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Ice-movement indicator mapping north of the Keewatin Ice Divide, Meadowbank area, Nunavut

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Abstract: Local-scale mapping of ice-movement indicators in the Meadowbank area, near Baker Lake in Nunavut, resulted from a joint effort by the Canada–Nunavut Geoscience Office and the Geological Survey of Canada. Preliminary results indicate three main phases of ice-movement. Phase 1 was to the north followed by phase 2 to the north-northwest. A later northward movement (phase 3a) occurred locally, perhaps reflecting convergence towards an esker tunnel and/or a small east-west re-entrant within the ice front near the Meadowbank gold deposits. A late phase (3b) to the northwest is probably part of a major, late, west-northwesterly movement that can be observed as far as Forde Lake, 100 km south of Baker Lake. The detailed mapping of ice-movement indicators provides a preliminary framework for interpreting glacial dispersal in areas that were located under the Keewatin Ice Divide across the region.

Résumé : La cartographie à l'échelle locale des marques d'écoulement glaciaire dans la région de Meadowbank, près de Baker Lake au Nunavut, a été effectuée par le Bureau géoscientifique Canada-Nunavut de concert avec la Commission géologique du Canada. Les résultats préliminaires de ces travaux indiquent qu'il y a eu trois grandes phases d'écoulement glaciaire. Un premier mouvement vers le nord (phase 1) a été suivi d'un deuxième vers le nord-nord-ouest (phase 2). Un mouvement vers le nord a eu lieu localement par la suite (phase 3a), possiblement associé à un mouvement convergent vers un tunnel d'esker ou à une indentation locale d'orientation est-ouest dans le front glaciaire, à proximité du gisement aurifère de Meadowbank. Une phase tardive (3b) vers le nord-ouest est probablement associée à un mouvement tardif majeur vers l'ouest-nord-ouest, dont on observe les marques jusqu'au lac Forde, à 100 km au sud de Baker Lake. La cartographie détaillée des marques d'écoulement glaciaire fournit un cadre général pour l'interprétation préliminaire de la dispersion glaciaire dans des zones qui étaient situées sous la ligne de partage des Glaces du Keewatin dans l'ensemble de la région.

INTRODUCTION

In 2003, the Canada–Nunavut Geoscience Office and the Geological Survey of Canada conducted local-scale ice-movement-indicator mapping in the vicinity of the Meadowbank gold deposits 70 km north of Baker Lake, Nunavut (Fig. 1). The Meadowbank gold deposits are found in northeast-trending iron-formation of the Woodburn Lake group (Sherlock et al., 2001) and are 100% owned by Cumberland Resources Ltd. Detailed geological mapping along strike is on-going by industry, complemented by reverse-circulation overburden drilling and surface sampling of till for geochemical analysis. This area of Nunavut, a portion of the former District of Keewatin, is 50 km northwest of the central axis of the Keewatin Ice Divide as mapped by Aylsworth and Shilts (1989). Previous surficial mapping in the area was at a regional scale by the GSC, with little ground truthing (Aylsworth et al., 1976, 1985; Thomas, 1981; Thomas and Dyke, 1981).

Reconstructing ice-movement history is fundamental to drift prospecting as it provides a means for interpreting glacial dispersal. The regional scale of previous mapping (1:125 000 and 1:250 000) and limited measurements of ice-movement indicators are not sufficiently detailed for interpretation of the geochemical results from a tightly spaced (~100 m) overburden-drilling and till-sampling grid. The objective of this work was to 1) provide a framework for interpreting glacial dispersal of mineralized debris at the local scale, and 2) contribute to a better understanding of the ice-movement chronology at a regional scale. This paper presents a preliminary interpretation of the ice-movement data collected in June and August of 2003.

PREVIOUS WORK

Previous regional mapping in the area included the measurement of a small number of ice-movement erosional features, and streamlined glacial landforms interpreted from aerial photographs. The following is a summary of literature related to the Quaternary geology of the study area and the position of the Keewatin Ice Divide.

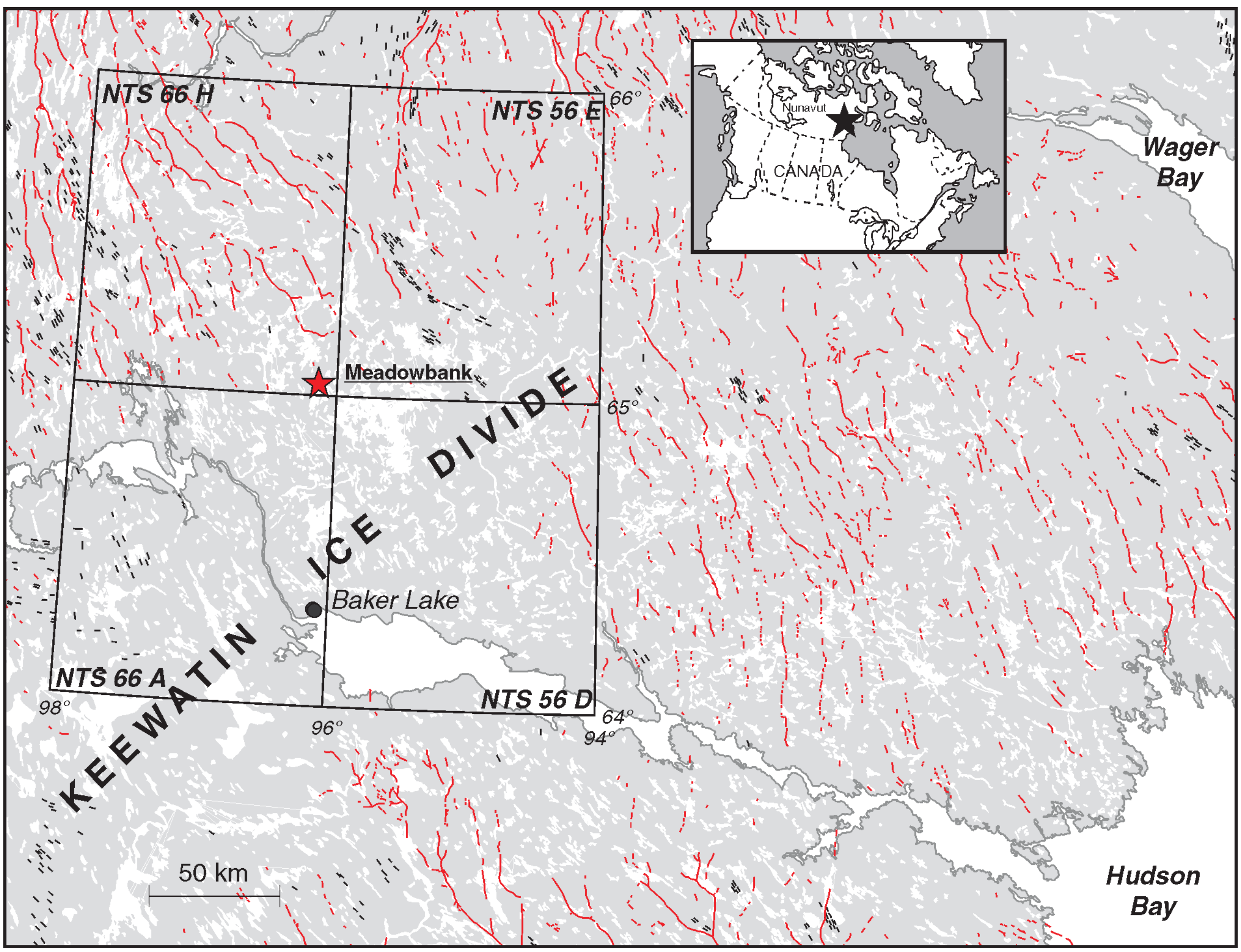

*Figure 1. Location of Meadowbank area within the region. Trends of major eskers (red) and streamlined landforms (black) are shown on either side of the Keewatin Ice Divide (*modified from *Aylsworth and Shilts, 1989).*

Early interpretations of ice movement indicators led Tyrrell (1897) to suggest a "Keewatin Glacier" centred in the District of Keewatin that served as one of a number of dispersal centres around Hudson Bay. In contrast, Flint (1943) proposed the model of a single ice dome centred over Hudson Bay during the last glacial maximum. Lee et al. (1957) modified this hypothesis by defining the Keewatin Ice Divide as the zone occupied by the last glacial remnants of the Laurentide Ice Sheet west of Hudson Bay. Although the Keewatin Ice Divide was recognized as a discrete dispersal centre, it was interpreted by Lee et al. (1957) as a deglacial feature that did not represent the full glacial configuration of the ice sheet.

The area south of Baker Lake was the focus of an extensive drift prospecting program in the 1970s by the GSC. Ice-movement indicators demonstrating pervasive ice movement towards Hudson Bay and glacial dispersal trains of distinctive Dubawnt Supergroup lithologies extending southeast from Baker Lake to the coast led Shilts et al. (1979) to redefine the Keewatin Ice Divide as a relatively static, long-lived feature of the Laurentide Ice Sheet.

Aylsworth and Shilts (1989) refined the position of the Keewatin Ice Divide based on interpreted "zones" of glacial landforms. The Meadowbank area straddles zone 1 ("the Keewatin Ice Divide and hummocky moraine") and zone 2 ("the zone of ribbed moraine"). Their placement of the divide is approximately northeast-southwest from Wager Bay, and corresponds closely to the 8.4 ^{14}C ka Keewatin Ice Divide of Dyke and Prest (1987).

Despite the acceptance of the general position of the divide, refinements of its dynamics have continued. Based on till composition in the Baker Lake area, Klassen (1995) recognized the predominance of a southeastward movement from a divide located northwest of the Keewatin Ice Divide central axis as previously defined by Shilts et al. (1979). Systematic mapping of ice-movement indicators and till stratigraphy in the central part of the region, immediately south of Baker Lake, have provided new evidence for the migration of ice divide(s) and resulting major shifts in ice-movement within the Keewatin Sector of the Laurentide Ice Sheet (McMartin and Henderson, 1999, 2004). These authors

Table 1. List of ice-movement-indicator measurements (locations in NAD 83).

Easting	Northing	UTM zone	Azimuth (°)	Definition	Relative age (1 = oldest)
637544	7214910	14 W	336	Well defined	0
637414	7215015	14 W	351	Well defined	0
637243	7214930	14 W	2	Well defined	2
637243	7214930	14 W	342	Well defined	1
637243	7214930	14 W	14	Poorly defined	0
634451	7217451	14 W	349	Well defined	0
634874	7217317	14 W	357	Well defined	1
634874	7217317	14 W	337	Well defined	2
634867	7216639	14 W	355	Well defined	0
634861	7216415	14 W	351	Well defined	0
635711	7216252	14 W	357	Well defined	0
636828	7215732	14 W	358	Well defined	0
636972	7215348	14 W	350	Well defined	0
636972	7215348	14 W	3	Poorly defined	0
637084	7214995	14 W	355	Well defined	0
637084	7214995	14 W	157	Well defined	0
636723	7214824	14 W	156	Well defined	0
639035	7213619	14 W	345	Well defined	0
639102	7213560	14 W	342	Well defined	0
639102	7213560	14 W	326	Well defined	0
639078	7213631	14 W	342	Well defined	0
639131	7213416	14 W	357	Well defined	0
638158	7213118	14 W	333	Well defined	2
638158	7213118	14 W	279	Well defined	1
637476	7213165	14 W	335	Well defined	0
637364	7214556	14 W	350	Well defined	0
637364	7214561	14 W	344	Well defined	0
636904	7214343	14 W	355	Poorly defined	0
637329	7213783	14 W	347	Poorly defined	0
638489	7215531	14 W	346	Well defined	0
638459	7215513	14 W	325	Well defined	1
638459	7215513	14 W	346	Well defined	2
638569	7216085	14 W	348	Well defined	1
638569	7216085	14 W	2	Well defined	2
638687	7216185	14 W	348	Well defined	0
639984	7215944	14 W	4	Poorly defined	0
640334	7215751	14 W	357	Well defined	0
640599	7215393	14 W	357	Well defined	0
641110	7214955	14 W	350	Well defined	2
641110	7214955	14 W	358	Well defined	1
640734	7218461	14 W	345	Well defined	0
640691	7218838	14 W	342	Well defined	1
640691	7218838	14 W	350	Well defined	2
640900	7220164	14 W	340	Well defined	0
640971	7220065	14 W	354	Well defined	0
640998	7220160	14 W	355	Well defined	0
634140	7212804	14 W	349	Poorly defined	0
634365	7212752	14 W	340	Poorly defined	0
634451	7212592	14 W	348	Well defined	0
634521	7212537	14 W	349	Well defined	0
634483	7211372	14 W	340	Well defined	0
634211	7210860	14 W	351	Poorly defined	0
634148	7210704	14 W	358	Well defined	0
633217	7210099	14 W	351	Poorly defined	0
633143	7209574	14 W	352	Well defined	0
632900	7208300	14 W	338	Well defined	1
632900	7208300	14 W	300	Well defined	2
632865	7207501	14 W	353	Well defined	0
632741	7207193	14 W	353	Well defined	0
632804	7206901	14 W	353	Well defined	0
624850	7223517	14 W	331	Well defined	0
622243	7233795	14 W	342	Well defined	0
363401	7227481	15 W	341	Well defined	0
363553	7227759	15 W	335	Well defined	2
363553	7227759	15 W	358	Poorly defined	1
363621	7227842	15 W	348	Well defined	0
362633	7227752	15 W	353	Well defined	0
361369	7227738	15 W	317	Poorly defined	0
361281	7227318	15 W	352	Poorly defined	0
361365	7226990	15 W	332	Poorly defined	0
361563	7226883	15 W	332	Well defined	0
360989	7226292	15 W	320	Well defined	0
360732	7226058	15 W	320	Well defined	2
360732	7226058	15 W	338	Well defined	1
360546	7225805	15 W	323	Well defined	0
361988	7237362	15 W	335	Well defined	0
382003	7221142	15 W	332	Well defined	0
382003	7221142	15 W	342	Well defined	0
367100	7203050	15 W	2	Well defined	0
365133	7220635	15 W	328	Well defined	0
365432	7220635	15 W	330	Well defined	0
365644	7220444	15 W	324	Well defined	0
365644	7220444	15 W	342	Well defined	0
365800	7220514	15 W	338	Well defined	0
367215	7220738	15 W	4	Well defined	0
367895	7220955	15 W	356	Well defined	0
368153	7221051	15 W	352	Well defined	0

established a sequence of six distinct regional ice movements, including four events that occurred prior to the decay of the Laurentide Ice Sheet towards the Keewatin Ice Divide.

METHODS

Measurements of small-scale features (i.e. striae and roches moutonnées) were made on subhorizontal outcrops using a Brunton compass. Measurements on magnetite-rich outcrops were obtained with a sun compass (Fig. 2a). In order to determine relative ages, azimuths were compared to large-scale features such as flutings, and crosscutting relationships (when present) were examined and resolved. Additionally, older events were determined from ice-movement indicators preserved on the lee side of obstacles (Fig. 2b).

RESULTS AND INTERPRETATIONS

Ice-movement-indicator measurements were collected at a total of 72 sites (Table 1). Several phases of ice movement were identified and are presented in Figure 3.

Primarily, ice movement was northward and north-northwestward (Fig. 2c). An earlier, poorly preserved event may have been to the southeast, as inferred from two measurements on the lee of two separate outcrops (157° and 156°). There is also one early west-east measurement (279°–99°); it is not clear if this represents an easterly or a westerly ice movement. In the northeast of the study area (NTS 56 E), there is an anticlockwise shift of ice-movement-indicator direction, from northward to north-northwest. The opposite relationship is seen in the northwest of the study area (NTS 66 H) (north-northwest first, followed by northward). In the southwest (NTS 66 A) there is an anticlockwise shift (northward, north-northwest, then to the northwest).

In combination, these data suggest ice movement was first to the north (phase 1), and then turned from northerly to north-northwesterly across the entire study area (phase 2). Phase 1 may have been preceded by a southeasterly movement as the ice-divide shifted towards the Baker Lake area, as suggested earlier by Klassen (1995). A later northward movement occurred locally (phase 3a), perhaps reflecting convergence towards an esker tunnel (in NTS 56 E) and/or a small east-west re-entrant within the ice front near the Meadowbank deposits (*see* Fig. 3). The late northwesterly movement in the southern part of the study area (phase 3b) is probably part of a major, late, west-northwesterly movement that can

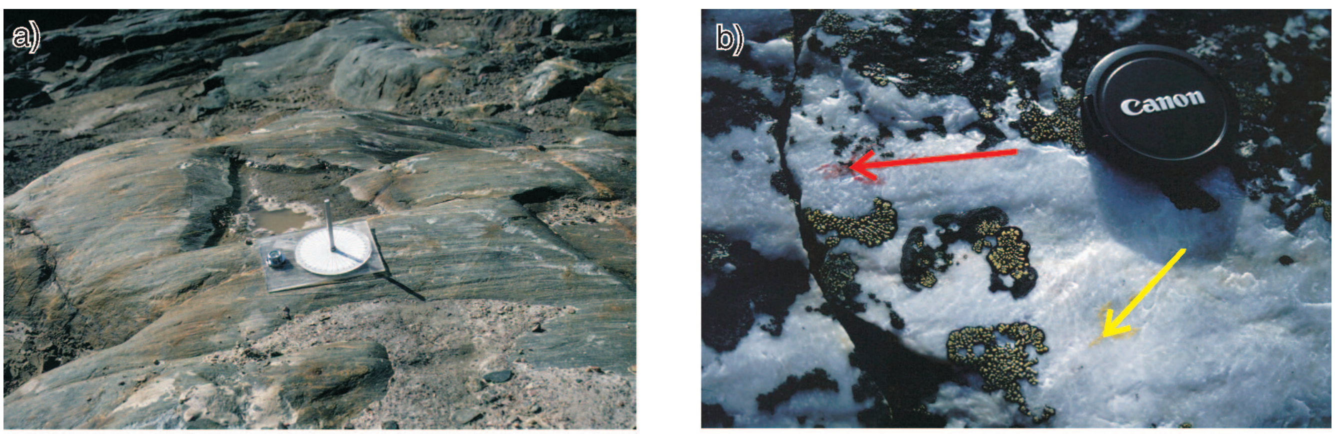

***Figure 2. a)** Photograph of striae measurements with a sun compass on felsic volcaniclastic rocks interbedded with iron-formation at the Third Portage deposit. **b)** Photograph of crosscutting striae sets on a quartzite outcrop of the Woodburn Lake group northwest of the Meadowbank camp. The main ice-flow event here was to the north (phase 1) with striae and grooves trending 357° (red arrow). A later event occurred to the north-northwest (phase 2) as recorded by delicate striae and crescentic fractures trending 337° (yellow arrow) and present mainly on the top of the north trending grooves. **c)** Photograph of well developed striae trending 332° indicating a north-northwest movement (phase 2) on ultramafic rocks of the Woodburn Lake group.*

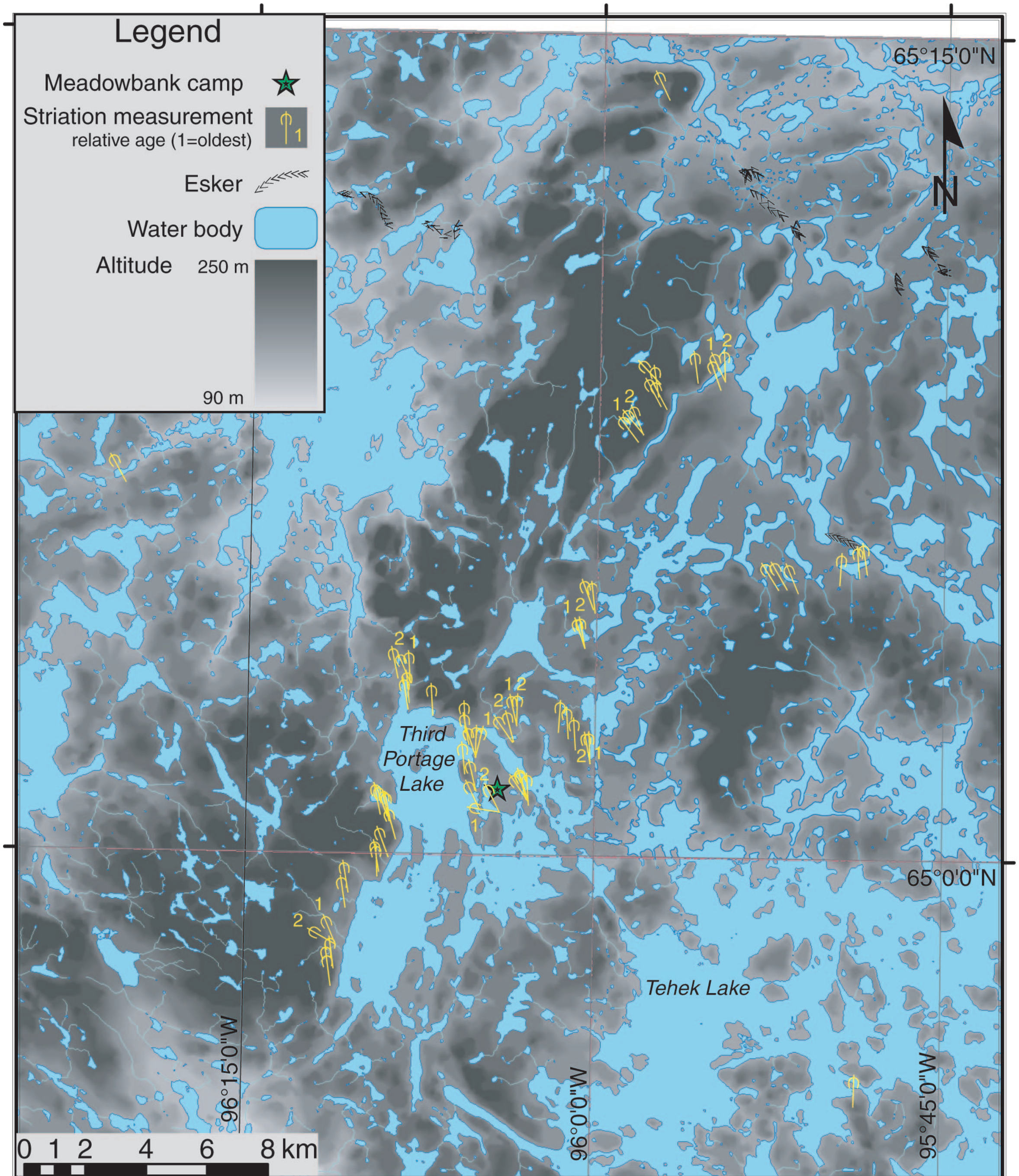

Figure 3. *Map of striation measurements shown with relative age relationships in the Meadowbank area. Digital elevation model is derived from 1:50 000 scale topographic maps.*

be observed as far south as Forde Lake, 100 km south of Baker Lake (Cunningham and Shilts, 1977; McMartin and Henderson, 2004). This late westerly movement suggests the migration of the Keewatin Ice Divide to an approximate north-south position, located more easterly than previously reported (McMartin and Henderson, 2004).

The ice-movement indicators record shifting and retreat of the Keewatin Ice Divide. These data suggest the divide was mainly south of the study area, and was first oriented east-west, then southwest-northeast, and then north-south. Interpretations of the latitude of the ice divide and its broader configuration necessitate interpretation of pebble-lithology provenances and correlation with regional striations. No such samples were collected, and the regional striae record is lacking, thus no evaluation of the effects on glacial dispersal can be made. A regional Quaternary mapping program by the GSC starting in the summer of 2004 (NTS 66 A) will help to assess the impact of the divide migration on till composition.

CONCLUSIONS

Field data collection of ice-movement features in the Meadowbank area in June and August 2003 was performed in response to industry interest in ice-movement analyses for interpretation of detailed till geochemistry sampling. The more detailed survey resulted in an increase in ice-movement-indicator data set and refinement of the location and evolution of the Keewatin Ice Divide, and as such provides a preliminary framework for interpreting glacial dispersal in areas located under the Keewatin Ice Divide across the region.

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