Clast fabric analysis of glacial diamict at the Allan Creek section and its implication for paleo-ice flow of Liard Lowland, southeastern Yukon

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ABSTRACT

The Allan Creek section was identified and briefly described during reconnaissance mapping of the Watson Lake map area (NTS 105A) several decades ago and provides southeastern Yukon's most complete known record of glaciation. The region supported ice sheets during multiple Quaternary glaciations, with landforms in Liard Lowland recording the ice flow toward the southeast during the Last Glacial Maximum (LGM). Inference of earlier ice-flow patterns requires sedimentologic characterization of glacial deposits underlying Liard Lowland. We expand macro-scale descriptions of the sequence of four diamict units exposed in the Allan Creek section to provide further insight on paleo-ice flow in southeastern Yukon. Pebble fabrics were measured from each diamict unit to compare with known LGM ice-flow directions and previously reported clast orientations. Three of the diamict units record ice-flow along the NW-SE trend of Liard Lowland. The second highest diamict in the sequence may record ice-flow directions both parallel and transvers to the basin's trend. Only the lowest diamict unambiguously indicates unidirectional ice-flow; it suggests southeastward paleo-flow during early glaciation of southeastern Yukon, similar to that during the LGM.

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INTRODUCTION

Most of the Yukon landmass was overridden by continental and montane ice during multiple Quaternary glaciations, but stratigraphic sections with evidence for multiple glacial intervals are relatively rare. One such site is the Allan Creek section (Fig. 1: 60.47823° N, 129.68341° W), which was previously described by Klassen (1978; 1987) during regional surficial mapping of southeastern Yukon (Klassen and Morison, 1982). The site consists of multiple sections along an ~85-m-high river bluff (Fig. 2) spanning several hundred metres of lateral exposure on the east bank of Liard River, ~4.5 km downstream of its confluence with Allan Creek. The Allan Creek site is the most important of four sites used by Klassen (1987; Fig. 1) to establish a stratigraphic succession for Liard Lowland and to reconstruct the advance and retreat of Quaternary ice sheets. Klassen's (1987) regional stratigraphic framework includes four diamict units of interpreted glacial origin. The Allan Creek section is the only known location where all four diamict units are present, making it the reference locality for regional glacial records.

Klassen's pioneering work focused on describing the succession of Tertiary-Pleistocene sediments in the Liard River basin, with the main conclusions that at least four southeast flowing glaciations are recorded, ranging in age from mid to late-Pleistocene, and nourished mainly by ice from the Cassiar and Pelly mountains. This study expands upon the initial macro-scale descriptions of glacial sediments from this key section. We report additional pebble fabrics to compare with Klassen's (1978, 1987) previous work, as well as the first ice-flow data for the oldest glacial unit in the section. Our preliminary interpretations provide insight on the variability of paleo-ice flow between multiple glaciations in southeastern Yukon.

REGIONAL SETTING AND GLACIAL HISTORY

Liard River in southeastern Yukon is entrenched into a broad plain of glacial and pre-glacial sediments known as Liard Lowland (Mathews, 1986) or by other authors as Liard Plain (Bostock, 1948; Klassen, 1987). Liard Lowland

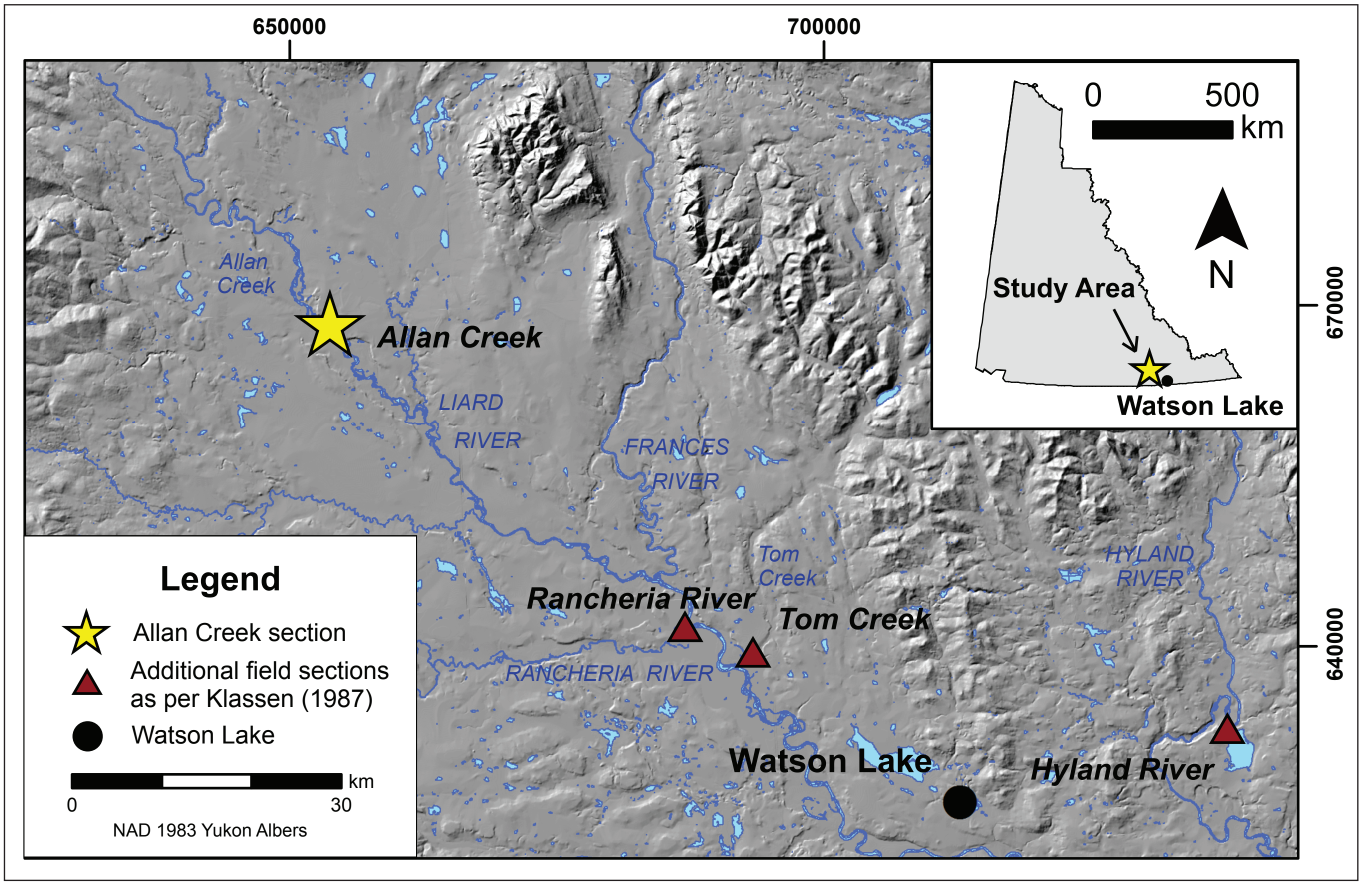


Figure 1. *Location of the study area in southeastern Yukon. The Allan Creek section, along with sections at Tom Creek, Rancheria River, and Hyland River, is the basis for Klassen's (1987) Quaternary stratigraphic framework of Liard basin.*

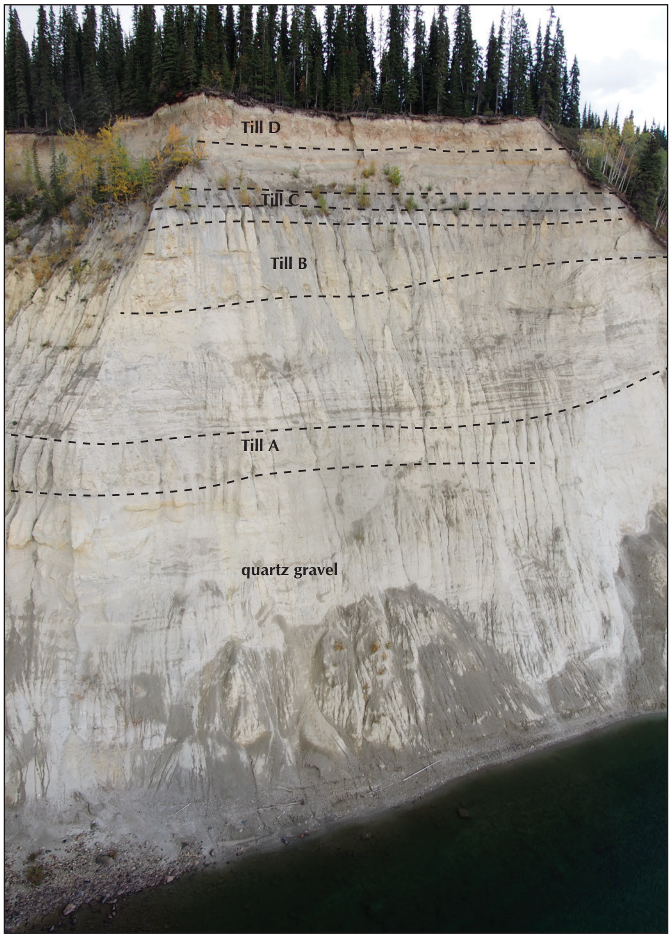


Figure 2. *Aerial view of the Allan Creek section. Tills A through D were initially identified by Klassen (1987) and are further examined in this study.*

is an intermontane basin comprising low hills and broad plains, surrounded by mountain ranges and elevated plateaus: Cassiar Mountains to the southwest; Selwyn Mountains and Hyland Highland to the northeast; and Pelly Mountains to the northwest. The basin is ~175 km long by 50 km wide and lies within Tintina Trench, a major lineament associated with the Tintina fault. Right-lateral strike-slip displacement along this fault, with associated or subsequent dip-slip movement, created several fault-bounded basins, including Liard Lowland (Roddick, 1967). Fault slip continued at least into the Eocene (Hughes and Long, 1980) and may be ongoing today (Leonard *et al.*, 2008). Pre-glacial basin fills include Paleocene-Eocene coal-bearing sediments (claystone, siltstone, shale, sandstone and pebble conglomerate), Tertiary or Pleistocene volcanic rocks, and widespread flat-lying quartz gravel of inferred Miocene age (Dawson, 1898; Hughes and Long, 1980; Klassen, 1987).

Southeastern Yukon was repeatedly glaciated by local montane and regional ice during the Quaternary, although the number of glacial events and most of their ages are unknown. Bostock (1966) recognized four glaciations in central Yukon, and magnetostratigraphy of sediment sequences along Tintina Trench demonstrates at least ten Pliocene and Pleistocene glaciations (Duk-Rodkin *et al.*, 2010; Barendregt *et al.*, 2010). The most recent ice advance in Liard Lowland occurred during the Last Glacial Maximum (LGM) of the Cordilleran Ice Sheet (CIS) *ca.* 25,000-18,000 years ago (Marine Isotope Stage 2). During that time, ice accumulated in the Pelly and Cassiar mountains and flowed southeast across the study area before coalescing with the Laurentide Ice Sheet ~200 km farther east (Hughes *et al.*, 1972; Klassen and Morison, 1982; Jackson *et al.*, 1991; Duk-Rodkin, 1999; Clague and Ward, 2011). Radiocarbon ages on plant macrofossils from the upper (23,900 ± 1140 ^{14}C yr BP; GSC-2811) and lower (>30,000 ^{14}C yr BP; GSC-2949) parts of an ~3.5-m-thick silt unit underlying the uppermost till at Klassen's (1987) Tom Creek section (Fig.1) provide the only chronologic constraint for the onset of LGM ice cover of the study area.

The broad valley bottom of Liard Lowland preserves extensive ice-flow features, most notably a drumlinized till plain that indicates a predominantly southeastern flow direction for the Liard lobe during the LGM (Klassen and Morison, 1982; Duk-Rodkin, 1999). An ice divide over Cassiar Mountains separated the predominantly westward-to-northwestward-flowing Cassiar lobe of the CIS from the southeastward-to-eastward-flowing Liard lobe (Jackson *et al.*, 1991; Fig. 3a). Flow of the Liard lobe was broadly fan-like, spreading from accumulation centres in the Pelly and Cassiar mountains and largely constrained by regional topography, although ice thickness was locally sufficient to overtop regional topographic barriers (Klassen and Morison, 1982; Jackson *et al.*, 1991; Margold *et al.*, 2013).

PREVIOUS WORK

Detailed ice-flow reconstruction of the Liard lobe from glacial landforms (Margold *et al.*, 2013) supports the overall southeastward-to-eastward flow suggested by earlier reconnaissance mapping (Klassen and Morison, 1982). However, several crosscutting sets of glacial lineations near Frances River also record both N-S and WSW-ENE flow, which were later overprinted by lineations recording southeastward-to-eastward flow (Fig. 3b). Margold *et al.* (2013) suggest that this overprinting may be the result of changing dominance of late-glacial dispersal centres, or that earlier lineations were formed by ice advancing out of Selwyn Mountains prior to the LGM. Klassen (1987) reports the general stratigraphy of the Allan Creek section and clast fabric measurements from the upper three diamict units (Fig. 4). His report states the fabric for the highest diamict aligns with the generally NW-SE orientation of drumlins and streamlined landforms. Klassen (1978, 1987) correlates this diamict with the highest diamict unit at the Tom Creek section, suggesting both were emplaced during the LGM. The lower three diamict units predate *ca.* 30,000 ^{14}C yr BP, but their ages are otherwise unconstrained. Clast fabrics range from SSW-NNE ("Till B") to W-E ("Till C") for the two lowest units measured by Klassen (1987); they are thus oblique to the main trend of landforms attributed to LGM flow of the Liard lobe.

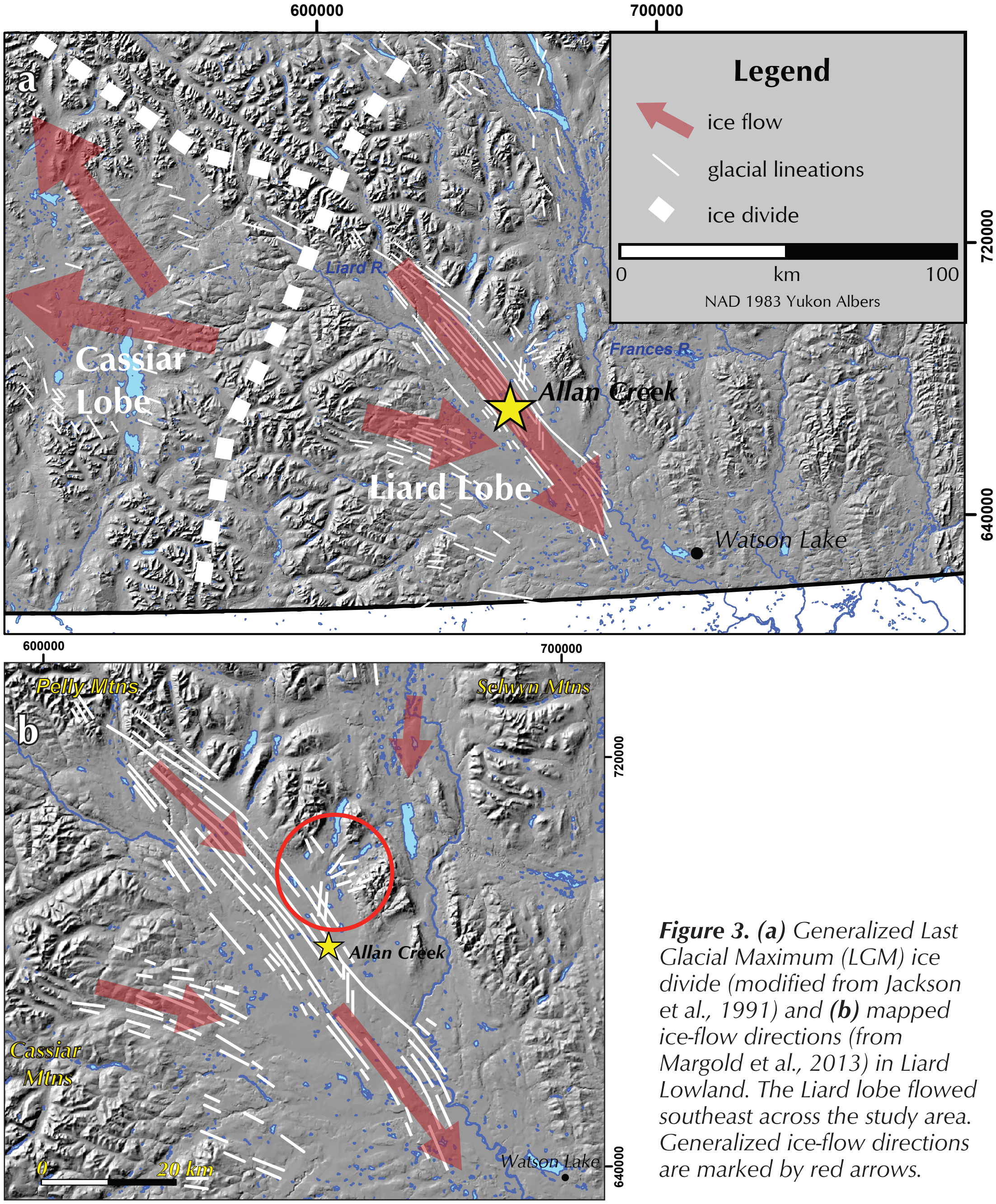


Figure 3. (a) *Generalized Last Glacial Maximum (LGM) ice divide (modified from Jackson et al., 1991) and* ***(b)*** *mapped ice-flow directions (from Margold et al., 2013) in Liard Lowland. The Liard lobe flowed southeast across the study area. Generalized ice-flow directions are marked by red arrows.*

METHODS

Following Klassen's (1987) stratigraphic framework (Fig. 4) we differentiate four diamict units in the Allan Creek section – from base to top Till A, Till B, Till C and Till D – separated by fine-grained, horizontally bedded inter-till units. Clast fabrics were measured in each of the four diamict units, where exposure and access was safe and possible, across a longitudinal span of ~100 m (Fig. 5).

Location information was acquired using a handheld GPS set to a NAD83 datum. Elevations were measured in metres above Liard River using a TruPulse 200 Laser Range Finder. Bulk samples (~5 kg) were collected and screened at 2 mm, 500 µm and 63 µm for more accurate grain-size distribution analysis.

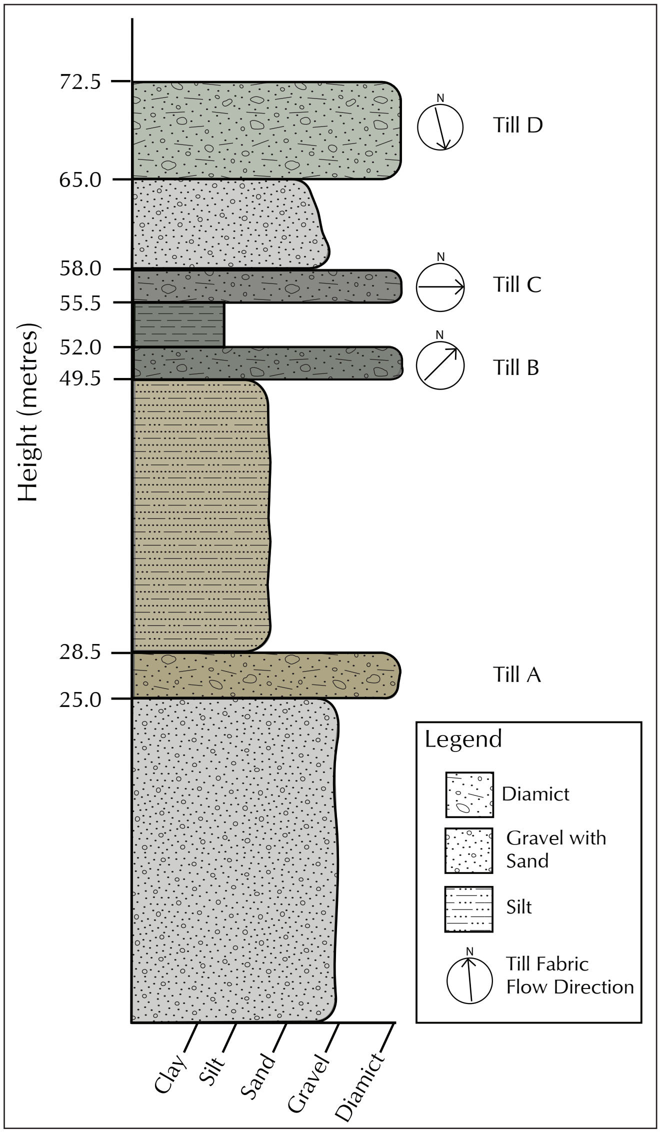


Figure 4. *Summary of the stratigraphy of the Allan Creek section as presented by Klassen (1987). Fabrics were measured only in the three uppermost diamict units (Klassen's "Till B", "Till C", and "Till D").*

Pebble fabric measurements were collected from each diamict unit by clearing two 1 by 1 m vertical exposures with similar elevations. These faces were cleared to fresh surfaces and general observations were recorded, including colour, texture, clast percentage, fissility, and any macro-scale deformation. With the exception of Till C, cleaned faces were oriented perpendicular to each other to reduce aspect bias in the measured clast orientations.

Clasts selected for fabric measurements included rod-shaped, bladed, and platy pebbles (2-6 cm in maximum dimension) with ideal length to width ratios of 2:1, and minimum ratios of 3:2. The trend and plunge of 25 pebbles were measured on each cleared face, yielding 50 clast orientations from each diamict unit. Clast dimensions, lithology, and any glaciogenic wear features were also recorded. Two-dimensional and three-dimensional representations of the pebble fabric for each unit were plotted using Stereonet (v 9.9.4) software as, respectively, rose diagrams and stereo plots. Principal eigenvectors and normalized eigenvalues calculated in the software were subsequently used to plot unit characteristics (glaciogenic sediment flow, lodgment till, or subglacial melt out till) on a May diagram.

RESULTS

TILL D

Till D is a weakly compact, matrix-supported, medium-grey, silty sand boulder diamict (Fig. 6). It is 7 m thick with its base at 78 m above Liard River. The lower contact is planar and gradational, transitioning from a sandy matrix at the base of the unit to a silty matrix towards the top of the unit. Till D forms the surface expression of the landscape at the study area and is discontinuously mantled by up to ~0.5 m of cliff-top loess. The exact nature of the diamict-loess contact is uncertain because of limited clean exposure and a lack of access; cleared faces for fabric measurements were located at the base of the unit ~10 m apart.

The matrix (~70% by volume) comprises 6% silt and clay, and 94% sand (36% coarse, 32% medium, 26% fine sand). Clasts range from pebble to boulder, although boulders are rare; most clasts are striated and faceted. Zones of rusty-purple oxidation occur in horizontal layers. Till D contains abundant oxidized fractures and highly weathered clasts.

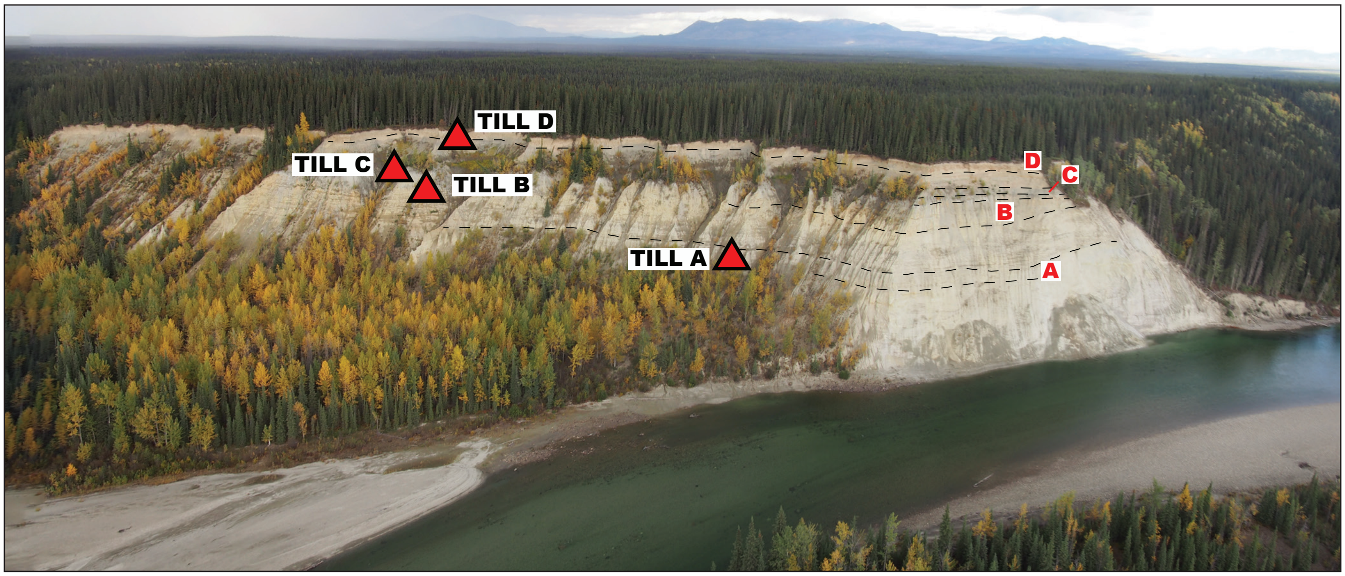


Figure 5. *Site locations of clast fabric measurements (triangles). The ~85-m-tall bluff on the east bank of Liard River is cut by deep gullies that provide fairly continuous lateral exposure and access to each of the units.*

The clast fabric of Till D has a NW-SE trend (Fig. 7). Long-axis clast plunge is generally shallow (<30°) and roughly equally concentrated to the NW and SE. The principal eigenvector has a trend and plunge of 087°/58°, but is not a useful indicator of preferred clast direction given the high dispersion of orientations around the great circle, despite having a strong S1 eigenvalue. The S1 and S3 eigenvalues for Till D are 0.6003 and 0.0543, respectively.

Figure 6. *Till D is a weakly compact medium-grey silty-sand diamict. It contains fewer clasts than stratigraphically lower diamict units, with a diverse variation in grain size. The contact (dashed line) between Till D and underlying glaciofluvial sand is marked.*

TILL C

Till C is a very compact, matrix-supported dark-blue-grey, silty clay pebble diamict (Fig. 8). The unit is poorly exposed in most locations at the Allan Creek section, so a trench was excavated to provide a fresh surface for sedimentologic

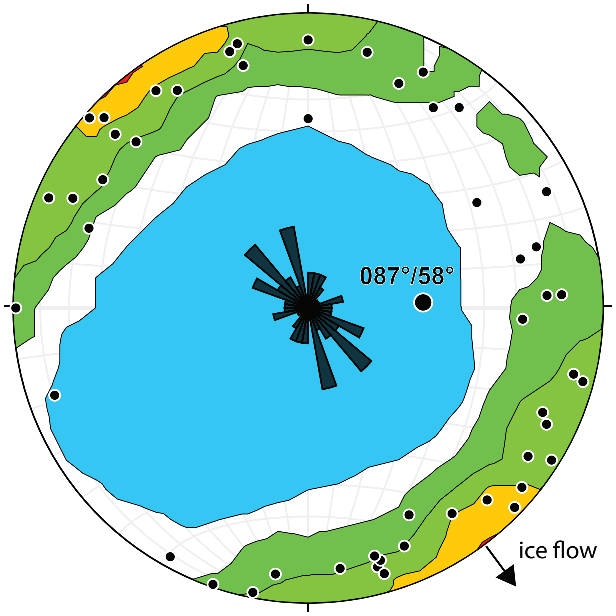


Figure 7. *Stereonet and rose diagram for Till D showing a NW-SE orientation. Each contour represents 2 sigma and the large black dot is the trend/plunge of the eigenvector. The stereonet is plotted on the lower hemisphere of a Schmidt diagram.*

and stratigraphic characterization. The unit is ~4 m thick, coarsening upward in the upper ~2 m from a fine silty-clay matrix to a sandy-silt matrix. The base of the unit is 69 m above Liard River. Till C has a distinctly different colour than tills A, B, and D. A sharp contact separates Till C from the underlying inter-till sediments. The upper contact is sharp and undulating, with concentrations of bright orange-red oxidized clasts.

In the coarser facies at the top of the unit (where the sample was taken), the matrix (~70% by volume) comprises 6% silt and clay and 94% sand (43% coarse, 28% medium, 22% fine sand). Clasts are finer than in the other four till units, with a marked absence of boulders. They range in size from granule to cobble and are predominantly subrounded, striated pebbles. Clasts are predominantly basalt and other volcanic rocks, with some quartzite and foliated metamorphic rocks. The matrix of Till C has oxidized veins and fractures and some clasts are heavily oxidized and weathered orange. In contrast to the other diamict units, joints and fissility were absent in the limited exposures of Till C.

The clast fabric for Till C is bimodal, with two trends oriented NW-SE and WSW-ENE (Fig. 9). The steepness of long-axis plunge is more varied than for the other three diamict units. The principal eigenvectors have a trend and plunge of 064°/31° and 146°/42° for, respectively, the primary and secondary trends. The primary clast trend is roughly WSW-ENE but is dispersed over ~40°. The NW-SE trend, although comprising fewer clasts, is more tightly clustered. The S_1 and S_3 eigenvalues for the entire population of clasts are 0.4627 and 0.2219, respectively.

Figure 8. *Typical appearance of Till C. It is a very compact dark-blue-grey, silty-clay diamict which coarsens in the upper ~2 m from a silty-clay matrix (pictured) to a sandy-silt matrix. The unit is not well exposed and has a distinctly different colour than tills A, B, and D.*

TILL B

Till B is a compact, matrix-supported medium-grey-brown, sandy-silty boulder diamict (Fig. 10). The unit is ~7.3 m thick with its base roughly 60 m above Liard River. It is densely jointed and fissile, with oxidation concentrated along fracture surfaces. The lower contact is sharp and erosive whereas the upper contact is sharp and conformable with overlying inter-till sediments.

The Till B matrix (~60%) comprises 15% silt and clay and 85% sand (31% coarse, 35% medium, 20% fine sand). Clasts range from granules to cobbles, with few boulders. Clasts are predominantly quartzite and basalt, with lesser contributions of granodiorite and foliated metamorphic rocks. Clasts are mainly subrounded, and less commonly rounded or subangular; many are bulleted or faceted. Reddish brown/rusty sand lenses are present throughout the unit and are considerably more cemented than surrounding material. Till B erodes as large vertical spires, making it easy to access different aspects of the unit.

The clast fabric is dominated by a well-defined NNW-SSE trend (Fig. 11). Clast plunges are roughly evenly distributed between the NNW and SSE. The principal eigenvector trend and plunge is 340°/37°. The S_1 and S_3 eigenvalues are 0.7152 and 0.0742, respectively.

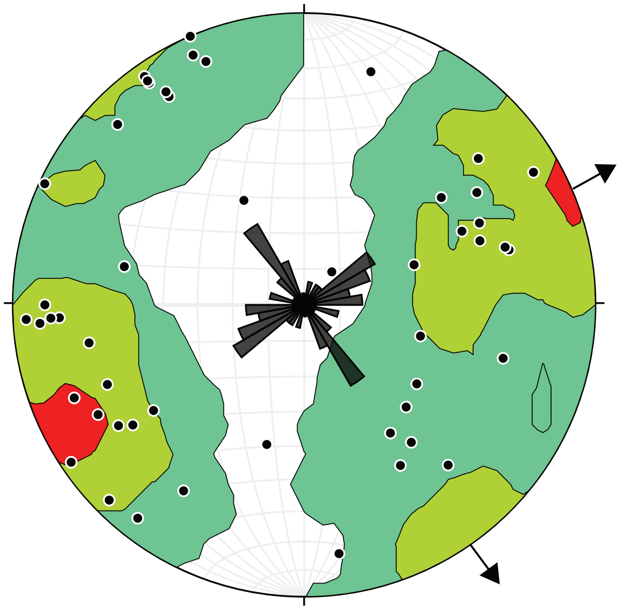


Figure 9. *Stereonet and rose diagram for Till C showing a bimodal trend, with a stronger WSW-ENE trend, and a weaker NW-SE component. Each contour represents 2 sigma. The stereonet is plotted on the lower hemisphere of a Schmidt diagram.*

Figure 10. *Typical appearance of Till B. It is a compact, medium-grey-brown, sandy-silty cobble diamict with weak stratification. Reddish brown/rusty sand lenses occur throughout the unit and are considerably more cemented than surrounding matrix.*

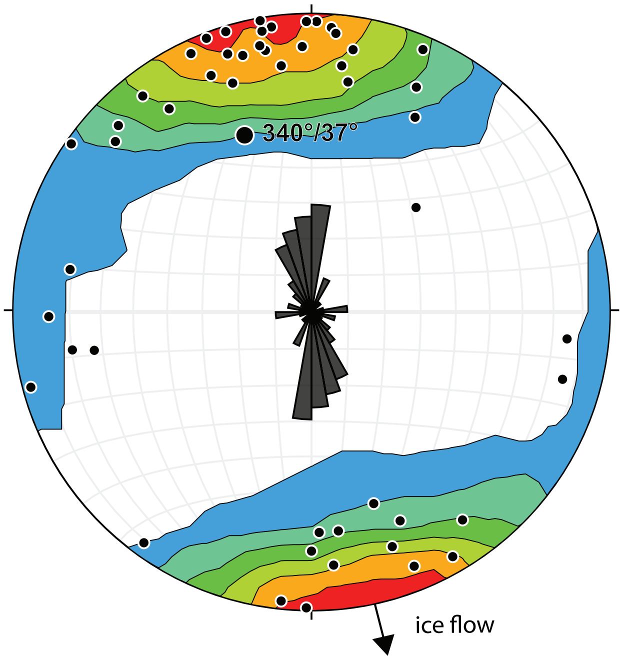


Figure 11. *Stereonet and rose diagram for Till B showing a well-defined NNW-SSE orientation. Each contour represents 2 sigma and the large black dot is the trend/plunge of the eigenvector. The stereonet is plotted on the lower hemisphere of a Schmidt diagram.*

TILL A

Till A is a compact matrix-supported, medium-brown, silty-sandy boulder diamict (Fig. 12) varying from 3.5 to 5.0 m thick. Both the upper and lower contacts are sharp and undulating, suggesting that they are erosive. The unit overlies at least 35 m of pre-glacial, quartz-rich bedded sand and gravel. It is densely jointed and fissile with oxidation concentrated on fracture surfaces, and erodes as large vertical spires providing variable exposure aspects (Fig. 13). Cleared faces for fabric measurements were located near the base of the unit ~4.5 m apart.

The matrix (60%) of Till A comprises 19% silt and clay, and 85% sand (22% coarse, 39% medium, 23% fine). Clasts range from granules to boulders (up to 1 m), and consist of quartzite, quartz, granite, and a minor component of basalt and foliated metamorphic rocks. Clasts are subrounded to subangular and are commonly striated, faceted or bullet-shaped. Striations on bullet-shaped clasts are parallel to the long axis. Granitic pebbles are abundant and distinctly bladed. Most of the potassium feldspar minerals are heavily weathered to orange.

The clast fabric measured in Till A has a strong, well-defined NW-SE trend (Fig. 14). The majority of clasts plunge toward the NW. The principal eigenvector has a trend and plunge of 319°/37°. The S_1 and S_3 eigenvalues are 0.6981 and 0.0731, respectively.

Figure 12. *Typical appearance of Till A. It is a compact medium-brown, silty-sandy cobble diamict. Abundant quartz, quartzite and granite pebbles in the unit are well-rounded, and many granitic pebbles are highly weathered.*

Figure 13. *Lower contact between inferred Tertiary sediments and Till A (marked with dashed line). It is heavily oxidized, horizontal, slightly undulating, and sharp.*

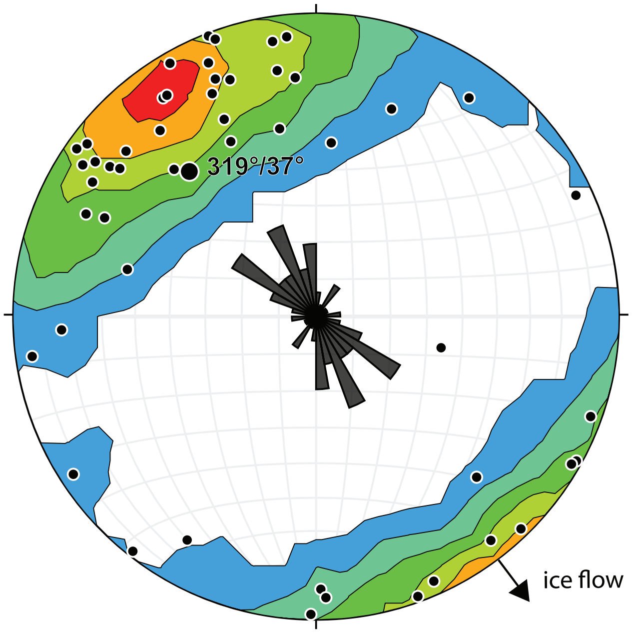


Figure 14. *Stereonet and rose diagram for Till A showing a strongly defined NW-SE orientation. Each contour represents 2 sigma, and the large black dot is the trend/plunge of the eigenvector. The stereonet is plotted on the lower hemisphere of a Schmidt diagram.*

DISCUSSION

Unit elevations, thicknesses and characteristics reported here (Fig. 15) generally agree with the stratigraphy reported by Klassen (1978, 1987; Fig. 4). New flow direction interpretations from clast fabrics measured in this work support the original fabrics measured by Klassen (1987) for the upper two diamict units. The uppermost diamict (Till D) records LGM glaciation of the Liard basin. The NW-SE clast fabric reported here for this unit is consistent

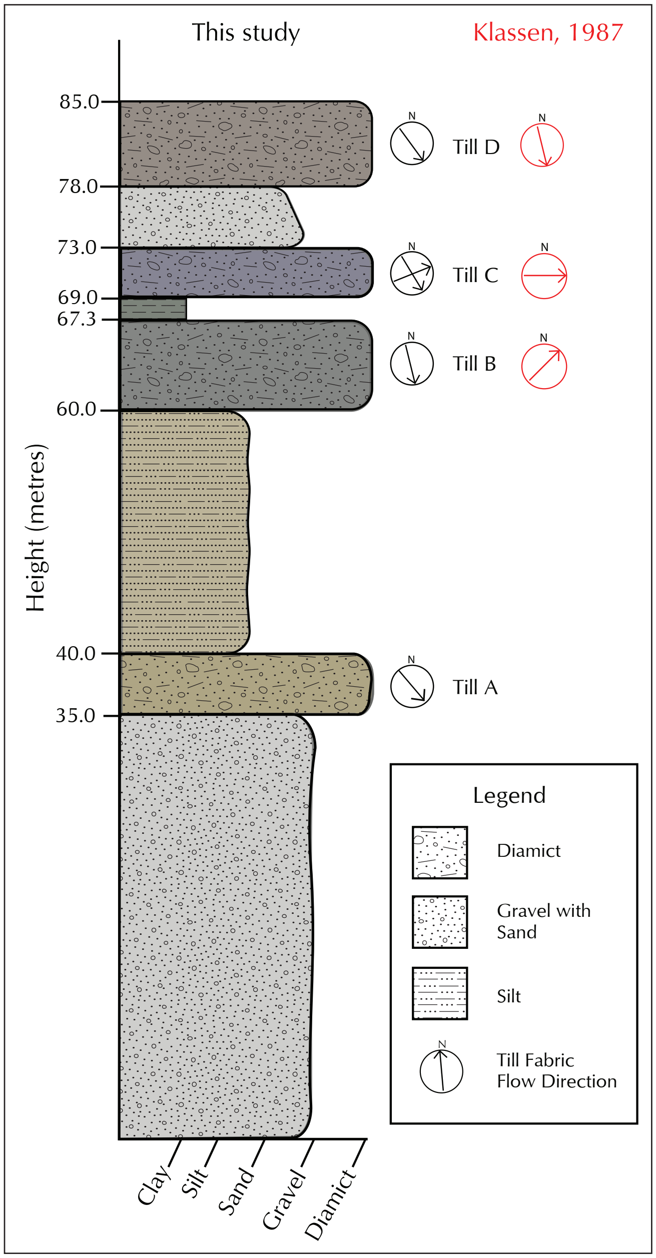


Figure 15. *Stratigraphy for the Allan Creek section measured in this study closely resembles the original stratigraphy presented by Klassen (1987; Fig. 4).*

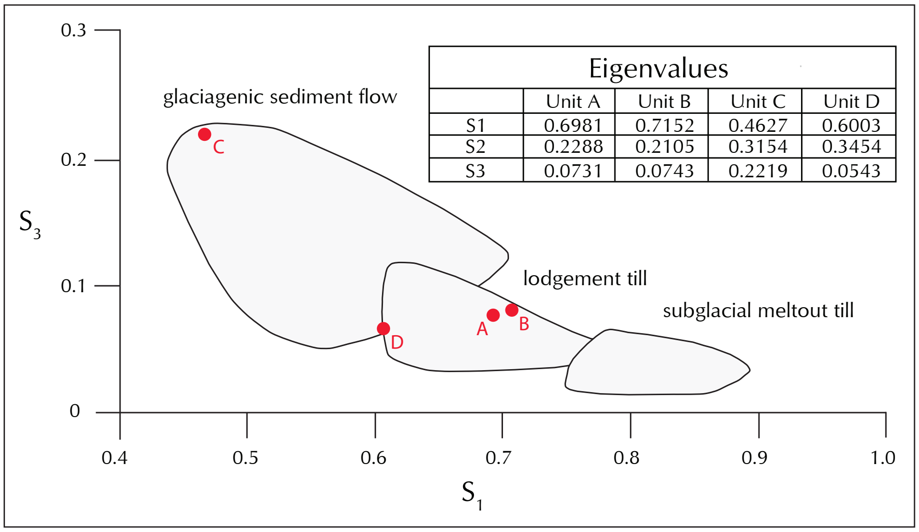
with previously reported fabrics (Klassen, 1987) as well as streamlined landforms across the Liard Lowland (Klassen, 1987; Margold *et al.*, 2013). The presence of glaciogenic wear features on clasts of all four diamict units suggests their lodgement beneath ice (*cf.* Lian and Hicock, 2010).

Till D plots in between the 'lodgement till' and 'glaciogenic sediment flow' classification of the May diagram (Fig. 16). The physical characteristics of Till D, along with the unidirectional flow shown in the contoured stereonets and rose diagrams, suggest it was deposited as a lodgement till. The NW-SE trend of this unit's clast fabric supports southeastward ice flow suggested by streamlined landforms that dominate the geomorphic grain of Liard Lowland.

The second highest diamict at the Allan Creek section (Till C) differs from the other three glacial units. It has a finer matrix, finer clasts, and overall lower clast content. Unlike the other diamict units, it does not display typical characteristics of a lodgement till (Fig. 16) such as clast long-axes clustered around a single orientation (Evans *et al.*, 2007) and prevalent signs of abrasion on clast surfaces (Benn and Evans, 2010). Thus, Till C may not accurately record ice-flow direction. Its clast fabric reveals concentration about two orientations and the unit plots in the 'glaciogenic sediment flow' classification of the May diagram (Fig. 16). The use of a May diagram with bimodal clast fabrics is problematic because this diagram was designed to work with unimodal fabrics. Therefore interpreting this unit as a glaciogenic sediment flow may not accurately represent the depositional environment (Hicock *et al.*, 1996). Our clast fabric concentrations (064°/31°) and (146°/42°) are similar to, respectively, Klassen's W-E fabric trend and the NW-SE trend of the basin. Both directions align with streamlined landforms in the vicinity of the Allan Creek section (Margold *et al.*, 2013; Klassen, 1987), although W-E landforms are rare (*see* Fig. 3).

The specific mode of emplacement of Till C, and thus the significance of its clast fabrics, is uncertain. Given the close alignment of this unit's fabric with W-E oriented landforms that Margold *et al.* (2013) interpret as having been overprinted during the LGM by a NW-SE geomorphic grain, it is tempting to interpret Till C as lodgement till recording basal ice-flow directions. The W-E orientations might record pediment or valley-bound glaciation emanating from the Selwyn Mountains that followed the Frances River valley.

Till B, the second lowest diamict in the sequence, plots in the 'lodgement till' classification of the May diagram (Fig. 16). The orientation of clast long-axes subparallel to the NW-SE trend of Liard Lowland (160°/37°; Fig. 11) as well as the physical characteristics of this unit, particularly extensive evidence of abrasion on clasts, further support an interpretation of a lodgement till. Although long-axes of clasts dip both to the northwest and southeast, the S1 eigenvector and strong S1 eigenvalue indicate a more dominant north-northwesterly plunge. Since the long-axes of elongate clasts typically plunge up-flow in lodgement tills (Evans *et al.*, 2007), Till B suggests ice flow toward the south-southeast. In contrast, Klassen (1987) reports a clast fabric with a SSW-NNE trend, roughly transverse to the trend of the Liard Lowland.



Eigenvalues

	Unit A	Unit B	Unit C	Unit D
S1	0.6981	0.7152	0.4627	0.6003
S2	0.2288	0.2105	0.3154	0.3454
S3	0.0731	0.0743	0.2219	0.0543

Figure 16. *May diagram with principal eigenvalues for Units A, B, C, and D. Base diagram modified from Hicock et al., (1996).*

The lowest and oldest till in the Allan Creek section (Till A) is of particular importance because Klassen (1978, 1987) did not report fabric measurements for it. This unit shows a strong NW-SE fabric (139°/37°). Till A plots in the 'lodgement till' classification of the May diagram (Fig. 16). The physical characteristics of Till A, including the prevalence of striated and faceted clasts, as well as the close alignment of its clast fabric (Fig. 14) with the trend of Liard Lowland suggest deposition as a lodgement till. Given the predominance of plunge of long-axes of elongate clasts to the northwest, the earliest ice flow recorded at the Allen Creek section was most likely from northwest to southeast (*cf.,* Evans *et al.*, 2007).

If fabric measurements of diamict units in the Allan Creek section faithfully record paleo-ice flow directions in Liard Lowland, at least three of the four glacial diamict units represent basal deposition and record glacial events with ice flow toward the NW or the SE. This is consistent with previously published descriptions of LGM glaciation in Liard Lowland, which indicate southeasterly flow. Our new measurements of NW to SE flow in Till A suggest ice flow during early glaciation of the region was similar to that during the LGM.

Limitations of clast fabric analysis include sample bias when choosing clasts and localities of sampling area as well as the potential for sampling material that has been influenced by post-depositional processes. Unimodal distributions for two-dimensional clast directions for three units – Tills A, B and D – suggest ice flow trending roughly parallel to the trend of Liard Lowland. Additional details enable interpretation of unidirectional ice-flow patterns for these three glacial diamict units. Concentrations of clast plunge directions reported here suggest ice flow to the southeast and south-southeast during emplacement of, respectively, Till A and Till B. Previous studies of LGM landforms indicate that Till D was similarly emplaced by southeast-flowing ice.

CONCLUSIONS

The Allan Creek section records four glacial events – possibly representing four separate glaciations – alternating with periods when fine-grained, non-diamict units were deposited. Clast fabrics from Tills A, B, and D suggest that regional ice-flow was along the NW-SE trend of Liard Lowland, although only Till A and B suggest a clear down-valley flow direction. Till C has a bimodal WSW-ENE and NW-SE fabric. The NW-SE fabric seen in these glacial diamict units aligns with known ice-flow direction during the LGM in Liard Lowland and is consistent with the orientation of streamlined landforms in the basin. The WSW-ENE component recorded by Till C, which was also noted during previous work at the site, aligns with rare crosscutting lineations in the region, but the depositional environment of this unit remains uncertain.

Sedimentologic and stratigraphic details reported here generally agree with previously reported reconnaissance studies including descriptions of unit thicknesses, and clast fabrics for the upper two glacial diamict units. Furthermore, plotting clast fabric eigenvalues on the May diagram provides support for environmental interpretation of all four glacial diamict units in this sequence. Our addition of clast orientations for Till A provides the first details on ice flow for the earliest glaciation of Liard Lowland, and likely one of the earliest glaciations of southeastern Yukon. Ice flow during this earliest glaciation, along with the second glaciation recorded in the region (Till B) and the most recent LGM (Till D), appears to have paralleled the trend of Liard Lowland.

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