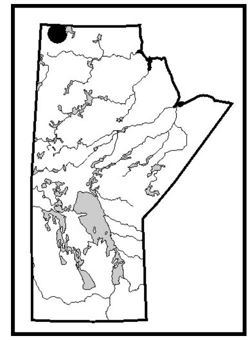

GS-14 Surficial geological investigations in the Kasmere–Putahow lakes area, northwestern Manitoba (parts of NTS 64N10, 11, 14 and 15)

by G.L.D. Matile

Matile, G.L.D. 2006: Surficial geological investigations in the Kasmere–Putahow lakes area, northwestern Manitoba (parts of NTS 64N10, 11, 14 and 15); *in* Report of Activities 2006, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 148–154.

Summary

An understanding of ice-flow history has long been an important aspect of mineral exploration in glaciated terrains. After two field-mapping programs in Manitoba's far north working closely with Precambrian bedrock geologists, it has become clear that understanding subglacial meltwater erosion is equally important in determining bedrock sources for sediment samples and potential ore-bearing surface and near-surface boulders. This conclusion is in agreement with work done by Quaternary geologists in similar glacial settings in nearby Phelps Lake area in northeastern Saskatchewan and the Lac de Gras area of the Northwest Territories.

Although, in the Kasmere–Putahow lakes area, the orientation of narrow cigar-shaped drumlins closely mimics the southerly ice-flow direction as determined by glacial striations, many other landforms in the area such as broader cresentic drumlins, Rogen moraines, tunnel channels and eskers can be highly variable in orientation. These landforms are believed to be derived from either erosional or depositional processes associated with turbulent subglacial meltwater flow.

This summer's mapping program included the collection of 21 diamict samples, each 20 kg in weight, from the shores of Kasmere and Putahow lakes with a sample spacing of approximately 5 km. Subtle variations in sediment sorting, or the lack thereof, within the matrix of these samples, is key to understanding the depositional environments and genesis of the landforms from which they were derived.

Introduction

Surficial mapping and glacial sediment sampling was carried out in conjunction with Precambrian bedrock mapping (Böhm and Anderson, GS-13, this volume) in the Kasmere–Putahow lakes area in support of mineral exploration. Kasmere Lake is located approximately 50 km east of the Saskatchewan border and 40 km south of Nunavut, and Putahow Lake, 40 km to the northeast, is within 5 km of the Nunavut border (Figure GS-14-1). Local relief tends to be around 10 to 15 m. The larger eskers are 30 m high. The largest ridges are up to 80 m high and are possibly, at least in part, cored with durable bedrock. Precambrian bedrock outcrop is sparse and typically badly weathered and consists of metasedimentary rocks of the Wollaston Domain and younger granitic intrusions (Böhm and Anderson, GS-13, this volume).

Both lakes are situated south of the treeline in an area of discontinuous permafrost. Permafrost and winter lake ice features, although present, are far less dramatic than in the Nejanilini Lake area, 180 km to the east (Figure GS-14-1), which was mapped in 2005 (Anderson et al., 2005). Common to Nejanilini Lake are well developed

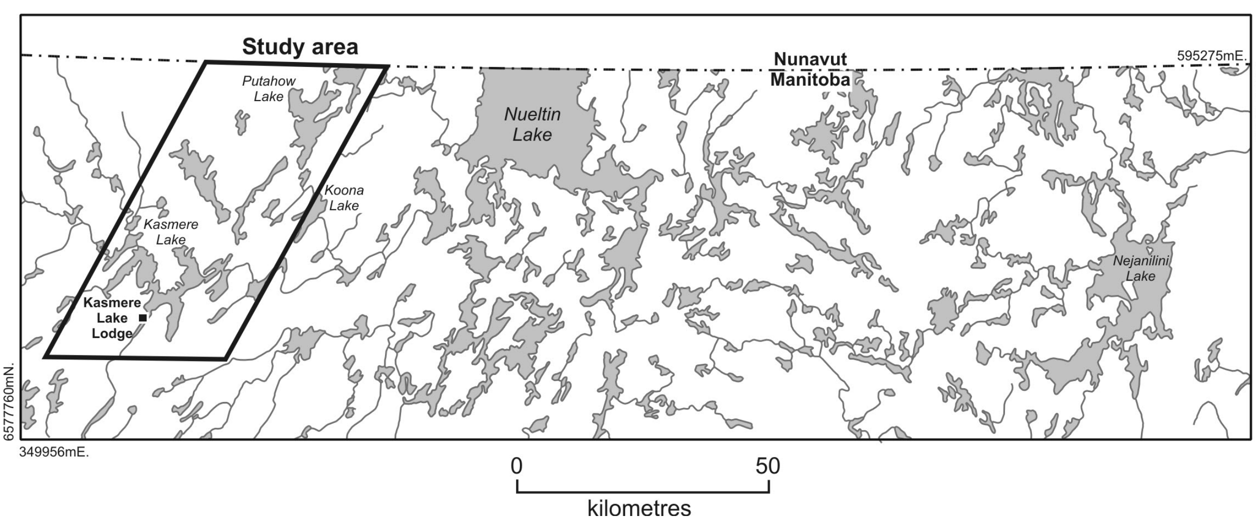

Figure GS-14-1: Location map of the Kasmere–Putahow lakes surficial map area (Matile, 2006) and Nejanilini Lake to the east.

‘fortress islands’, shorelines with boulders pushed landward and concentrated on the lakeshore by thermally expanded and contracted winter lake ice. On Kasmere and Putahow lakes these ‘islands’ were uncommon and restricted to short stretches of shoreline up to 100 m in length. Permafrost and permafrost features such as patterned ground, common in the Nejanilini area, were only observed in one location during this year’s mapping. Felsenmeer, fields of frost-shattered bedrock, were frequently observed and helpful to bedrock mapping in the absence of local bedrock outcrop.

The area is situated within the Keewatin Sector of the Laurentide ice sheet. Glacial ice flowed southward over Precambrian rocks producing a glacial diamict with a very sandy matrix. Glacial diamict is the prominent surface material, followed by organic wetlands and glaciofluvial sediments (eskers and esker complexes). As was the case in the Nejanilini Lake area, glacially derived boulders litter the landscape. Bedrock outcrops are typically badly weathered and as a result there were very few measurable glacial striations and no readily identifiable water-sculpted bedrock forms observed during field mapping. Major south-southwest–trending eskers occur approximately every 20 km laterally with numerous smaller tributary eskers in between. The area was previously sampled and mapped in the late 1970s at a scale of 1:250 000 by Dredge et al. (1982) and later released as a 1:500 000 scale map compilation for northwestern Manitoba by Dredge et al. (1986). Campbell (2002) mapped the Keseechewun Lake area in nearby northeastern Saskatchewan and concluded that “subglacial meltwater erosion played a major role in the formation of the present-day landscape”. Rampton (2000) also describes an array of erosional and depositional landforms in southeastern Northwest Territories, which he attributes to broad subglacial meltwater flows. Horseshoe-shaped depressions, with the closed end pointing up-ice and commonly filled with water, are numerous and are strong evidence of the presence of turbulent subglacial meltwater.

Twenty-one glacial diamict samples were collected from hand-dug holes. No natural exposures were found in the diamict. The diamict sample sites were generally within 100 m of the lakeshore with a spacing of approximately 5 km. The samples were taken 10 to 20 cm below an abrupt decrease in soil oxidation; which was interpreted as the C horizon. Samples were taken within a 40 to 50 cm interval, at a depth ranging from 0.4 to 1.0 m depending on soil thickness and stone content. Pebbles in the 2 to 4 cm size range were collected separately and classified back at camp by the bedrock mappers based on the regional bedrock. The diamict samples will be processed for indicator minerals, gold grains and geochemistry.

Mineral occurrences

There are a number of mineral occurrences in the Kasmere–Putahow lakes area. In 1980, U-rich boulders were reported from the north end of Kasmere Lake (Assessment File 93481, Manitoba Science, Technology, Energy and Mines, Winnipeg). Detailed investigations were carried out in the area and 55 to 60 U-rich boulders were found. Some of these boulders were also Au-rich and the bedrock source was determined to be approximately 100 m from the location of the boulders (A.F. 93481). In 1981, U-Pb, Ni-Cu and Ni-Co showings were reported south of Kasmere Lake (Assessment File 93489, Manitoba Science, Technology, Energy and Mines, Winnipeg). In 2006, CanAlaska Ventures Ltd. reported mineralized boulders, south and west of Kasmere Lake, containing up to 11% U_3O_8 and 5% Mo and one bedrock outcrop sample containing 10% U_3O_8 (Dasler, 2006). Six diamict samples were taken by Dredge and Pehrsson (2006) in the Kasmere–Putahow lakes map area, but anomalous values were only recorded in the Putahow Lake area: Co, Cr, Cu, Fe, Mo, Ni, Zn, Pb, U to the west, Cr, Cu to the north and U to the south.

During field investigations for this project, a 40 m bedrock trench was encountered exposing uranium mineralization in leucogranite 400 m southwest of Kasmere Lake Lodge on Kasmere Lake. Also, a concentration of sulphide-rich arkosic boulders was discovered 2.5 km north of Kasmere Lake Lodge. The significance of this boulder concentration, other than its mineralization, is that it is a good example of how concentrated boulders of a single lithology can occur, and how rapidly boulder lithology can change, indicating an extremely short glacial transport distance. In this particular example, all the boulders in this concentration are the same lithology, and both the boulders and the fine sediments in between (the diamict matrix) are heavily oxidized. Also, a well defined line could be drawn diagonally down the west slope of the drumlin on which the boulders were found; with the mineralized boulders to the south of the line and granitic boulders to the north, which were an equally lithologically homogeneous boulder cluster.

Surficial geology

Peat-filled wetlands make up a small portion of the surface material in the Kasmere–Putahow lakes area. The peat is commonly more than 3 m thick and contains abundant charcoal layers. Glaciofluvial sand and gravel also makes up a small portion of the surface material. Unlike the Nejanilini Lake area where stratified sand essentially covered the entire area at depth (Anderson et al., 2005), stratified sand and gravel in this area appears to be restricted to esker corridors, which can be up to 2 km across. Major eskers up to 30 m high meander across the landscape trending south-southwest and tend to occur at a fairly regular interval of 20 km. Eskers generally have a central peaked ridge or in places multiple ridges (Figure GS-14-2) and were deposited in a pre-existing tunnel channel. Tributary eskers are arranged at acute angles to the major eskers and tend to be significantly smaller. The eskers are composed primarily of sand, particularly in the flanking fans, but can contain very coarse gravel including clast-supported, open-framework boulder gravel.

Due to the pristine nature of the landforms (e.g., peaked esker ridges) and other smaller surficial features (e.g., perched boulders) and the lack of lacustrine sediments, it is believed that there was no proglacial lake along the retreating glacial ice margin in this area. This was also true for the Nejanilini Lake area (Anderson et al., 2005) and, as a result, it is believed that glacial Lake Agassiz did not extend this far north in Manitoba.

Surface sediments are dominated by glacial diamict. The diamict is typically light grey in colour. The Munsell colour ranged from 5Y 7/2 to 2.5Y 5/3 (Munsell Color, 1975). It is generally uncompacted (loose) and homogeneous with a matrix texture of silty sand. The diamict was found to be noncalcareous even in areas where the local bedrock was strongly calcareous, supracrustal metasedimentary rocks. The stone content is highly variable and generally decreases downwards. At three of the diamict sample sites, the diamict matrix displayed some degree of sorting and was less silty than normal. The thickness of the diamict is unknown but hand-dug sample holes never penetrated the diamict. In contrast, in the Nejanilini Lake area, the typical stratigraphy comprised more than 5 m of stratified sand overlain by approximately 1 m of glacial diamict (Anderson et al., 2005). This diamict was less homogeneous than diamict from this year's map area and generally contained numerous sand seams.

The diamict surface is overwhelmingly streamlined in a south-southwest direction (Matile, 2006). There does appear to be some organization to the landforms. Individual landform types are typically found in clusters or commonly grouped in curvilinear corridors (Figure GS-14-3a), which are aligned subparallel to the drumlins and ice flow in the area. The landforms include spindle drumlins (Figure GS-14-3b), crescentic drumlins (Figure GS-14-3c), Rogen moraines (Figure GS-14-3d), tunnel channels (Figure GS-14-3e) and eskers (Figure GS-14-3f). The degree to which the surface in the area of these landforms has been eroded seems to increase from spindle drumlins (spindle-shaped landforms can be ridges or grooves), which tend to be found on smoother, elevated terrain, to tunnel channels, which tend to be a clean box-style channel with an increased probability of bedrock outcrop within the channel. In some situations there seems to be an interference pattern between landform types possibly leading to a more disorganized pattern such as hummocky terrain.

Local relief on the landforms tends to be around 10 m. However, Rogen moraines and eskers can be up to 30 m high. Rogen moraines are transverse landforms with a gentle northern slope and a steep southern slope. In several cases, meltwater corridors appear to be determining the shape of lakes suggesting that the land within the corridor has been deflated more than the surrounding area (Figure GS-14-4).

Boulders are virtually always found lying on or imbedded in the surface of the diamict. The boulders are surprisingly consistent lithologically in a particular location and the lithology changes rapidly from area to area, presumably mimicking the local bedrock. Similarly, in the Nejanilini Lake area, 2 to 4 cm pebble lithology from diamict samples and observations in boulder fields were found to be very similar to the local bedrock (Anderson et al., 2005). Pebble counts from the diamict samples in the Kasmere–Putahow lakes area also suggest a short transport distance. Dredge (1981) also concluded that the glacial transport distances were very short,

Figure GS-14-2: *Multiple ridged esker, 30 m high, in the North Arm of Kasmere Lake.*

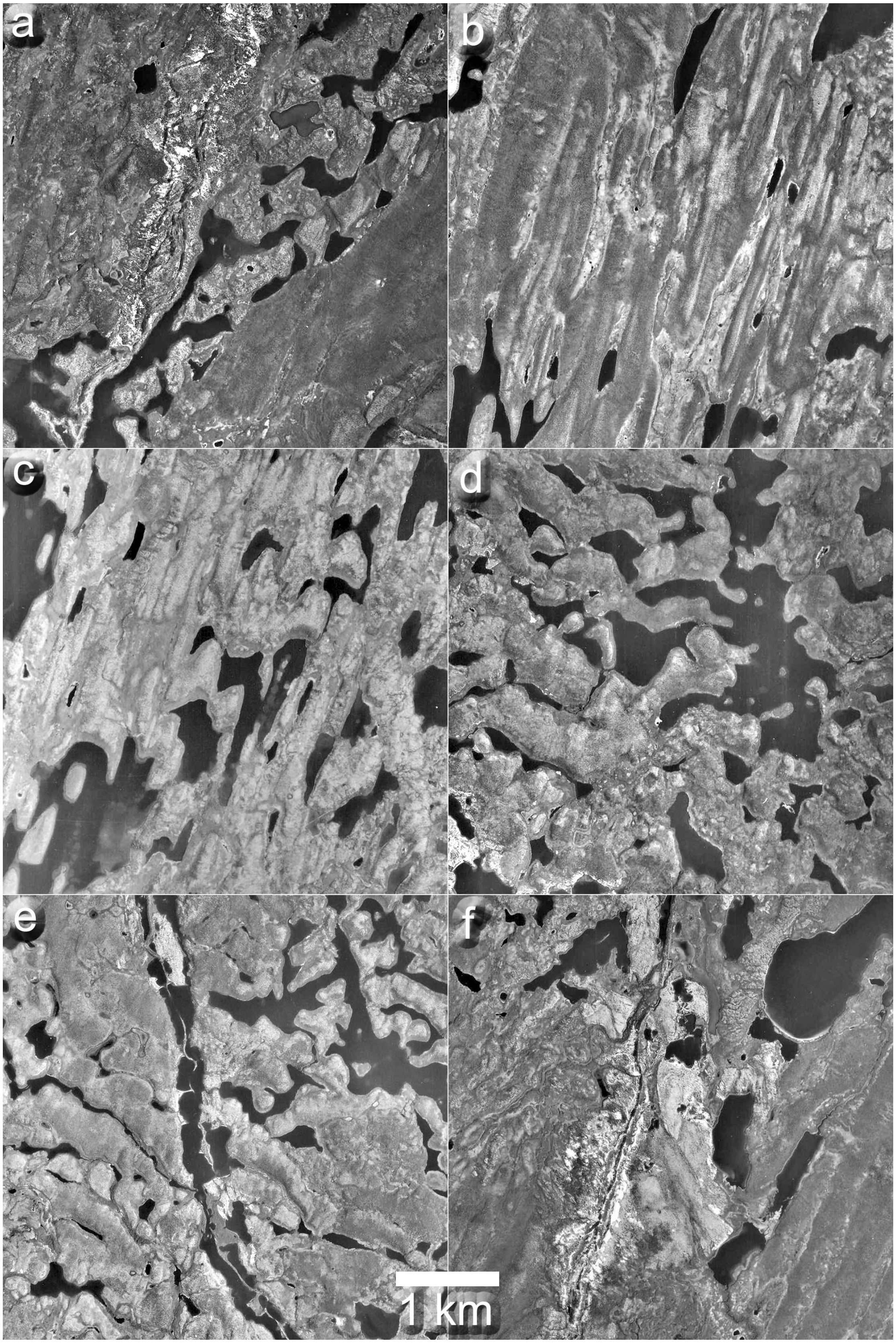

Figure GS-14-3: *Examples of landforms found in the map area:* ***a)*** *meltwater corridor, notice the increased number of lakes within the corridor;* ***b)*** *spindle drumlins;* ***c)*** *crescentic drumlins;* ***d)*** *Rogen moraines;* ***e)*** *tunnel channel, notice the small esker deposited within the tunnel channel;* ***f)*** *large esker ridge with associated fan deposits, notice that the esker has a prominent central ridge.*

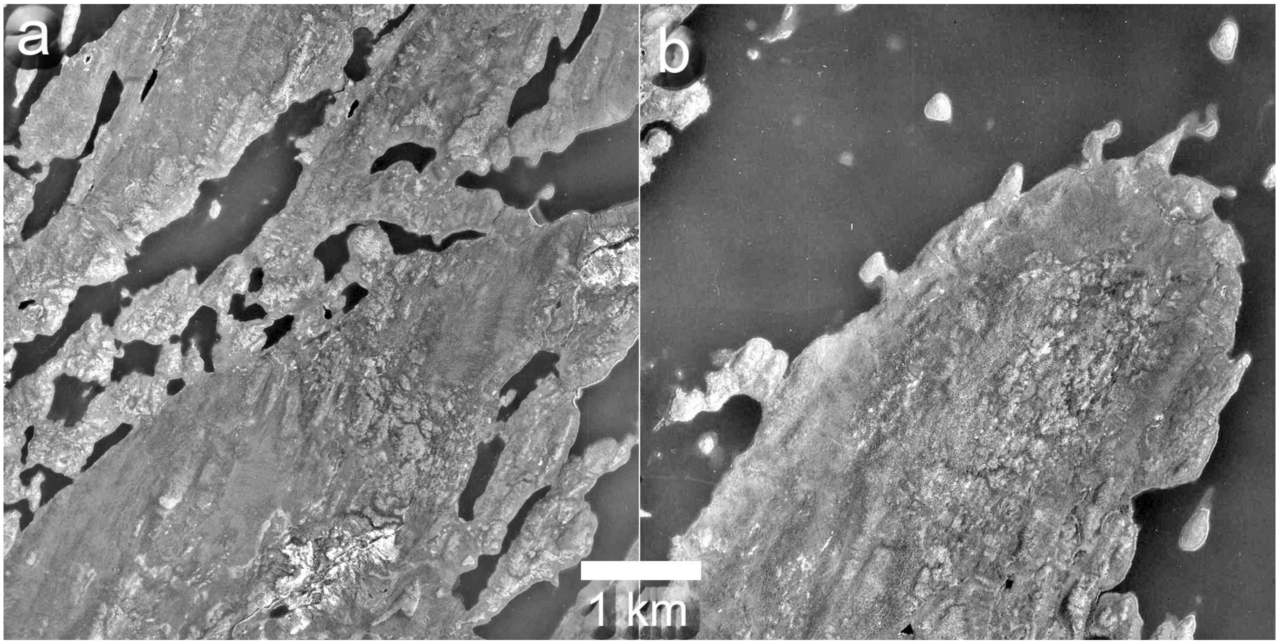

Figure GS-14-4: *Examples of meltwater corridors:* ***a)*** *a landform corridor cutting through a cluster of spindle drumlins, extending southwestward out of Koona Lake (on the right edge of the image);* ***b)*** *southern portion of Kasmere Lake, notice the spurs on the lakeshore and how they resemble the way in which the landforms in a) meet the edge of the meltwater corridor.*

probably between 1 and 5 km. Clast-supported open-framework boulder fields are commonly found in troughs between ridges. These boulder fields are, in part, depositional, probably having been eroded from the adjacent ridge. Counts and observations in eskers found largely exotic lithologies indicating a longer glacial transport for the eskers (Anderson et al., 2005).

Landform genesis

Turbulent subglacial meltwater played a major role in the formation of the present-day landscape in this area (Rampton, 2000; Campbell, 2002; Anderson et al., 2005). The model invoked for the development of the landforms in the Kasmere–Putahow lakes area is based on the meltwater hypothesis as described by J. Shaw (e.g., Shaw and Sharpe, 1987; Shaw, 2002), which suggests that erosion and deposition by glacial meltwater in the form of subglacial sheet floods is responsible for producing such landforms as drumlins, Rogen moraines and tunnel channels.

During the tens of thousands of year that this area was under glacial ice in the late Wisconsinan period, there was a buildup of glacial diamict (till) that is probably in excess of 5 m thick. During deglaciation, water began to accumulate in reservoirs under the glacier. This meltwater was periodically released in the form of turbulent sheet floods. These sheet floods caused the glacier to temporarily lift off from the diamict surface. Turbulence within the sheet flood was responsible for the bulk of the erosion, and the style of the vortices in any particular location largely determined the shape of the resultant landform. These vortices not only eroded into the diamict and bedrock surface, but also eroded a similar shape into the glacial ice above (Shaw, 2002). As the sheet flood passed and the volume of meltwater diminished, the glacier was progressively let down forcing the meltwater to organize into channels. This had two effects: 1) the areas where the glacier had been let down were protected from further erosion and this is probably where clusters of spindle drumlins are found, and 2) as the channels became narrower, the erosion intensified (Figure GS-14-3) due to the constriction and duration of flow. Eventually only tunnel channels remained open to meltwater flow. These channels are the narrowest and most deeply eroded, both in terms of diamict erosion and glacial ice erosion. Therefore, because glacial meltwater finds its course from high to low pressure within and below the glacier, and these tunnel channels would be relatively low pressure areas, when seasonal drainage within the glacier was re-established, esker conduits would likely re-occupy these tunnel channels.

This process is responsible for a continuum of landforms from drumlins to crescentic drumlins to Rogen moraines to tunnel channels. Eskers are not part of the continuum. They are deposited in the tunnel channels after the sheet flood has passed and seasonal drainage has been re-established. This continuum of landforms can have a depositional origin in other areas (Shaw, 2002), however, in the Kasmere–Putahow lakes area the continuum appears to be erosional, with the possible exception of Rogen moraines.

Numerous models have been invoked for the formation of Rogen moraines. Sarala (2005) suggested that with the glacier frozen to the substrate, plucking and stacking of sediments and bedrock blocks could generate Rogen moraines. This model predicts a very short glacial transport distance for the glacial debris, from 50 to 300 m, and probably the presence of angular boulders on and in the Rogen moraines. Angular boulders were not observed in Rogen moraines in the Kasmere–Putahow lakes area Fisher and Shaw (1992) cut trenches through Rogen moraines in Newfoundland and discovered that the internal bedding of the features was conformable with the upper surface of the Rogen moraine and as a result concluded that they were a depositional landform, which they believe was deposited by hyperconcentrated and subaqueous debris flows within a subglacial sheet flood. In this study, in the absence of natural exposures, landform analysis is unfortunately restricted to aerial photography interpretation, surface observations and observations within 1 m deep hand-dug holes.

In the Kasmere–Putahow lakes area, with the observed landform associations, it would appear difficult to invoke a glacial thrusting model for the formation of the Rogen moraines, however, it is possible, within a meltwater corridor, that the Rogen moraines began to migrate down flow and that they were, in part, deposited by hyperconcentrated meltwater.

Economic considerations

Geochemical surveys in the Kasmere–Putahow lakes area have defined anomalous values of Co, Cr, Cu, Fe, Mo, Ni, Zn, Pb and U. Mineral exploration by private exploration companies and field mapping by the MGS have discovered showings of uranium, gold and sulphides. For exploration purposes, it is important in glaciated areas to understand ice flow patterns. In the Kasmere–Putahow lakes area, landscape analysis has shown that when hand sampling near-surface glacial sediments in this area, it is important to understand the distribution of subglacial meltwater flow corridors when determining the bedrock source for potential mineral anomalies. These corridors can deviate significantly from the ice-flow direction as determined from glacial striations. These corridors can be traced parallel to streamlined drumlinoid landforms and perpendicular to transverse landforms such as Rogen moraines. Landform and diamict analysis also suggests a very short sediment transport distance, possibly less than a kilometre, at least in the near-surface diamict. The sediments found in eskers have been transported a long distance and this in combination with the meandering nature of an esker makes it difficult to determine a bedrock source for anomalous mineral-bearing sediments found in eskers.

Acknowledgments

Thanks to N. Brandson for thorough logistical support. S. Anderson and C. Böhm provided helpful discussion and field support. K. Reid provided enthusiastic field assistance. H. Groom and G. Keller reviewed the manuscript.

References

Anderson, S.D., Böhm, C.O. and Matile, G.L.D. 2005: Bedrock and surficial geological field investigations in the Nejanilini Lake area, northern Manitoba (parts of NTS 64P5, 12 and 13); *in* Report of Activities 2005, Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, p. 92–103.

Campbell, J.E. 2002: Phelps Lake project: highlights of the Quaternary investigations in the Keseechewun Lake area (NTS 64M-9, -10, -15, and -16), *in* Summary of Investigations 2002, Volume 2, Saskatchewan Industry and Resources, Miscellaneous Report 2002-4.2, CD-ROM, Paper A-2, 16 p.

Dasler, P. 2006: 2006 winter exploration program commences, CanAlaska identifies multiple uranium zones at north east Athabasca project, Saskatchewan; CanAlaska Ventures Ltd., news release, January 16, 2006, URL http://www.canalaska.com/i/pdf/011606CVV.pdf [September 18, 2006].

Dredge, L.A. 1981: Trace elements in till and esker sediments in northwestern Manitoba; Geological Survey of Canada, Paper 81-1A, p. 377–381.

Dredge, L.A., Nixon, F.M. and Richardson, R.J. 1982: Surficial geology, Kasmere Lake, Manitoba; Geological Survey of Canada, Preliminary Map 19-1981, scale 1:250 000.

Dredge, L.A., Nixon, F.M. and Richardson, R.J. 1986: Surficial geology, northwestern Manitoba; Geological Survey of Canada, “A” Series Map 1608A, scale 1:500 000.

Dredge, L.A. and Pehrsson, S.J. 2006: Geochemistry and physical properties of till in northernmost Manitoba (NTS 54E,F,K,L,M; 64I,J,K,N,O,P); Geological Survey of Canada, Open File 5320, 134 p.

Fisher, T.G. and Shaw, J. 1992: A depositional model for Rogen moraine, with examples from the Avalon Peninsula, Newfoundland; Canadian Journal of Earth Sciences, v. 29, p. 669–686.

Matile, G.L.D. 2006: Surficial geology of the Kasmere–Putahow lakes area, northwestern Manitoba (parts of NTS 64N10, 11, 14 and 15); Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2006-6, scale 1:50 000.

Munsell Color 1975: Munsell Soil Color Chart (1975 edition); Munsell Color, Macbeth a division of Kollmorgen Corporation, Baltimore, 1 v. (loose-leaf).

Rampton, V.N. 2000: Large-scale effects of subglacial meltwater flow in the southern Slave Province, Northwest Territories, Canada; Canadian Journal of Earth Sciences, v. 36, p. 81–93.

Sarala, P. 2005: Glacial morphology and dynamics with till geochemical exploration in the ribbed moraine area of Perapohjola, Finnish Lapland; academic dissertation, University of Oulu–Geological Survey of Finland, Rovaniemi, 17 p.

Shaw, J. 2002: The meltwater hypothesis for subglacial bedforms; Quaternary International, v. 90, p. 5–22.

Shaw, J. and Sharpe, D.R. 1987: Drumlin formation by subglacial meltwater erosion; Canadian Journal of Earth Sciences, v. 24, p. 2316–2322.