GM 67722

QUATERNARY INVESTIGATION OF THE MONDAY RADIOACTIVE BOULDER TRAIN, OTISH SOUTH URANIUM PROPERTY

CENTRE D'ÉTUDE APPLIQUÉE DU QUATERNAIRE

Quaternary investigation of the Monday radioactive boulder train Cameco's Otish South Uranium Property, Otish Mountains mineral district of Northern Québec

(NTS sheets 32P16 and 22M13)

FINAL REPORT

Marc-André Bernier, M.Sc., P.Geo. (OGQ No. 329)
Senior Geoscientist

March 12, 2012

958, 3e Rue, Chibougamau (Québec) G8P 1R6
Téléphone : 418 748-1141 Télécopieur : 418 748-6511 Site : www.tjcm.ca

Cover Page: Clockwise starting from the upper left: (1) Cameco geologist S. Rogers examining a meter-sized, angular to subangular, radioactive sandstone boulder at site MBT-004 located 1.6 km down-ice from the first identified radioactive on the Monday boulder train (MBT-066); (2) North-westerly view of hu

mmocky moraine north and west of Camie River, 1.8 km up-ice from the head of the train; (3) Close-up shot of boulder MBT-001 showing disseminated yellow uranium oxide products immediately to the right of the main fracture (5 cm left and down from the pencil). Boulder MBT-001 returned the highest scintillometer reading of the survey (27, 700 CPS); (4) Meter-sized, subangular and fractured radioactive sandstone-granulestone boulder at site MBT-001 located 1.3 km down-ice from the head of the Monday boulder train.

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1. Introduction

At the request of Alexandre Aubin, Ph.D., P.Geo., Project Geologist – Nunavut, Northwest Territories and Quebec for **Cameco Corporation** ("Cameco" or the "Company"), the **Centre d'étude appliquée du Quaternaire** (the "CÉAQ") of Chibougamau conducted a reconnaissance Quaternary investigation of the Monday radioactive boulder train located on the Company's wholly-owned **Otish South uranium property**, northern Québec.

The Otish South property (the "Property"), comprises of 557 map-designated claims distributed in three (3) claim blocks (total area: 294.3 km^2) located within NRCan 1:50,000-scale NTS sheets 32P16 (Main block and West blocks 1 and 2) and 22M13 (Main block) (Figure 1). The Property straddles the southern, east-trending boundary of the Proterozoic Otish Sedimentary basin. The Monday radioactive boulder train occurs north of this boundary and west of Camie River, within the Main block of claims, at the southeast corner of NTS sheet 32P16. The head of the boulder train crosses onto the southwest corner of the **Camie River uranium property**, jointly held by Cameco and Areva Canada.

The Quaternary field reconnaissance was carried out over a period of 5 days, from September 11 to 15, 2011, including two and ½ days mobilisation time to and from the Property from Chibougamau by way of road travel (Hwy 167 from Chibougamau to the Témiscamie air base) and by float plane (Témiscamie air base to the Property).

While in the field, the author was accompanied by Cameco project geologists Scott Rogers, G.I.T., and Eric Bort, G.I.T. Accommodations were provided at Cameco's Otish base camp located within the Main claim block (UTM coordinates: WGS 84 18U 0696193E/5746125N), 5.6 km to the East of the Otish Mountain winter access road. A Eurocopter AS350-D™ helicopter owned and operated by Panorama Helicopters Ltd. of Alma, Québec, and capable of transporting six people plus prospecting equipment, was used to travel to and from Cameco's base camp to the Monday boulder train survey area.

This report documents the findings from the 5-day Quaternary reconnaissance of the Monday boulder train and broader boulder train area and provides recommendations for follow-up exploration work.

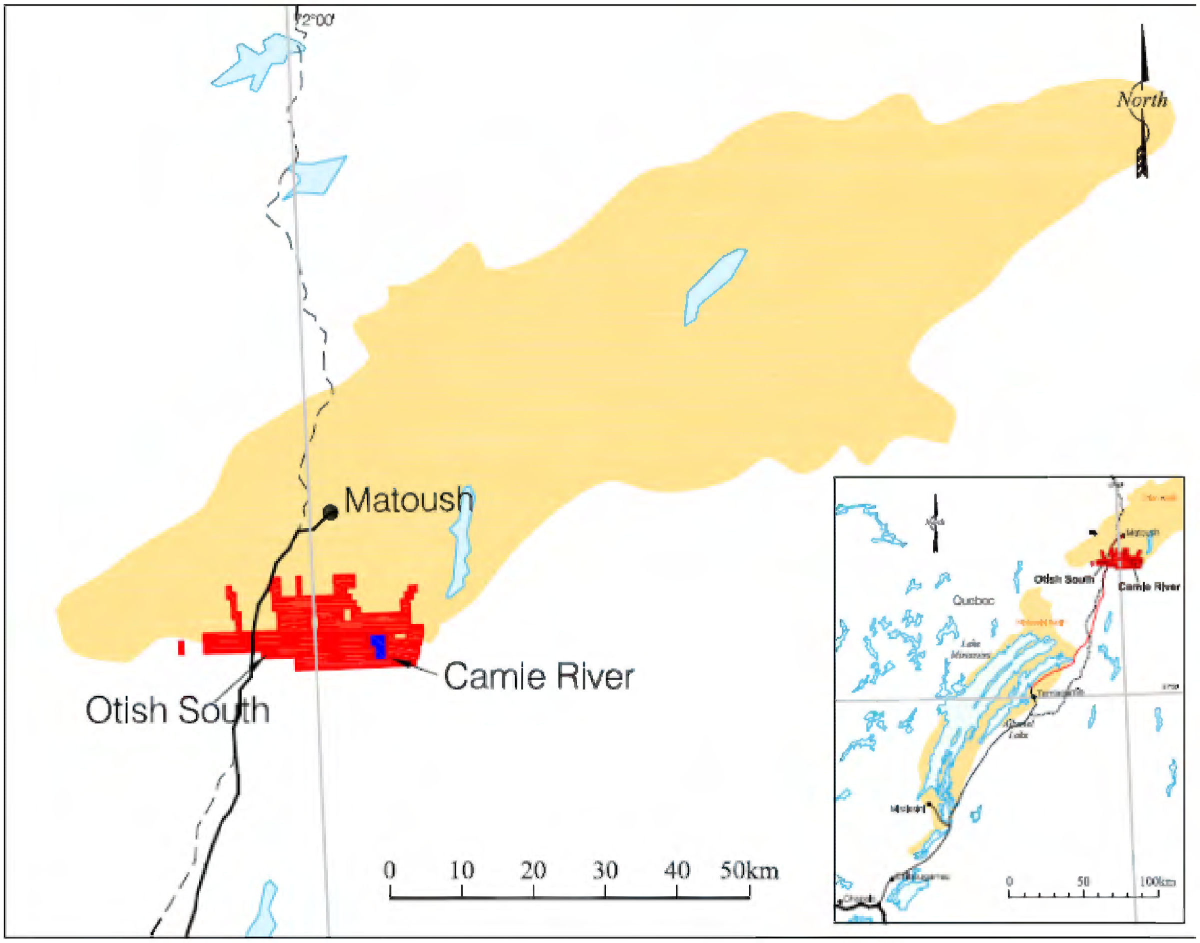

Figure 1. Location of Cameco's Otish South property (red) in relation to the Otish Sedimentary basin (orange) and Camie River property (blue). Source: Cameco (November 2011).

2. About the CÉAQ

The Centre d'étude appliquée du Quaternaire ("CÉAQ ") is a not-for-profit applied research facility based in Chibougamau, northern Québec. The CÉAQ is a division of the Table jamésienne de concertation minière ("TJCM"), a regional development organisation founded in 2001 with the goal of promoting sustainable mineral development practices by governments and industry across the James Bay territory and broader Nord-du-Québec administrative region.

The CÉAQ's principal mandate is to augment the Quaternary knowledge base for northern Québec through geoscientific research and data acquisition. The CÉAQ conducts target or area-specific Quaternary investigations on behalf of government and mining industry clients, as well as regional mineralogical and geochemical surveys aimed at assessing the mineral potential of emerging or neglected sectors of the territory.

The CÉAQ, through its laboratory arm, also provides wet and dry mineral processing services ahead of external geochemical analysis as well as sample archiving and shipping services.

3. About the author

The author is a certified practicing geoscientist (P.Geo) in both Ontario (APGO member 1049) and Québec (OGQ member 329) and a trained Quaternary geologist and exploration geochemist (B.Sc.H and M.Sc.) with over 26 years of professional experience in: (a) designing and managing drift-based mineralogical and geochemical surveys and broader mineral exploration programs in Canada and abroad; and (b) conducting regional reconnaissance scale to site-specific Quaternary investigations and landscape studies on behalf of Canadian government agencies and mining companies.

The author has been employed as a Quaternary geoscientist with the TJCM since 2003 and has been acting as senior geoscientist for the TJCM's CÉAQ division since 2009.

4. Scope of work

Work conducted by the author ahead of the Quaternary reconnaissance comprised of:

(a) Acquiring background geological and mineral exploration information on the Property and broader property area from the Québec government's SIGÉOM website (http://sigeom.mrnf.gouv.qc.ca); from select junior mining company Websites and company statutory disclosures at www.sedar.com [Arrowhead Gold Corp. (formerly Otish Energy Inc.; www.arrowheadgold.com); Virginia Energy Resources Inc. (formerly Santoy Resources Ltd.; www.santoy.ca); and Strateco Resources Inc.; www.stratecoinc.com)]; and from a data CD of historical company reports compiled by Cameco and supplied to the CÉAQ ahead of the Quaternary reconnaissance;

(b) The down-loading from NRCan (http://geogratis.cgdi.gc.ca/geogratis/en/index.html) of remotely sensed panchromatic Spot™ images and 1:50,000-scale digital vector topographic maps covering NTS sheets 32P16 (Lac Hippocampe) and 22M13 (Lac Indicateur); the registering of the satellite images and vector topographic files onto a MapInfo™ workspace; the de-archiving of CÉAQ digital Quaternary maps and dataset for the southern Otish Mountains-Lake Mistassini region (Bernier, 2004; 2005); and

(c) A preliminary analysis of the dominant Quaternary landform-sediment associations in the area of the Monday radioactive boulder train and in the general vicinity.

Work conducted by Cameco at the request of the CÉAQ ahead of the Quaternary reconnaissance comprised of the systematic radiometric resurveying of the Monday boulder train (100 m-spaced lines); the flagging and GPS positioning of radioactive boulders; and the recording of scintillometer counts and basic physical characteristics, namely dimensions, textures and composition.

Upon arrival in the field, two maps were generated by Cameco geologists from this data: (1) a proportional circle plot of the distribution of uranium-bearing boulders as a function of ranges of long axes (Figure 2); and a proportional circle plot of the distribution of the uranium-bearing boulders as a function of ranges of scintillometer counts.

In the field, the reconnaissance survey comprised of:

(a) An inspection of the historical Gordon's Lake fracture-hosted sandstone uranium occurrence together with the surveying of dominant glacial landforms and the recording of ice-flow indicators on bedrock (grooves and striae);

(b) The resurveying of the Monday boulder train starting from the tail of the train and moving up-ice along its longitudinal axis to its head area and up to 500 m past its head;

(c) The radiometric prospecting of projected extensions of the Monday boulder train over similar subglacial till-dominated terrain at 2.0 km, 2.7 km and 5.7 km respectively, up-ice from the head of the train; and

(d) A Quaternary reconnaissance of the dead-ice terrain and fluvioglacial landform-sediment associations within Camie River valley to the North and West of Camie River, up-ice from the head of the Monday boulder train.

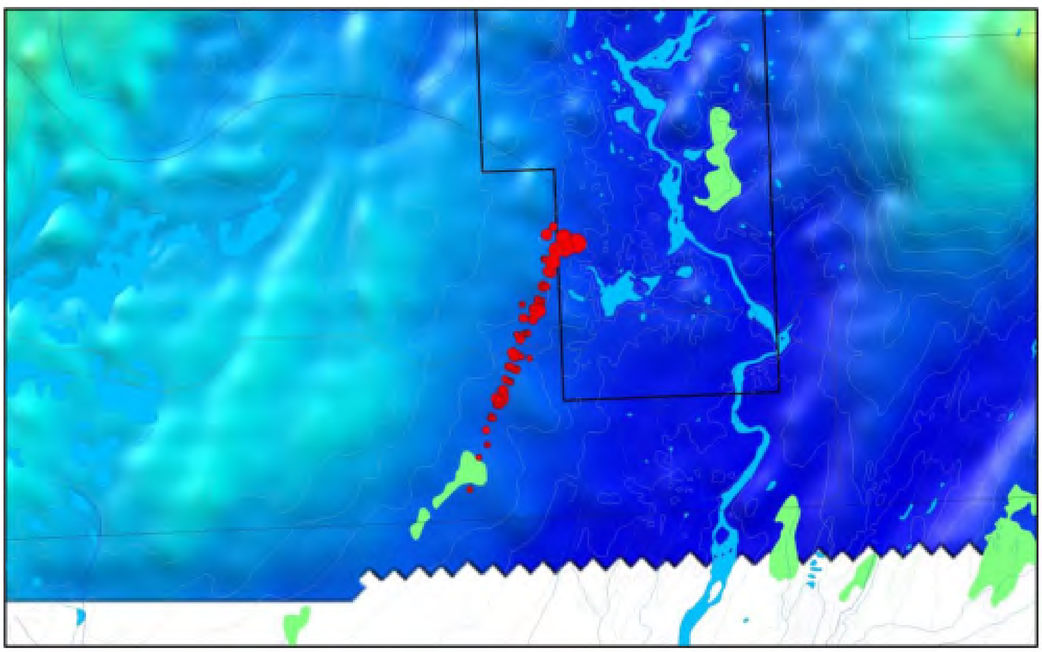

Figure 2. Preliminary proportional circle plot of the distribution of uranium-bearing boulders as a function of size of the boulders, Monday radioactive boulder train. Colour-contoured topographic base provided by Cameco. The Camie River runs from north to south, east of the Monday boulder train. The total length of the glacial dispersal train is 2.5 km.

Observations at each radioactive boulder site comprised of the recording of the geomorphic setting as well as the physical characteristics of individual boulders (shape; size; composition and texture). The location of each boulder was verified using a Garmin™ 76CSx hand-held GPS unit. Select physical and compositional features were also documented by digital photography.

A total of 43 out of the 64 radioactive boulders identified by Cameco within the Monday train where surveyed as part of the Quaternary reconnaissance. A SAPHYMO SPP-2™ portable scintillometer was brought along on the second and third days of Quaternary reconnaissance (September 14 and 15). The known boulders were re-surveyed and two (2) new radioactive boulders were recorded along the longitudinal axis of the glacial dispersal train (boulders MBT-065 and MBT-066). An additional four (4) radioactive boulders (MBT-067 to 070) were identified more than 2 km to the northeast of the northernmost radioactive boulder recorded by Cameco (MBT-066) while surveying the projected up-ice path of the train. It should be noted that radioactivity readings of the Monday train boulders using the SPP2 scintillometer were on average 50% lower than the values recorded in Cameco's 2011 project database (the readings in the database are assumed to have taken using a Radiation Solutions RS-125™ portable spectrometer).

Where appropriate and at selected boulder sites, test pitting was performed to assess the nature of the surficial sediment cover. In practically all cases, the pitting never broke through the coarse clast-supported cobble-boulder surface layer characteristic of the Monday radioactive boulder train and broader encompassing boulder field.

The Monday boulder train was also prospected in search for outcrop exposures and ice-flow indicators, but no outcrops were found. Large exposures of near flat-lying banded hematitic sandstone and granulestone containing layers of quartz pebbles were observed within the Camie River valley immediately up-ice from the head of the Monday train and limited exposures of sandstone were also found while prospecting two of the three target areas located up-ice from the head of the train.

Finally, during the reconnaissance, selected radioactive boulders were sampled by Cameco geologists for uranium and trace element geochemical analysis.

5. Previous Quaternary investigations

The Monday radioactive boulder train was the subject of a previous Quaternary investigation by geologist J. Murphy carried-out on behalf of Uranerz in 1980 (Murphy, 1980). This investigation comprised of two days of field surveying and follow-up data analysis and modelling aimed at calculating provenance distance to source based on glacial drift thickness and boulder size and roundness. In his report, Murphy estimated the primary source of the Monday boulder train to lie between 500 to 1,000 m up-ice from the first document occurrence of radioactive erratics. Murphy pushed his interpretation a step further by suggesting that the primary uranium mineralisation occurred in narrow, 20-30 m-long subcropping fracture zones exposed normal to ice direction but trending in a north-easterly direction.

To the author's knowledge, the source area of the Monday boulder train outlined by Murphy has not been the subject of additional investigation in search for primary uranium mineralisation nor to validate his provenance model.

6. Quaternary setting of the Monday boulder train and Otish South property

The Quaternary geology of the Lake Mistassini to southern Otish mountains region including the eastern half of the Otish South property has been previously investigated using remotely sensed imagery and mapped at 1:250,000 scale by the author (Bernier, 2004; 2005). Huss (2002; GM 61340, as part of her regional geoscientific compilation of the Otish sedimentary basin and Papaskwasati sub-basin, produced a Quaternary geology compilation map which covers roughly the same region mapped by Bernier.

The Otish South property and broader Mistassini and Otish sedimentary basin were glaciated by the Eastern sector or lobe of the Laurentide ice sheet during the last continental-scale glaciation. During the maximum of the Laurentide glaciation, ice flowed radially in a westerly to southerly direction across the James Bay territory from the centre of the Labrador Peninsula (Figure 3), moving with it vast quantities of bedrock-derived material away from the ice divide which were then laid-down tens and up to hundreds of kilometres away as subglacial, englacial and proglacial sediments.

The major valleys leading away from the continental ice divide towards the James-Bay/Hudson coasts, such as the Témiscamie, Rupert and Eastmain river valleys contain thick and abundant sequences of subglacial sediments (both till and eskers) and proglacial outwash while the adjacent interfluves or upland areas are usually either plastered with continuous sheets of subglacial sediments arranged in streamlined forms (drumlinoid or ribbed-type moraines); discontinuous subglacial sediments and streamlined bedrock stripped of overburden cover; or bedrock-drift complexes capped by thick or thin englacial (dead-ice) moraine and/or organic deposits.

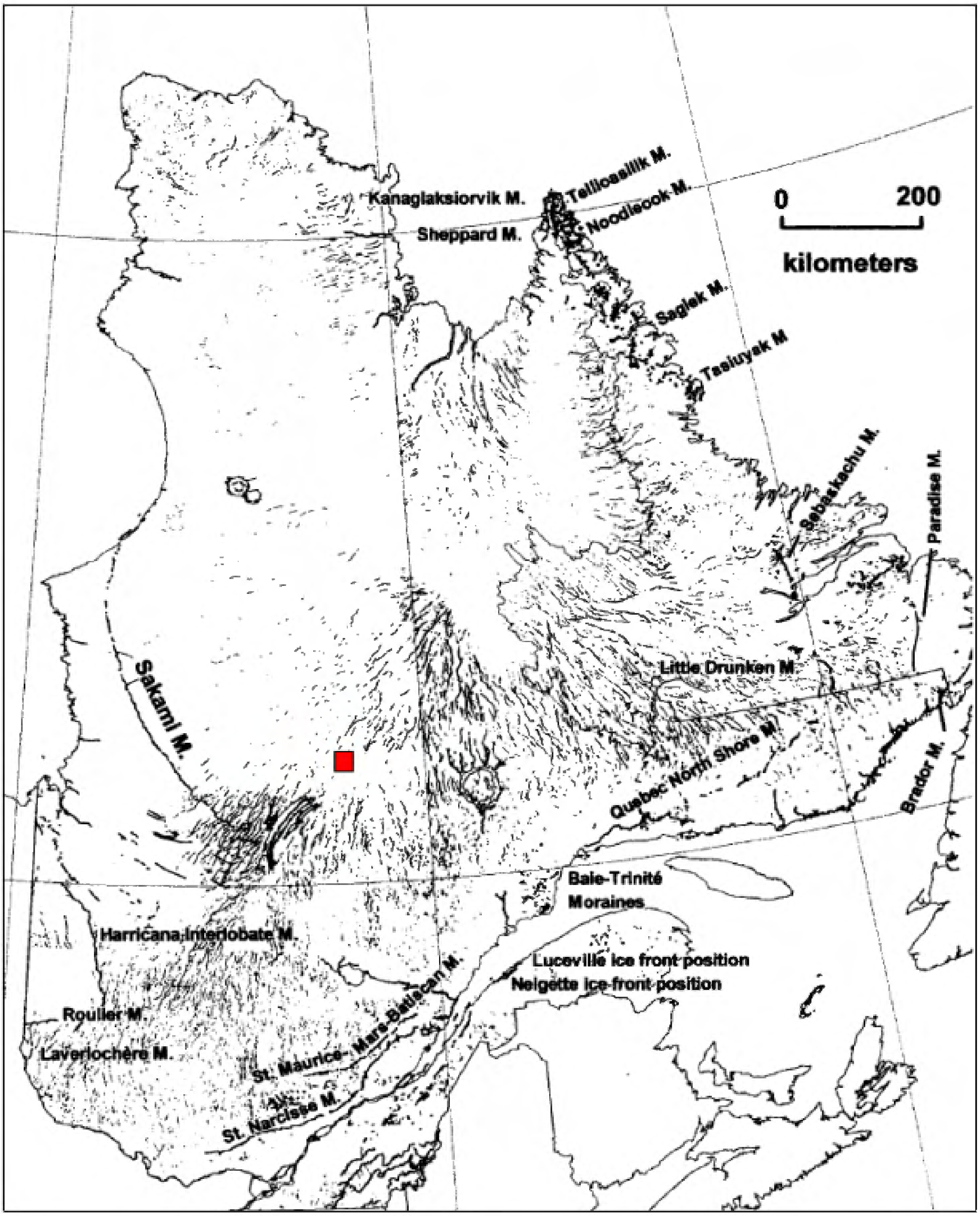

Figure 3. Location of Cameco's Otish property on a Québec-scale map of late Wisconsinan – early Holocene map of moraines and eskers (source: Occhietti et al., 2003)

In the Otish sedimentary basin area, the ice flow regime oscillated between erosional and depositional according to topographic setting, dominant bedrock lithology and structure. Well-developed landform-sediment associations, both subglacial or proglacial (drumlins; ribbed-moraine; eskers; kames or other such features) occupy broad low-lying areas and major structural depression while protruding outcrop ridges, hills and cuestas of resistant lithologies (sedimentary; metavolcanics) are generally stripped clean of glacial overburden and are faceted in the main direction of ice movement; are capped by a thin and discontinuous veneer of englacial material (ablation till and loose surface boulders dominantly of local origin) or littered with rubble or colluvium on slopes.

The Quaternary setting of the Otish South property is dominated by subglacial landform-sediment associations alternating between drumlinized moraine forms which are elongated in the direction of ice-flow, and fields of ribbed moraines (Rogen-type; Bouchard, 1989) whose individual ribs trend normal to ice-flow. The field of ribbed moraines occupy relatively narrow (0.9 to 2.0 km-wide) structural depressions which also run parallel ice flow. At deglaciation, these narrow structural depressions acted as melt water and sediment drainage paths both subglacial (eskers) and proglacial (fluvioglacial outwash and valley train sediments), as well as sites of accumulation of residual ice which upon melting produced hummocky or “dead-ice” moraine landscapes. The Otish Mountains winter access road which crosses the property west of the Otish South base camp is built on one of the eskers. A second, smaller esker occupies a large track of hummocky moraine immediately to the East of the base camp, while the at least 3 eskers (and related proglacial outwash) are preserved within a second large track of hummocky moraine along the Camie River valley. Scattered outcrop exposures and small surface accumulations of angular boulders occur within drift-dominated terrains where the drift cover is thinner. The latter, known as felsenmeer, are interpreted to be derived from the shattering of bedrock and localised entrainment of bedrock fragments at the bedrock-ice interface, most likely at the deglaciation, with further *in situ* fracturing and remobilisation of rock fragments through freeze-thaw action post deglaciation. Other surface accumulations of boulders, referred to as boulder fields, cover large tracks of ground and occur both in areas of thick drift and over outcrop-dominated terrain. Boulder fields are interpreted as late stage subglacial dispersal features. They can be wide and elongate to fan-shaped features, with widths of tens to hundreds of meters and lengths of up to over 3 km (a function of the geometry of the outcrop source or of shifting ice flow direction). Boulder trains, on the other hand, are by definition narrow and linear, owing to their provenance from a point or narrow bedrock source and to linear glacial dispersal. Boulder trains can be part of boulder fields, as is the case with the Monday radioactive boulder train.

Modern first order drainage lines such as Camie River and upper tributaries of the Témis, Takwa and Toco rivers together larger lakes such as Lac Hippocampe and Lac Leppin follow the dominant ice flow direction which is turn reflects regional structure. Second-order drainage lines and lesser-sized lakes tend to follow local topography, both in drift-dominated terrains (drumlins and ribbed moraines) and rock-dominated terrains. Tracks of organic deposits, small to large in size, are wide spread across the Otish South property occupying depressions between drumlinoid forms and ribbed moraines.

Two large tracks of sedimentary bedrock form highlands within the property, both located immediately to the East and West of Camie River, while two large east-trending metavolcanic ridges run along the southern limit of the Property, just outside property limits. Such bedrock-dominated areas are locally capped by bedrock rubble, thin ablation material and bedrock colluviums on steep slopes.

6.1 Ice flow directions

Glacial flow across the Otish sedimentary basin is well preserved and documented in the patterns of depositional features (drumlinoid ridges; ribbed moraines and eskers) and in the erosional record on bedrock (striae; grooves; crescentic fractures; rat-tail features and whale-back forms) (Bernier, 2004; 2005). In general, the Laurentide ice sheet flowed towards the South-Southwest across the Otish sedimentary basin following the trend of the Grenville Orogenic Front which also parallels the longitudinal axis of the Otish basin.

At the Otish South property, the longitudinal axis of drumlinoid ridges and bedrock streamlined bedrock forms record a dominant ice-flow direction at 205°-210° (Figure 4). This dominant ice flow direction is also recorded in the axis of the Monday uranium-bearing boulder which runs at 206° which is consistent with previous measurements of 204° (Murphy, 1980). Ground measurements of striae, grooves and other erosional features on bedrock give similar measurements (Plates 1 and 2).

Variations in ice flow directions of up to 10° are noted on the ground and across the Property. Such deflections record local topographic influence on ice movement, principally at the time of deglaciation when the ice was thinner.

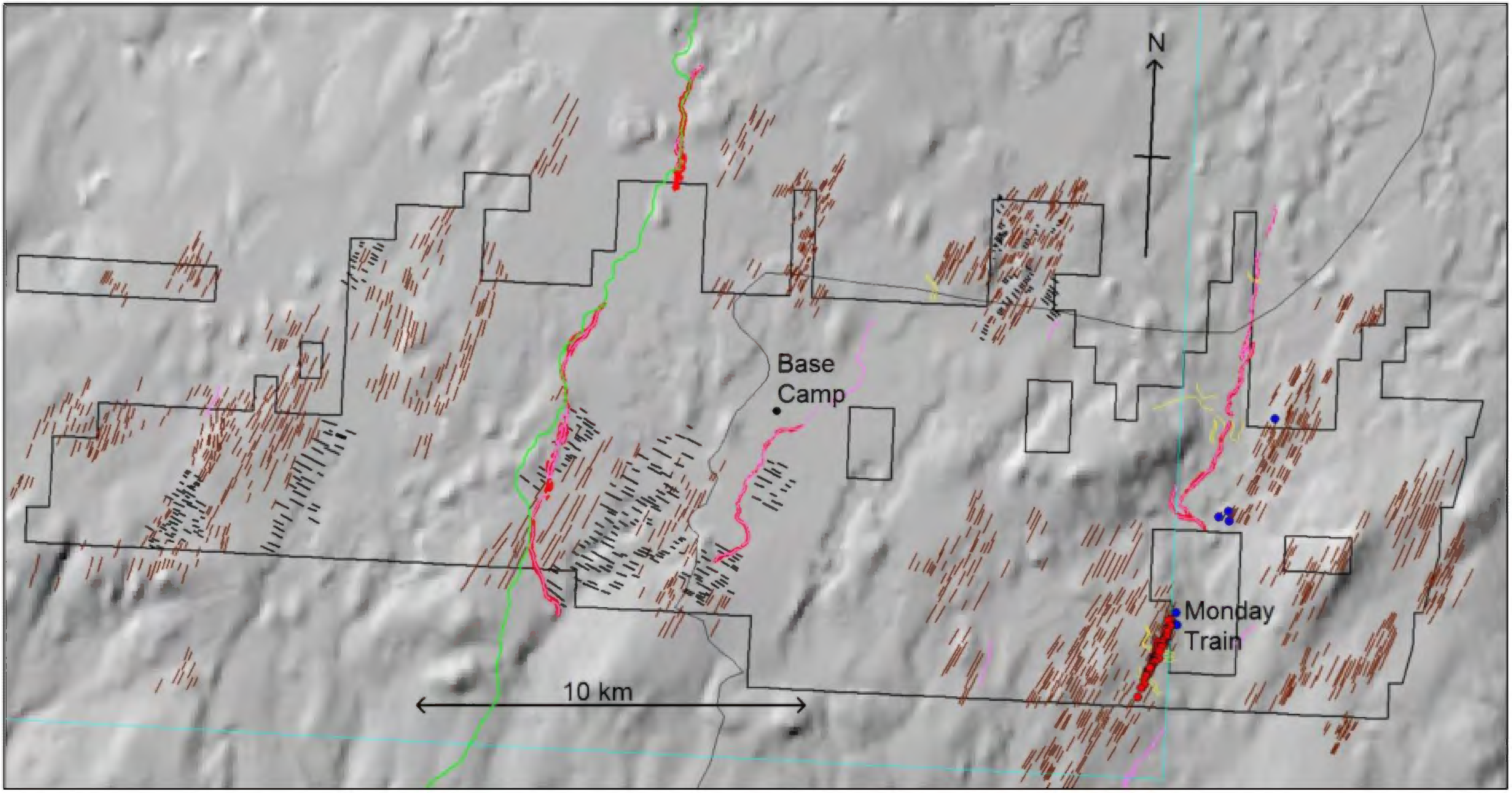

Figure 4. Map of ice flow indicators, Otish South property. The dominant ice-flow direction is at 205°-210°. *Brown lines are drumlinoid feature axes; short black lines are ribbed moraine axes; pink lines and red polygons are eskers. The Otish winter access road is shown in green. Red points are radioactive boulders forming the Monday erratic train. Blue points are radioactive boulders surveyed as part of the CÉAQ Quaternary reconnaissance. Base: Grey-shaded digital elevation model (source: MDDEP-Québec, 2004).*

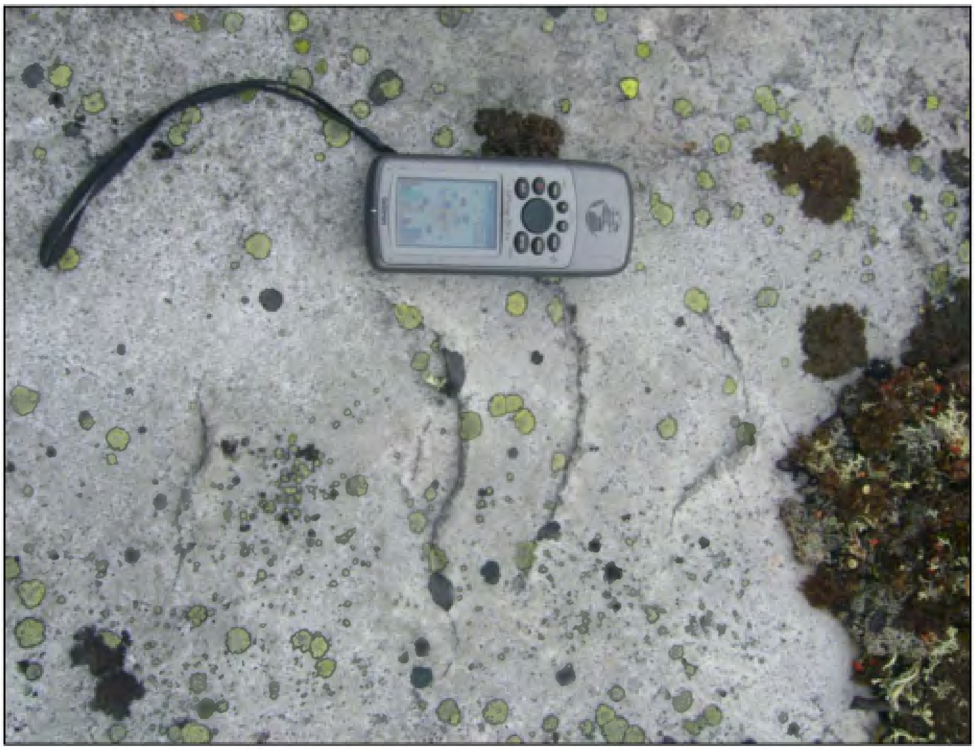

Plate 1. Glacial chatter marks recorded on coarse-grained sandstone within Camie River valley.

Plate 2. Glacial striae at 210°(towards pencil tip) on the tail end of a streamlined sandstone outcrop at Gordon's Lake. The gently incurved rock face below the GPS unit represents a plucking surface.

7. Monday boulder train survey: Key Observations

A total of 49 radioactive boulders where surveyed by the CÉAQ as part of the Quaternary reconnaissance of the Monday boulder train and boulder train area. Of the 49 boulders surveyed, four (4) (MBT-067 to 070) were found over similar subglacial drift-dominated terrain located along the up-ice projection path of the train, between 3 km and 5.7 km from its head.

The Monday boulder train itself comprises of 64 radioactive boulders surveyed by Cameco ahead of the Quaternary reconnaissance (MBT-001 to 064), plus two (2) new radioactive boulders discovered while traversing the axis of the train (MBT-065 and MBT-066). Collectively, these radioactive boulders define a narrow, less than 150 m-wide on average, linear glacial dispersal train some 2.5 km in length starting from boulder MBT-066 (UTM WGS-84 Z19 0293224E/5741821N) and ending at boulder MB-061 (UTM WGS-84 Z18 0706209E/5739562N) (Figures 4, 5, 6). Murphy (1980) reported over 200 radioactive boulders over a total dispersal train length of 1.4 km and train width of 50 m.

The axis of the Monday boulder train trends at 206°. This direction is consistent with other ice-flow indicator measurements in the area (striae, grooves, whaleback forms and axes of drumlinoid features) and with Murphy's (1980) previous measurement of 204°. The radioactive boulder train is widest at its head (240 m; Figures 5, 6) and progressively decreases in width down-ice, most likely as a function of dilution away from its source.

The Monday radioactive boulder train occurs within a broader, minimum 500 m-wide field of extremely coarse (0.5 to over 2 m) clast-supported, subangular to angular sandstones and granulestones boulders with very little or no interstitial matrix (Plates 3, 4).

Plate 3. Westerly view of the sandstone-granulestone boulder field hosting the Monday uranium-bearing boulder train. A dry glacial melt water channel (center of the picture) flows across the field and the Monday boulder train from the top right (northwest) to the bottom left (east) of the

photograph. The axis of the boulder train runs diagonally across the photograph from the upper left to the lower right. The photographs covers boulders MBT-038 to 049 (September 12, 2011).

Plate 4. Extremely coarse, clast-supported surface boulder deposit characteristic of the Monday Uranium-bearing boulder train. Site MBT-004 (September 12, 2011).

The radioactive boulder train and encompassing boulder field lie at the eastern margin of a large track of relatively low-relief subglacial drift comprising of what is interpreted to be thick to thin till shaped into drumlins with occasional intervening exposures of organic terrain and streamlined outcrop. This subglacial drift-dominated landscape forms a gently south-sloping plateau which extends over an East-West distance of about 8 km, from Camie River in the East to a large field of ribbed moraine in the West. The till-dominated plateau transitions into bedrock-drift complex, streamlined sedimentary bedrock and massive sedimentary bedrock to the North. To the southwest, it is partly bounded by a large east-trending metavolcanic ridge which lies just below the southern Property limit.

Attempts to manually expose the near-surface glacial overburden stratigraphy along the axis of the Monday boulder train failed to break through the coarse surface boulder layer. Evidence of thick subglacial drift stratigraphy below the Monday radioactive boulder train is provided by limited historical vertical drill hole information by Uranerz Exploration and Mining Ltd. (holes OM-37 and 39) which intersected over 24 m of glacial overburden. Murphy's (1980) comment that, despite the clast-supported fabric and relative homogeneity of boulder composition (coarse sandstone to granulestone), the absence of an interstitial matrix and the angularity of the surface boulder layer, the Monday boulder is not a felsenmeer supports the model of a thick subglacial overburden stratigraphy below the boulder train and encompassing boulder field. The presence of subrounded dark brown boulders of mafic lithologies, possibly basement-derived (massive mafic metalvolcanics or gabbro; Plate 5) indicative of a more distal provenance than the dominant sandstones and granulestones, also supports the interpretation that the radioactive boulder train and host boulder field are not held in felsenmeer. No other basement lithologies were noted during the traversing of the axis of the boulder train.

Plate 5. Subrounded, 0.7 m-long boulder of basement lithology (metavolcanic or gabbro) at site MBT-001 (Backpack at top of the picture for scale)

Boulders within the Monday train and encompassing boulder field are covered by at least two species of acidophilous crustose lichens, yellow-green Rhizocarpon geographicum and gray Porpidia along with a black foliose lichen, an Umbilicaria (Source: J. Gagnon, Québec MDDEP; personal communication, 2011).

Radioactivity measurements on the Monday train boulders range from a high of 27,700 CPS (MBT-001) to a lower pre-selected threshold value of 450 CPS and average 5,300 CPS while background is less than 100 CPS. The radioactivity appears to be associated with narrow fractures and peripheral alteration zones within the coarse sandstone-granulestone boulders. The alteration zones on either sides of the fractures show limonite and/or hematite alteration and rarely, such as is the case with boulder MBT-001, disseminated yellow uranium oxide products.

The Monday radioactive boulder train begins in the up-ice direction at a marked change in Quaternary setting, whereby the subglacial-drift dominated terrain hosting the train and encompassing boulder field are abruptly truncated by Camie River and gives way to hummocky moraine, eskers, bare bedrock and fluvioglacial outwash within the river valley. This is an important feature of the Monday boulder train to consider when assessing provenance as the northern part of the train, host boulder field and underlying thick subglacial drift stratigraphy are interpreted to have been eroded away during deglaciation. In fact, the Camie River valley and related esker, dead-ice and proglacial sediments occupy 2.7 km of terrain immediately up-ice of the head of the Monday train, almost the equivalent of the total length of the train (2.5 km).

The sequence of glacial events leading to the current distribution of landform-sediment associations found in the vicinity of the Monday radioactive boulder train can be conceptualized as follows:

1. Major ice advance @ 205°-210° across the eastern Otish Mountains resulting in significant glacial abrasion and plucking of paleo-Proterozoic bedrock, subglacial and englacial transport of erosional products and localised deposition of sub-glacial drift. Drumlinoid and Rogen moraines are the principal landform sediment association generated throughout this period. Boulder fields (trains or fans) are continuously generated from the shattering and basal entrainment of subcropping sandstone/granulestone hills and ridges but these are continuously winnowed down and transformed or incorporated into subglacial till by the basal entrainment process. The Camie river valley (including its west flank, host to the Monday radioactive boulder train) is filled with thick subglacial drift.
2. Topographic influence on ice flow becomes apparent during deglaciation as ice thickness and strength start to decrease resulting in localised shift of 5-10° in ice flow direction. The content of basal debris which acts as an abrasive and as a source of fines for subglacial drift also decreases. Ice flowing into Camie River is still powerfull enough to erode a still-preserved protruding sandstone-granulestone ridge. Large angular meter-sized boulders, some of which are radioactive, are entrained and then are deposited onto the basal drift cover over a down-ice distance of +3 km.
3. Ice still flows but is no longer powerful enough to continue the entrainment process and winnow down the boulder field (and Monday boulder train) leaving the angular boulders intact at the basal ice-drift interface, with little or no interstitial matrix. Localised ice-flow within Camie River valley erodes part of the subglacial drift cover causing partial obliteration of the head of the boulder field (and of the Monday radioactive boulder train). Eskers form at the bedrock-ice interface to channel mounting volumes of melt water and to evacuate basal ice debris. A dendritic esker system is formed within Camie River valley. This esker system further degrades the subglacial drift cover that was present in Camie River, including the boulder field. Ice-contact stratified drift in the form of kames accumulated along valley walls adjacent to the esker system.
4. Ice no longer flows within the Camie River area leaving blocks of residual or "dead" ice containing englacial and supraglacial debris in the valley which when melted leave behind tracks of hummocky moraine. Valley walls and upland areas become clear of ice. Melt waters from residual ice on the upland west of Camie River cut east to southeast-trending channels across the boulder field and Monday boulder train flushing-out fines. Proglacial meltwaters emanating from an ice front in the Otish Mountains to the North are channelled within the Camie River valley and degrade both the esker system, mounds of hummocky moraine and any remaining subglacial drift and leave large patches of exposed sandstone-granulestone bedrock. Sand and gravel carried by the proglacial waters fill surface

depressions around outcrop and mounds of hummocky moraine. Proglacial waters settled down to produce the current drainage pattern of Camie River.

On the basis of the hypothesis that the Monday radioactive boulder train is truncated in its head area, limited radiometric prospecting was undertaken up-ice of boulder MBT-066 over a one and one-half day period (September 14 and 15; Figure 5). The up-ice prospecting was conducted in search of possible extensions to the train and/or its "true" head: at 2.0 km, over a small highland area located within Camie River valley (Target area 1); and at 2.7 km and 5.7 km respectively, over similar streamlined subglacial drift terrain (Target areas 2 and 3). Target area 1 contained no subglacial drift or surface boulder field of the Monday-type; Target area 3 displayed an extensive subglacial drift cover but no Monday-type coarse surface boulder field and only one small weakly radioactive boulder was found (MBT-067: 200 CPS using the SPP2 scintillometer); Target area 2 displayed both subglacial drift and streamlined outcrops but no Monday-type coarse surface boulder field. Three (3) widely-spaced (+300 m), weakly radioactive (200-350 CPS using the SPP2 scintillometer) semi-angular sandstone-granulestone boulders were however noted (MBT 068-070).

The fact that no obvious extensions of the boulder field hosting the Monday radioactive boulder train were encountered while prospecting similar subglacial-drift dominated terrain up-ice from the "truncated" head of the train suggests that the provenance of the boulders lies within the confines of Camie River valley (and the Camie River Uranium property), between 0.1 to 2.7 km to the northeast of boulder MBT-066. Murphy (1980) on the basis of till thickness and boulder size and roundness, estimated the primary source of the Monday boulder train to lie between 500 to 1,000 meters up-ice from the first occurrence of radioactive erratics. His model, however did not factor in the possible truncation of the head of the train by the Camie River valley, so that a longer provenance distance, up to 2.7 km from the first observed radioactive boulder is possible.

Other evidence, namely boulder size and boulder density suggest a "closer" rather than "further" provenance distance within Camie River valley. Near the head of the Monday train, the boulder field is marked by a high-density of extremely large (+ 2 m-sized) angular to subangular sandstone-granulestone boulders distributed over the surface in almost clast-supported manner indicative of a proximal source possibly within the first 500 m up-ice from boulder MBT-066 (Plates 6, 7).

It is proposed that the source of the Monday radioactive boulder train was a once prominant sandstone-granulestone ridge located on the West side of Camie River valley. This ridge was completely dismantled; its fragments entrained by basal ice (most likely during the later stages of glaciation to account for its surface occurrence over thick subglacial drift), and then mechanically dispersed down-ice over a total minimum distance of 2.5 km. This ridge contained one or more fracture-hosted or fracture-related uranium-bearing zones, most likely of the Gordon's lake type. Any possible remnants of this ridge lie beneath the boulder field underneath to immediately up-ice of boulder MBT-066 or are buried below hummocky moraine, eskers and related fluvioglacial sediments, or by water and organic deposits held with Camie River Valley.

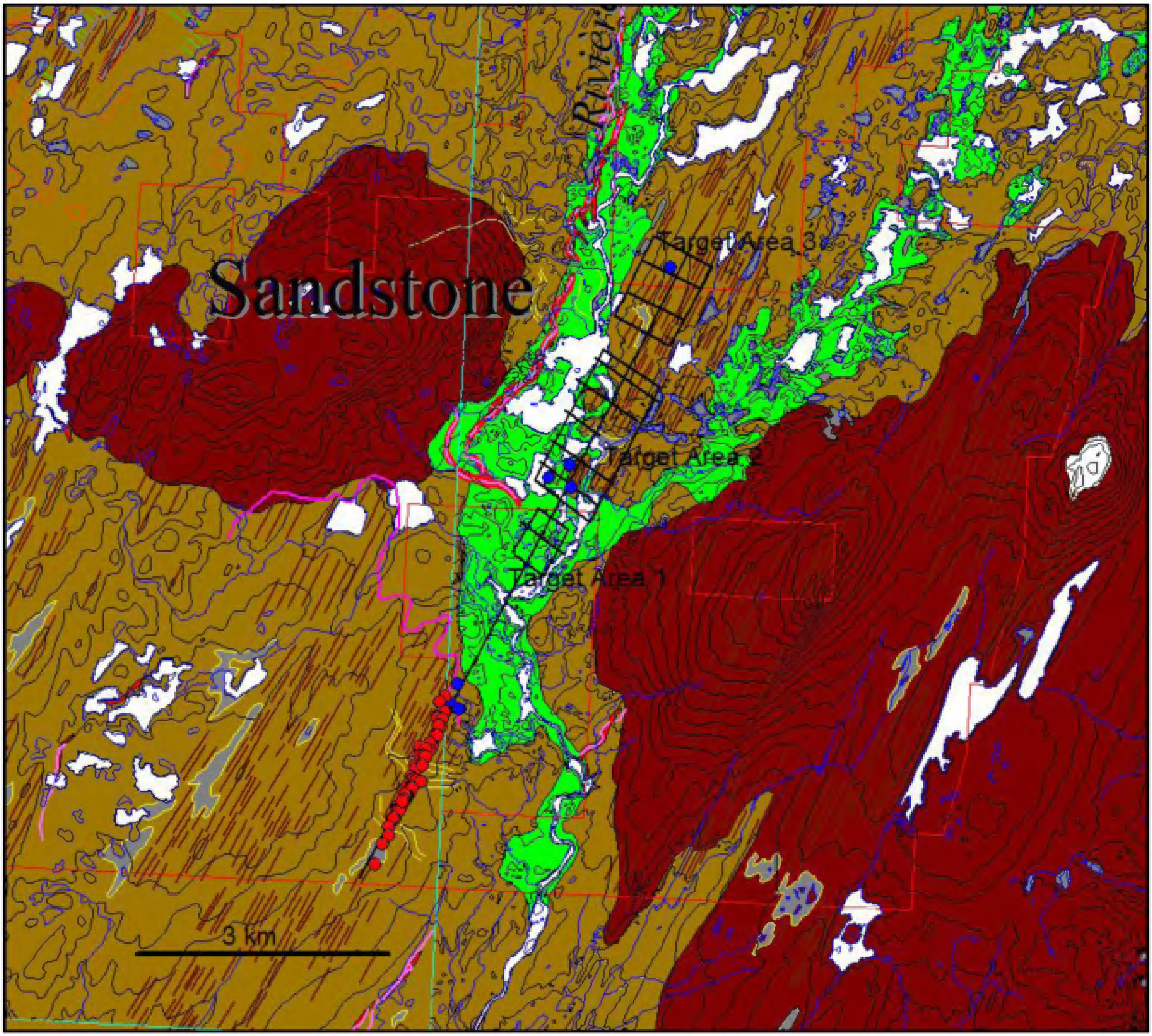

Figure 5. Location of the 3 target areas prospected up-ice of the truncated head of the Monday radioactive boulder train. Radioactive boulders located in UTM Zone 18 (WGS 84) are coloured red while those in UTM Zone 19 (WGS 84) are coloured blue. Camie River valley is host to eskers (red) and hummocky moraine (green) and lies in-between two large bedrock-supported uplands (dark red). The Monday radioactive boulder train occurs in streamlined sub-glacial drift dominated terrain (brown). Red lines mark the axes of streamlined forms.

The size distribution of the Monday radioactive boulders, decreasing from 1.5-2.5 m near the head down to 0.2 m at the tail of the train (Figure 6), also supports the interpretation of a close provenance.

Plates 6 and 7. Clast-supported arrangement of +2 m-sized sub-angular to angular sandstone-granulestone boulders characteristic of the head of the boulder field hosting the Monday radioactive train.

All data considered, the real significance and exploration potential of the Monday radioactive boulder train lies not its actual subcropping source but rather in the style of mineralisation recorded by the boulders which is indicative of surface uranium seepage from deep-seated fracture zones located in Camie river valley. The Camie River is marked by two prominent southeast-trending lineaments mapped from satellite imagery and interpreted to be fracture zones. These fractures, which may part of the group of north-northwest fractures distributed uniformly across the Otish sedimentary basin (Madon, 1983), along with other possible fracture zones located in Camie River valley should be targeted in future exploration programs.

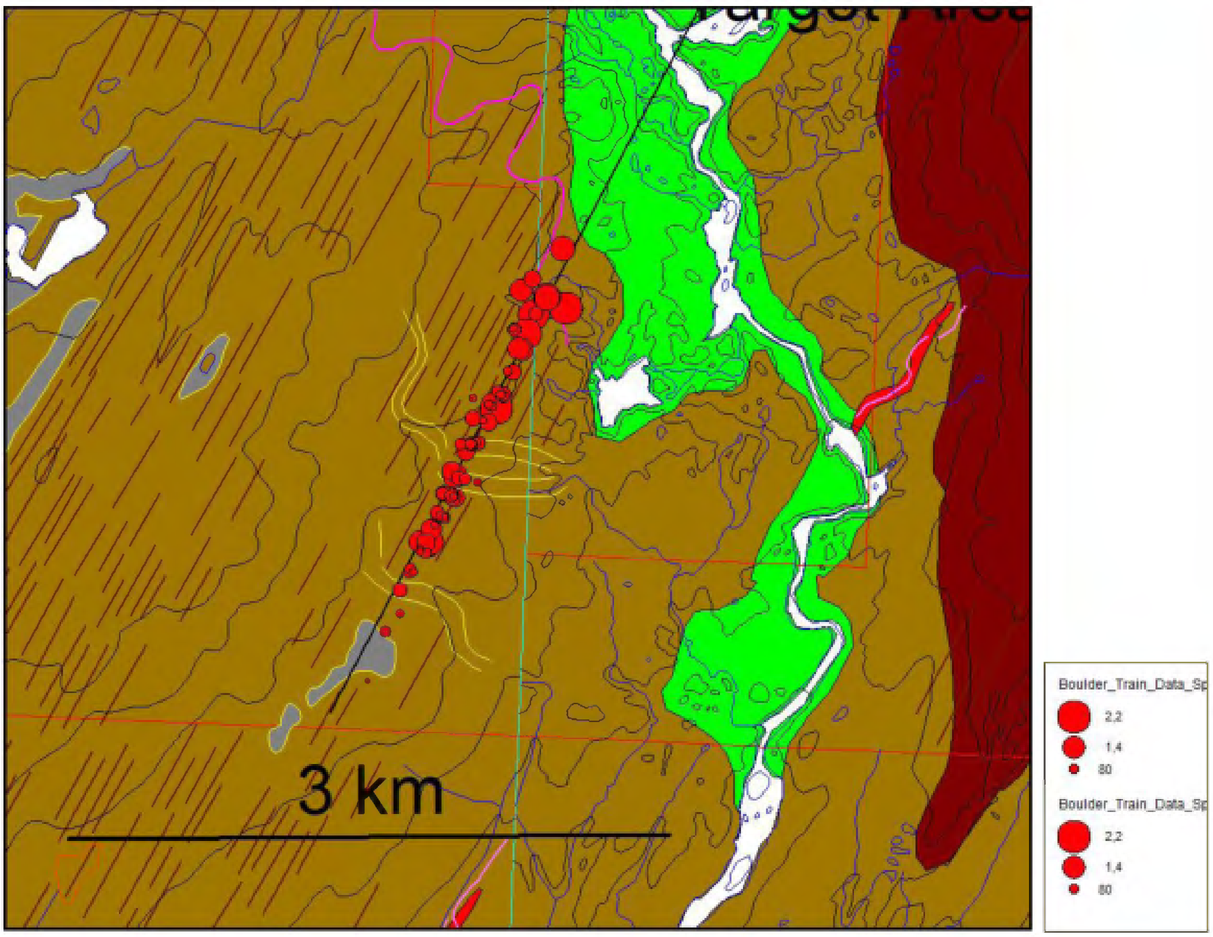

Figure 6. Proportional circle plot of the length of the long axis of radioactive boulders forming the Monday boulder train.

8. Conclusions, discussion and recommendations

The Monday radioactive boulder train comprises of 64 uranium-bearing boulders (MBT-001 to 064) surveyed by Cameco during the summer 2011 field season, in preparation for a Quaternary reconnaissance by the CÉAQ, plus two new radioactive boulders discovered while traversing the axis of the train (MBT-065 and MBT-066). Collectively, these boulders define a narrow, less than 150 m-wide, linear glacial dispersal train some 2.5 km in length starting from boulder MBT-066 (UTM WGS-84 Z19 0293224E/5741821N) and ending at boulder MB-061 (UTM WGS-84 Z18 0706209E/5739562N). The axis of the Monday boulder train trends at 206°. This direction is consistent with other ice-flow indicator measurements in the area (striae, grooves, whaleback forms and axes of drumlinoid features) and with previous measurements of 204° by Murphy (1980). The radioactive boulder train is widest at its head (240 m; Figure 1), averages 150 m, and progressively decreases in width down-ice, most likely as a function of physical dilution away from bedrock source.

Radioactivity measurements on the Monday train boulders range from a high of 27,700 CPS (MBT-001) to a lower pre-selected threshold value of 450 CPS and average 5,300 CPS, while background is less than 100 CPS. The radioactivity appears to be associated with narrow fractures and peripheral alteration zones within the coarse sandstone-granulestone boulders. The alteration zones bordering the fractures show limonite and/or hematite alteration and rarely, such as is the case with boulder MBT-001, disseminated yellow uranium oxide products.

The Monday radioactive boulder train is part of a larger field of coarse, clast-supported sandstone-granulestone boulders. This field of boulders appears to lie over thick subglacial drift and it is interpreted to be a late subglacial dispersal feature rather than washed ablation till as proposed by Murphy (1980). An important feature of the Monday radioactive boulder train is its apparent truncation at its head area by Camie River valley, which complicates any attempt to estimate provenance distance to source. Limited prospecting undertaken on similar streamlined subglacial drift-dominated terrain up-ice of boulder MBT-066 at 2.0, 2.7 and 5.7 km distance, despite leading to the discovery of four (4) new radioactive boulders, failed to identify an extension to the coarse boulder field and Monday radioactive boulder train. The source of the Monday train is interpreted to lie within Camie River valley (and within the Camie River Uranium property) between 0.1 to 2.7 km to the northeast of boulder MBT-066. Other evidence from the Monday radioactive boulder train, namely boulder size and boulder density suggest a "closer" rather than "distal" provenance in Camie River valley, within the 500 m to 1 km range proposed by Murphy (1980). The head of the Monday train is marked by a high-density of extremely large (+ 2 m) angular to subangular sandstone-granulestone boulders distributed over the surface in almost clast-supported fabric indicative of a proximal source possibly within the first 500 m up-ice from boulder MBT-066.

The narrow width of Monday boulder train (less than 150 m) suggests a narrow to point-source subcropping up-ice source. The CÉAQ, however, finds no evidence to support Murphy's additional suggestion that the subcropping mineralisation "must have been a small cliff on its southwest side to have allowed glacial plucking enabling the large uraniferous erratic to form". Rather, the source of the radioactive boulders is postulated to be one or more narrow fracture zones within a prominent sandstone-granulestone ridge once located within Camie River valley which was shattered and then entrained by basal ice during the later stages of glaciation. These fractures zones would have been exposed to the ice within a single, maximum 150 m-wide subcropping area, corresponding to the width of the train. The overall coarseness of the boulders, up to over 5 m at the head of the Monday radioactive boulder train, is rather a function of the proximity and competency of the sandstone-granulestone bedrock ridge which was subjected to glacial fracturing, plucking and ice transport.

Ultimately, the uranium exploration potential of the Monday boulder train area may lie not in the character and exact provenance of the radioactive boulders but rather in the style of mineralisation recorded by the boulders which is indicative of uranium-bearing fracture zones located within Camie river valley, the closest analogy being the historical Gordon's Lake fracture-hosted sandstone uranium occurrence. The Camie River valley is marked by two prominent southeast-trending lineaments mapped from satellite imagery and interpreted to be brittle fracture zones.

These two fractures, which may be part of the group of north-northwest fractures distributed uniformly across the Otish sedimentary basin (Madon, 1983), along with other possible fracture zones located in Camie River valley should be targeted in future exploration programs. Assuming the source radioactive fracture zones are vertical to sub-vertical, a first pass exploration program could comprise of a series of angled 300 m-length core drill holes oriented at 300° and spaced 100 m apart over a total of 500 m starting from Boulder MBT-066. Once the source is located, the next phase of the exploration program should be directed at (a) investigating the uranium distribution and grade down and along structure up to and below the contact with the basal unconformity in search for economic-grade uranium mineralisation; and (b) at broadening the search area to locate additional buried uranium prospects. Structural mapping from remotely sensed imagery and airborne magnetics may also help identify prospective fracture zones.

Geochemical or mineralogical sampling of hummocky moraine material preserved in Camie River valley is not recommended as provenance of any uranium anomalies generated will be difficult to establish. Alternatively, an electret ionization chamber (EIC) radon survey over hummocky terrain may be useful in outlining uraniferous bedrock sources for the Monday boulder train.

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M.A. Bernier, M.Sc., P.Geo. (OGQ No. 329)
Chibougamau, March 12, 2012

10. APPENDIX 1 : Monday boulder train photographs


Boulder MBT-001a


Boulder MBT-001b


Boulder MBT-002


Boulder MBT-003

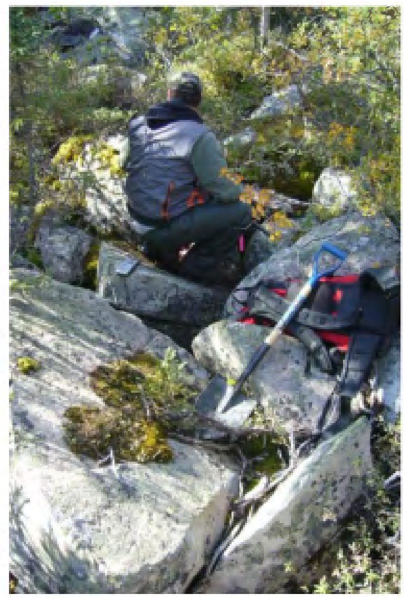

Boulder MBT-004


Boulder MBT-005

Boulder MBT-006

Boulder MBT-007a

Boulder MBT-007b



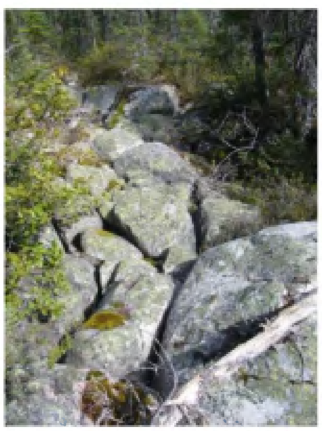
Boulder MBT-008

Boulder MBT-009a

Boulder MBT-009b

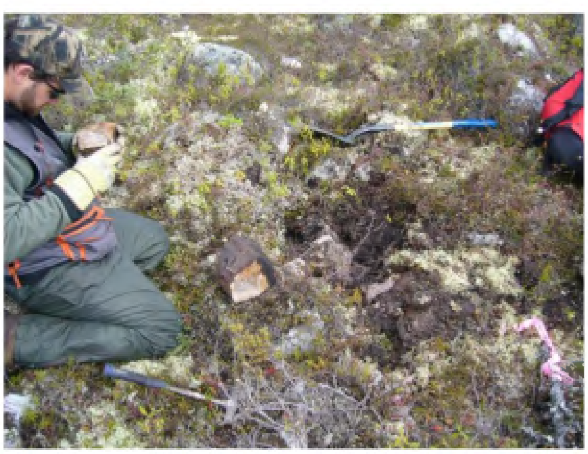
Boulder MBT-010

Boulder MBT-011a



Boulder MBT-011b

Boulder MBT-012a



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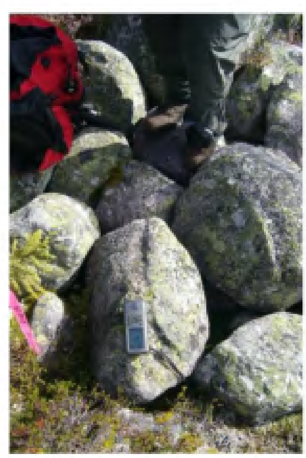


Boulder MBT-013

Boulder MBT-014

Boulder MBT-015

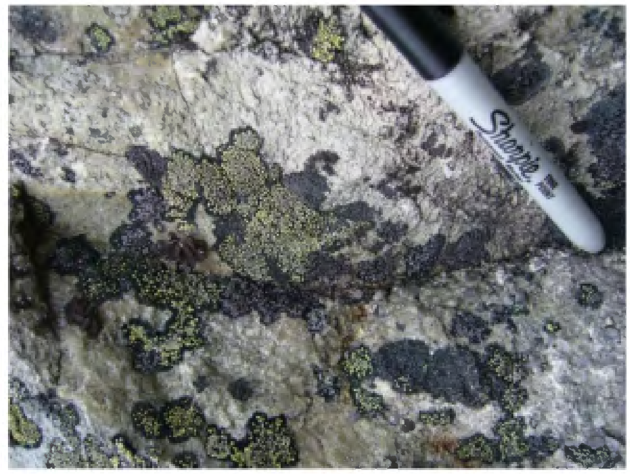
Boulder MBT-016

Boulder MBT-017

Boulder MBT-018a

Boulder MBT-018b

Boulder MBT-019a



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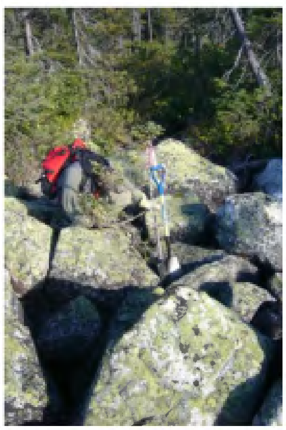

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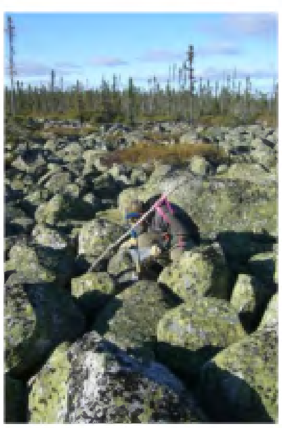
Boulder MBT-038b



Boulder MBT-039

Boulder MBT-040

Boulder MBT-041a

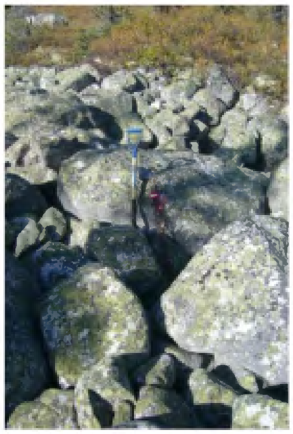
Boulder MBT-041b

Boulder MBT-042a

Boulder MBT-042b

Boulder MBT-043

Boulder MBT-044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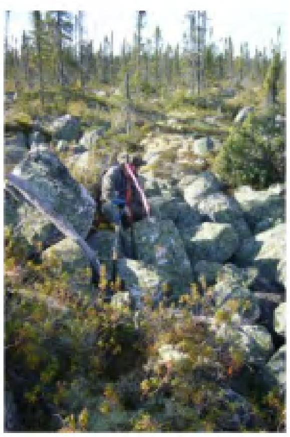
Boulder MBT-046


Boulder MBT-047


Boulder MBT-048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Boulder MBT-052


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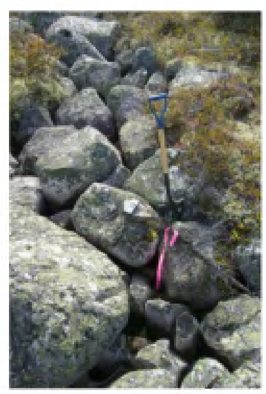
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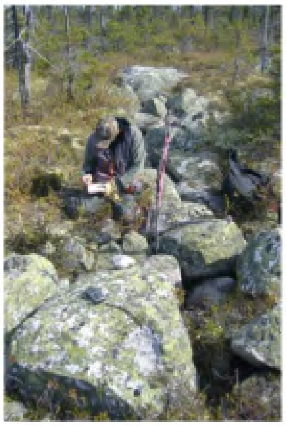
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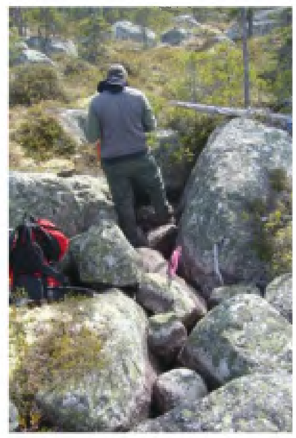
Boulder MBT-058a


Boulder MBT-058b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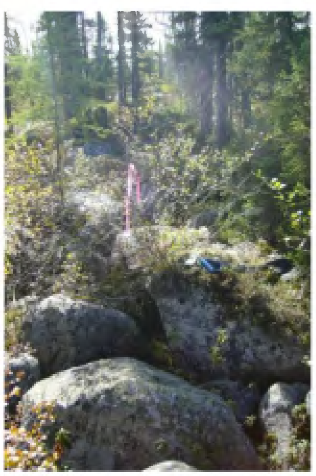
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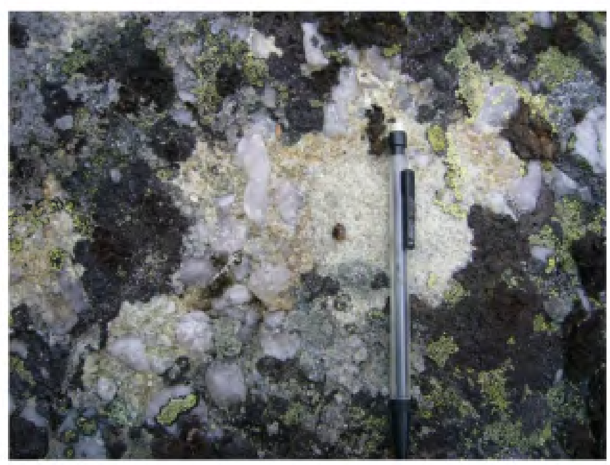
Boulder MBT-064a

Boulder MBT-064b

Boulder MBT-065

Boulder MBT-066a

Boulder MBT-066b

Boulder MBT-067

Boulder MBT-068


Boulder MBT-069


Boulder MBT-070