GS2018-14

Till composition of the Kaskattama Kimberlite No. 1 drillcore, Kaskattama highland region, northeastern Manitoba (part of NTS 54B7)

by T.J. Hodder

In Brief:

- Four till units were identified in drillcore KK1 based on composition data
- Shale and siltstone clast concentrations in till suggest that this bedrock unit is more extensive in this region than previously realized, corroborating recent magnetotelluric geophysical interpretations

Citation:
Hodder, T.J. 2018: Till composition of the Kaskattama Kimberlite No. 1 drillcore, Kaskattama highland region, northeastern Manitoba (part of NTS 54B7); *in* Report of Activities 2018, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 166–174.

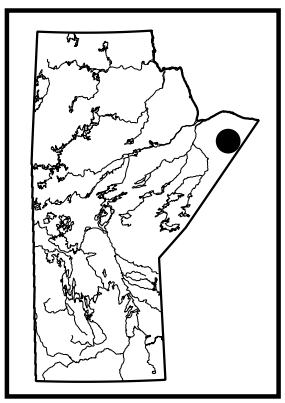
Summary

Drillhole Kaskattama Kimberlite No. 1 (KK1) intersected a thick sequence of Quaternary sediments in the Kaskattama highland area of northeastern Manitoba. Permafrost conditions allowed for excellent recovery of till during diamond drilling and this study focuses on documenting till composition through till-clast–lithology counts and till-matrix geochemistry.

Interpretation of till-composition data identified a minimum of four till units. The undifferentiated greenstone and greywacke clast concentration (17.8–20.4 count [ct.] %) present in two surficial till samples is elevated relative to till sampled in drillcore KK1 (maximum 6.4 ct. %), which suggests a stronger eastern provenance influence for the surficial till in this region. The concentration of black to grey shale and siltstone (BSS) clasts is elevated (maximum of 16.3 ct. %) within till from KK1, and far exceeds concentrations present in surficial and shallowly buried (<30 m) till samples in the region (maximum of 1.1 ct. %). The highest concentration of BSS clasts is present from 83.0 to 102.0 m true vertical depth. This interval of elevated concentration of BSS clasts is >100 m above local shale strata, which was observed at depths below 223.0 m. This would suggest that these BSS clasts have undergone some glacial transport into the area and are not simply sourced directly from the underlying bedrock. This is a significant observation and corroborates recent interpretations from a magnetotelluric geophysical survey, which suggest that the shale unit present in drillcore KK1 is likely more extensive in this region than previously understood.

Introduction

The Kaskattama Kimberlite No.1 (KK1) drillhole was drilled by Foran Mining Corporation during the summer of 2004 near Bouchard Lake in the Kaskattama highland region of northeastern Manitoba (Figure GS2018-14-1; Assessment File 74223, Manitoba Growth, Enterprise and Trade, Winnipeg). Drillhole KK1 tested a circular magnetic anomaly and was drilled to a total depth of 332.0 m true vertical depth (TVD; Assessment File 74223). The drillcore intersected a thick sequence of Quaternary sediments (up to 223.0 m) overlying a black shale of possible Cretaceous-age, underlain by Paleozoic carbonate rocks of the Hudson Bay Basin (Nicolas and Armstrong, 2017). Apart from Quaternary sediments exposed along river sections, this drillcore is the only subsurface observation for the entire highland region and represents a valuable source of Quaternary and Paleozoic stratigraphic data (Nicolas and Armstrong, 2017). The purpose of this study is to examine the composition of till recovered from drillcore KK1 through clast-lithology counts and till-matrix (<63 µm size-fraction) geochemistry, to contribute to ongoing regional investigations into the Quaternary geology (Hodder and Kelley, 2016; Hodder, 2017; Hodder and Kelley, GS2018-13, this volume) and subsurface structure (Craven et al., 2017) of the Kaskattama highland region.



Methods

In 2017, the KK1 drillcore was pulled from archive and examined in detail to verify previous core descriptions and sample the till. The KK1 drillcore was obtained by diamond drilling and the recovery of Quaternary sediments was poor until permafrost conditions were encountered. Recovery of sand and gravel sediments was minimal, but diamict

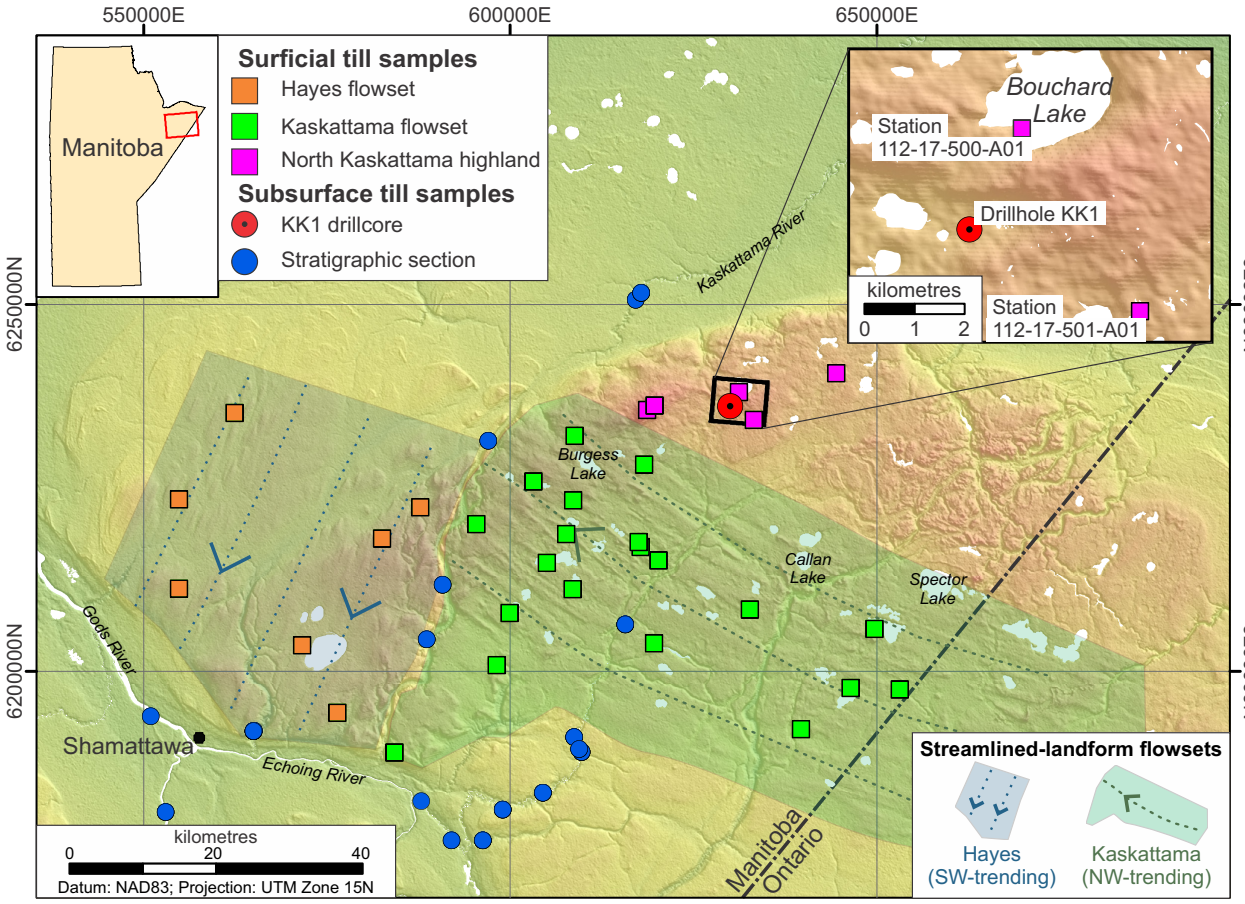


Figure GS2018-14-1: *Location of the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillhole and till samples collected nearby during the 2016 and 2017 field seasons in the Kaskattama highland region of northeastern Manitoba. Background hillshade image was generated using Canadian Digital Surface Model (Natural Resources Canada, 2015). Abbreviations: NW, northwest; SW, southwest.*

recovery was good (e.g., Figure GS2018-14-2a, b), and sediment and rock were recovered from 16.8 to 332.2 m TVD. Original observations made in the field (Assessment File 74223) were compiled and verified. Till was sampled at approximately 5 m intervals, where appropriate material was present, totalling 15 samples. The 5 cm (2-in.) diameter drillcore was first halved to maintain an archived record and till was sampled over 0.5–0.8 m intervals to obtain a sufficient amount of material for till-matrix geochemistry and clast-lithology analysis. Two surficial till samples were collected nearby the KK1 drillhole location during the 2017 field season (Figure GS2018-14-1) and are discussed in this report. These till samples were collected from C-horizon material in hand-dug pits and/or auger holes (Figure GS2018-14-2c–e).

Drillcore till samples were submitted to Saskatchewan Research Council Geoanalytical Laboratories (SRC; Saskatoon, Saskatchewan) and surficial till samples to Activation Laboratories Ltd. (Actlabs; Ancaster, Ontario) for initial processing. Till samples were wet sieved at SRC and dry sieved at Actlabs to obtain <0.063, 0.063–2 and >2 mm size-fractions. Following initial sieving, the >2 mm size-fraction was further sieved into 2–4, 4–8 and >8 mm size-fractions at the laboratory of the Manitoba Geological Survey Midland Sample and Core Library (Winnipeg, Manitoba) and submitted for clast-lithology counts internally. Clasts from the 2–4, 4–8 and >8 mm size-fractions were separated into 15 detailed lithology classes with the assistance of a 10 times optical microscope (e.g., Figure GS2018-14-3). These 15 detailed classes were grouped into six simplified classes for interpretation purposes (Table GS2018-14-1). An average of 353 clasts was counted for each sample (range of 323–381) and results are expressed as a count percentage. The <63 µm size-fraction was partially digested in an aqua regia (1:3, HNO_3:HCl) solution and analyzed for 63 elements by inductively coupled plasma–mass spectrometry (ICP-MS) and –emission spectrometry (ES) at Actlabs. The <63 µm size-fraction was also submitted to Actlabs for near-total digestion (HF:HNO_3:$HClO_4$:HCl) and analyzed for 58 elements by ICP-MS. Carbonate content was determined by the Ca/Mg method on the <63 µm size-fraction at Actlabs. Till-matrix geochemistry and clast-lithology count

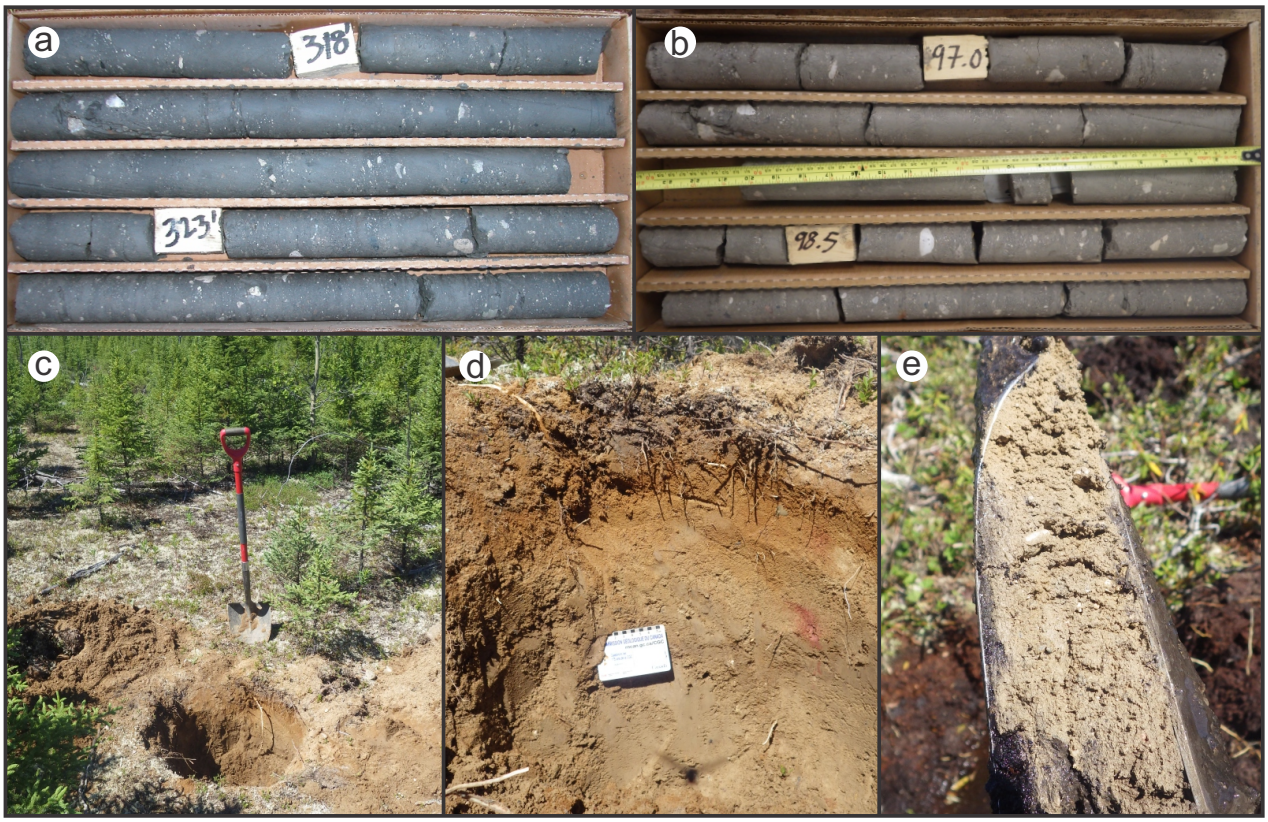


Figure GS2018-14-2*: Examples of till sampled as part of this study:* ***a)*** *till from the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore when first drilled (2004) and* ***b****) when sampled by this study;* ***c, d****) hand-dug pit exposing C-horizon till at station 112-17-501-A01; and* ***e)*** *auger of till at station 112-17-500-A01.*

data are published as data repository item (DRI2018002[1]) in co-ordination with this report (Hodder, 2018).

Results

Till stratigraphy

Drillcore KK1 intersected a thick sequence of Quaternary sediments (Figure GS2018-14-4). Insufficient core recovery from 2.7 to 12.2 m and 25.9 to 29.3 m inhibited sampling of the diamict observed in these intervals. Two nearby surficial till samples (Figure GS2018-14-1) are likely representative of the composition of the uppermost till unit observed in drillcore KK1 (2.7–12.2 m depth). Excellent core recovery allowed for the sampling of diamict from 80.0 to 170.1 m (Figure GS2018-14-4). This diamict, interpreted as a till based on the presence of striated clasts, is remarkably homogeneous in appearance throughout this entire interval. The diamict is dark grey (blackish-grey when wet), matrix supported and contains 10–15% clasts.

Till-clast–lithology composition

Analysis of clasts within till can assist with the delineation of glacial transport directions and distances, as well as identify unmapped, drift-covered bedrock units. Glacial dispersal can be mapped at varying scales from continental (hundreds of kilometres) to regional (tens of kilometres) to local (<10 km). Four till units are identified based on the clast-lithology count concentrations (Figure GS2018-14-5).

The surficial till (Till-1) near KK1 is characterized by high concentrations of undifferentiated greenstone and greywacke (UGG) clasts (Figure GS2018-14-5), which range from 17.8–20.4 ct. %. This contrasts with till sampled from drillcore KK1, which has a maximum of 6.4 ct. % (Figure GS2018-14-5). Till-2 (Figure GS2018-14-5) is characterized by high concentrations of black to grey shale and siltstone (BSS) clasts (8.5–16.3 ct. %) and low concentrations of UGG clasts (0.8–2.8 ct. %). Till-3 (Figure GS2018-14-5) is characterized by the presence of BSS clasts (1.2–6.5 ct. %) and increased concentrations

[1] MGS Data Repository Item DRI2018002 containing the data or other information sources used to compile this report is available online to download free of charge at https://www.gov.mb.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Growth, Enterprise and Trade, 360–1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

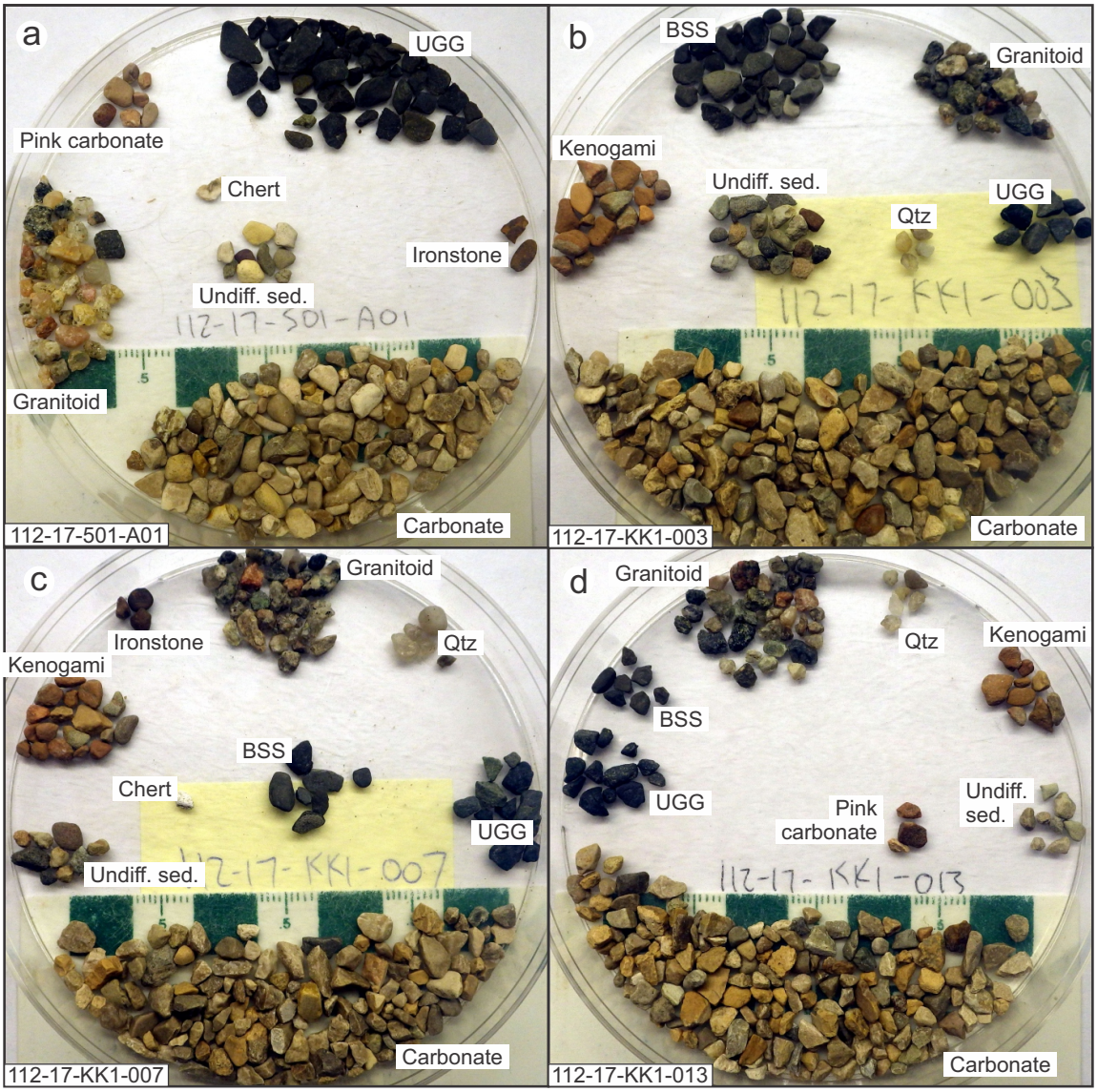


Figure GS2018-14-3*: Examples of 2–4 mm size-fraction clasts from till samples, separated by lithology:* ***a)*** *sample 112-17-501-A01 (till-1);* ***b)*** *sample 112-17-KK1-003 (till-2);* ***c)*** *sample 112-17-KK1-007 (till-3);* ***d)*** *sample 112-17-KK1-013 (till-4). Abbreviations: BSS, black to grey shale and siltstone; Carbonate, grey, tan, white carbonate; Kenogami, Kenogami Formation; Qtz, quartz; UGG, undifferentiated greenstone and greywacke; Undiff. sed., undifferentiated sandstone and siltstone.*

Table GS2018-14-1: Detailed and simplified clast-lithology classes for till samples from the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore.

Simplified class	Undifferentiated Hudson Bay Basin	Total carbonate	Total granitoid	Undifferentiated greenstone and greywacke	Kenogami Formation	Black to grey shale and siltstone
Detailed classes	Ironstone	Grey, tan, white carbonate	Granitoid	Undifferentiated greenstone and greywacke	Fine-grained red sandstone	Black to grey shale and siltstone
	Oolitic jasper	Paleozoic fossil	Quartz			
	Chert	Pink carbonate		Quartzite		Sulphides
	Shell fragment					
	Undifferentiated sandstone and siltstone					

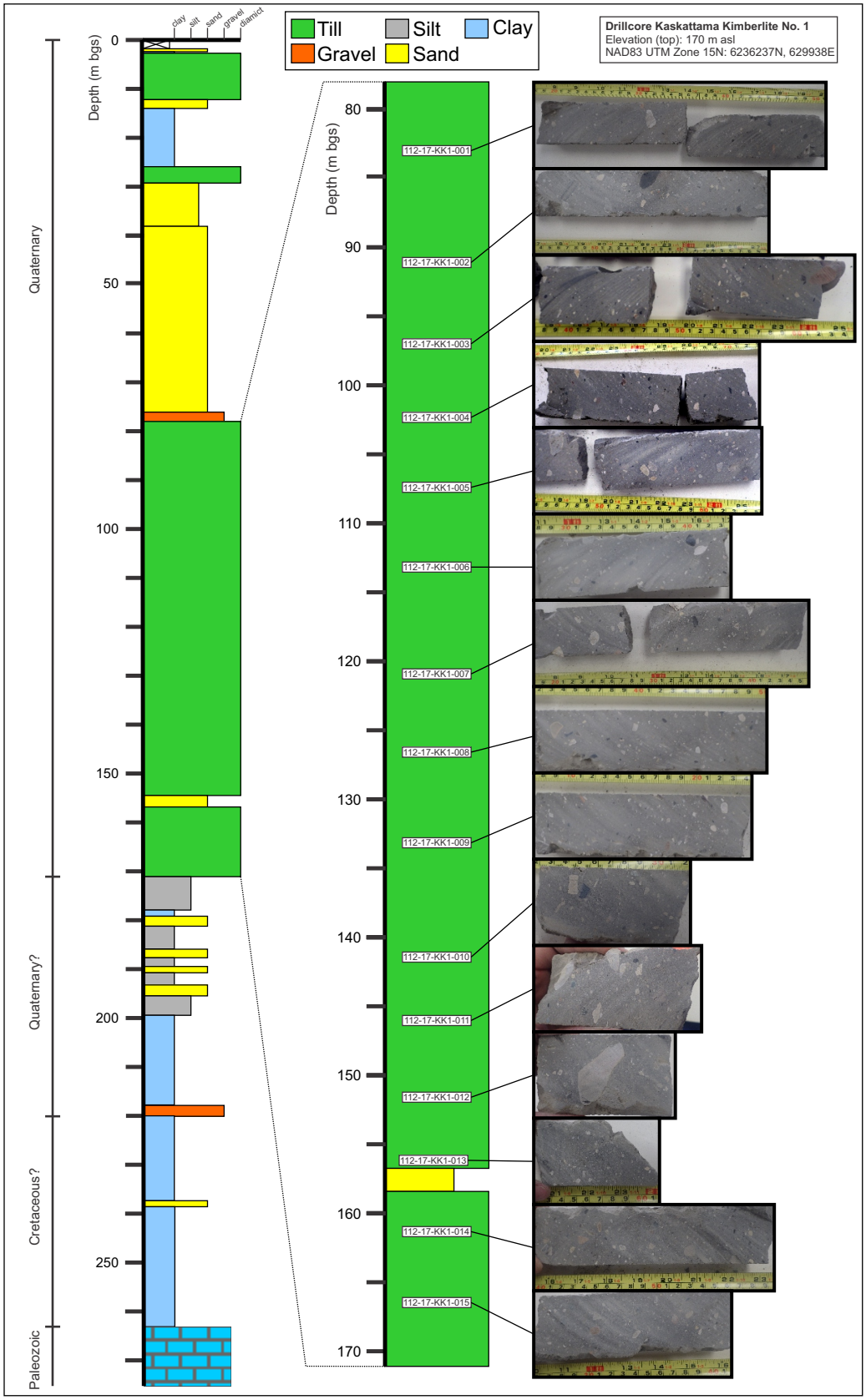


Figure GS2018-14-4*: Simplified Quaternary stratigraphy of the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore. Till sample numbers are denoted by the white boxes, which indicate the depths at which the samples were taken. A photo of the interval sampled is displayed along the right side of the figure. Abbreviation: bgs, below ground surface.*

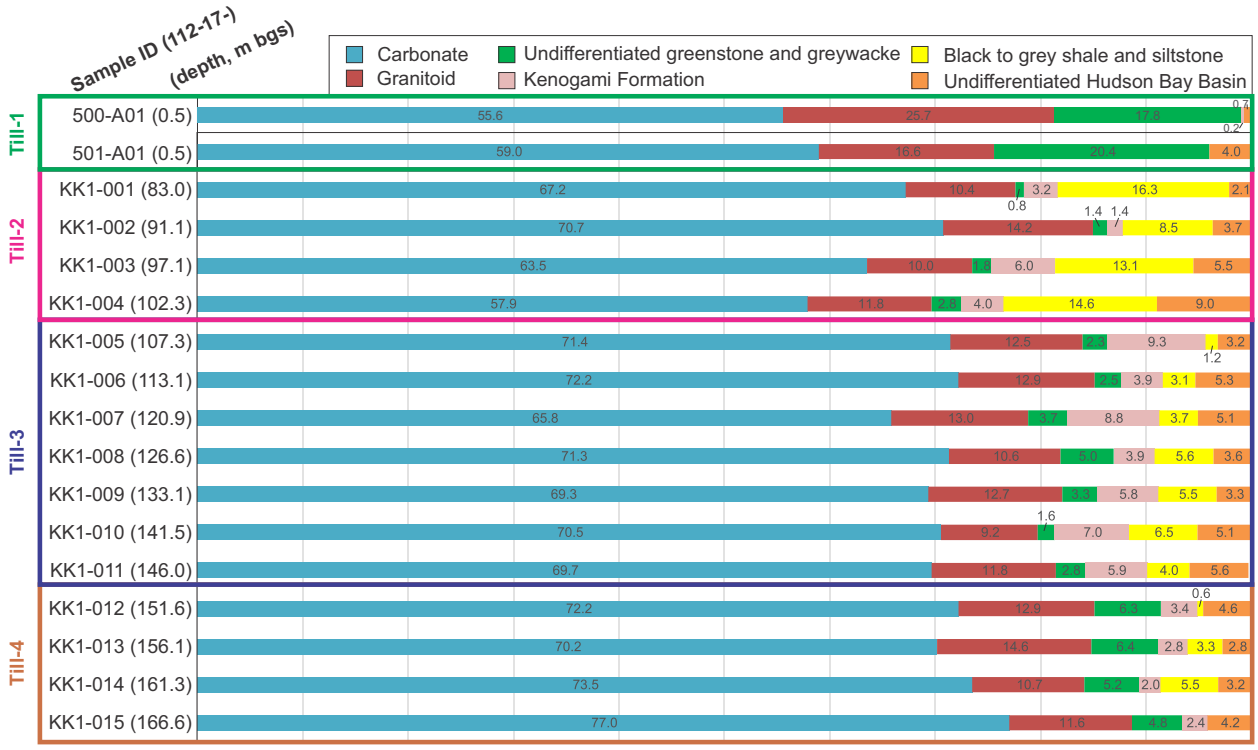


***Figure GS2018-14-5**: Simplified clast-lithology count results (in ct. %) for till samples from the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore and two nearby surficial sample sites. Abbreviation: bgs, below ground surface.*

of Kenogami Formation clasts (3.9–9.3 ct. %). Till-4 (Figure GS2018-14-5) is characterized by an increased concentration of UGG clasts (4.8–6.4 ct. %) and decreased concentration of Kenogami Formation clasts (2.0–3.4 ct. %).

Comparing the till-clast–lithology count results from KK1 with a regional dataset (n=116; Hodder and Kelley, GS2018-13, this volume) indicates that till-clast composition of the surficial till has significantly higher UGG concentration compared to subsurface tills in the area (Figure GS2018-14-6a). This would suggest a strong influence of west-trending ice flow for the surficial till (Hodder and Kelley, GS2018-13, this volume) compared to ice-flow events that deposited till sampled in drillcore KK1. Drillcore KK1 samples have a significantly higher concentration of Kenogami Formation clasts than all surficial till samples and most of the shallow subsurface (<30 m TVD) stratigraphic till samples in the region (Figure GS2018-14-6b). The Kenogami Formation of the Hudson Bay Basin is mapped 20 km to the northeast of KK1 drillcore, striking northwest-southeast (Nicolas and Armstrong, 2017).

Till-matrix geochemistry

The carbonate content of till matrix (<63 µm size-fraction) is a proxy for the proportion of Paleozoic carbonate detritus present within till. Carbonate content of till matrix from the KK1 drillcore varies from 23.99 to 31.73%; vertical variations of the carbonate content correspond to the till classes derived from clast-lithology interpretations (Figure GS2018-14-7a). The surficial till is unique from subsurface till and has an increased carbonate content (33.26–39.39%). Till-2 carbonate content ranges from 23.99 to 26.95% and the upper two samples have a higher carbonate content. This decrease in content down unit is similar to carbonate-clast–lithology counts that indicate a decrease in the concentration of carbonate clasts downward within this interval. The carbonate content and clast-lithology count composition indicates a sharp compositional variation between till sampled at 102.0 and 107.0 m TVD, where the boundary for till-2 and till-3 has been placed. Till-3 exhibits a consistent carbonate content throughout the unit ranging from 28.05 to 31.73%. Till-4 has a consistent carbonate content ranging from 25.46 to 26.50%, which is similar to the upper part of till-2 (82.7–91.4 m TVD).

The total rare earth element (TREE) concentration in till matrix is inversely correlated to the carbonate concentration of till (Figure GS2018-14-7a). The TREE concentrations are often used as a proxy for the granitoid content of till (e.g., Trommelen, 2015), but in this specific geological context (where granitoid content of till is minimal),

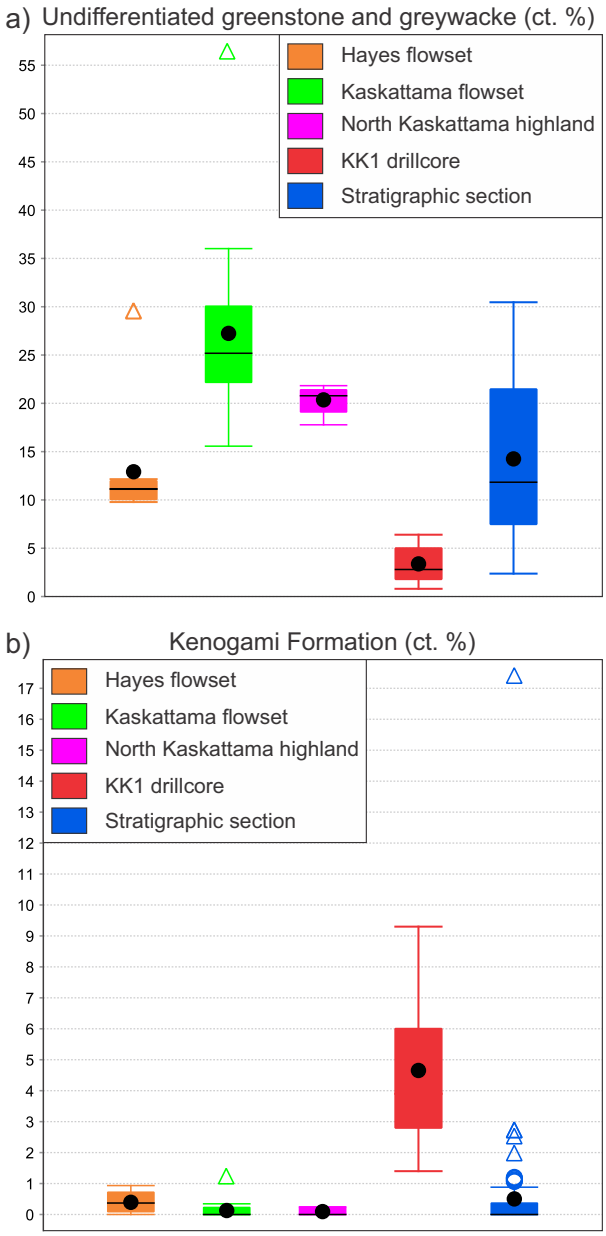


***Figure GS2018-14-6**: Box plots for **a)** undifferentiated greenstone and greywacke and **b)** Kenogami Formation clast concentrations in till sampled in the Kaskattama highland region and the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore.*

the highest TREE concentrations are not associated with granitoid detritus. The highest TREE concentrations are in till samples 112-17-KK1-003 and -004. These samples have among the lowest carbonate (63.5 and 57.9 ct. %) and the highest BSS (13.1 and 14.6 ct. %) clast concentrations (Figure GS2018-14-5) in the dataset. Although this is a small sample size, it would broadly appear TREE concentrations are influenced by BSS lithologies (Figure GS2018-14-7b). These relationships should be investigated further with a larger dataset.

Discussion

Implications of shale content in till

The concentration of BSS clasts within KK1 till samples ranges from 0.0 to 16.3 ct. %. No BSS clasts were recovered within the surficial till samples from near drillhole KK1. Additionally, BSS concentrations in surficial and shallowly buried (<30 m TVD) till in the region do not exceed 1.1 ct. % (n=116). The relatively high proportion of BSS clasts in till from the KK1 drillcore is intriguing because there is no known bedrock source mapped in the region (Nicolas and Armstrong, 2017). A black shale unit was observed in drillcore KK1 at 223.0–257.0 m TVD (Figure GS2018-14-4; Nicolas and Armstrong, 2017) and preliminary results from a magnetotelluric geophysical survey in the region indicate that this unit is more extensive in the subsurface than previously suspected (Craven et al., 2017). Considering the highest concentration of BSS clasts was present in till-2 (83.0–102.0 m TVD; Figure GS2018-14-5), which is >100 m above the black shale encountered in KK1, it would suggest that these clasts were not directly incorporated from the observed underlying shale. These clasts have most likely been glacially transported from additional shale sources in the region. The lack of BSS clasts in the regional surficial and shallow subsurface samples (<30 m TVD) indicates that clasts in this till are likely locally sourced. These additional shale and/or siltstone sources are likely part of the same unit described from drillcore KK1 and interpreted from the magnetotelluric survey, which lends credence to the notion of a more significant and extensive shale bedrock unit in this region. The BSS clasts recovered from KK1 tills have variable lithology and include coarse siltstone (Figure GS2018-14-8a) to laminated shale (Figure GS2018-14-8b) and can contain fish scales (Figure GS2018-14-8c, d). Prior to this study, till observed in the KK1 drillcore was collectively grouped based on qualitative characteristics as a 'black till'. This study has quantitatively shown there are variations with depth, which have provided insight into till provenance.

Previous Quaternary stratigraphy investigations along river sections in the Hudson Bay Lowland have only encountered one site with a black till that contained black to grey shale and siltstone clasts. This section (14115MT405; 58.002°N, 94.930°W) is located 312 km northwest of the KK1 drillcore on the Churchill River (M. Gauthier, work in progress). At this site, a two till stratigraphy was observed with a dark grey-black till situated beneath a light brown to grey-brown till. The dark black to grey till contains 4.0–7.0 ct. % black to grey shale clasts (M. Gauthier, work in progress). The source of these clasts is also unknown and could indicate additional shale

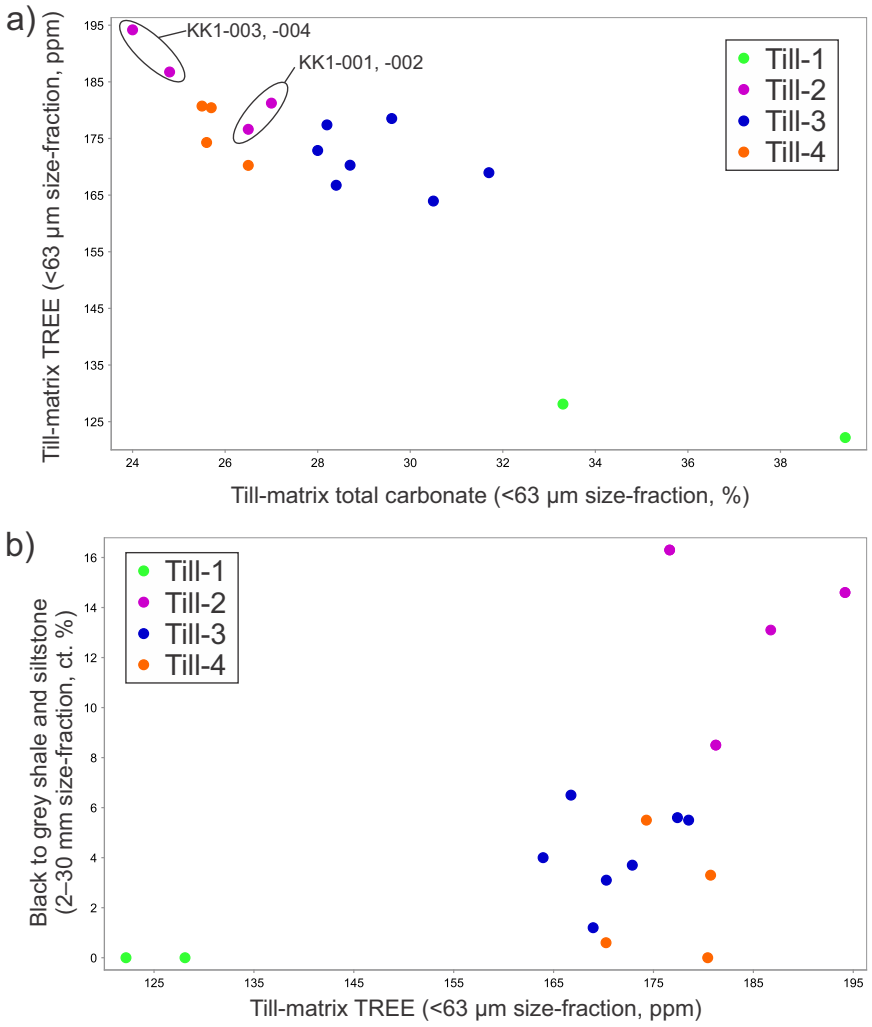


***Figure GS2018-14-7**: Total rare earth element relationship to **a)** total carbonate content of the till-matrix and **b)** black to grey shale and siltstone clast concentrations (2–30 mm size-fraction), from the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore and two nearby surficial sample sites. Abbreviation: KK1-, sample number 112-17-KK1-; TREE, total rare earth elements (sum of La+Ce+Pr+Nd+Sm+Eu+Gd+Tb+Dy+Ho+Er+Tm+Yb+Lu).*

sources in the Hudson Bay Basin of northeastern Manitoba.

Economic considerations

The subsurface in the Kaskattama highland region is largely unexplored. This drillcore provides the only source of information on the subsurface and has changed the understanding of the bedrock geology. Further understanding of the subsurface is paramount to understanding the origin of the highland, as well as elucidating the economic potential of this region. The study area has historically been a target for diamond exploration and recent indicator-mineral studies have hinted at kimberlite potential for this region. This study directly contributes to the understanding of the Quaternary stratigraphy in this region and corroborates the notion of a local shale and/or siltstone source.

Acknowledgments

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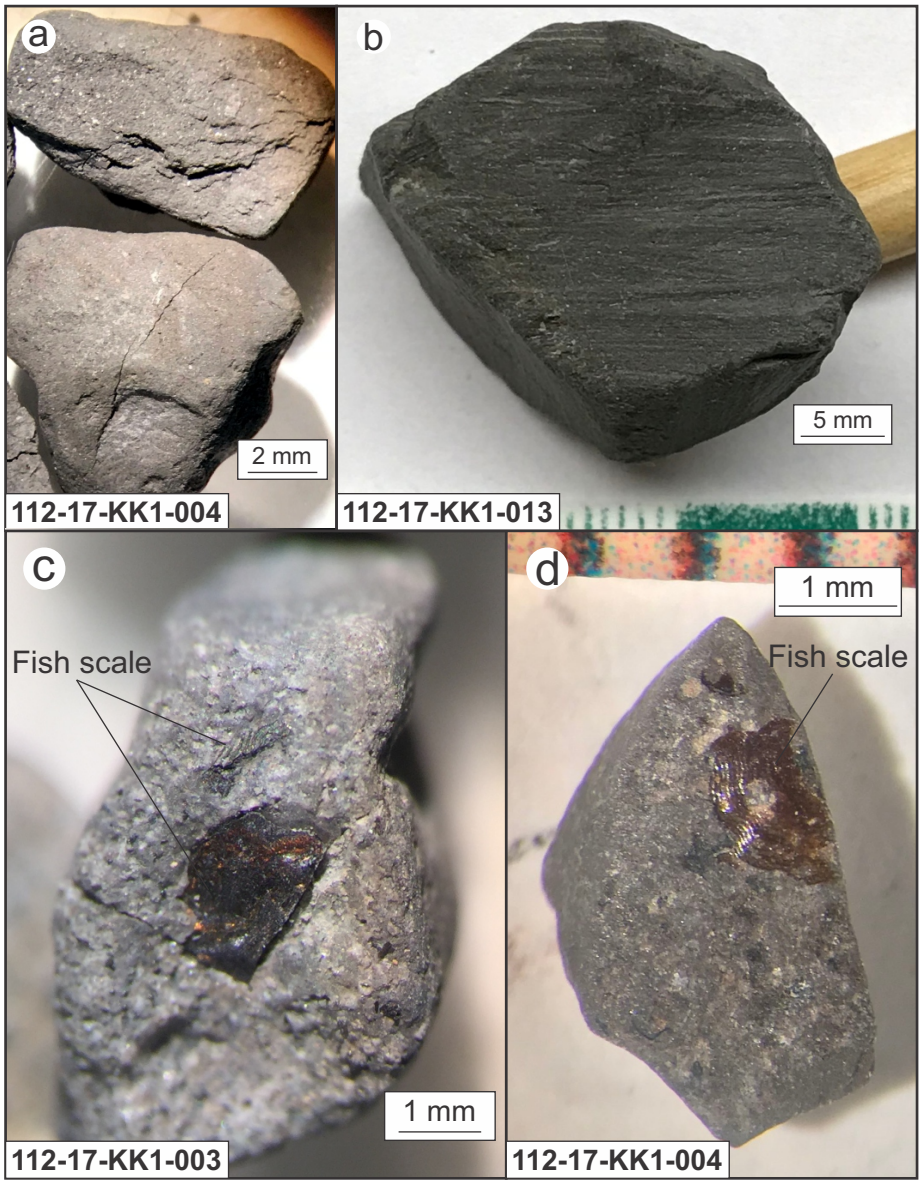

Figure GS2018-14-8*: Example of black to grey shale and siltstone clasts recovered in till from the Foran Mining Kaskattama Kimberlite No.1 (KK1) drillcore:* ***a)*** *light grey siltstone;* ***b)*** *laminated shale; and* ***c, d)*** *siltstone clasts with fish scale(s).*

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