

Jackfish Basin Project: Preliminary Investigations of Athabasca Group Sedimentary Rocks, Northern Lake Athabasca, Saskatchewan (Parts of NTS 74N/06, /07, /08, /10, and /11)

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Bosman, S.A. (2014): Jackfish Basin Project: preliminary investigations of Athabasca Group sedimentary rocks, northern Lake Athabasca, Saskatchewan (parts of NTS 74N/06, /07, /08, /10, and /11); in Summary of Investigations 2014, Volume 2, Saskatchewan Geological Survey, Sask. Ministry of the Economy, Misc. Rep. 2014-4.2, Paper A-4, 12p.

Abstract

The Jackfish Basin, located on the west side of the larger Athabasca Basin, was the first depocentre to receive Athabasca Group detritus. This detritus, mainly transported from the east, formed the Fair Point Formation. Outcrops on the west side of Lake Athabasca and a few drillholes have loosely constrained the depositional extent of the Fair Point Formation; however, its east and northeast extents remain uncertain. The islands in the vicinity of the southern Crackingstone Peninsula on Lake Athabasca contain exposures of both Athabasca Group conglomerate and sandstone, and the unconformity with underlying basement quartzites of the Murmac Bay group, Beaverlodge Domain. Similar to the Fair Point Formation conglomerate on the west side of the Jackfish Basin, the conglomerate in the study area is monomictic, poorly sorted, and mainly clast supported. Therefore, it is interpreted as part of the Fair Point Formation rather than the Manitou Falls Formation, Warnes member, as published on recent compilation maps. Preliminary paleocurrent measurements indicate a south to southwest paleoflow, which would suggest that the Jackfish depocentre was towards the southwest and the source terrain to the northeast. Field observations indicate that much of the source material was derived from the Murmac Bay group quartzite.

Keywords: Athabasca Group, Murmac Bay group, Martin group, Jackfish Basin, Fair Point Formation, Beaverlodge Domain, Athabasca Basin, Paleoproterozoic, paleocurrents, sandstone dykes.

1. Introduction

The Jackfish Basin Project was initiated in 2014 in order to investigate questions related to development of the Jackfish Basin in northwest Saskatchewan. This basin was the first of several depositional basins in the larger Athabasca Basin and the first to receive Athabasca Group detritus, most of which was sourced from the east (Ramaekers *et al.*, 2007). The Jackfish Basin is located on the west side of the Athabasca Basin and has a northeast-trending axis (Figure 1). Outcrops on the west side of Lake Athabasca and a few drillholes have loosely constrained the depositional extent of the Jackfish Basin (Fair Point Formation), but its east and northeast extents remain uncertain. The focus area for this project encompasses three main areas that contain Athabasca Group rocks, basement rocks, and the unconformity between them: 1) several islands in the area around the southern Crackingstone Peninsula, Lake Athabasca, 2) parts of Crackingstone Peninsula itself, and 3) Charlott Island near Camsell Portage (Figure 1). This project location was chosen because of known good exposures of the bedrock, and because it is located near the inferred northeast edge of the Jackfish Basin. The rocks in this area include the northern edge of the Athabasca Group and metamorphosed rocks of the Beaverlodge Domain.

This project has two main goals. The first is to determine the relative stratigraphic position within the Athabasca Group of the rocks being studied. More specifically, if these sedimentary rocks are stratigraphically equivalent to the Fair Point Formation, the basal formation of the Athabasca Group, they would represent some of the initial deposits in the Jackfish Basin. Provided that these clastic sedimentary rocks are Fair Point Formation, mapping and determining the sedimentary environment could assist in interpreting the tectonic environment in which the Jackfish Basin initially formed. The Athabasca Group in the study area mainly consists of conglomerate and sandstone with a minor component of mudstone. These rocks are generally flat lying, apart from a few outcrops that mantle underlying topography. These sedimentary rocks were deposited unconformably on Mesoarchean to Orosirian² rocks of the Rae Province basement complex (Hartlaub *et al.*, 2004), which are dominated by Rhyacian Murmac Bay group (MBG) rocks (Ashton *et al.*, 2013) in the southern Crackingstone Peninsula area and Orosirian Martin group rocks (Ashton *et al.*, 2009; Morelli *et al.*, 2009) at the Camsell Portage location (Figure 1).

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² The following subdivisions of Paleoproterozoic time have been adopted from Gradstein *et al.* (2004): Siderian (2.50 to 2.30 Ga), Rhyacian (2.30 to 2.05 Ga), Orosirian (2.05 to 1.80 Ga), and Statherian (1.80 to 1.60 Ga).

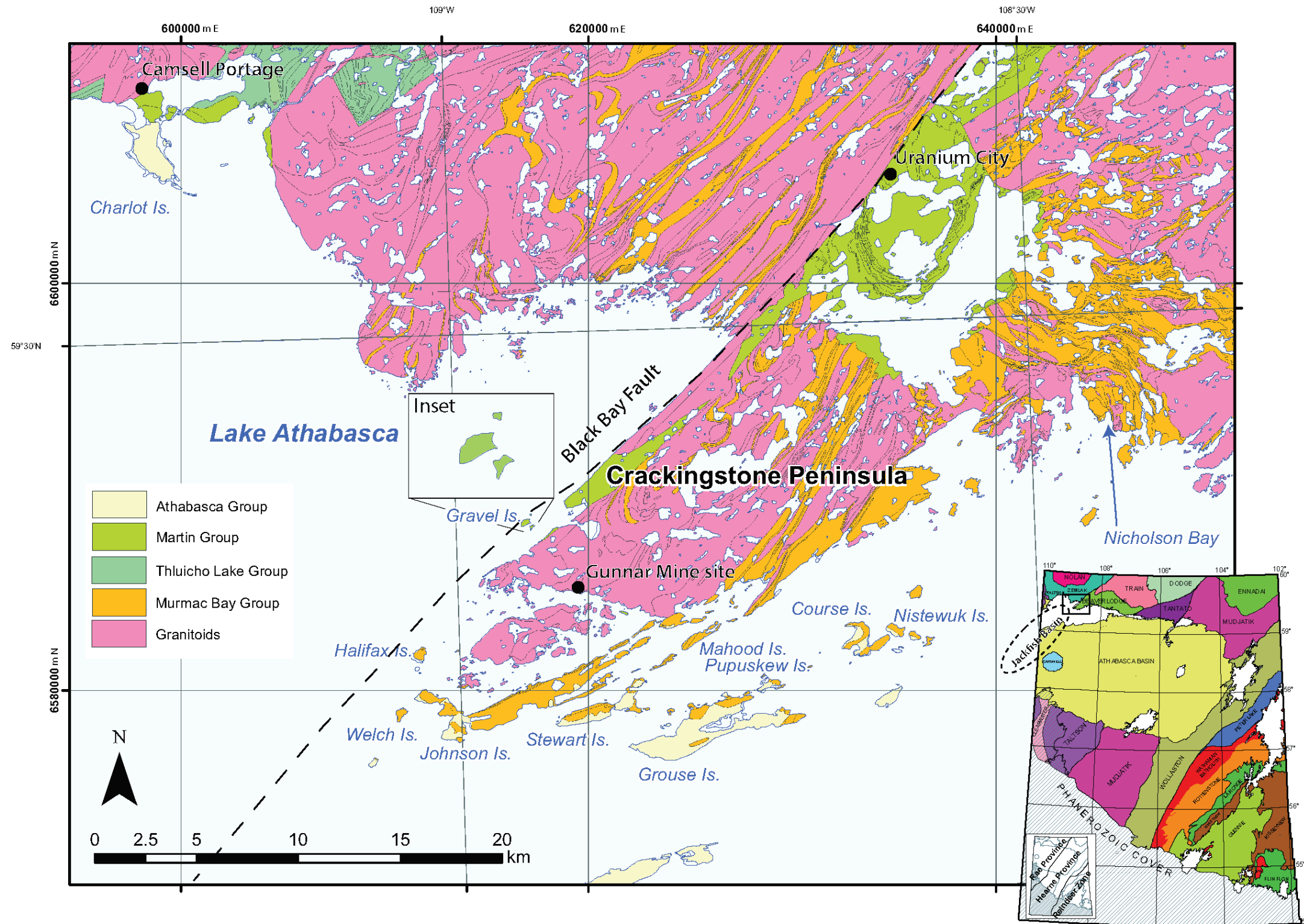


Figure 1 – Modified regional geological map of the northern Athabasca Basin and Beaverlodge Domain (Ashton and Hartlaub, 2008), showing study sites and locations discussed in text. Large-scale inset map shows the regional northern Saskatchewan geology including geological provinces, lithotectonic domains, and the Jackfish Basin depocentre (Ramaekers et al., 2007). Small-scale inset provides detail of the Gravel Islands³.

³ All coordinates referenced in this report use the Universal Transverse Mercator (UTM) projection system and the North American Datum 1983 (NAD83), Zone 12.

The second goal of the project is to determine the relationships between the Athabasca Group and some of the older sedimentary successions, namely the Murmac Bay, Thluicho Lake and Martin groups. Identifying depositional contacts between these groups may elucidate a long history of stacked sedimentary basins in the Athabasca Basin region, which may shed light on their rich uranium endowment. Previous mapping in the area (Ashton and Hartlaub, 2008) clearly delineates the unconformity between the Athabasca Group and the MBG, and leaves open the possibility that the inferred unconformity between the Martin and Athabasca groups may be exposed between Charlott Island and the mainland (Figure 1). Anecdotal evidence from assessment reports in the 1980s also noted that a drillhole (N-60; Saskatchewan Ministry of the Economy (ECON) assessment file 74N07-0222) drilled by Norex Uranium Limited (Norex) in 1968 may contain the Athabasca Group/Martin group unconformity along with the Martin group/MBG unconformity. Therefore drillcore from this hole was sought in the field; however, although the Norex exploration camp site was located, the drillcore was not salvageable. No exposures of the Athabasca Group/Martin group contact were observed during the course of the field work.

The southern Crackingstone Peninsula and islands south of it have been extensively explored due to the presence of numerous uranium, and to a lesser extent, gold occurrences. The Stewart Island prospect, which has a historical resource (non NI 43-101-compliant) of 2,561 tons of uranium ore grading 0.47% U₃O₈ (Saskatchewan Mineral Deposit Index file #1254), is also within the study area. In addition to maps produced by industry, a number of Saskatchewan Geological Survey and Geological Survey of Canada geologists have mapped the area for different purposes and a discussion around the current state of the mapping is presented below (see “Discussion”). Due to the wealth of information from previous mappers, the current study was not focussed on mapping but on sedimentology, as well as determining the relationships between the Athabasca Basin and its basement.

A hand-held, high-sensitivity, gamma and neutron radiation spectrometer (Radiation Solutions-Exploranium® GR-135 Plus Identifier) was used to establish average concentrations of eU⁴, eTh and K for the rock types described below (Table 1) and may be used to establish background values or to characterize different rock types.

Table 1 – Average and range of spectrometer results from the main rock types investigated during the Jackfish Basin study.

Rock Type		n=	eU (ppm)	eTh (ppm)	%K	Total cps
Murmac Bay Group Argillite	Avg	3	1.47	16.57	1.63	10
	Range		0-2.9	9.4-21.5	1.1-2.2	8-13
Murmac Bay Group Quartzite	Avg	9	0.93	7.8	0.22	3.67
	Range		0-4.8	1.3-22.5	0-0.9	1-8
Martin Group Conglomerate	Avg	2	1.6	24.9	0.5	9.5
	Range		0-3.2	22.8-27	0.2-0.8	8-11
Martin Group Sandstone		1	0.2	10.8	0	4
Athabasca Group Conglomerate	Avg	38	2.53	14.53	0.17	6.84
	Range		0-31.7	0.6-124.6	0-1.4	1-42
Athabasca Group Sandstone	Avg	51	1.05	9.69	0.15	4.18
	Range		0-3.9	0.1-37.2	0-1.1	1-14
Mineralized Athabasca Group Sandstone		1	10846	38946	*	13263

*denotes spurious values of %K due to improper internal spectrometer corrections for eU concentrations above several hundred ppm
n = number of readings; cps = counts per second

2. Description of Main Units

a) Murmac Bay Group

The dominant basement rocks in the southern Crackingstone Peninsula area belong to the Murmac Bay group (MBG) (previously part of the Tazin Group; see Ashton *et al.*, 2000 for explanation). The reader is referred to Ashton and Hartlaub (2008) for detailed geology and descriptions of the basement complexes. Although the MBG includes a variety of rock types (Ashton and Hartlaub, 2008), quartzite containing minor feldspathic quartzite was the most commonly observed below the unconformity of the Athabasca Group (Figure 2). The MBG quartzite is

⁴The ‘e’ is an abbreviation of ‘equivalent’ inferring that these elements are not measured directly. Also note the K contents are reported as %K and not %K₂O. To convert, multiply %K values by 1.2047.

generally white to red (ferruginous), fine to medium grained, non-magnetic, and interpreted as recrystallized quartz arenite. Primary structures in the MBG, although noted by Ashton and Hartlaub (2008), were not observed in this study. In one occurrence, white, non-ferruginous quartzite occurs as semicircular features that are surrounded by ferruginous quartzite (Figure 2B). These features are generally decimetre- to metre-scale, are within a few metres of the MBG/Athabasca Group unconformity and have gradational contacts, which imply they were developed by a fluid process rather than a mechanical process. In three other places, MBG psammite to psammopelite was observed and these rocks are grey to red, fine to medium grained, and contain centimetre-scale layering, which is accentuated by the introduction of red hematitic ferruginous material.



Figure 2 – Examples of Murmac Bay group (MBG) quartzite: A) MBG quartzite (bottom left) and associated quartz veining in contact (white dashed line) with overlying Athabasca Group conglomerate; SB14-03-015⁵, UTM 621163 m E, 6579086 m N; B) isolated semicircular zones of white quartzite in ferruginous quartzite; SB14-04-023, UTM 620230 m E, 6578769 m N; C) massive, white MBG quartzite (upper right) in contact with Athabasca Group conglomerate (lower left); SB14-05-030, UTM 622308 m E, 6578727 m N; D) white MBG quartzite (lower right) draped by Athabasca Group conglomerate (black dashed line marks contact; conglomerate weathers white in lower part of photo due to wave action of Lake Athabasca); SB14-08-040, UTM 610886 m E, 6579115 m N; E) MBG quartzite (lower left) with quartz veining in contact with Athabasca Group conglomerate (white dashed line marks contact; hammer for scale indicated by white arrow); SB14-08-041, UTM 610611 m E, 6578643 m N; F) steeply dipping MBG quartzite (left) in contact with pebbly to cobbly Athabasca Group sandstone (hammer for scale indicated by black arrow); SB14-10-063, UTM 613943 m E, 6577875 m N.

⁵ Denotes the station number.

b) Martin Group Sedimentary Rocks

The Martin group sedimentary rocks, mainly located in the immediate Uranium City area (Figure 1; Figures 3A, 3B), are interpreted to be older than the Athabasca Group rocks. They postdate the 1.91 Ga peak metamorphism in the area and were probably deposited in response to the *ca.* 1.8 Ga Trans-Hudson orogeny (Ashton *et al.*, 2009). Mafic intrusions emplaced at 1.82 Ga intrude the lowermost strata of the Martin group (Beaverlodge Formation) and are geochemically very similar to Martin group volcanic rocks of the overlying Gillies Channel formation (Morelli *et al.*, 2009). The Martin group was subsequently folded, presumably during late Trans-Hudson deformation. This has resulted in generally steep dips in the bedding, which is one way that Martin group strata can be distinguished from flat-lying rocks of the younger Athabasca Group (Morelli *et al.*, 2009; Ashton *et al.*, 2009). The Gravel Islands contain the most southerly known exposures of Martin group and were visited to look–unsuccessfully–for a Martin group/Athabasca Group exposed unconformity. The Martin group dips steeply to vertically on these islands and comprises interbedded ferruginous conglomerate and sandstone (Figures 3C to 3F).

The Martin group conglomerate on the north and south Gravel islands (inset on Figure 1) is polymictic and includes clasts of granite, gneissic material, sandstone, quartzite, other quartz-rich rocks (quartz veins), and some finer-grained mafic rocks, which is significantly different from the generally monomictic quartz-rich conglomerate of the Athabasca Group. Some of the Martin group conglomerate sandstone clasts contain small quartz veins (Figure 3E). Clasts are poorly sorted, range from very coarse pebbles to boulders, are subangular to well rounded and have a low to high sphericity. On the north island, conglomerate is interbedded with sandstone. Conglomerate beds range in thickness from ~10 cm to 2 m. Although clast imbrication was not observed, the long axes of some clasts were aligned with bedding (Figure 3E). On the easternmost Gravel Island, only conglomerate is present. The conglomerate on this island is very similar to that on the north island; however, it is massive to possibly bedded and seems to contain more granitic and quartz-rich clasts. No mud fragments were observed in the massive conglomerate.

The Martin group sandstone on the Gravel Islands is more feldspathic than that of the Athabasca Group. It is crossbedded, horizontally bedded and laminated, and is generally a medium to coarse grained sandstone with some floating pebbles. Clasts in the sandstone include granite, intraformational sandstones, mud chips and quartz-rich material. Small channels were observed cutting down through lower beds and bed thickness was between 4 cm and 1 m. The younging direction as determined through crossbedding was towards the west. Brittle fractures offset some of the sandstone beds (Figure 3F). Although the Gravel Islands outcrops were studied in the most detail, the stratigraphic position of these sedimentary rocks within the Martin group has not been determined (Morelli *et al.*, 2009).

c) Athabasca Group Conglomerate

The Athabasca Group conglomerate in the study area is generally a monomictic, clast-supported and, to a lesser extent, matrix-supported, granule to boulder conglomerate that contains MBG quartzite clasts up to 2.5 m in diameter (Figure 4). The conglomerate is generally very poorly sorted, and has angular to well-rounded clasts with a low to high sphericity. Clast types other than quartzite are rare, amounting to <1% of total clasts, and generally include pebbles of very fine-grained mafic rocks, tonalite and intraformational sandstone.

The morphology of the conglomerate is quite variable and includes channelized bedforms, centimetre- to metre scale massive beds, small fan features on the sides of quartzite basement highs, and some breccia. In one of the largest outcrops of conglomerate, on the east side of Stewart Island, a vertical exposure of conglomerate up to 20 m in height and over 300 m in length shows a complex set of channel deposits. At the northern end of this exposure, the conglomerate unconformably overlies the MBG quartzite. The paleotopographic surface of the quartzite dips towards the southwest. From a distance, large channels are observed, some of which cut down through the entire exposed section. Sandstone is also present in this exposure, and has also been cut into/scoured by the conglomerate. This sandstone, which is a minor component of this exposure, is horizontally bedded and crossbedded, and contains interbeds of pebble to cobble conglomerate that are a few centimetres to 20 cm thick. In addition to the channel scour surfaces, beds that are slightly oblique to the main bedding may represent migrating channel bars. The centimetre- to metre-scale massive beds typically do not have any internal structure and are commonly interbedded with metre-thick sandstone. Small, fan-shaped depositional features are located throughout the study area, with the best exposures on Halifax and Welch islands as well as the west end of Johnson Island (Figure 1). The conglomerate commonly emanates from an elevated, somewhat constricted area relative to the base of the exposure where it fans out. Outcrops that are completely breccia are relatively rare; however, very angular clasts are common in the other conglomerate discussed above, but these clasts are typically part of the smaller size fraction. In general, all of the different morphologies of conglomerate grade into, and become interbedded with, sandstone. This gradation from conglomerate to sandstone was observed over a distance of as little as 5 m from the basement quartzite, the source for much of the coarse detritus. The MBG quartzite clearly had topographic relief at the time of Athabasca Group deposition, with conglomerate either surrounding or draping quartzite highs. It commonly appears as if quartzite detritus has simply tumbled down a small hill and, although seemingly sourced from these adjacent topographic highs, the clasts are not commonly very angular.

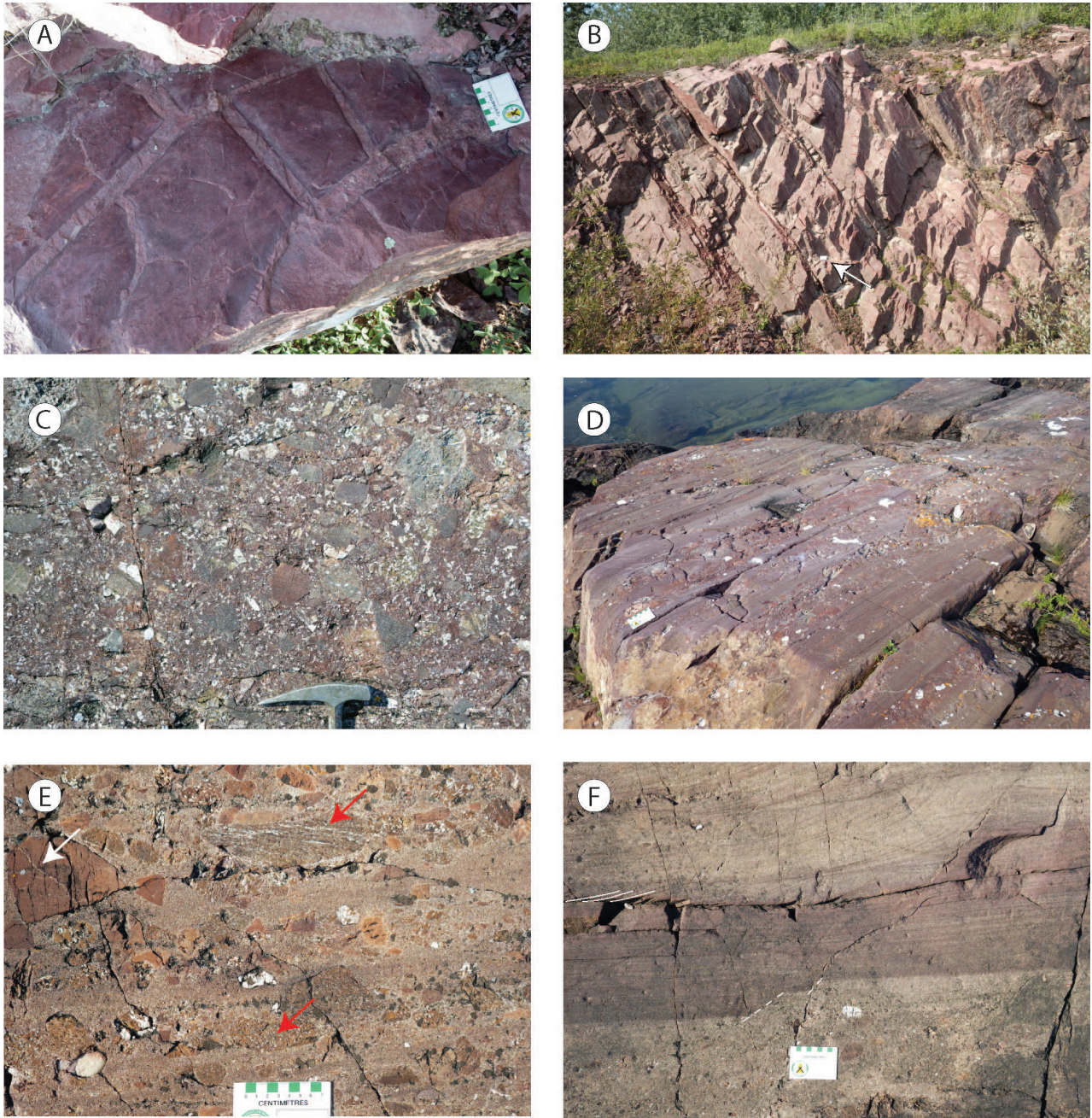


Figure 3 – Examples of Martin group conglomerate and sandstone: A) road-cut exposure of upper Martin group, Melville Lake Formation containing polygonal cracks in mudstone laminations that are filled with medium- to coarse-grained sandstone and some granules; from near Uranium City, SB14-17-095, UTM 636090 m E, 6605045 m N; B) another road-cut exposure of steeply dipping, horizontally bedded, very fine- to medium-grained sandstone (scale card indicated by arrow) of the upper Martin group, Melville Lake Formation; from near Uranium City, SB14-17-097; UTM 637540 m E, 6604890 m N; C) poorly sorted, polymictic, clast-supported conglomerate from the eastern Gravel Island; SB14-11-071, UTM 617146 m E, 6588066 m N; D) steeply dipping, interbedded Martin group sandstone and conglomerate on the most northerly Gravel Island; SB14-11-070, UTM 617173 m E, 6588644 m N; E) close-up of conglomerate from (D), clasts are angular to well rounded with low to high sphericity; some contain quartz veining (white arrow) and some clasts are aligned with their long axes parallel to bedding (red arrows); F) close-up of some sandstone from (D) displaying trough crossbedding (some foresets highlighted by white lines), horizontal laminations, and small-scale brittle faults (white dashed lines).

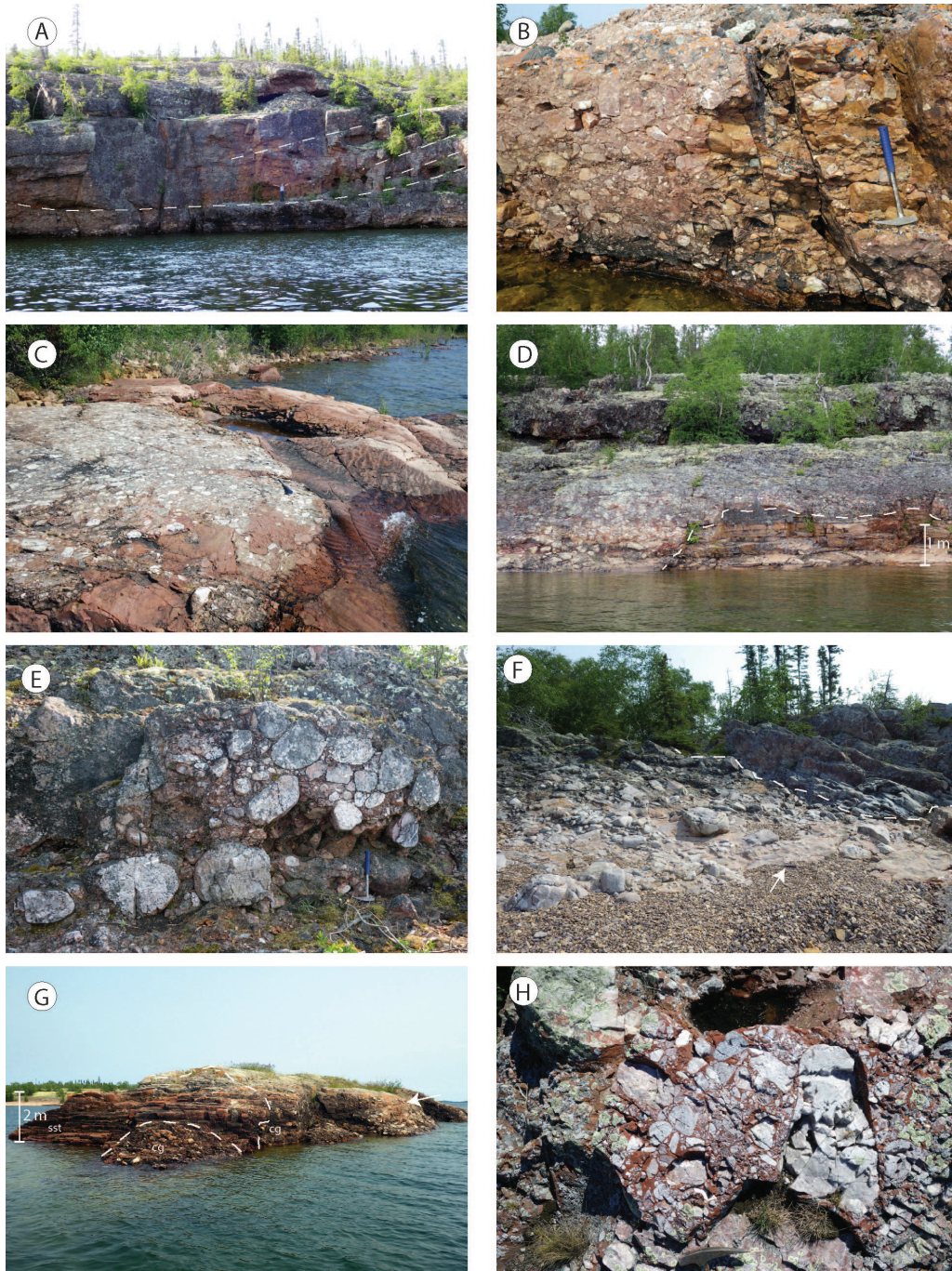


Figure 4 – Examples of Athabasca Group conglomerate: A) portion of large vertical exposure of conglomerate with minor components of sandstone (not observed at this scale); channels can be seen cutting into underlying stratigraphy (dashed line); SB14-13-085, UTM 622304 m E, 6579832 m N; B) another, smaller, vertical exposure of poorly sorted, clast-supported conglomerate; SB14-06-032, UTM 621953 m E, 6578968 m N; C) outcrop with conglomerate and sandstone; sandstone is possibly cutting into the conglomerate, ripples are also present on the right side of the photograph; SB14-06-032, UTM 621953 m E, 6578968 m N; D) matrix- to clast-supported, monomictic conglomerate deposited on top of and cutting into the underlying horizontally bedded Athabasca Group sandstone (contact marked by dashed line); SB14-03-015, UTM 621163 m E, 6579086 m N; E) monomictic, clast-supported conglomerate with dominantly subrounded to well-rounded pebbles to boulders; SB14-13-083, UTM 624021 m E, 6578351 m N; F) monomictic, poorly sorted conglomerate and sandstone directly adjacent to the MBG quartzite (standing high in the back of the photograph); SB14-06-031, UTM 622825 m E, 6579035 m N; G) small island south of Stewart Island containing MBG quartzite (not visible in photo, on far side of island) overlain by Athabasca Group conglomerate (cg) and sandstone (sst); conglomerate is cut by a sandstone dyke (arrow) shown in Figure 5A; SB14-05-030; UTM 622308 m E, 6578727 m N; H) very angular to well rounded MBG quartzite clasts in a red muddy sandstone matrix on the top of the island shown in (G).

Sandstone dykes were also observed in the conglomerate and imply dewatering of a lower sandstone unit likely due to the overlying pressure of the conglomerate. These sandstone dykes are centimetre- to decimetre-scale, and the longest dyke observed was several tens of metres in length (Figure 5). In one place, a sandstone dyke includes a conglomerate clast that was plucked from the conglomerate it had intruded. In other places, clasts within the conglomerate are fractured by these dykes (Figure 5D).



Figure 5 – A) Subvertical sandstone dyke within conglomerate; SB14-05-030, UTM 622308 m E, 6578727 m N. B) Close-up of portion of (A); muddy sandstone clasts (white arrows) are present within the dyke and flow structures along the conglomerate-sandstone boundary (black arrow). C) Close-up of both quartzite clasts and conglomerate clast (arrow) within the sandstone dyke. D) Smaller sandstone dyke fracturing quartzite clasts within the conglomerate; SB14-13-083, UTM 624021 m E, 6578351 m N.

d) Athabasca Group Sandstone

As with the conglomerate, the Athabasca Group sandstone is commonly preserved around local basement topographic highs and, in places, clearly onlaps the MBG quartzite. The sandstone is generally a quartz arenite, although future petrography may indicate local variations. Grain size ranges from very fine- to very coarse-grained sandstone but most is medium- to coarse-grained sandstone (Figure 6). The degree of sorting is also variable, ranging from moderately to well sorted and, less commonly, poorly sorted. Clay intraclasts are common in many places with their long axes generally <1 cm but in places up to 15 cm. These clay intraclasts are typically white, but include red and purple varieties. The sandstone is massive, horizontally bedded and, in several locations, contains trough crossbedding. Crossbedding is decimetre- to metre-scale with widths of up to 3 to 5 m (Figures 6C, 6D). Other sedimentary structures include ripples, groove casts, clay rip-ups, and possibly wind fluting and rain-drop casts. Although a more detailed analysis of the paleocurrent directions needs to be completed, initial observations place paleoflow in a south to southwest direction. The sandstone locally contains pebbles to boulders of MBG quartzite and grades into either the matrix-supported or clast-supported conglomerate near basement exposures. Minor amounts of mudstone is present in the sandstone as thin laminae. These mudstone laminae commonly contain desiccation cracks. Outcrops farther south (*i.e.*, Grouse and Course islands) are more sandstone rich.

Many of the uranium occurrences on Johnson and Stewart islands are in the Athabasca Group conglomerate or sandstone. The Stewart Island prospect is on the south shore of Stewart Island and is hosted in a ferruginous medium- to coarse-grained sandstone. The highest counts per second (cps) recorded were >65535 cps and 105 microsieverts per hour. Using the spectrometer, an assay taken where the highest cps were recorded provided the following results: eU at 10846 ppm, and eTh at 38946 ppm (Table 1); %K could not be determined at this site because of incorrect spectrometer corrections resulting from high concentrations of eU. The mineralized zones generally have a black appearance with accompanying yellow secondary minerals. A second ferruginous exposure, between 50 to 100 m to the west, is also elevated in radioactivity. The outcrops, including the nearby bleached ones, are highly silicified and contain abundant druzy quartz.

3. Discussion

Regional Athabasca Basin stratigraphic studies, including those of Fahrig (1961), Ramaekers (1990), Ramaekers *et al.* (2007) and previous publications by this author, as well as bedrock maps by Ashton and Hartlaub (2008) do not include observations related to the conglomerate observed in this study; however, it is noted in more local maps by industry geologists (ECON assessment files 74N07-0126, -0159, -0222, -0262, -0283, -0284, -0285, -0306, -0307, -0328) and by the Geological Survey of Canada (Bell, 1959, 1961, 1962a, 1962b). Fahrig (1961) described the sedimentary rocks in the study area as having the finest grain size on his regional Athabasca Basin lithology map. The work by Ramaekers (1979, 1990) improved upon previous regional stratigraphic maps; however, outcrops containing conglomerate were not reported. Due to the presence of clay intraclasts in the sandstone, the stratigraphic unit within the study area was defined as Manitou Falls Formation, Dunlop member. During the EXTECH IV program, the stratigraphy was revised again and clay intraclast-rich sandstones within the study area were defined as a subunit of the Manitou Falls Formation, Raibl member (Ramaekers *et al.*, 2007). Other sandstone lithofacies in the study area without clay intraclasts were assigned to other Raibl member subunits; however, the conglomerate was not observed. Subsequent regional stratigraphic work maintained the previously described classification since the northwest part of the Athabasca Basin had not been investigated further (Bosman and Korness, 2007; Bosman *et al.*, 2008; Bosman and Schwab, 2009). Recent work by the author and Dr. Paul Ramaekers (MF Resources Inc., Calgary, personal communication, 2014) has demonstrated that the Raibl member in the north and the stratigraphically equivalent Warnes member on the south side of the Athabasca Basin could be mapped along the eastern side of the Athabasca Basin and joined. The Warnes member was chosen to represent this continuous unit, making the Raibl member obsolete. Although the conglomerate-rich units in the study area were previously mapped by industry geologists, they had yet to be incorporated into the regional stratigraphic maps noted above.

This study provided an opportunity to focus on a small area in the northwest part of the Athabasca Basin to investigate the stratigraphy and sedimentology in greater detail. By focussing on this area, information from previous work as well as the findings from the 2014 field work will be incorporated into future regional stratigraphic maps. Part of the first goal is to determine the stratigraphic position of the rocks, and more specifically the conglomerate, and place it within the Athabasca Group stratigraphic sequence. There are several possible positions including: a) the Fair Point Formation (Athabasca Group succession⁶ 1), b) the Read Formation (Athabasca Group succession 2), c) conglomerate of a new stratigraphic unit (unknown succession), and d) conglomerate of the Martin group (pre-Athabasca Group).

⁶ The Athabasca Group contains four sedimentary successions each separated by an unconformity. Succession 1 includes the Fair Point Formation; succession 2 includes the Read, Smart and Manitou Falls formations; succession 3 includes the Lazenby Lake and Wolverine Point formations; succession 4 includes Locker Lake, Otherside, Douglas and Carswell formations (Ramaekers *et al.*, 2007).

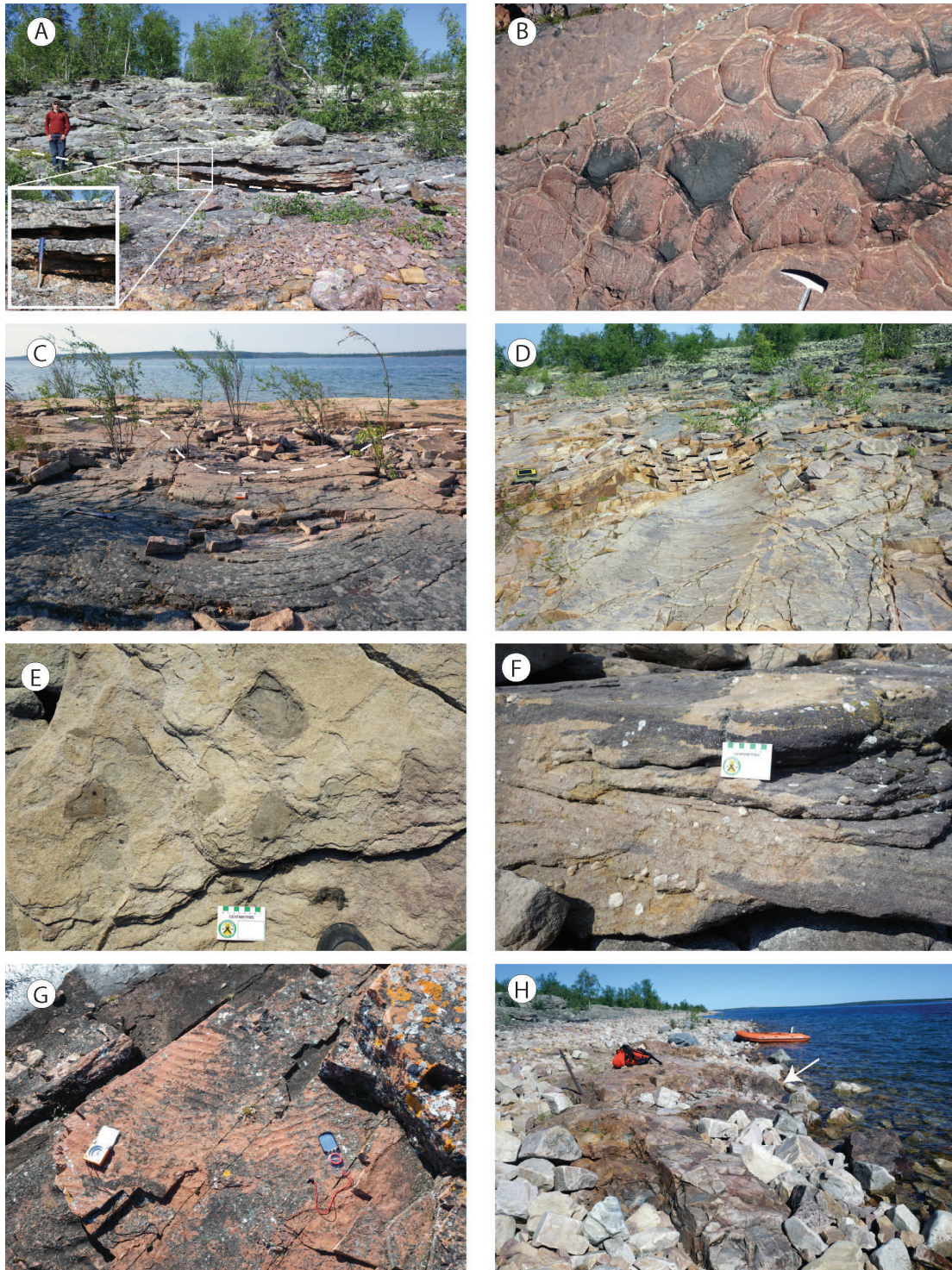


Figure 6 – Examples of Athabasca Group sandstone: A) sandstone channel (white dashed line) with a basal conglomerate lag (inset); SB14-10-063, UTM 613943 m E, 6577875 m N; B) desiccation cracks or fluid-escape structures following pre-existing desiccation cracks at same location as (A); C) trough crossbedded, medium-grained sandstone (one foreset marked by white dashed line); SB14-13-084, UTM 622664 m E, 6577431 m N; D) trough crossbedded, medium-grained sandstone (several foresets marked by black dashed lines); SB14-15-089, UTM 612065 m E, 6579406 m N; E) medium-grained intraformational sandstone clasts in a medium to very coarse sandstone with occasional granules to fine pebbles; SB14-11-069, UTM 599350 m E, 6606733 m N; F) pebbly trough crossbedded sandstone; SB14-11-068, UTM 599431 m E, 6606860 m N; G) linear arcuate ripples on a horizontal bedding plane; SB14-05-030, UTM 622308 m E, 6578727 m N; H) Stewart Island uranium prospect; highest grade zone highlighted with white arrow; SB14-01-007, UTM 619274 m E, 6578285 m N.

At the present time, the most probable stratigraphic position for the conglomerate seen in the study area is equivalent to that of the Fair Point Formation. The monomictic, quartz-rich nature of the clasts is similar to those on the west side of Lake Athabasca (Ramaekers, 1979, 1990). The conglomerate is also most closely related geographically to the conglomerate of the Fair Point Formation currently mapped on the immediate west side of the Black Bay fault. The conglomerate in the study area is generally flat lying and has a matrix that is quartz rich; this is notably different from the observed Martin group conglomerate on the Gravel islands, which is polymictic, steeply dipping, has a feldspathic matrix and is very ferruginous. The Read Formation, the lowest unit of sequence 2 of the Athabasca Group stratigraphy (Ramaekers *et al.*, 2007), contains a conglomerate similar to that at the south end of the Crackingstone Peninsula, but the coarsest material of the Read Formation is located on the east side of the Athabasca Basin and fines towards the northwest. Therefore, the conglomerate in the study area is unlikely to be a Read Formation equivalent unless there was a sediment source from the north not previously documented. Finally, the conglomerate could be assigned to a new stratigraphic unit, representing a wedge of coarse clastic material derived from the north unrelated to other depositional systems in the Athabasca Basin; however, at this time, this seems an unnecessary complexity, so the conglomerate has been correlated with the Fair Point Formation.

The poorly sorted, texturally immature conglomerate with quartzite clasts up to boulder size implies a high energy environment, which was probably deposited as ephemeral debris flows or braided fluvial systems as evident from the massive and channelized deposits, respectively. The conglomerate draping and creating small fans mantling underlying quartzite suggests a type of talus scree or alluvial fan deposit that was sourced from the subjacent topographic highs formed by MBG quartzite. However, such environments do not typically support well rounded, high-sphericity clasts, which are found in many of the outcrops, and therefore the cause of the roundness and high-sphericity remains unresolved at this time. The sandstone may represent the waning stages of flooding during these ephemeral events. Based on the location of these deposits relative to the depocentre of the Jackfish Basin, as well as the south to southwest paleoflow, these coarse-grained sedimentary rocks represent a coarse clastic influx of material from the north to northeast.

4. Conclusions and Future Work

Based on the field work in 2014 on Lake Athabasca south of the Crackingstone Peninsula and maps from previous workers, the distinction between the Martin group and Athabasca Group is quite clear, with the former containing folded rocks, polymictic clasts and feldspathic matrix and the latter containing flat lying, generally monomictic clasts and a quartz-rich matrix. Lithological similarities between the conglomerate in the study area and the Fair Point Formation on the west side of Lake Athabasca make this the most probable interpretation for stratigraphic correlation of the conglomerate. The Fair Point Formation was deposited into the Jackfish Basin, the first of a series of stacked basins that comprise the larger Athabasca Basin. Paleocurrent information, indicating a south to southwest paleoflow supports a Jackfish Basin depocentre towards the southwest. MBG quartzite was a major contributor of coarse detritus to the Fair Point Formation in this area. Sandstone dykes as well as MBG exposures displaying topographic relief with Fair Point Formation surrounding and draping them indicate a variable relief during deposition, suggesting a tectonically active environment during deposition. Future petrographic, geochemical, isotopic, and geochronological analyses are planned, which will add to the depositional history of the Fair Point Formation and the development of the Jackfish Basin.

5. Acknowledgements

The author is grateful to the staff at the Saskatchewan Research Council, including Ian Wilson, Chris Reid and Brooke Parisien, for logistical support while in the Uranium City area, as well as lodging, meals and access while at the Gunnar Mine site. Ken Ashton (Saskatchewan Geological Survey (SGS)) assisted with providing background knowledge of the area as well as insightful conversations concerning the relationship between the basement and Athabasca Group rocks. Levi Paradis provided able assistance while in the field. A field visit by Gary Delaney and Hal Sanders (both with the SGS) was pleasant and instructive. Dave Thomas (Cameco Corp.) provided photographs and insightful discussion prior to the summer field program. Ken Ashton, Michelle Hanson, and Gary Delaney are thanked for their insightful discussions and comments during the reviewing process of this paper, which greatly improved the content.

6. References

- Ashton, K.E. and Hartlaub, R.P. (2008): Geological compilation of the Uranium City area; Sask. Ministry of Energy and Resources, Open File 2008-5, set of four 1:50 000-scale maps.
- Ashton, K.E., Hartlaub, R.P., Bethune, K.M., Heaman, L.M., Rayner, N., and Niebergall, G.R. (2013): New depositional age constraints for the Murmac Bay group of the southern Rae craton, Canada; *Precamb. Resear.*, v232, p70-88.

- Ashton, K.E., Hartlaub, R.P., Heaman, L.M., Morelli, R.M., Card, C.D., Bethune, K., and Hunter, R.C. (2009): Post-Taltson sedimentary and intrusive history of the southern Rae Province along the northern margin of the Athabasca Basin, western Canadian Shield; *Precamb. Resear.*, v175, p16-34.
- Ashton, K.E., Kraus, J., Hartlaub, R.P., and Morelli, R. (2000): Uranium City revisited: a new look at the rocks of the Beaverlodge mining camp; *in* Summary of Investigations 2000, Volume 2, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 2000-4.2, p3-15.
- Bell, C.K. (1959): Milliken Lake, sheet 1, Saskatchewan; *Geol. Surv. Can.*, Map 38-1959, scale 1:9,600.
- Bell, C.K. (1961): Milliken Lake, sheet 2, Saskatchewan; *Geol. Surv. Can.*, Map 33-1961, scale 1:9,600.
- Bell, C.K. (1962a): Milliken Lake, sheet 3, Saskatchewan; *Geol. Surv. Can.*, Map 10-1962, scale 1:9,600.
- Bell, C.K. (1962b): Milliken Lake, sheet 4, Saskatchewan; *Geol. Surv. Can.*, Map 11-1962, scale 1:9,600.
- Bosman, S.A., Elmer, S., and Jefferson, C.W. (2008): Preliminary report: lithostratigraphic investigations of the Athabasca Basin; *in* Summary of Investigations 2008, Volume 2, Saskatchewan Geological Survey, Sask. Ministry of Energy and Resources, Misc. Rep. 2008-4.2, CD-ROM, Paper A-1, 15p.
- Bosman, S.A. and Korness, J. (2007): Building Athabasca stratigraphy: revising, redefining, and repositioning; *in* Summary of Investigations 2007, Volume 2, Saskatchewan Geological Survey, Sask. Ministry of Energy and Resources, Misc. Rep. 2007-4.2, CD-ROM, Paper A-8, 29p.
- Bosman, S.A. and Schwab, M. (2009): Preliminary report: lithostratigraphic investigations of the north and northeast Athabasca Basin, Saskatchewan; *in* Summary of Investigations 2009, Volume 2, Saskatchewan Geological Survey, Sask. Ministry of Energy and Resources, Misc. Rep. 2009-4.2, Paper A-6, 13p.
- Fahrig, W.F. (1961): The geology of the Athabasca Formation; *Geol. Surv. Can.*, Bull. 68, 41p.
- Gradstein, F.M., Cooper, R.A., Sadler, P.M., Hinnov, L.A., Smith, A.G., Ogg, J.G., Villeneuve, M., McArthur, J.M., Howarth, R.J., Agterberg, F.P., Robb, L.J., Knoll, A.H., Plumb, K.A., Shields, G.A., Strauss, H., Veizer, J., Bleeker, W., Shergold, J.H., Melchin, M.J., House, M.R., Davydov, V., Wardlaw, B.R., Luterbacher, H.P., Ali, J.R., Brinkhuis, H., Hooker, J.J., Monechi, S., Powell, J., Röhl, U., Sanfilippo, A., Schmitz, B., Lourens, L., Hilgen, F., Shackelton, N.J., Lasker, J., Wilson, D., Gibbard, P., and van Kolfschoten, T. (2004): *Geologic Time Scale 2004*; Cambridge University Press, Cambridge, UK, 589p.
- Hartlaub, R.P., Heaman, L.M., Ashton, K.E., and Chacko, T. (2004): The Archean Murmac Bay Group: evidence for a giant Archean rift in the Rae Province, Canada; *Precamb. Resear.*, v131, p345-372.
- Morelli, R., Hartlaub, R.P., Ashton, K.E., and Ansdell, K.M. (2009): Evidence for enrichment of subcontinental lithospheric mantle from Paleoproterozoic intracratonic magmas: geochemistry and U-Pb geochronology of Martin Group igneous rocks, western Rae Craton, Canada; *Precamb. Resear.*, v175, p1-15.
- Ramaekers, P. (1979): Sections through the Athabasca Basin; 1:1 000 000-scale prelim. map *with* Summary of Investigations 1979, Saskatchewan Geological Survey, Sask. Miner. Resour., Misc. Rep. 79-10.
- Ramaekers, P. (1990): Geology of the Athabasca Group (Helikian) in northern Saskatchewan; *Sask. Energy Mines*, Misc. Rep. 195, 49p.
- Ramaekers, P., Jefferson, C.W., Yeo, G.M., Collier, B., Long, D.G.F., Drever, G., Mchardy, S., Jiricka, D., Cutts, C., Wheatley, K., Catuneanu, O., Bernier, S., Kupsch, B., and Post, R.T. (2007): Revised geological map and stratigraphy of the Athabasca Group, Saskatchewan and Alberta; *in* Jefferson, C.W. and Delaney, G. (eds.), EXTECH IV: Geology and Uranium EXploration TECHnology of the Proterozoic Athabasca Basin, Saskatchewan and Alberta; *Geol. Surv. Can.*, Bull. 588, p155-191 / *Sask. Geol. Soc.*, Spec. Publ. 18 / *Geol. Assoc. Can.*, Min. Dep. Div., Spec. Publ. 4.