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SURFICIAL GEOLOGICAL SURVEY FOR ASSESSING MINERAL RESOURCE POTENTIAL, GREAT NORTHERN PENINSULA: PRELIMINARY RESULTS

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ABSTRACT

A multi-year surficial-mapping and till-sampling program was initiated on the Great Northern Peninsula in the 2018 field season, with the objectives of completing detailed (1:50 000) surficial mapping, reconstructing glacial flow and detecting geochemical anomalies associated with known and unknown mineralization. The map areas are NTS 2M/12 (Raleigh), 2M/11 (Quirpon), 2M/05 and 2M/06 (St. Anthony) and 2M/04 (St. Julien's). The study area has a complex bedrock geology owing to multiple regional deformation events, hosts numerous Zn (± Pb), Au, Cu and Ag occurrences, and was successively overridden by both the Laurentide Ice Sheet (LIS) and the Newfoundland Ice Cap (NIC), resulting in a complex regional glacial flow. Ice-flow mapping, in conjunction with previous work, has resulted in a better understanding of the regional ice flow.

Three distinct ice-flow movements have been identified in the study area: an early, east-southeastward movement, a subsequent east-northeastward movement and the final phase of north-northeastward movement. Preliminary surficial mapping identified marine diamicton, glaciofluvial sand and gravel, colluvial blankets and cones, and beach ridges. Frost polygon features in bedrock and poorly developed mudboil features in till were also documented, which reflect the subarctic climatic conditions of the study area.

INTRODUCTION

A regional surficial-mapping (1:50 000 scale) and till-sampling program was initiated on the Great Northern Peninsula (GNP) during the summer of 2018. This region has a complex bedrock geology and is host to numerous occurrences of base and precious metals, including Zn (± Pb), Cu, Au and Ag. Recent years have seen an increase in exploration activity in this region (Altius Minerals Corporation, 2018; Newfound Gold Corp., 2018; White Metal Resources, 2018a, b), therefore, there is a need to assess the regional surficial geochemistry to detect dispersion patterns from areas of known and unknown mineralization.

The surficial geology of the GNP has been mapped at reconnaissance level by Grant (1986, 1989, 1992), and more recently, Putt *et al.* (2010) did a study of the regional ice flow. However, no detailed surficial geology mapping (1:50 000 scale) of the GNP has ever been completed. Previous regional geochemical sampling includes a regional lake-sediment sampling survey (Davenport *et al.*, 1994) and Ricketts and Vatcher (1996) completed an aggregate assessment report for the St. Julien's map area.

OBJECTIVES

Fieldwork objectives for 2018 were: 1) map the surficial geology of the study area; 2) identify the ice-flow directions; 3) reconstruct the glacial and postglacial history; and 4) characterize the regional background till geochemistry and, identify any geochemical and mineralogical anomalies associated with known and/or unknown mineral occurrences.

Fieldwork targeted the Raleigh (NTS 2M/12), Quirpon (NTS 2M/11), St. Anthony (NTS 2M/05 and 2M/06), and St. Julien's (NTS 2M/04) map areas (Figure 1), which have seen a recent increase in exploration (Newfound Gold Corp., 2018 and White Metal Resources, 2018a, b). Work was also carried out on the St. Julien's map area to take advantage of trenches dug on Newfound Gold Corp. and Altius Minerals Corporation's Sail Pond property exposing basal till and mineralization. The property hosts a sediment-hosted Ag–Cu–Pb–Zn–Sb deposit, with grab samples containing up to 2030 g/t Ag and 7.08% Cu (Altius Minerals Corporation, 2018; Newfound Gold Corp., 2018).

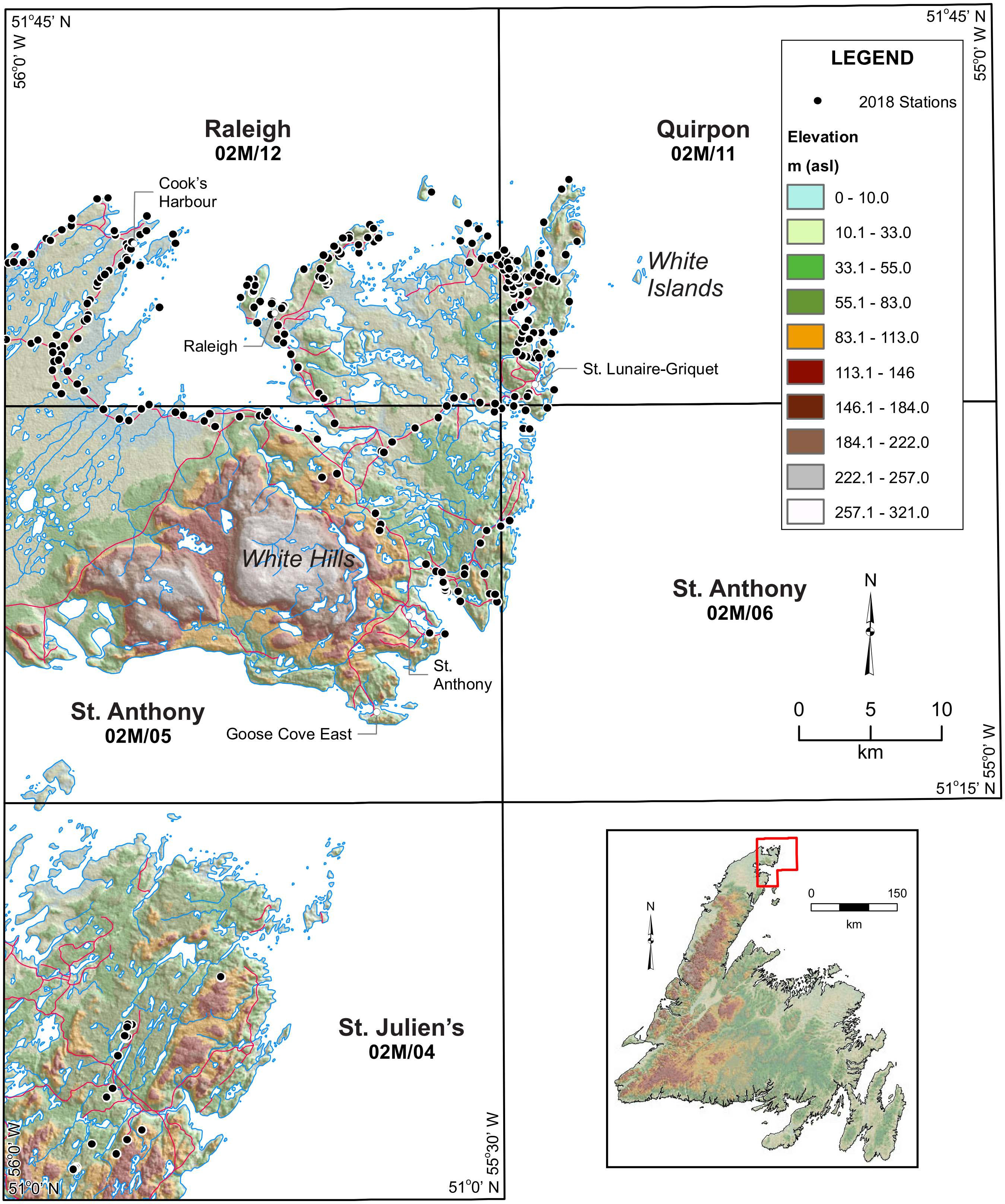

Figure 1. *Location of study area and 2018 stations.*

LOCATION, ACCESS AND PHYSIOGRAPHY

This study area is located on the northern tip of the GNP. The focus of fieldwork in 2018 was the NTS 1:50 000-scale map areas of Raleigh (2M/12), Quirpon (2M/11) and St. Anthony (2M/05 and 2M/06), as well as limited work in the St. Julien's area (NTS 2M/04). The Raleigh, St. Anthony and Quirpon map areas are located between latitudes 51°45′N and 51°30′N and longitudes 56°30′W and 55°00′W, and the St. Julien's map area is located between latitudes 51°15′N and 51°00′N and longitudes 56°00′W and 55°30′W (Figure 1). Most of the study area is easily accessible from regional Highway 430, which connects to the Trans-Canada Highway and to routes 432, 433, 435, 436 and 437.

The highest elevation is at 321 m asl (above sea level), in the southern part of the St. Anthony map area, in the coastal uplands (the White Hills). The average elevation in the study area is approximately 16 m asl.

Relief is low, with areas of higher elevation dominated by exposed bedrock (having variable moss cover) and those of lower elevation dominated by organics (bog). Moss, stunted pine and fir trees in the Quirpon, Raleigh and St. Anthony map areas dominate vegetation. The climate is near arctic (Hare, 1952) and the region is classified as "forest-tundra", a transitional zone characterized by moss, shrub, stunted spruce and tamarack (Grant, 1992); boreal conditions near the base of the White Hills mark by the presence of spruce and fir. The St. Julien's map area is characterized by undulating topography, with peat and bog in topographic lows, a variable glacial sediment cover and thick vegetation (balsam fir, black spruce and cedar trees) in topographic highs.

BEDROCK GEOLOGY

The bedrock geology has been summarized by Stouge and Godfrey (1982), Knight and Edwards (1986a, b), Colman-Sadd *et al.* (1990), Waldron and Stockmal (1994) and King and Conliffe (2017). The study area is situated within the Humber tectonostratigraphic zone and consists of allochthonous sedimentary and volcanic rocks, and authochthonous platform sedimentary rocks, all underlain by Grenvillian (*ca.* 1 Ga) basement (Waldron and Stockmal, 1994). The oldest sedimentary rocks are authochthonous Neoproterozoic to Middle Cambrian Labrador Group (which includes quartz arenite, calcareous sandstone, shale and limestone as mapped on the White Islands (NTS 2M/11)) (Figure 2), Middle Cambrian to Early Ordovician Port au Port Group (consisting of muddy carbonates, silty mudstone, stromatolites and dolomites), and Early to Middle Ordovician St. George Group (consisting of dolomitic bioturbated, grey and black limestone, shale, chert and dolostone–pebble conglomerate).

The Middle Ordovician Taconic orogeny marked the transition from passive margin sedimentation to a marine foreland basin. This resulted in the deposition of shallow to deep-water, subtidal sequences, consisting of Middle Ordovician Table Head Group (characterized by grey, massive-bedded, fossiliferous and argillaceous dolomites and limestones), overlain by Middle to Late Ordovician Goose Tickle Group (consisting of graptolitic black shale, sandstone and siltstone as well as limestone and dolomite).

Late-stage thrusting during the Taconic orogeny resulted in the emplacement of the Hare Bay Allochthon (Waldron and Stockmal, 1994), which comprises six structural slices of transported rocks (Colman-Sadd *et al.*, 1990). Rocks of the Hare Bay Allochthon are considered to be highly prospective, and host Au, Ag and Mo mineralization in the Quirpon map area (*see* Mineral Occurrences section).

MINERAL OCCURRENCES

Several Zn–Pb, Au, Cu, Ni and Cr occurrences have been reported for the study area (Geological Survey of Newfoundland and Labrador, 2016a). The Cr and Au occurrences are associated with the Hare Bay Allochthon, and the Zn–Pb occurrences are all associated with the St. George Group and the underlying Port au Port Group:

1. The Gunner's Cove Au, Ag and Mo showing comprises the East and West Gunner's Zone and Mossberg Zone, and is located within the community of St. Lunaire-Griquet, approximately 20 km north of St. Anthony (Figure 2). The mineralization is hosted within the Maiden Point Formation of the Middle Ordovician Hare Bay Allochthon and occurs, as inclusions, within pyrite nodules in the graphitic argillaceous shales (Bostock *et al.*, 1983; Geological Survey of Newfoundland and Labrador, 2016a; White Metal Resources, 2018a). Recent work by White Metal Resources (2018b) reported select grab samples with up to 5.86 g/t Au, 8 g/t Ag, 0.13% Cu and 375 ppm Mo.

2. The North Boat Harbour Zn showing is located in the Raleigh map area (Figure 2). Zinc is hosted in sphalerite grains within stratabound pods and lenses in carbonate rocks of the Early Ordovician St. George's Group (Knight and Edwards, 1986b; Geological Survey of Newfoundland and Labrador, 2016a).

3. The Sail Pond Ag–Cu–Pb–Zn–Sb mineralization, hosted within claims owned jointly by Newfound Gold

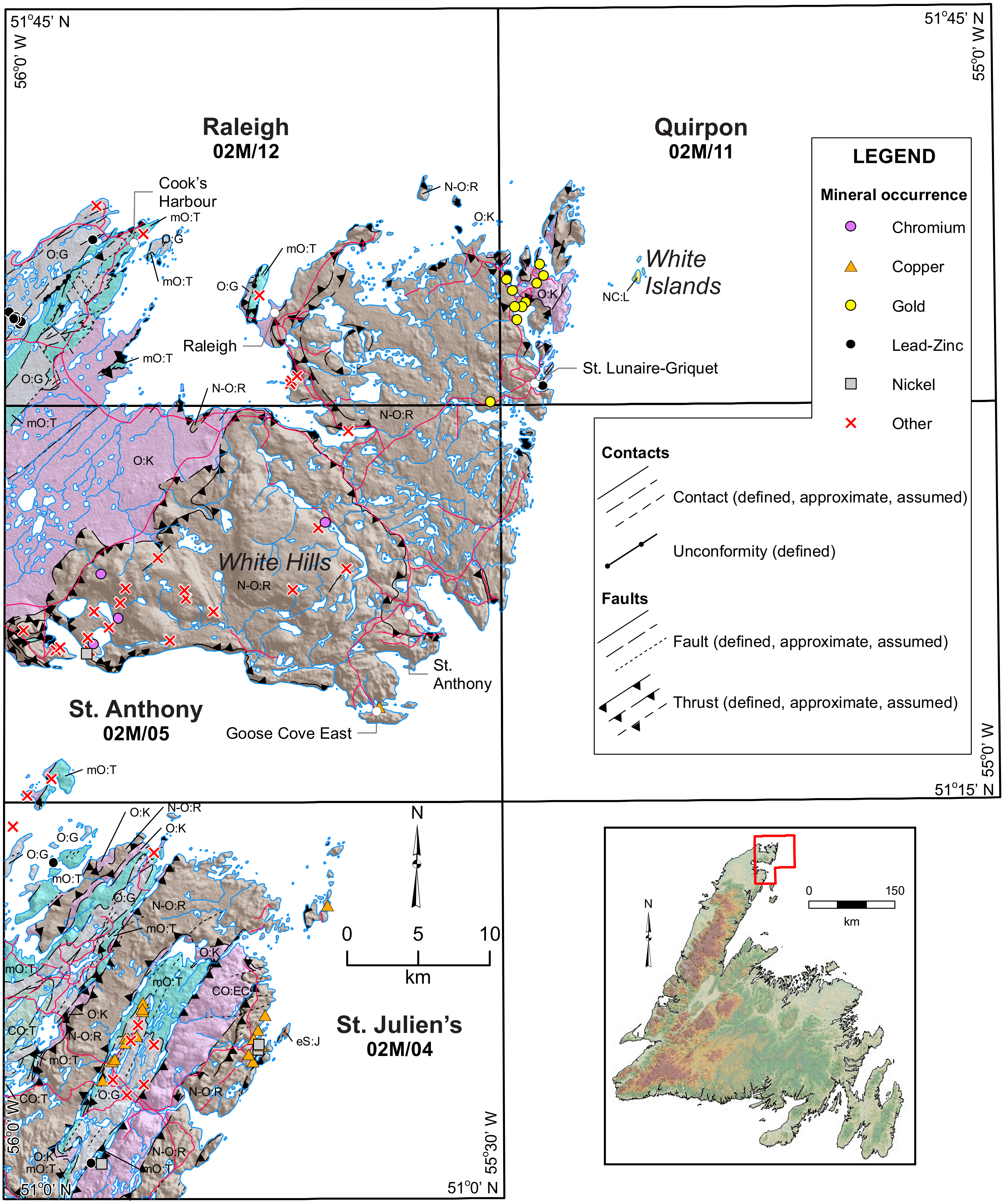

Figure 2. *Regional bedrock geology, and select mineral occurrences in the study area. Bedrock geology modified after Colman-Sadd* et al. *(1990).*

LEGEND (for Figure 2)

Post-Ordovician Units

Overlap Sequences

Early Silurian

St. Julien Island Formation

eS:J Red to purple, polymictic conglomerate and minor greywacke

Laurentian Margin

Humber Zone (Shelf and Related Rocks)

Middle to Late Ordovician

Goose Tickle Group

O:K Lower dark-grey to black, graptolitic shale (Black Cove Formation) overlain by the American Tickle Formation of dark-grey shale (metamorphosed to slate and phyllite in more deformed areas) interbedded with green-grey sandstone, siltstone and yellow- and grey-weathering, thin-bedded limestone and dolostone, and locally shale-pebble conglomerate

Middle Ordovician

Table Head Group

mO:T Dark-grey to light-grey, thick- to massive-bedded, stylonodular, fossiliferous, dominantly fine-grained, argillaceous and dolomitic limestone

Early to Middle Ordovician

St. George Group

O:G Off-white, light-grey, grey, dark-grey to black, bioturbated, stromatolitic, thrombolitic, thinly bedded and laminated, clean and dolomitic limestone as well as intraclastic, peloidal, skeletal and rarely ooliticgrainstone; burrow-mottled, bioturbated, thin-bedded and laminated and lesser stromatolitic, light-grey to grey dolostone and dololaminite and lesser green-grey and grey shaly dolostone and shale; rare chert and dolostone pebble conglomerate and sand layers associated with disconformity surfaces

Middle Cambrian to Late Ordovician

Epine Cadoret formation

CO:EC Black and grey slate, and minor brown-weathering sandstone; may be equivalent to either Ordovician Goose Tickle Group or Cambrian March Point Formation

Middle Cambrian to Early Ordovician

Port au Port Group

CO:T Muddy carbonate rocks, oolitic sequences, silty mudstone, and stromatolites, variably dolomitized, deposited in a subtidal to peritidal environment on a narrow, high-energy carbonate platform

Neoproterozoic to Middle Cambrian

Labrador Group

NC:L Red, pink, purple and grey arkosic conglomerate, arkosic, micaceous and hematitic sandstone and siltstone; white, green, red and pink quartz arenites and calcareous sandstones; olive-grey, grey, black and red shales (metamorphosed to phyllites and slates in deformed areas) locally with limestone concretions; black, grey, red and pink, intraclastic fossiliferous, oolitic, oncolitic and stylonodular, argillaceous and arenaceous, fine to grainy limestones and rarely dolostone; dark-grey, mafic volcanics occur locally

Humber Zone (Slope and Related Rocks)

Neoproterozoic to Early Ordovician

Fleur de Lys Supergroup

N-O:F Metaclastic schists with interlayered amphibolite and greenschist; the supergroup has been polydeformed by up to three major deformations; metamorphism is in the upper greenschist or lower amphibolite facies, or locally in the middle amphibolite facies

Hare Bay Allochthon

N-O:R Six structural slices of transported rocks comprising: 1. shale and sandstone, 2. greywacke, volcanic rocks and dykes, 3. sandy limestone and conglomerate, 4. shale-matrix melange, 5. pillow lava and shale, and 6. peridotite, mafic volcanic rocks, amphibolite and schists

Corp. and Altius Minerals Corporation, is located in the St. Julien's map area. In the Mineral Occurrence Database System (MODS), it is referred to as the White Arm Prospect (Geological Survey of Newfoundland and Labrador, 2016a). The two main zones of mineralization, termed the North Zone and the South Zone, are striking northeast and southeast dipping (Newfound Gold Corp., 2018). The mineralization is hosted in deformed, calcareous sedimentary rocks of the White Arm Anticline, comprising the Goose Tickle and Table Head formations and the St. George Group (Altius Minerals Corporation, 2018). Both zones are characterized by dolomite that has undergone brittle deformation, and are folded and bound by thrust faults. Grab samples from the mineralized zones contain up to 2030 g/t Ag and 7.08% Cu (*ibid.*). Mineralization is disseminated in quartz veins, and consists of chalcocite, tetrahedrite, pyrite, boulangerite, bornite, covellite, mimetite, tennantite, sphalerite and galena (*ibid.*). Silver is almost exclusively associated with the tetrahedrite (*ibid.*).

QUATERNARY GEOLOGY

Grant (1986, 1989, 1992) mapped the Blanc-Sablon region of Québec and the northern portion of the GNP, where he studied the regional ice-flow dynamics and Quaternary glacial stratigraphic record, documented the surficial sediments and marine limits, and reconstructed paleo shorelines. He established that the glaciers affecting the Great Northern Peninsula were part of the Appalachian Ice Complex, characterized by smaller ice caps originating within the Long Range Mountains and the Laurentide Ice Sheet (LIS), resulting in a complex ice-flow history for the region. He described crosscutting ice-flow patterns that recorded marine, regional and local ice-flow regimes.

Later, Shaw *et al.* (2006) compiled regional studies into an integrated model for the Late Wisconsinan Glaciation in Atlantic Canada; Putt *et al.* (2010) examined the ice-flow dynamics in the GNP and undertook a comprehensive ice-flow mapping program encompassing all of NTS map areas 2M and 12P and part of 12I. They studied dispersal of boulder erratics, using anorthosites (sourced from southern Labrador) and peridotites (sourced from the White Hills) as indicators, and deduced regional ice flow using both striations (Figure 3) and indicator-clast lithology as proxies. The chronological sequence of events described below are in radiocarbon years.

The last glaciation to have affected the study area, referred to as the Long Range Zone (Grant 1992), is correlated with the Late Wisconsinan (25–10 Ka). At the Late

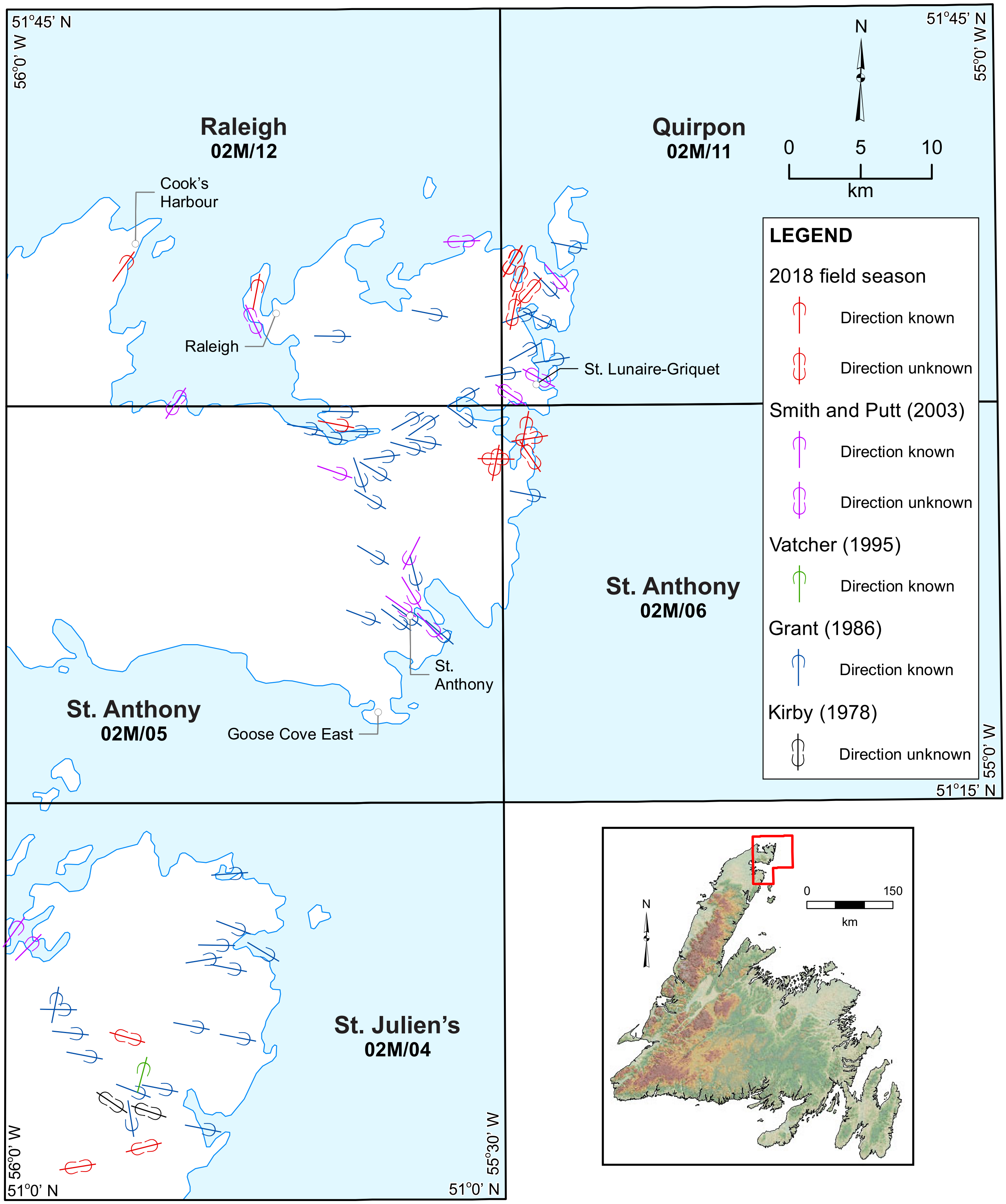

Figure 3. *Striation measurements from previous studies and the 2018 field season. The colours distinguish each study. Data retrieved from Grant (1986) and Geological Survey of Newfoundland and Labrador's striation database (2016b).*

Wisconsinan maximum, the LIS crossed the Strait of Belle Isle and covered the west coast of the GNP, eventually merging with the Newfoundland Ice Cap (NIC), originating in the Long Range Mountains, (Grant, 1992; Shaw *et al.*, 2006). The last glacial maximum was likely between 19.5 and 15 Ka (Shaw *et al.*, 2006).

Putt *et al.* (2010) discovered striations indicating ice flow to the west (oldest), east-southeast (second oldest) and southwest (youngest). They interpreted these as suggesting that the ice originating from the Long Range Mountains flowed west, whereas the LIS flowed southeast, across the Strait of Belle Isle. The ice masses coalesced on the western part of the GNP, deflecting the glaciers originating in the Long Range Mountains to the southwest. Further, they described striations suggesting a dominant southeastward flow and documented clusters of anorthosite boulders (on raised beaches) in the northeastern part of the GNP. These observations were interpreted as showing the LIS advancing southeastward onto the GNP.

Ice retreat may have commenced between 13–10 Ka (Grant, 1992), whereby ice sheets disintegrated primarily *via* ablation and ice stagnation, becoming isolated and shrinking into multiple ice-caps (Grant, 1989, 1992; Shaw *et al.*, 2006). As deglaciation proceeded, ice sheets became topographically controlled as they retreated toward the Long Range Mountains (Grant, 1992; Shaw *et al.*, 2006). Putt *et al.* (2010) also proposed the development of an ice-divide over the White Hills during deglaciation, resulting in ice flowing radially out of the White Hills (*i.e.*, to the northwest, north and northeast). They supported the proposal of an ice divide by the presence of peridotite boulders north-northwest and southeast of the White Hills (their probable source of provenance). The proposed ice divide of Putt *et al.* (2010) likely disintegrated *ca.* 12 Ka as deglaciation proceeded.

By 12 Ka, ablating ice of the NIC in western Newfoundland was discharging meltwater into the Gulf of St. Lawrence and the Strait of Belle Isle was ice free (Shaw *et al.*, 2006) and the Goldthwait Sea marine limit was established in the study area (Grant, 1992). The suggested positions of the marine limit are based on ^{14}C dated marine shells and are approximately 60 m asl along the St. Lunaire coastline, at 130 m asl on Quirpon Island, and at 120 m asl in the St. Julien's map area. However, smaller ice caps, such as the ice cap originating in the White Hills, persisted until approximately 11 Ka (Shaw *et al.*, 2006). Grant (1992) identified a large moraine (the Ten Mile Lake moraine) southwest of the study area that he suggested (based on ^{14}C dates) was formed in a re-advance related to the globally recognized Younger Dryas cooling period. Deglaciation was mainly complete by 10 Ka (Grant, 1992; Shaw *et al.*, 2006).

Deglaciation of the region resulted in isostatic rebound and relevant changes in sea level (Grant, 1992). Liverman (1994) integrated marine shell dates with theoretical modelling of sea-level change curves (after Quinlan and Beaumont, 1981, 1982) to calculate the rate of isostatic rebound within Newfoundland. Based on the age of marine shells recovered from the tip of the GNP, it was demonstrated that at 8.5 Ka, the study area was still submerged and that after deglaciation of the GNP, the area either underwent continued emergence (or isostatic uplift) or a more complex pattern of emergence, submergence and later re-emergence.

FIELDWORK

MAPPING

Till sampling and surficial geology mapping were completed *via* truck, all-terrain vehicle (ATV) and foot traverses between June and August, 2018. Surficial geology was initially mapped on orthoimagery in ArcGIS and ground-truthed using a Trimble GPS unit. Google Earth™ digital hill shade imagery, derived from shuttle radar topography mission (SRTM) data, and orthoimagery, taken from the Department of Forestry, were also used to study macro-scale ice-flow indicator features (streamlined bedrock, flutings, rôches moutonnées). Information entered at mapped stations includes GPS coordinates, elevation, sediment type and characteristics and geomorphic signature. Orientation measurements of macro-scale features such as rôches moutonnées and streamlined bedforms (Plate 1A, B, C), and micro-scale features were also made at selected sites (Plate 1D, E).

SAMPLING

Till sampling in the St. Julien's map area was completed following the GSNL sampling protocol (Plate 1F). Samples were collected in the immediate vicinity of the North Zone and South Zone mineral occurrences, and at intervals of 1 km along forestry roads and trails, using truck and ATV, as well as by foot traverse. At each site, the sediment face was cleaned and dug to expose till. Most of the samples collected were of C-horizon material; however, at a few sites, the B/C horizon was sampled. C-horizon till is the optimal surficial medium to sample as it is mostly unaffected by physical and chemical weathering (Levson, 2001). At each site, 2 to 3 kg of material were collected for geochemical analysis. Field duplicates were collected at a frequency of 1 every 11 samples to test site variability. A 10–15 kg bag of material was also collected at each site for heavy-mineral separation, provided that sufficient material was available. Information collected at each sample site include: 1) GPS coordinates, 2) site description, 3) till colour, 4) relative percentages of clast and matrix (*i.e.*, % sand, silt and

Plate 1. *Field photographs. A) Panoramic view overlooking Quirpon Island taken from Trinity Bight; B) Rôche moutonnée on White Islands; C) Macro-scale streamlined bedform; D) Striations in the Raleigh map area; E) Striation measurement taken at Sail Pond property; F) Profile from which till sample was collected in the St. Julien's map area.*

clay), 5) elevation, 6) clast features, 7) till features such as matrix content and colour, and 8) general site observations such as evidence of agricultural activity in the vicinity. Weathering and soil-horizon information were also recorded, and photographs taken at each site. The influence of marine environments on till geochemistry was also taken into account, and therefore, all samples collected in the vicinity of Sail Pond were taken above the marine limit and each sample was thoroughly checked to ensure that it did not contain any marine shells.

LABORATORY WORK

Sample Preparation

Till samples collected for geochemistry analyses have been submitted to the GSNL laboratory for preparation and analysis. Samples were dried and sieved to the -63 µm fraction (230 mesh) to recover the silt and clay fraction. This fraction is considered to be the optimal size fraction for analysis because it is easy, time- and cost-effective to sieve, and ore minerals, especially sulphides, are preferentially concentrated into this fraction, and as a result enrichment with respect to the background is enhanced (Levson, 2001; Spirito *et al.*, 2011).

Quality Assurance and Quality Control

Several measures were taken in the field to ensure the integrity of the samples. Sampling tools were cleaned before and after the collection of each new sample to reduce the risk of cross-contamination. Quality control methods in the laboratory include the insertion of laboratory duplicates to check precision and till standards to check the accuracy (see Finch *et al.*, 2018).

Analytical Techniques

Sieved samples will be analyzed at the Geological Survey's laboratory in St. Johns, where minor and trace-element content will be analyzed following methods described by Finch *et al.* (2018) using inductively coupled plasma-optical emission spectroscopy (ICP-OES) after a multi-acid ($HF/HCl/HNO_3/HClO_4$) digestion. Samples will also be sent for instrumental neutron activation analysis (INAA) to Maxxam Analytics (Mississauga).

RESULTS

ICE FLOW

Striations, grooves, rat-tails, crag-and-tail, and stoss-and-lee relationships were used, in conjunction with macro-scale landforms, to interpret the region's ice-flow history. Unfortunately, the ice-flow features are poorly developed, and caution was taken in the interpretation of field data. Three distinct ice-flow directions were identified:

1) Striations, grooves and rat-tails with azimuth ranging between 100 and 145°. These were measured at lower elevations and/or on the protected lee side of outcrops.

2) Striations and grooves with azimuth ranging between 65 and 90°, measured on the tops of the outcrops, and

3) Micro-scale striations, grooves, rat-tails and macro-scale crag and tails ranging between 0 and 40° (Table 1).

The data presented shows a sequence of ice-flow events from an early southeastward flow, followed by a later east-northeastward flow, followed, in turn, by a north-northeastward movement. The earliest southeastward flow is interpreted to have been as a result of the LIS, which overrode the White Hills and flowed out into the Atlantic Ocean (Figure 4). This interpretation agrees with those of Grant (1989, 1992) and Putt *et al.* (2010). It is not clear if the southeastward and the east-northeastward flows were distinct movements, *i.e.*, whether they both occurred as a result of the LIS advance over the northern three map areas, or whether the east-northeastward flow was a later movement, influenced by the coalescence of LIS and the NIC. The southeastward-flowing LIS likely did not reach the White Islands (situated approximately 5 km off the coast of the community of St. Lunaire-Griquet). Macro-scale streamlined landforms (rôches moutonnées) mapped on the White Islands are all oriented north-northeastward, suggesting that they were formed by NIC ice. The youngest north-northeast flow correlates well with Putt *et al.*'s (2010) model, whereby a later radial re-advance of ice from the White Hills Ice Cap would have resulted in a north-northeastward flow in the northernmost three map areas (St. Anthony, Quirpon and Raleigh). Ice flow at this time would have largely been controlled by topography; this would provide an explanation for minor deviations observed in ice-flow measurements at lower elevations (*see* Table 1). It is likely that this flow produced the rôches moutonnées observed on the White Islands. Additional ice-flow indicators need to be measured in the St. Julien's map area to establish azimuth and chronological sequence of the glacial flow.

SURFICIAL GEOLOGY

The 2018 field mapping survey has delineated the following preliminary surficial units within the study area:

1) Bare, exposed rock is the most prevalent surficial unit mapped (Plate 2A). It is present in topographic highs,

Table 1. Striation data collected during the 2018 field season

Station ID	UTM East (NAD 27 Zone 21	UTM North (NAD 27 Zone 21	Elevation (m asl)	NTS Map Area	Azimuth (degrees)	Feature and Comments
02M/06/180124	606066	5704551	29	(St. Anthony) 02M/05, 02M/09	10	Faint striations and grooves on top surface. Moderately developed
02M/05/120007	603708	5705814	32	(St. Anthony) 02M/05, 02M/06	10	Faint grooves and striations on a poorly streamlined outcrop. These northeast-southwest striations cross-cut earlier southeast–northwest striations preserved in the lee of the northeast–southwest oriented outcrop
02M/06/180124	606066	5704551	29	(St. Anthony) 02M/05, 02M/08	10	Striations on the top of the outcrop
02M/06/180127	605743	5704651	24	(St. Anthony) 02M/05, 02M/13	10	Poorly developed rat-tails on the top of the outcrop
02M/11/180030	604807	5712870	39	(Quirpon) 02M/11	10	Poorly developed grooves on the side slope
02M/11/180030	604807	5712870	39	(Quirpon) 02M/11	10	Worn grooves on the side slope
02M/12/180108	586771	5712849	62	(Raleigh) 02M/12	10	Striations and grooves on the top of the outcrop
02M/11/180253	604464	5716270	28	(Quirpon) 02M/11	15	Striations and grooves on the top of the outcrop
02M/11/180053	605211	5715101	24	(Quirpon) 02M/11	20	Striations and grooves on the top of the outcrop
02M/06/180125	605948	5704574	26	(St. Anthony) 02M/05, 02M/10	25	Striations on the top of the outcrop crosscutting striations oriented east-west.
02M/06/180127	605743	5704651	24	(St. Anthony) 02M/05, 02M/14	25	Stossed bedform (plucked on the stoss side)
02M/11/180252	604718	5716408	28	(Quirpon) 02M/11	30	Striations on the top of the outcrop
02M/11/180252	604718	5716408	28	(Quirpon) 02M/11	30	Striations on the side of the outcrop
02M/11/180252	604718	5716408	28	(Quirpon) 02M/11	30	Rat-tails on the top of the outcrop
02M/12/180208	577467	5715616	28	(Raleigh) 02M/12	35	Crag and tail feature with rat-tails within
02M/11/180035	605980	5714237	62	(Quirpon) 02M/11	40	Grooves on the top of the outcrop
02M/12/120008	586668	5713869	74	(Raleigh) 02M/12	40	Stossed bedform
02M/06/180125	605948	5704574	26	(St. Anthony) 02M/05, 02M/11	65	Striations on the top of the outcrop
02M/04/180275	579824	5655108	136	(St. Julien's) 02M/04	75	Striations and grooves on the top of the outcrop
02M/06/180125	605948	5704574	26	(St. Anthony) 02M/05, 02M/12	75	Striations on the top of the outcrop
02M/04/180256	575238	5652421	119	(St. Julien's) 02M/04	80	Striations on the top of the outcrop
02M/06/180124	606066	5704551	29	(St. Anthony) 02M/05, 02M/07	80	Striations on the top of the outcrop
02M/04/180275	579824	5655108	136	(St. Julien's) 02M/04	85	Striations and grooves on the top of the outcrop
02M/05/120007	603708	5705814	32	(St. Anthony) 02M/05, 02M/06	90	Worn grooves and rat-tails on the side slope of the outcrop
02M/05/180164	592517	5704813	49	(St. Anthony) 02M/05, 02M/15	100	Striations and grooves on the top of the outcrop
02M/04/180258	575033	5652284	116	(St. Julien's) 02M/04	105	Striations and grooves on the top of the outcrop
02M/04/180260	578574	5661571	79	(St. Julien's) 02M/04	105	Striations and grooves on the top of the outcrop
02M/04/180265	578644	5661618	91	(St. Julien's) 02M/04	120	Striations and grooves on the top of the outcrop
02M/06/180124	606066	5704551	29	(St. Anthony) 02M/05, 02M/06	145	Striations on the protected lee of the outcrop

locally overlain by a variable veneer (<1 m; Plate 2B) of till, and partially obscured by vegetation.

2) Bare exposed rock is also mapped in frost polygon features (Plate 2C) indicative of periglacial conditions. Some regions have poorly developed soil (a few centimetres thick of coarse to fine sand) within frost shattered bedrock.

3) Poorly to well-stratified, granule to boulder-sized gravel and sand are mapped in two distinct areas in the Raleigh and Quirpon map areas (Plate 2D).

4) Medium- to coarse-grained sand and granule-sized gravel are mapped as littoral/nearshore and beach deposits around most shorelines (Plate 2E). Most of the beach deposits were formed as a result of littoral reworking of till, outwash and colluvium (where steep cliff faces have been recorded).

5) Colluvium consisting of silt, sand and granule to boulder-sized gravel is associated with sediment and rock failures and is mapped as colluvial fans, cones, blankets and veneers along most shorelines (Plate 2F).

6) A grey stony, sandy silt, of glaciomarine origin, was found along the shores of St. Lunaire-Griquet map area (Plate 2G). This deposit is characterized by clay, silt, medium to fine sand and granule to boulder-sized gravel. The gravel is glacially derived (faceted, bullet-shaped) and contains shells within its matrix. The presence of fine-grained material is suggestive of a deep-water depositional environment. It is likely that this glaciomarine deposit correlates with Grant's (1992) "fossiliferous stony mud" deposit.

7) Lastly, organic deposits, consisting of bog and fen, are prevalent in the coastal lowlands as well as within bedrock depressions (Plate 2H).

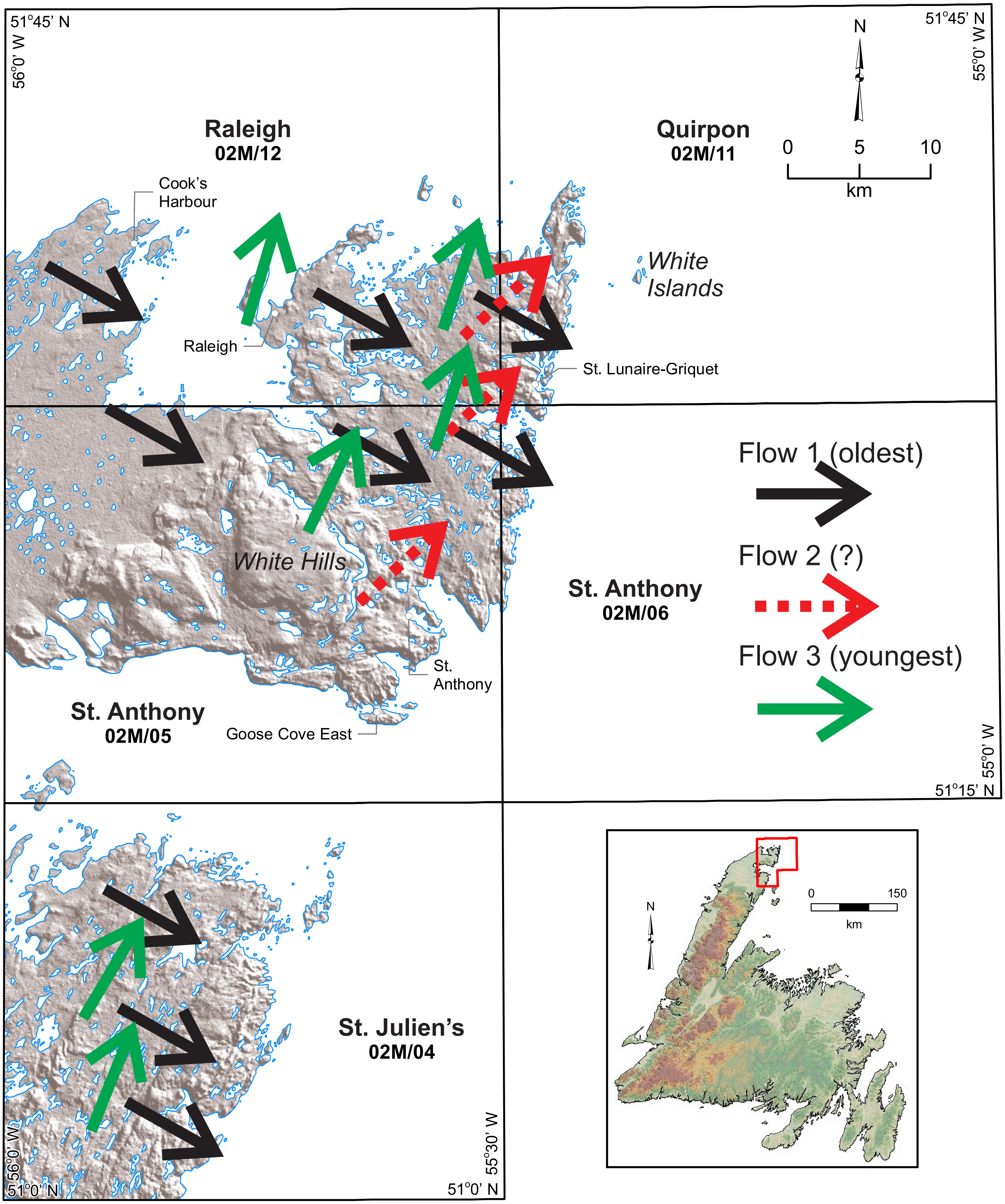

Figure 4. *Glacial movement reconstruction based on previous work by Grant (1992), Putt* et al. *(2010) and the current study.*

Plate 2. *Field photographs. A) Bedrock with thin topsoil and vegetation; B) Bedrock overlain by a thick veneer (<1 m) of sphagnum peat; C) Frost polygons in the Raleigh map area; D) Glaciofluvial outwash in the Quirpon map area; E) Raised beach deposits formed by reworked till, outwash and nearby colluvium deposits; F) Colluvial cones mapped at the edge of steep cliff slopes.*

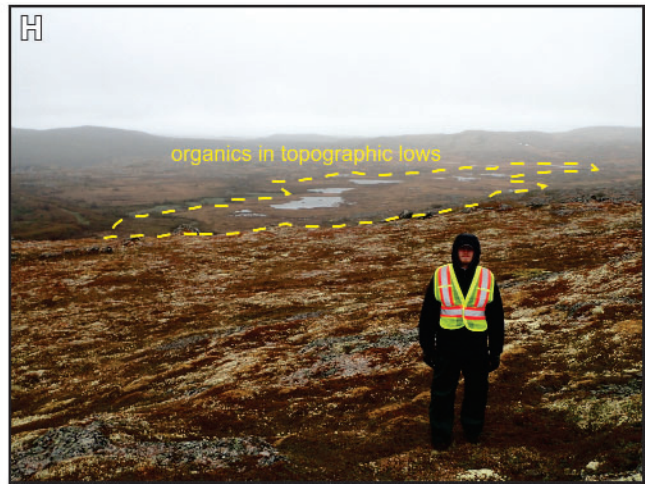

Plate 2. ***Continued.*** *Field photographs. G) Marine deposits in the Quirpon map area; H) Organics in topographic lows.*

PRELIMINARY MINERAL EXPLORATION RESULTS

The widespread occurrence of weathered bedrock (most would have been below the marine limit just prior to deglaciation) has limited the number of measurements collected, thus limiting the regional ice-flow model. Further, the paucity of till in the northern three map areas resulted in only one till sample being collected, in the Raleigh map area. The remaining samples were collected in the St. Julien's map area (Sail Pond Ag–Sb–Pb property). The marine limits estimated for the study area are variable, therefore, extreme caution was taken when sampling till for geochemical (and mineralogical) dispersal studies in the Sail Pond region. All till samples were taken above the marine limit in the area. Each sample was also thoroughly checked to ensure that no marine shells were present.

FUTURE WORK

Fieldwork for the 2019 survey season will include ice-flow measurements, surficial mapping and till sampling in the remaining portions of the St. Anthony and St. Julien's map areas. Four, 1:50 000 scale surficial geology maps will incorporate the preliminary mapping completed during the 2018 field season, and the analytical results of the till sampling program in the St. Julien's map area will be released as an Open File Report next year.

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