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R.H. Rainbird and A. Ielpi

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R.H. Rainbird[1] and A. Ielpi[2]

[1] Geological Survey of Canada, Natural Resources Canada, Ottawa, Ontario
[2] Canada-Nunavut Geoscience Office, Iqaluit, Nunavut

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Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to investment in responsible resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the summer 2014, GEM's new research program has been launched with 14 field activities that include geological, geochemical and geophysical surveying. These activities have been undertaken in collaboration with provincial and territorial governments, northerners and their institutions, academia and the private sector. GEM will continue to work with these key collaborators as the program advances.

The **Elu Basin Geoscience Project** is a sub-activity of the **Geology and Mineral Potential of the Chantrey-Thelon Area activity within the Rae Project** (led by GSC in collaboration with C-NGO). Its primary focus is to define the main basin depositional elements of the Elu Basin and evaluate its potential to host stratabound and/or unconformity-type mineralization, particularly of uranium (Figure 1).

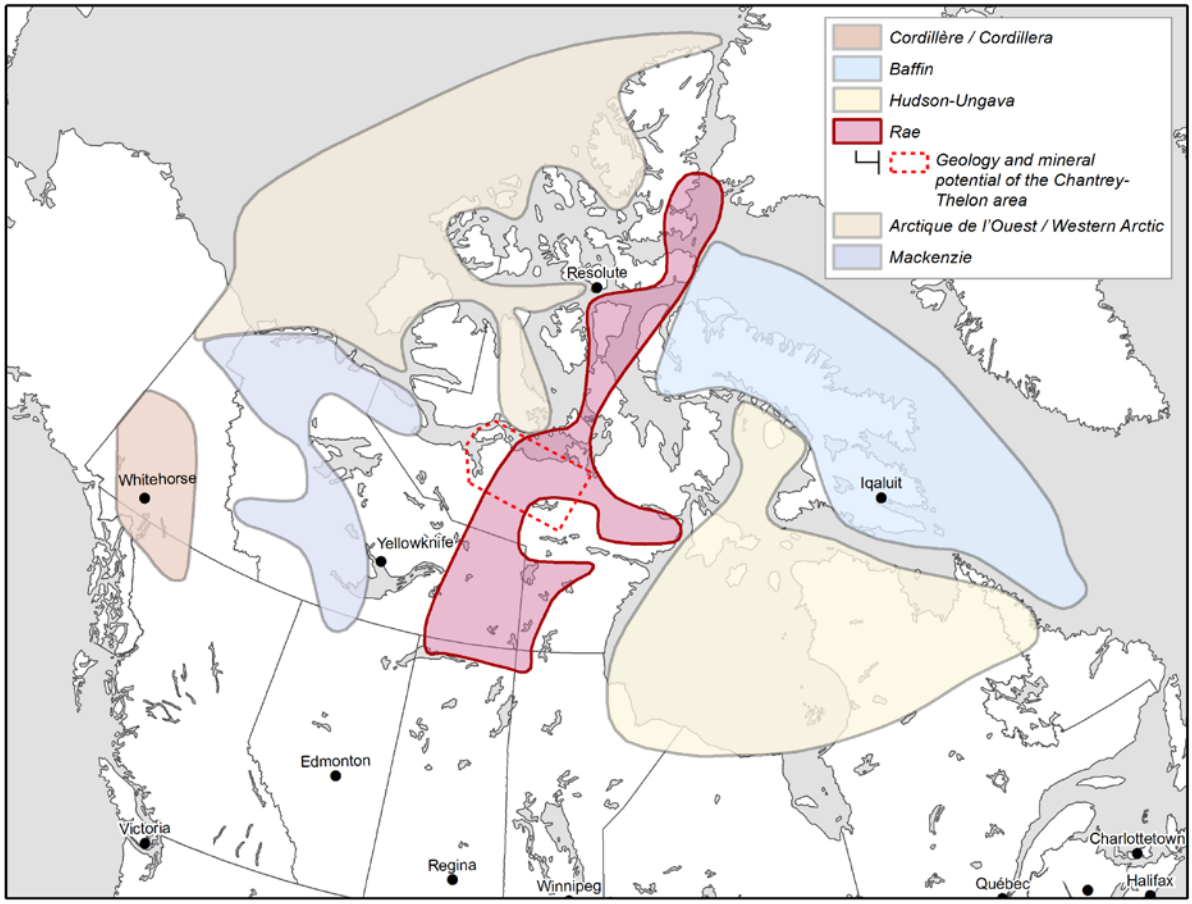

Figure 1. GEM2 Program areas of interest. Elu Basin is at the northwestern extremity of the area enclosed by the red dashed line.

Introduction

The Elu Basin Geoscience Project was initiated in 2014 as a 3-year, field-based study developed to evaluate the stratigraphy, sedimentology, and economic potential of Paleo- to Mesoproterozoic sedimentary rocks of western Nunavut. The Elu Basin is located in the Kitikmeot Region of Nunavut and is one of several correlative Paleo- to Mesoproterozoic intracratonic depocentres on the Canadian Shield (Fraser et al., 1970). Geological study of the Elu Basin was last performed during the late 1970s (e.g. Campbell, 1979), and the area has been largely ignored since then. However, correlative basins such as the Athabasca, Thelon and Hornby Bay have well-known economic potential for uranium (e.g. Jefferson et al., 2007), and, to a lesser extent, Pb-Zn, Ni, Co, Cu, Fe, Mn, As, S, and Se (Long and Turner, 2012). The main goal of the project is to fill knowledge gaps regarding the depositional history of the Elu Basin and its economic potential.

In this first year of the project, reconnaissance geological mapping was integrated with depositional architectural analysis on large outcrops, as well as with targeted sampling and analysis with a hand-held gamma-ray spectrometer. A database of rock-spectral signatures was collected on both sedimentary and basement rocks to evaluate patterns of preferential U-Th mineralization, as well as for characterization of sedimentary provenance.

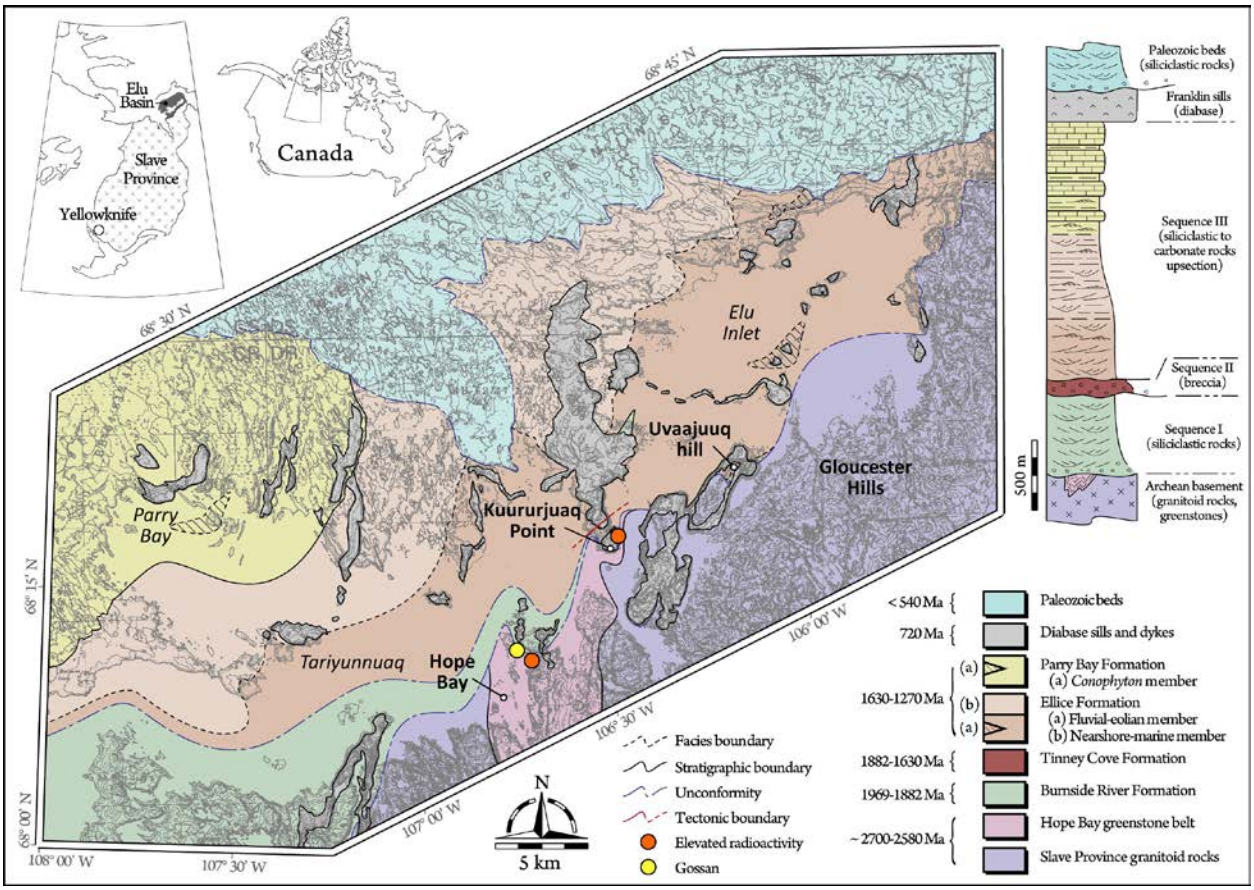

Figure 2. Geology of Elu Basin, modified from Campbell (1979). Geochronology from Bowring and Grotzinger, (Bowring and Grotzinger, 1992) and Heaman et al., (1992).

Geological Setting

The Elu Basin comprises an irregular ~100 x 30 km, ENE-WSW-oriented belt of Paleo- to Mesoproterozoic siliciclastic and carbonate rocks, which are exposed along the shores of Melville Sound and Elu Inlet, on the northern mainland, east of Bathurst Inlet (Figure 2). These undeformed, flat-lying rocks rest unconformably on Archean rocks of the Slave Province, which are exposed along

the SSE flank of the basin. Within the basement, the Hope Bay Greenstone Belt is a dominant N-S--trending belt of volcanogenic rocks, bounded to the east and west by granitoid and gneissic rocks (Sherlock et al., 2012). The Elu-Basin's fill comprises 4 lithostratigraphic units: the Burnside River, Tinney Cove, Ellice and Parry Bay formations that are interpreted as belonging to three unconformity-bounded stratigraphic sequences (Figure 2). These sequences are correlated across much of the Canadian Shield (e.g. Rainbird et al., 2007). The basin fill is cut by diabase sills and dykes of the 720 Ma Franklin event (Heaman et a. 1992), and covered to the NNE by sedimentary deposits of suspected Cambrian to Ordovician age (O'Niell, 1924).

Methodology

Helicopter-supported mapping during the second half of July 2014, covered an area of approximately 100 x 30 km within NTS map 77A (Elu Inlet). The main units of study are the Burnside River and Ellice formations, because they are mainly composed of fluvial sandstones. It was decided to focus on the Ellice Formation in 2014 and that excellent exposures of the Burnside River Formation in the western part of Melville Sound would be studied in 2015. Detailed sedimentological observations, and measured stratigraphic sections, were obtained along stepped, shore-platform and cliff exposures, that are up to 60 m high, and laterally continuous for up to 400 m. Facies architectural analysis was aided by line-drawing on photographic panels derived from ground and oblique aerial imagery. Some 1300 paleoflow measurements from cross-bedding aided our paleogeographic reconstruction. Gamma ray measurements are presented herein as total radioactivity dose rate measured in the field, in nanosieverts per hour (nSv/h), potassium (as percentage), and uranium and thorium (as parts per million), using a Radiation Solutions RS-125 spectrometer. Field analyses were supplemented by collection of 27 representative rock samples (for results, see Ielpi and Rainbird, 2014).

Geochronological Studies

Six samples of heavy mineral-bearing sandstone were collected for detrital zircon U-Pb geochronology from the base, middle and the top of the Ellice Formation and from the underlying Burnside River Formation. Data from this work will be compared with similar studies in the Athabasca and Thelon basins (Rainbird and Davis, 2007; Rainbird et al., 2007).

Results

Basal Contact Relationships

In the study area, basal strata of the Elu Basin exhibit variable relationships with underlying rocks. In Melville Sound and Elu Inlet, the Burnside River Formation overlies granitoid rocks, whereas in Hope Bay it overlies rocks of the Hope Bay greenstone belt, here consisting of folded metasedimentary, mafic metavolcanic, as well as mafic intrusive rocks (Sherlock et al., 2012). There is extensive hematitic alteration of the volcanic rocks, which are unconformably overlain by dark maroon sandstone and quartz-pebble-rich conglomerate that was deposited in erosional depressions interpreted as paleovalleys. To the northeast, at Kuururjuaq Point (Figure 3a), an up to 30 m-thick lenticular, cliff-face exposure of angular, sandstone-clast breccia/conglomerate belonging to the Tinney Cove Formation overlies ~ 10m of maroon arkosic sandstone of Burnside River Formation, from which the sandstone clasts were derived (Figure 3b). The Burnside River Formation overlies in turn foliated Archean volcanic rocks exposed along the shore. Here, the contact is partly obscured by large blocks of Franklin diabase derived from the cliff top. Further to the east, coarse micaceous sandstone of the basal Ellice Formation unconformably overlies hematite- and sericite-altered, red, granitic rocks of the Slave Province.

Figure 3. Basal conglomerate units: (a) unsorted, hematite-stained conglomerate of the Burnside River Formation overlying altered Archean metasedimentary rocks of the Hope Bay greenstone belt (left foreground); (b) basal breccia of the Tinney Cove Formation composed exclusively of angular clasts of underlying Burnside River Formation sandstone.

Sedimentology of the Ellice Formation

The Ellice Formation is a ~1 km-thick, upward-fining succession of quartz-rich sandstone with minor conglomerate, shale, and carbonate rocks. Conglomerate is more abundant in the lower 200 meters of the formation, whereas the upper 500 meters are dominated by interbedded fine-grained sandstone, shale, and dolostone. Following this distinction, the Ellice Formation is here informally subdivided into a lower coarse-clastic member and an upper carbonate-clastic member.

In the coarse-clastic member, conglomerate and weakly sorted sandstone are ubiquitously trough-cross bedded in cross-cutting lensoid units (when clast-rich; Figure 4a), or large-scale inclined beds (where sandstone-dominated; Figure 4b). These units display a mildly dispersed paleoflow pattern lower in the section or in their coarser portions, whereas the upper sandstone-dominated portions are less dispersed with paleoflow consistently to the northwest. Due to their weak sorting and abundance of unidirectional current indicators, these deposits are interpreted as representing a fluvial environment. Gravel-rich lensoid units possibly represent the fill of amalgamated channel belts, whereas sandstone-dominated inclined beds are possibly the product of accretion and reworking of compound channel bars.

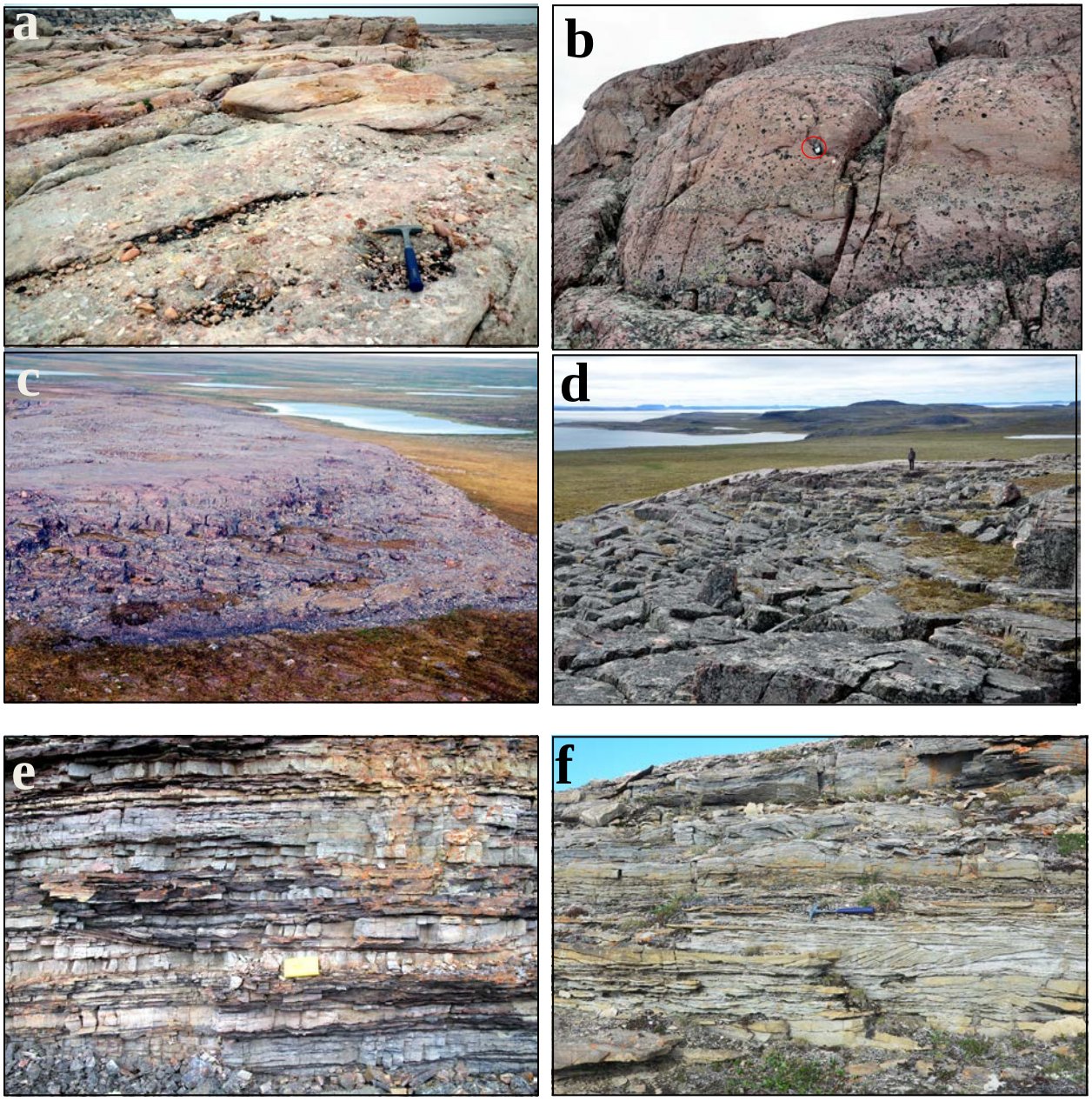

Figure 4. Ellice Formation: (a) lenses of pebble-cobble conglomerate are commonly preserved in the lower member (rock hammer for scale); (b) large trough-cross beds in pebbly sandstone of the lower member (hand-held radio circled for scale); (c) oblique aerial view of large, eolian cross-beds in the basal member (foresets are inclined to right; station R16; field of view approximately 50 m in foreground); (d) Outcrop-view of cross-bedding shown in (a) with geologist in background for scale; (e) heterolithic strata of the upper member (notebook for scale); (f) stromatolitic dolostone beds (above rock hammer) in the uppermost part of formation typify the gradational transition into the overlying Parry Bay Formation.

At two localities (R16 and R28; Figure 2), large, planar-cross beds composed of very well sorted, fine- to medium-grained quartz sandstone occur within the lower member fluvial deposits (Figure 4c, d) . The deposits comprise tabular cross-bed sets up 4 meters thick that display a polymodal range of paleotransport. Due to their textural and compositional maturity, and distinctive large-scale cross-bedding, these deposits are interpreted to represent eolian dunes.

In the upper carbonate-clastic member, fine-grained sandstone, siltstone and dolostone form decimeter-thick layers that appear to be planar and laterally extensive. The abundance of carbonate

increases up-section toward the gradational contact with the overlying Parry Bay Formation. The clastic portion is compositionally mature but poorly sorted, ranging from fine-grained sand to silt. Typical lithofacies are parallel-laminated dark siltstone and wavy to parallel-laminated tan-weathering dolomitic sandstone (Figure 4e). Wavy-lenticular bedding is common. Thicker and coarser sandstone beds are lenticular with scoured bases and cross-stratified fill recording unimodal north-west paleotransport. Further to the east, in the transition to the Parry Bay Formation, cross-bedded and wavy bedded sandstone is intercalated with dome-topped strata composed of laterally linked stromatolites (Figure 4f). This interbedding is interpreted to characterize a nearshore-marine to coastal plain setting that was subject to deltaic progradation and shoreface aggradation during periods of enhanced clastic supply, alternating with shallow-water carbonate shelves that expanded during periods of clastic starvation. The overall upward increase in carbonates beds records an overall marine transgression.

Gamma-Ray Spectrometry

Gamma-ray spectrometry was focussed on granitoid, greenstone (i.e. both extrusive and intrusive mafic rocks), and metasedimentary rocks of the Archean Slave Province. Granitoid rocks showed the highest overall radioactivity, with an average dose of 73.3 nSv/h and a maximum of 118 nSv/h. Mafic meta-igneous and associated metasedimentary rocks both gave average dose rates between 30.2 nSv/h, and maximum of 55.6 nSv/h. Higher radioactivity is attributed to concentrations of potassium rather than uranium and thorium in granitoid rocks, because the U+Th/K ratio varies between 1.2×10^{-5} and 1.25×10^{-4}. Greenstone and metasedimentary rocks have more dispersed U+Th/K ratios (0 to 4×10^{-3}), but overall appear to be relatively enriched in U+Th when compared to the granitoid rocks.

Within the Elu Basin, dose rates vary from 7.8 to 216 nSv/h, averaging 68 nSv/h. Elevated dose rates in the lower stratigraphic units (i.e. Burnside River and Tinney Cove formations), occur in proximity to erosional unconformities. At Kuururjuaq Point, deposits of these two formations are characterized by dose rates of 92.8 and 97.5 nSv/h respectively, with peaks of 111.0 and 144.0 nSv/h. These values are attributed to values of K, U, and Th of up to 3.8%, 9.3 ppm, and 26.6 ppm. Lower readings occurred along the eastern shore of Hope Bay, where the lowermost deposits of the Burnside River Formation yielded an average dose rate of 57.6 nSv/h, and peak of 93.1 nSv/h. In these deposits, radioactivity depends on concentrations of K, U, and Th of up to 1.7%, 3.6 ppm, and 22.7 ppm, respectively. We noted a significant discrepancy between the natural radioactivity of basement rocks and of their overlying deposits at both these locations. Stratigraphically higher in the basin fill, the fluvial and aeolian deposits of the Ellice Formation yielded background values, with an average dose rate of 39.3 nSv/h, and a peak of 164 nSv/h (from several locations). The nearshore-marine deposits of the Ellice Formation yielded slightly higher dose rates, with an average of 164.4 nSv/h and peak of 216 nSv/h. These values are brought about by concentrations of K, U, and Th of up to 9.5%, 4.9 ppm, and 48.1 ppm, respectively.

Economic Considerations

In comparison with correlative sedimentary basins such as the Thelon and Athabasca (Jefferson et al., 2007), there is potential for the discovery of economic concentrations of uranium and thorium at or near the unconformity between Archean supracrustal rocks of the Slave Province and the overlying Proterozoic terrestrial deposits, either the Ellice, Tinney Cove or Burnside River formations (Figure 2). Anomalous gamma-ray readings were previously reported from the Burnside River and Tinney Cove at locality R1 (Figure 2; Campbell, 1979). Our observations confirm this anomaly, with concentrations of uranium and thorium as high as 5.9 and 25.3 ppm, respectively. At location R8, concentrations of uranium and thorium up to 3.6 and 22.7 ppm, respectively, were recorded in the Burnside River Formation. These results suggest that higher concentrations of uranium and thorium

occur where the basal unconformity overlies metavolcanic and metasedimentary rocks of the Hope Bay Greenstone Belt.

Conclusions

The Ellice Formation is here informally subdivided into a lower coarse-clastic member deposited in fluvial and newly recognized eolian depositional environments, and an upper carbonate-clastic member deposited in nearshore-marine to coastal plain environments. An upward increase in carbonate interlayers records an overall transgressive setting. Fluvial paleoflow patterns are distributed between west and north in lower, coarser-grained strata, whereas the upper, sandstone-dominated portions exhibit unimodal paleoflow toward the northwest. Eolian cross-bedding displays polymodal flow.

Field based gamma-ray spectral measurements were obtained from representative Archean basement rocks and unconformably overlying sandstones and conglomerates. Results suggest that higher concentrations of uranium and thorium are located where the basal unconformity overlies metasedimentary and metavolcanic rocks of the Hope Bay Greenstone Belt. Highest values of radioactivity were recorded in nearshore-marine sandstones, and are related to higher concentrations of potassium in clay minerals.

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