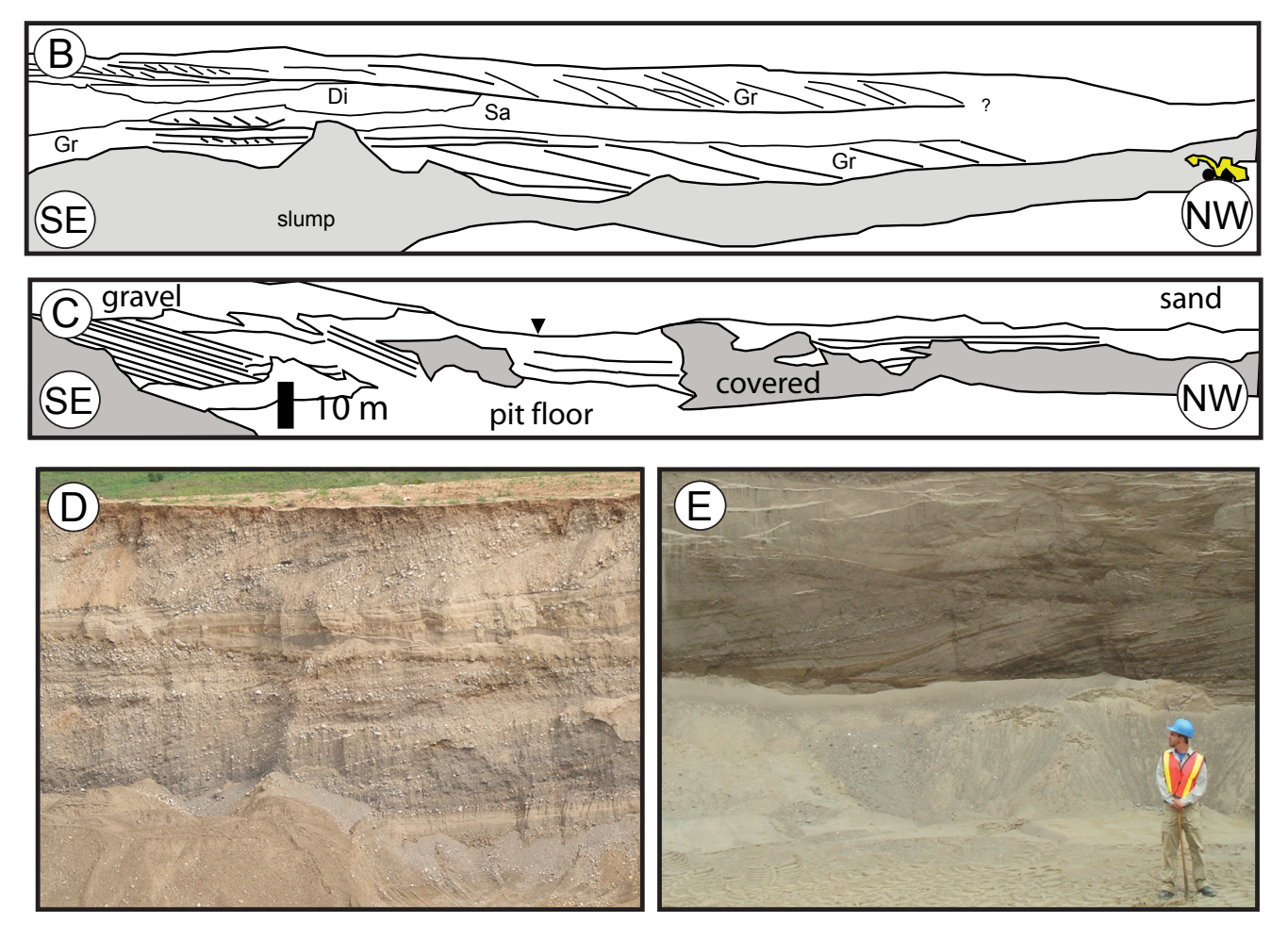


Figure 17. A) Sedimentological log illustrating stacked foresets of gravel and intervening interval of mud, fine sand and diamicton at the Brampton TCA site. B) Line drawing illustrating large-scale foresets prograding to the northwest. C) Line drawing of large-scale gravel foresets from the southwest side of the pit illustrating proximal to distal transition. Foresets are > 10 metres in height. D) Stacked foresets illustrated in A. E) Dune-scale cross-stratified sand downflow of large-scale gravel foresets.

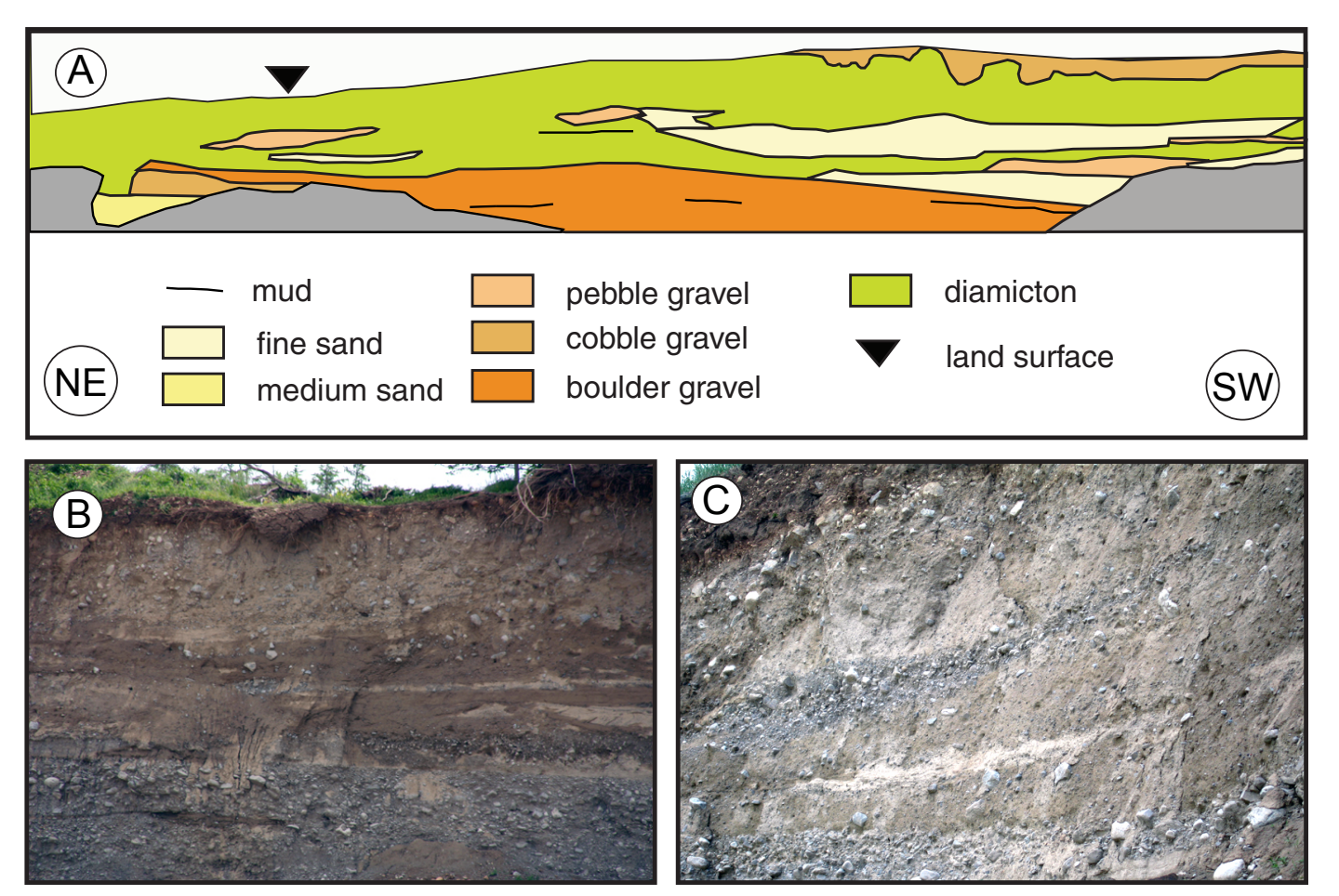


Figure 18. Line drawing of sediment facies in southern face of TCA pit illustrating succession of gravel - diamicton and sand - gravel interbeds. B) Diamicton with grading and interbeds of sand and gravel. C) Diamicton section with sand and gravel interbeds and amalgamated diamicton units. Note grading in diamicton. Diamictions interpreted to be debris flow units.

Summary

- Paris and Galt moraines are part of an extensive moraine network in Southern Ontario that remains poorly understood.
- Recent landform analysis indicates the moraine consists of numerous sub-elements and overlies an erosional landscape.
- Moraine stratigraphy requires detailed mapping to provide an improved hydrostratigraphic framework.
- Moraine thickness and composition show consistent north to south trends reflecting differences in ice sheet dynamics, and the nature of the glacier foreland, terrestrial (north) versus glacilacustrine (south).
- Local sediment aquifers may occur within moraine sediment or in the submoraine succession. The extent and continuity of intervening aquitard units is poorly known.
- Improved understanding of the moraine geomorphology and sedimentology (eg. Sadura et al., 2006) will assist hydrogeological understanding of the role of the moraine for sustaining recharge and stream baseflow.

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