Quaternary stratigraphy and till provenance across the drumlinized terrain of the McArthur River Uranium Mine area in the eastern Athabasca Basin: Preliminary results

S Scott[1], M Ross[1] [1]University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1. Email: Shawn.Scott@uwaterloo.ca

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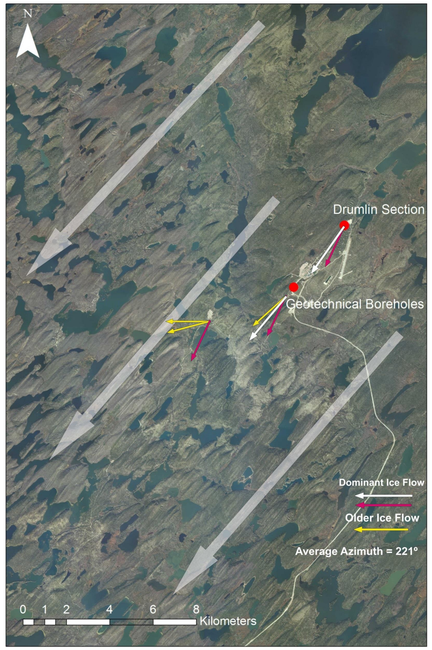
1. Introduction

The McArthur River uranium mine is located in northern Saskatchewan **(Fig. 1)** within a corridor of elongated drumlins and long dispersal trains that have been associated to a major ice stream of the Laurentide Ice Sheet (Ross *et al.*, 2009). The high-grade uranium deposit is associated with the intersection of reactivated basement faults and the unconformity between sandstones of the Athabasca Group and the underlying basement rocks. It is located at an approximate depth of 500 m. The alteration footprint extends above the deposit but the depth of the deposit, combined with the complex Quaternary geology, makes it challenging to apply drift prospecting successfully. A new study aims at describing and analyzing the Quaternary stratigraphy and till composition in the vicinity of the mine. One of the main goals is to develop an understanding of till provenance and production in the study area and to get insights into the potential role of fast-flowing ice, which could have implications for drift prospecting in that and other similar prospective regions.



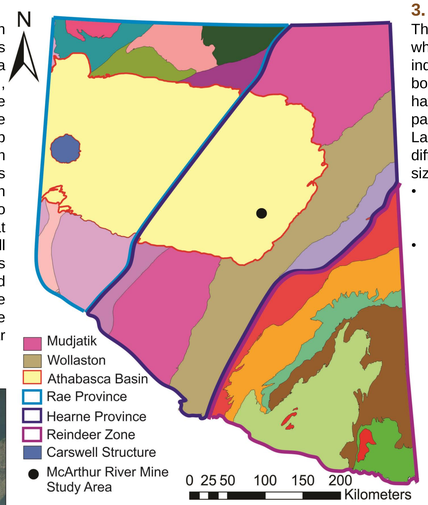


Fig 1: The Athabasca Basin and McArthur River Mine study area located within the Canadian Shield of in northern Saskatchewan (modified after the Geological Atlas of Saskatchewan) .

2. Research Problems

As current shallow uranium deposits are exhausted there is the need to look for deposits located deeper in the Athabasca basin. However, in deep deposits mineralization is not obvious at surface and the alteration footprint must be used instead during drift prospecting. While there are known boulder trains in the area, it is unknown as to whether the mineralization's footprint extends to the underlying till and its finer fractions. In addition, the main mineral hosting fault is parallel to the dominant direction of ice flow **(Fig.2)** further complicating the provenance of any altered detritus. Due to the complex glacial history in the area (Campbell, 2009), tracing any footprint in the Quaternary stratigraphy to its source requires an understanding of the till provenance and till production in the area.

Fig. 2: Location of the Drumlin Section and geotechnical boreholes at the McArthur River Mine. Also shown is the dominant direction of ice flow and trend of ice flow indicators on lodged boulders and outcrops..

3. Research Methods

The McArthur River Mine study area is covered in till except for two locations where sandstone outcrops. At these locations measured erosional flow indicators were compared to the orientation of local drumlins and lodged boulders. In addition a total of 71 samples of till (with few fluvial type samples) have been collected at 48 different sample locations within the study area. In particular, one section through a drumlin was studied in detail for stratigraphy. Laboratory work included grain size analysis involving both dry sieving and laser diffraction, along with pebble lithological counts on both the 4-8mm and >8mm size fractions.

- Material was dry sieved through 8mm, 4mm, 2mm, 1mm, 0.5mm, 0.25mm, 0.125mm and 63um screens before the <63um material underwent laser diffraction (Fritsch Analysette 22 NanoTec plus).
- Pebble lithology was first split between sandstone (local) and basement (distal) clasts. Sandstones could be further split into white sandstone, red sandstone and orange sandstone while the basement clasts were further split into felsics, mafics and quartz.

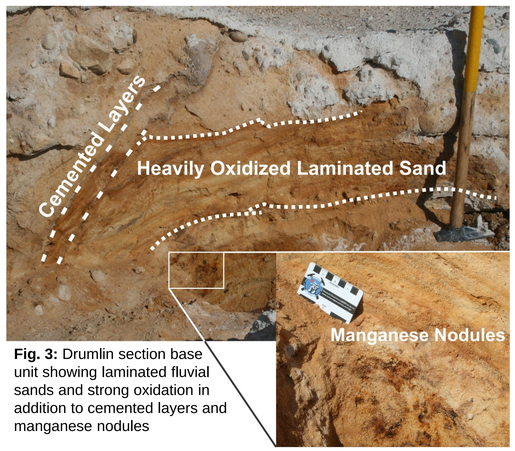


Fig. 3: Drumlin section base unit showing laminated fluvial sands and strong oxidation in addition to cemented layers and manganese nodules

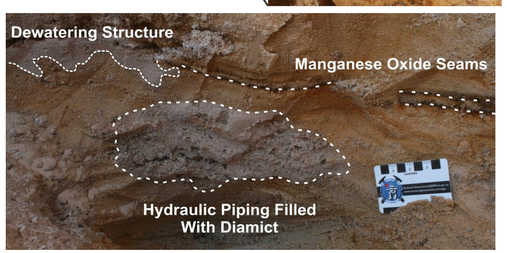


Fig. 4: Lower in the oxidized unit, hydro-fracturing filled with diamict, manganese oxide seams and dewatering features exist.

4. Results

Results to date show at least one sub-till fluvial unit mostly consisting of coarse and medium grained sand. This unit is also heavily oxidized and contains abundant iron and manganese oxide nodules **(Fig. 3)**. In addition the presence of diamictic dykes **(Fig. 4)** provides evidence of subglacial hydro-fracturing (Phillips & Hughes, 2014). The distinctive unit extended across the whole exposed section of the drumlin **(Fig. 5)** and are identified in geotechnical boreholes in another nearby drumlin**.**

Overlying this unit is a **series of stacked till sheets that make up the core of the drumlin**. Within these units, a greyish brown stiff till exists with a finer grained matrix, and an increased proportion of basement clasts **(Fig. 6 A)**. Surrounding this unit, the till sheet is rich in the local sandstone lithologies **(Fig. 6 B)**, along with an increasing pebble content. **These more 'local' tills are widespread at the surface throughout the study area**.

Multiple lodged sandstone boulders in the drumlin section and two sandstone outcrops were examined for ice flow indicators **(Fig. 2)**. Most striations present on lodged boulders and the Northern outcrop trended between 210º and 220º with older striations trending 228º. The Southern outcrop had some striations trending 270º but most trended 205º. The **total resultant ice flow direction is 221º** which agrees with the surrounding drumlins.

5. Discussion

The oxidized sand layer and the grey basement-rich till are pervasive throughout the drumlin section. These two units have yet to be found at surface and are only exposed in large sections through drumlins and rare roads cuts. Material has yet to be sampled from beneath the oxidized unit, and cannot yet be characterized, but a GPR survey is being planned to visualize the lower part of the sandy unit and determine the depth to bedrock in that area.

Results to date indicate multiple till sheets were deposited, with at least one showing a **'distal' signature sandwiched in-between tills with a 'local' signature**. The most 'local' tills (sandstone >85%) are found near the top of the sequence above the grey unit suggesting that the glaciers had access, probably in the drumlin swales, to fresh and altered bedrock. This local till could be related to the drumlinization phase and fast flowing ice despite the local signature in the coarse fractions. Considering that **this 'local' more recent till** did erode sandstone and is the least travelled, it is **the target for drift prospecting** to discover dispersal trains of uranium mineralization or the associated alteration footprint.

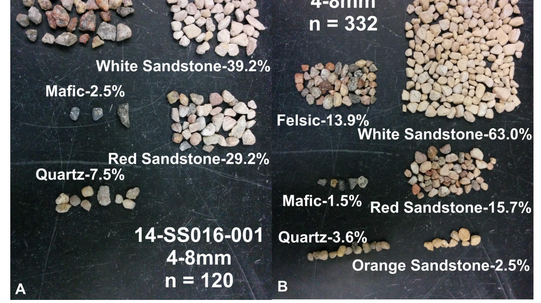


Fig. 6: Pebble counts on the 4-8mm size faction of **A)** a siltier basement clast rich till and **B)** a sandier, sandstone clast rich till from a higher elevation

Fig. 5: Section through a drumlin in the study area. Percentages denote amount of basement derived clasts. The greyish brown till in the middle of the section is also exposed at a road cut a few kilometers away and shares the same colour, stiffness, and percent of basement clasts.

Acknowledgments

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References

Campbell, J. E. (2009). Drift Prospecting for Uranium in the Athabasca Basin , Saskatchewan. In R. C. Paulen & I. McMartin (Eds.), Application of Till and Stream Sediment Heavy Mineral and Geochemical Methods to Mineral Exploration in Western and Northern Canada (GAC Short Course 18, pp. 207–214). Geological Association of Canada..

Phillips, E., & Hughes, L. (2014). Hydrofracturing in response to the development of an overpressurised subglacial meltwater system during drumlin formation: An example from Anglesey, NW Wales. Proceedings of the Geologists' Association, 125(3), 296–311. http://doi.org/10.1016/j.pgeola.2014.03.004

Ross, M., Campbell, J. E., Parent, M., & Adams, R. S. (2009). Palaeo-ice streams and the subglacial landscape mosaic of the North American mid-continental prairies. *Boreas*, *38*(3), 421–439. http://doi.org/10.1111/j.1502-3885.2009.00082.x

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