Targeted Geochemical and Mineralogical Surveys in the TREK Project Area, Central British Columbia (Parts of NTS 093B, C, F, G): Year Two

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Introduction

The objective of the **T**argeting **R**esources through **E**xploration and **K**nowledge (TREK) project is to provide a better geological understanding of the central part of British Columbia's Interior Plateau through the integration of surficial geochemistry, airborne geophysics and geology data (Figure 1). The project is focused on an area of Stikine terrane that has the potential to host a variety of mineral deposit types, including porphyry Cu, porphyry Mo and epithermal Au deposits. Exploration in this region has been hindered by Neogene Chilcotin Group basalt flows and extensive glacial drift, which obscures underlying and prospective bedrock units.

The surficial geochemistry survey of the TREK project is currently underway and aims to provide a comprehensive geochemical database for the project area. Presented here are the program details and summary of the first two years' activities.

The TREK geochemistry program consists of three components:

- compilation of historical data from previous geochemical surveys;
- collection of new geochemical and mineralogical data; and
- reanalyses of archived till samples.

Various combinations of geochemical data from lake and stream sediment, water, till and biological material exists for different parts of the project area. Typically, geochemical data from these types of materials are not comparable due to different methods of transport and accumulation. Lake sediment and till geochemical data, however, have been shown to be correlative (Cook et al., 1995; Rencz et al., 2002). The present survey targets basal till, which is a common material throughout the region and well suited to assessing the mineral potential of areas covered by glacial drift (Levson, 2001; McClenaghan et al., 2001; Lett et al., 2006). Basal till potential maps (BTPMs; Sacco et al., 2014a–j) were produced and used to assist in the planning and execution of this ambitious survey. Where basal till or access is limited, higher order bedrock derivatives that are comparable to the historical geochemical data are assessed for sampling. Till geochemical data from previous surveys is integrated with new data from this survey by reanalysis of available archived samples using modern laboratory techniques to produce a directly comparable, more comprehensive till geochemical dataset for the project area.

Keywords: *TREK, mineral exploration, till geochemistry and mineralogy, regional geochemical data, basal till potential mapping*

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Project Area

A summation of the known bedrock and surficial geology and references for the project area are provided in Sacco et al. (2014k). The project area is located in the Interior Plateau (Mathews, 1986), south of Vanderhoof and approximately 60 km west of Quesnel. It occupies parts of NTS 093B, C, F and G and covers more than twenty-eight 1:50 000 scale NTS map areas, approximately 25 000 km^2 (Figure 1). Access is through a network of forest service roads in the Vanderhoof, Quesnel, Chilcotin and Central Cariboo forest districts.

The project area includes parts of the Nechako Plateau, Fraser Plateau and the Fraser Basin physiographic regions (Holland, 1976; Figure 1). Thick surficial deposits composed dominantly of till and glacial lake sediments obscure most bedrock exposures. Higher relief features include the Nechako and Fawnie mountain ranges of the Nechako Plateau and the Ilgachuz and Itcha mountain ranges of the Fraser Plateau.

Economic Geology

There are five developed prospects, seven prospects and 39 mineral showings in the TREK project area. Four developed prospects contain Au, Ag, Zn, Pb and Cu mineralization and include the Blackwater-Davidson intermediate sulphidation epithermal Au-Ag deposit (NTS 093F/02; MINFILE 093F 037; BC Geological Survey, 2013), the Capoose subvolcanic Cu-Ag-Au (As-Sb) and porphyry-related Au deposit (NTS 093F/06; MINFILE 093F 040), and

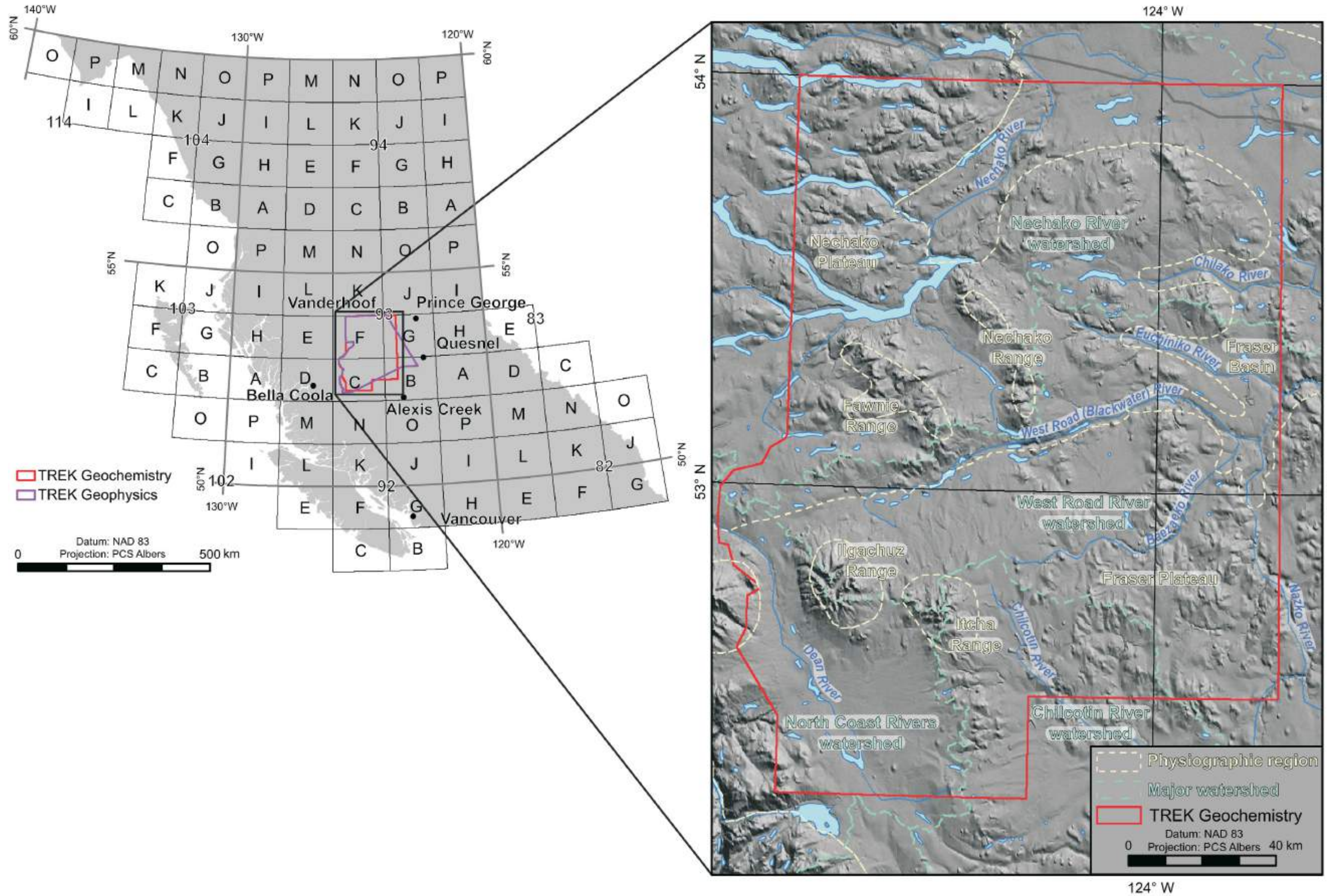

Figure 1. TREK project geochemistry and airborne geophysics boundaries in central British Columbia. Inset map illustrates physiographic regions (Holland, 1976) and major drainages of the geochemical survey area. Digital elevation model from Canadian digital elevation data (GeoBase®, 2007).

the 3Ts polymetallic Ag-Pb-Zn±Au veins (NTS 093F/03; MINFILE 093F 068) and low-sulphide epithermal Au-Ag-Cu deposit (NTS 093F/03; MINFILE 093F 055). The fifth developed prospect, the CHU deposit, hosts porphyry Mo (low F-type) mineralization (NTS 093F/07; MINFILE 93F 001).

The Baez (NTS 093C/16; MINFILE 093C 015), Clisbako (NTS 093C/09; MINFILE 093C 016), Trout (NTS 093F/10; MINFILE 093F 044) and Wolf (NTS 093/F03; MINFILE 093F 045) prospects all host low-sulphidation epithermal Au-Ag mineralization. In contrast, the April Au-Ag-Zn prospect has been classified as high-sulphidation epithermal Au-Ag-Cu mineralization (NTS 093F/07; MINFILE 093F 060). At Laidman prospect (NTS 093F/03; MINFILE 093F 067), Au, Ag, Pb and Zn occur within Au- quartz veins whereas at Bob prospect, Au, Ag, As, Sb and Hg occur within carbonate-hosted and disseminated Au-Ag mineralization (NTS 093B/13; MINFILE 093B 054).

Historical Geochemical Data

Beginning in the early 1990s, several multimedia regional geochemical surveys have been conducted in the project area. This previously published biogeochemical, lake and stream sediment and till geochemical data are listed in Table 1 and depicted in Figure 2. Pine tree bark was targeted for biogeochemical sampling. The bark was reduced to ash and analyzed for multiple elements by instrumental neutron activation analysis (INAA) and inductively coupled plasma–emission spectrometry (ICP-ES) following an aqua-regia digestion (Dunn and Hastings, 1998, 1999, 2000). An abundance of lakes provided opportunity to conduct several lake sediment and water sampling programs. A selection of archived sediment pulps from programs completed prior to 2000 were recently reanalyzed by Jackaman (2006, 2008a, b, 2009a, b). Reanalysis of lake sediments was by inductively coupled plasma–mass spectrometry (ICP-MS; 35 elements) following an aqua-regia digestion. Original geochemical analysis included INAA (25 elements), and analysis for fluoride using specific ion electrode (SIE). Till samples collected during previous surveys were originally analyzed by outdated ICP analytical techniques for various elements plus INAA for total gold determinations plus 34 elements. Samples have been re-analyzed for minor and trace elements by ICP-MS following aqua-regia digestion (53 elements), major and minor elements by ICP-ES following a lithium borate fusion and dilute acid digestion. The compilation of historical geochemical data will be released as a Geoscience BC report in 2015.

Till Geochemical and Mineralogical Survey

Basal till is well suited to assessing mineral potential of an area because it is a first derivative of bedrock (Shilts, 1993) and therefore has a similar geochemical signature. It was eroded, transported and deposited under ice, thus its transport history is relatively simple and can be determined by reconstructing ice-flow histories. Furthermore, it produces a geochemical signature that is areally more extensive than the bedrock source and potentially easier to locate (Levson, 2001). Basal till in the project area is a massive, dense, dark brown, matrix-supported diamicton. In most exposures, it exhibits subhorizontal fissility and vertical jointing resulting in a blocky appearance (Figure 3a). The matrix composition varies; generally in the north it is silt to sandy silt and in the south it has a higher sand content. The matrix propor-

Table 1. Historical geochemical data reports for the TREK project area, central British Columbia.

Survey year	NTS map area	Type	Sample sites[1]	Reference
1996	093F/09, /10, /15, /16	Tree bark	224	Dunn and Hastings, 2000
1997	093F/13, /14, /12	Tree bark	100	Dunn and Hastings, 1998
1998	093K/02, /03	Tree bark	2	Dunn and Hastings, 1999
1980, 1985[2]	093A, B, G, H, J, K, N, O	Stream	470	Jackaman, 2008a
2005	093C, F	Stream	66	Jackaman, 2006
2008	093E, F, G, J, K, L, M, N, O	Stream	32	Jackaman, 2009b
1993	093F	Lake	380	Jackaman, 2009a
2005	093C, F	Lake	1324	Jackaman, 2006
2007	093G, H, J, K, N, O	Lake	89	Jackaman, 2008b
1992	093C/09, /16	Till	176	Lett et al., 2006
1993	093F/03	Till	171	Levson et al., 1994; Plouffe et al., 2001
1994	093F/07	Till	143	Weary et al., 1997; Plouffe et al., 2001
1994, 1998	093F	Till	292	Plouffe et al., 2001
1996, 1997	093F	Till	314	Plouffe and Williams, 1998; Plouffe et al., 2001

[1]Only sample sites within the study area are listed
[2]Samples reanalyzed in 2007

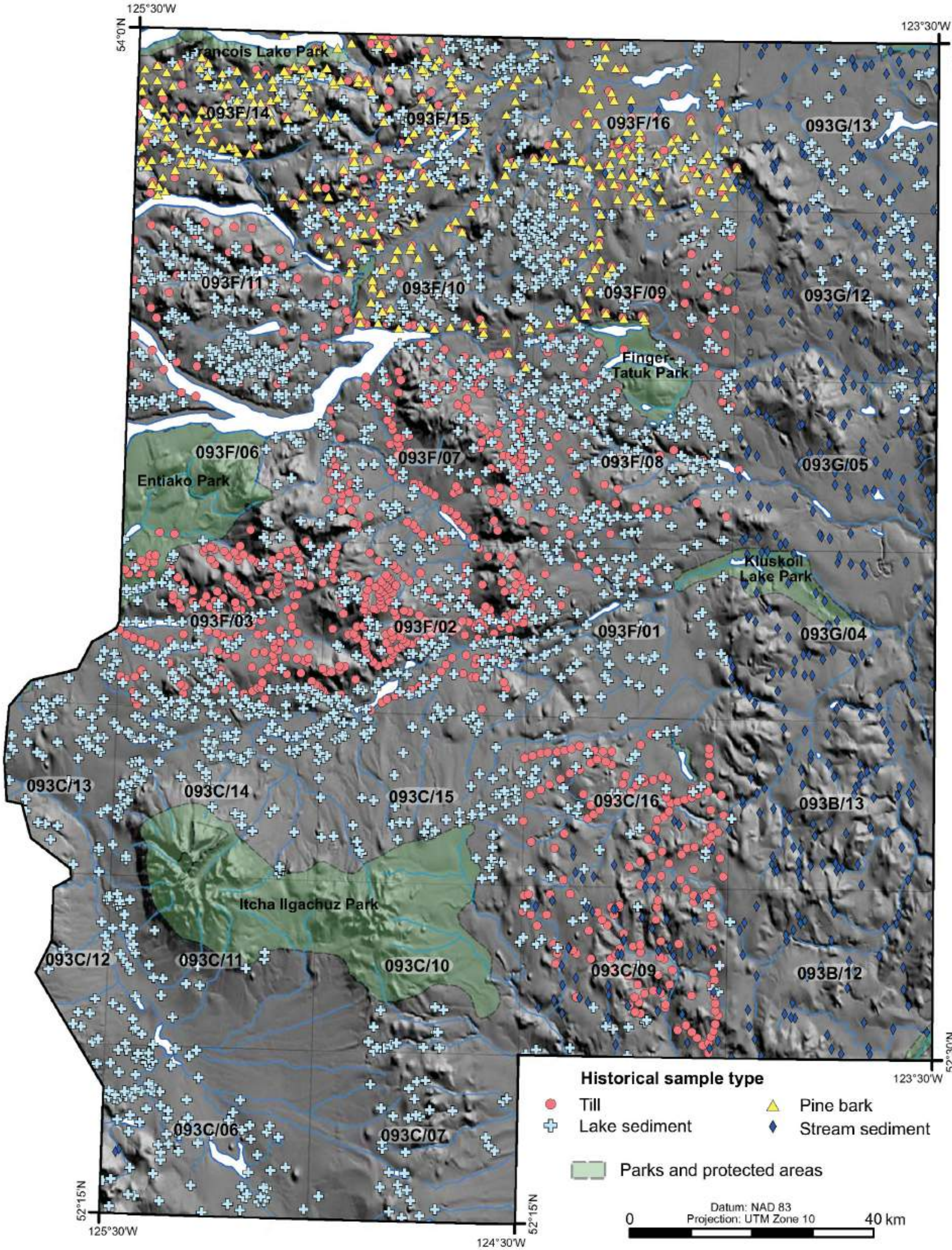

Figure 2. Distribution of archive till (red circle), lake (light blue cross) and stream (dark blue diamond) sediment geochemical data and biogeochemical (pine bark) data (green triangle), TREK project area, central British Columbia. See text for references. Digital elevation model from Canadian digital elevation data (GeoBase®, 2007).

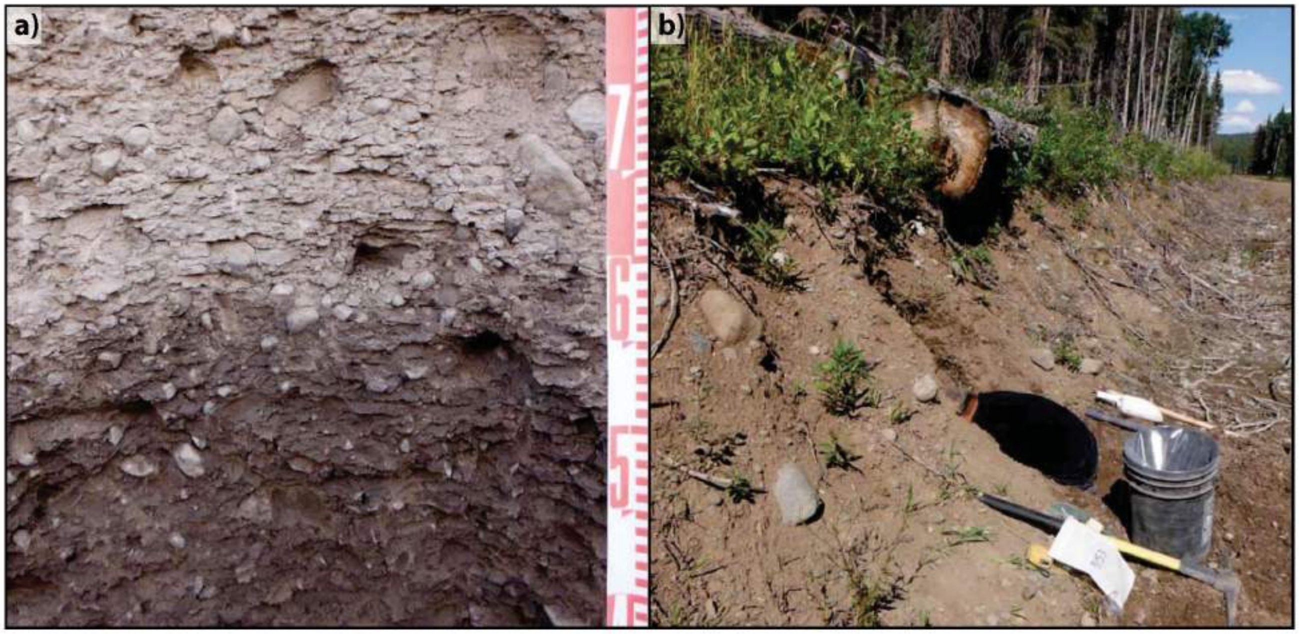

Figure 3. a) A basal till exposure displaying typical massive structure, fissility and jointing. In situ material targeted for sampling is highlighted by the darker colour. Scale in metres. **b)** Typical roadcut exposure used to access in situ basal till that is found below depths of 1 to 1.5 m, TREK project area, central British Columbia.

tion varies from 70 to 85% with a modal clast size of small to medium pebble and a range up to boulder.

Sediments that hinder the survey include ablation till and glaciolacustrine deposits. Ablation till is found in areally small deposits in depressions or basins throughout the project area, and is widespread to the north and west of the Ilgachuz and Itcha mountain ranges. Ablation till is differentiated from basal till by the lack of density, and high sand content in the matrix. It is generally matrix supported, shows some stratification, and contains sand or gravel lenses, but can also be clast supported or massive. Areally extensive glaciolacustrine deposits occur within the Fraser Basin in the northeastern part of the project area, and in the north coast river system watershed in the southwest. Diamictons deposited in a glaciolacustrine environment can be difficult to distinguish from basal till; however, they typically lack density and have a matrix composed almost entirely of silt.

Basal Till Potential Mapping

Basal till potential maps (BTPMs) delineate areas where basal till is likely to occur and where it may be necessary to implement different geochemical sampling protocols. These maps are an extremely valuable tool for planning regional surveys and assisting exploration companies conduct detailed follow-up activities. The BTPMs are also an important tool in determining genesis of existing surface geochemistry samples. A comprehensive description of map protocols and production can be found in Sacco et al. (2014k). Aerial photographs were interpreted using surficial geology mapping standards (Deblonde et al., 2012) that were modified to include addition information about basal till potential and till genesis. The BTPMs were instrumental in the planning and implication of the survey. Ten 1:50 000 scale BTPMs have been published for the eastern portion of the TREK project area (Sacco et al., 2014a–j). In addition, eight complete and two partial map areas have been interpreted and ground truthed, and eight map areas are thus far unmapped (Figure 4). Unfortunately, the loss of the BC Geological Survey from the TREK project included access to digital resources and technology critical to the production of high quality maps. As a result, BTPMs will not be completed at this time for the remaining 16 complete and two partial map areas.

Field Methods

Sampling locations are based on a 2 km, staggered grid, aligned with ice flow (see Levson, 2001). These locations, however, are restricted in some areas due to lack of material, access or exposure. Natural or anthropogenic exposures (>1 m) were typically required to obtain in situ basal till, which had not been altered by soil-forming processes or biological activity (Figure 3b). These exposures occurred predominantly as roadcuts and in some cases, borrow pits or river and lake cuts. Pits were hand dug in some situations. At each sample location 2–3 kg till samples were collected for major-, minor- and trace-element geochemical analyses and 50 stones, of large pebble to small cobble size, were collected for lithological studies. At approximately every other site, a 10–12 kg sample was collected

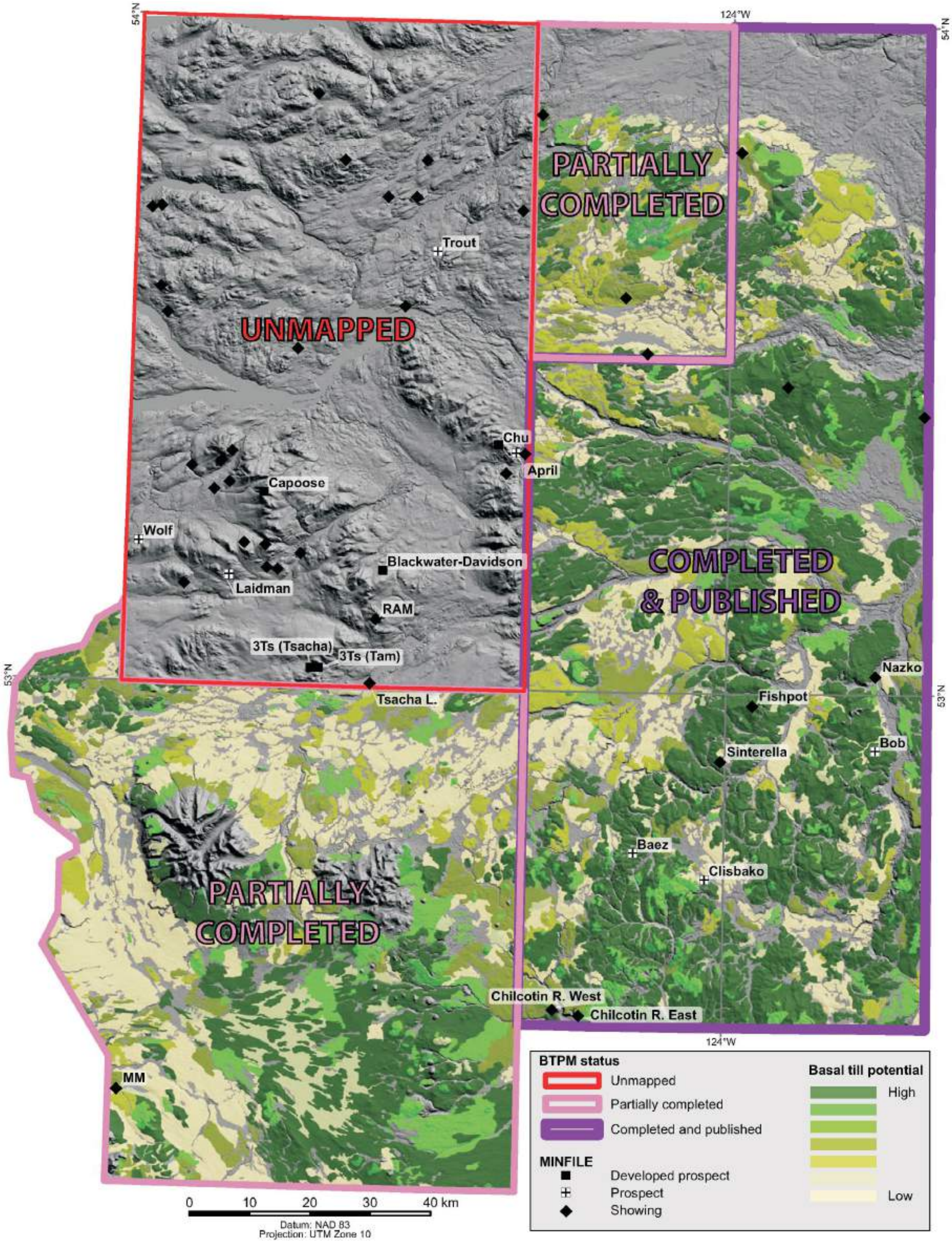

Figure 4. Basal till potential mapping (BTPM) coverage and completion status for the TREK project area. These BTPMs are a valuable asset to the planning and implementation of surface geochemical exploration projects. Ten, 1:50 000 scale map areas have been published (purple box; Sacco et al., 2014a–j). Eight complete and two partial map areas have been interpreted and ground truthed; however, the ground-truthing has not been applied to the initial interpretations (pink boxes). Mapping has not been conducted in eight map areas (red box). The loss of the BC Geological Survey from the TREK project has hindered map production, leaving areas with high potential for economic mineralization without this exploration tool. Digital elevation model from Canadian digital elevation data (GeoBase®, 2007).

for gold grain counts and heavyweight– and medium-weight–fraction mineral separations.

The 2013 field season focused on regions in the eastern part of the study area that had not previously been sampled. A total of 684 till samples of 2–3 kg each and 336 till samples of 10–12 kg each was collected (Figure 5). The 2014 field season focused on areas of NTS 093F, which were previously sampled at a low density (Levson et al., 1994; Weary et al., 1997; Plouffe and Williams, 1998; Plouffe et al., 2001), and NTS 093C, which have never been sampled for geochemical analysis. In this year, 582 till samples of 2–3 kg each and 277 till samples of 10–12 kg each were collected (Figure 5).

Sample Analysis

Till samples collected for geochemistry and archived till samples were sent to Acme Analytical Laboratories Ltd. (Vancouver, BC) for preparation and major-, minor- and trace-element analyses. Tills were dried, an archive of the original till sample was generated, and the remaining material was sieved to produce splits of the silt plus clay-sized (<0.063 mm) fraction. The 10–12 kg till samples were sent to Overburden Drilling Management Limited (Nepean, Ontario) where samples were panned for gold, sulphides and platinum group minerals, concentrated by size (0.25–2.0 mm) and specific gravity (2.8–<3.2 and ≥3.2) and picked for indicator minerals (Figure 6).

Samples were analyzed for minor- and trace-elements by ICP-MS following aqua-regia digestion (53 elements), major and minor elements by ICP-ES following a lithium borate fusion and dilute acid digestion, and total gold determinations plus 34 elements by INAA. All geochemical analyses were completed at Acme Analytical Laboratories Ltd. (Vancouver, BC), except INAA, which was conducted at Becquerel Laboratories Inc. (Mississauga, Ontario).

Quality Control

In addition to contract labs in-house quality control procedures, additional quality control for analytical determinations includes the use of field duplicates, analytical duplicates, reference standards and blanks. For each block of 20 samples, one field duplicate (taken at a randomly selected sample site), one analytical duplicate (a sample split during the preparation process), and one reference standard is included in geochemical analyses. Reference standards are CANMET till 1 and 4, TREK till standards A and B, and NVI 1, 2, 3 and 4. Duplicate samples determine sampling and analytical variability and reference standards measure the accuracy and precision of the analytical methods. Blanks are introduced throughout the sample stream to determine if there is any cross-contamination between samples.

Progress and Future Work

To date, 1546 new geochemical samples have been collected in the TREK project area. The geochemical, mineralogical and pebble data from the 684 till samples (e.g., Figure 7) and geochemical data from 280 lake sediment and water samples collected in 2013 have been released (Jackaman and Sacco, 2014). Data from the 582 till samples collected in 2014 and the reanalyzed archived till samples will be released in 2015. The TREK geochemistry program has provided adequate till geochemical sample density for the majority of the study area (see Figure 5). Low sample density still exists in the southwest, around the Itcha Ilgachuz Park, where thick units of ablation till and glaciolacustrine material overlie the basal till. Due to the limited access in these areas, a helicopter-supported biogeochemical treetop survey is the best option to attain useful geochemical data. Furthermore, the complex glacial history in the south needs to be resolved to allow for proper interpretation of the basal till geochemical data.

As a multiyear program, further TREK project geochemical activities will include the assembly of recently acquired survey data plus the further development of geoscience information required for additional field surveys in regions lacking the desired sample medium or access. The project action plan includes the following:
- evaluate and compile analytical results and field data for new basal till and pebble samples;
- evaluate and compile analytical data determined from the reanalysis of archived samples and provide additional information on sample media and genesis;
- complete BTPMs based on field survey ground-truthing exercises (if necessary resources can be acquired); and
- assess the use of treetop biogeochemical surveys to cover areas with challenging access or limited availability of other target media types.

Generating a comprehensive collection of regional, high quality, geochemical analytical data and field information is the primary objective of the geochemical component of the TREK project. This is being accomplished through the compilation of previous multimedia geochemical data, the collection of new samples, the reanalysis of archived samples using modern techniques, the collection of geological information necessary to successfully interpret the data, and the production of BTPMs, which provide a basis for the planning and implication of this and follow-up surveys. When packaged and released to the public, this dataset will be utilized in the exploration and discovery of new mineral occurrences.

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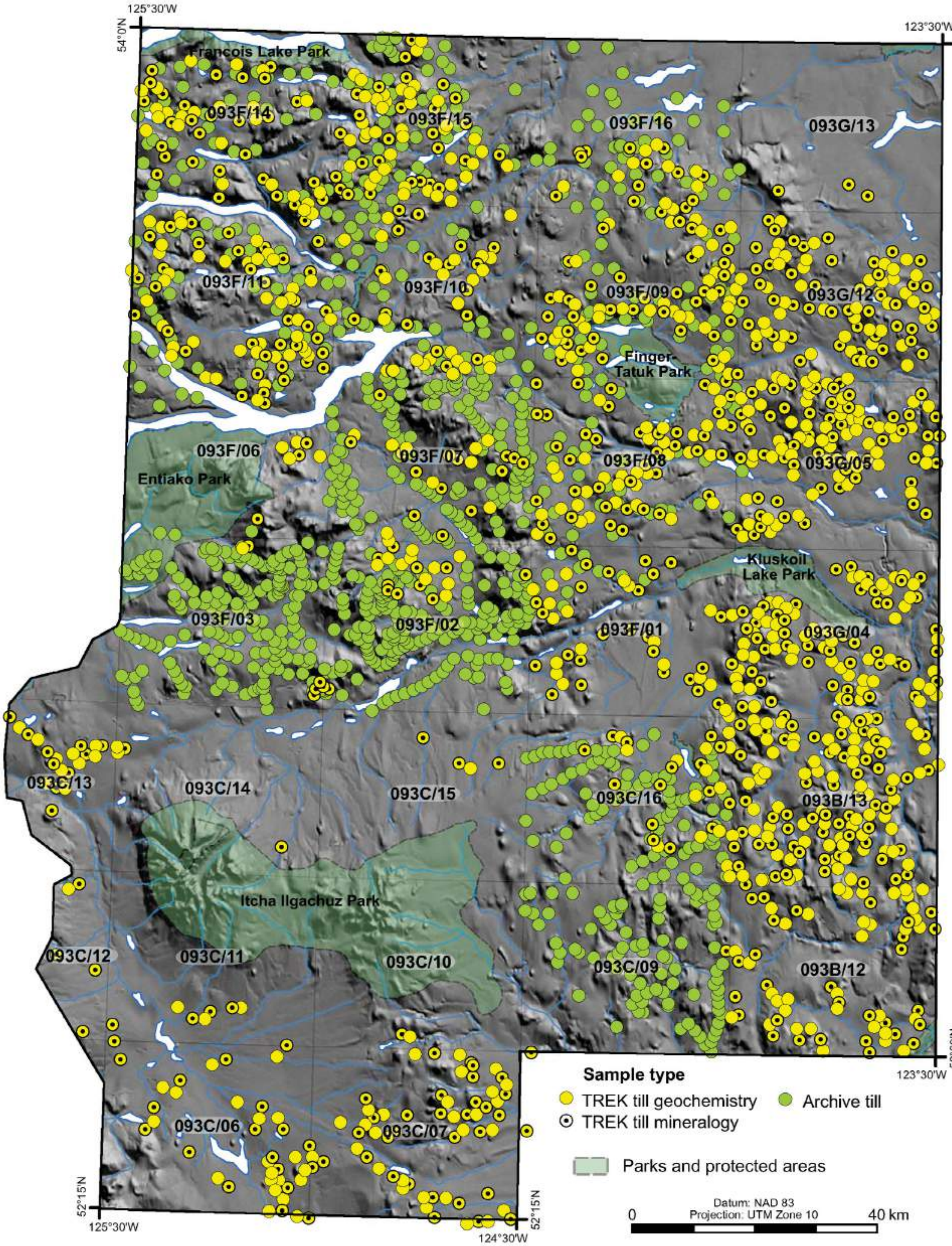

Figure 5. Distribution of previous and new sample locations in the TREK project area, central British Columbia. Digital elevation model from Canadian digital elevation data (GeoBase®, 2007).

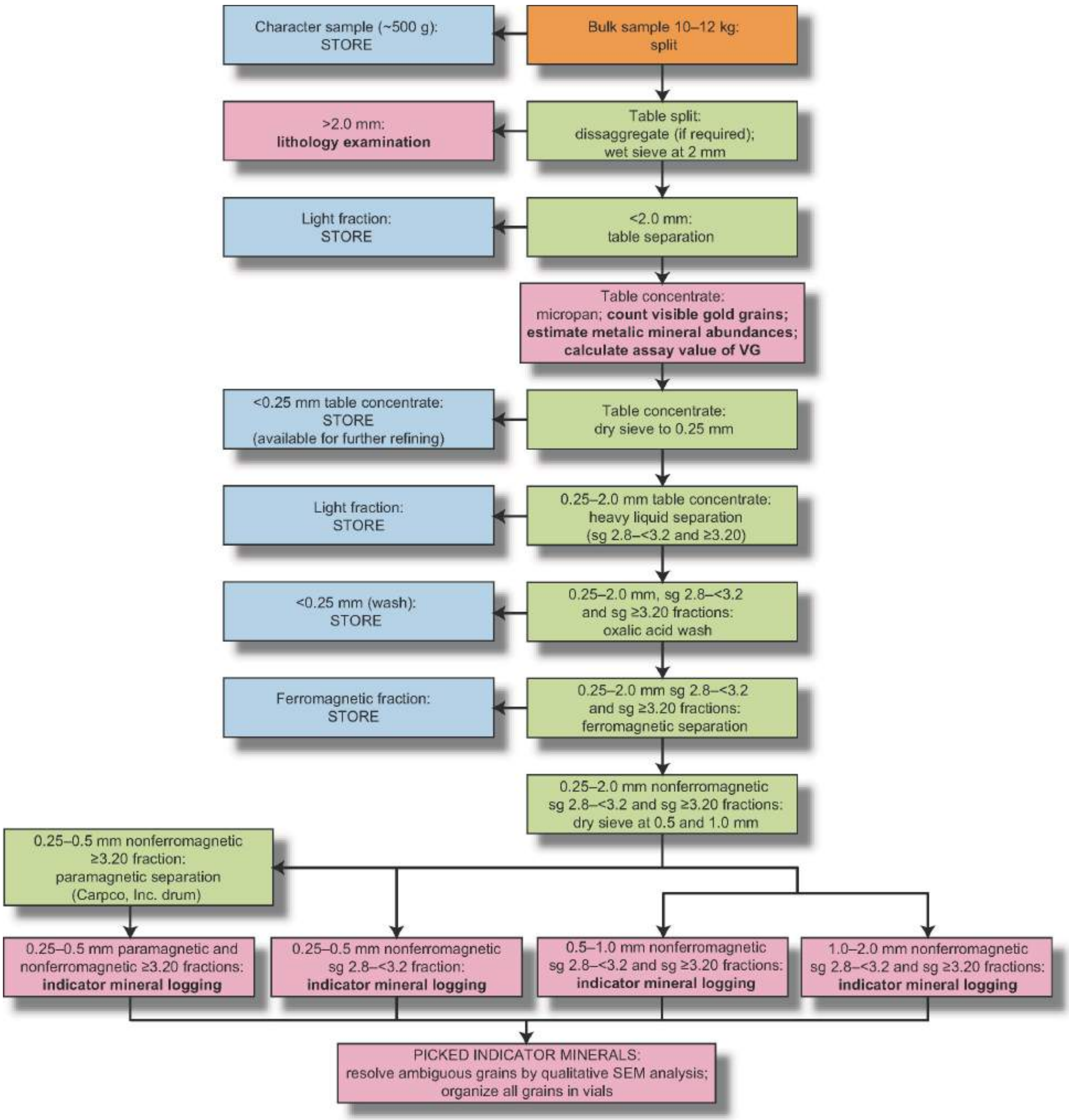

Figure 6. Processing flowsheet for indicator minerals and gold grains. Analysis conducted at Overburden Drilling Management Limited (Nepean, Ontario). Abbreviations: SEM, scanning electron microscope; sg, specific gravity; VG, visible gold.

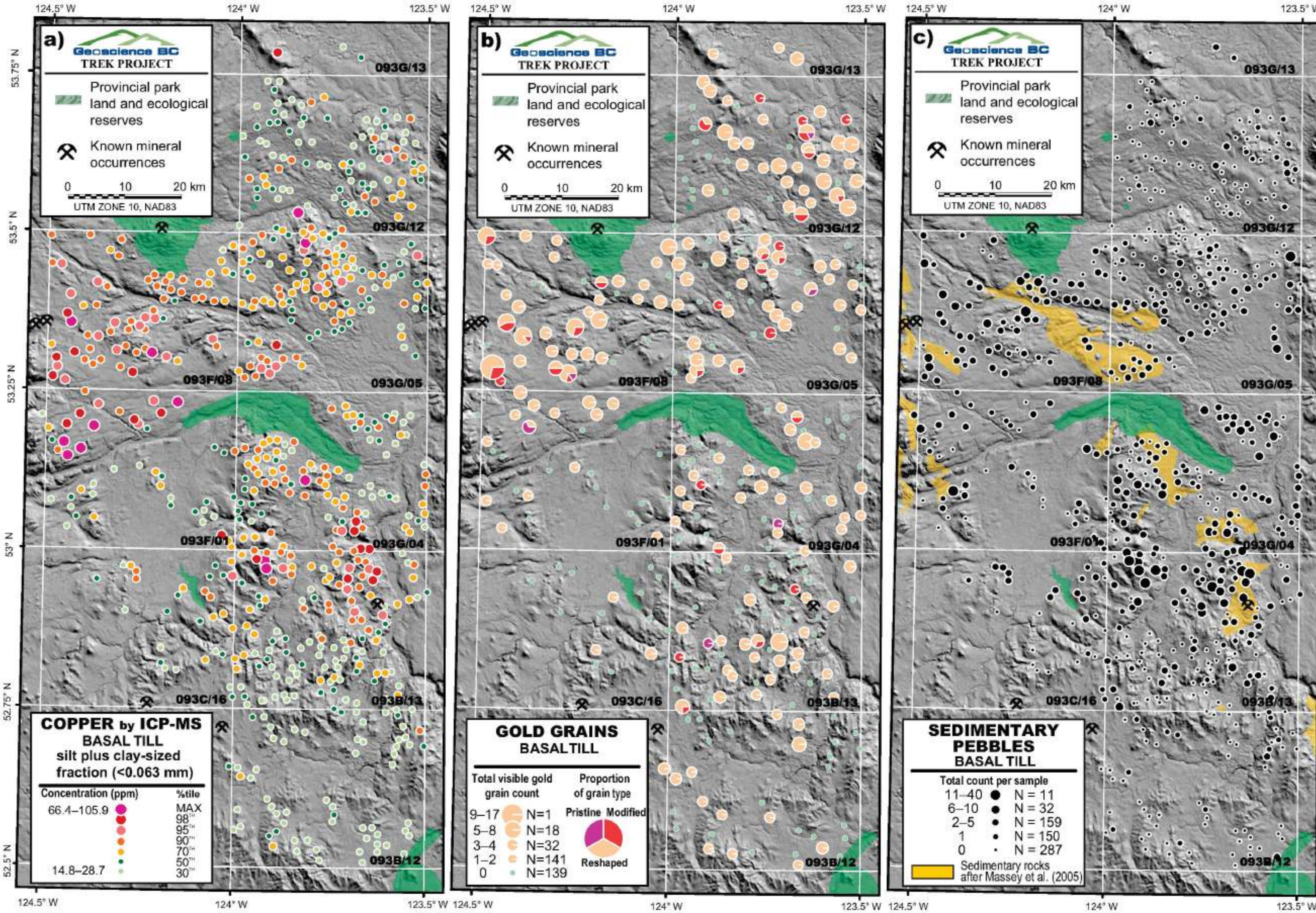

Figure 7. Examples of dot proportion plots from the TREK project 2013 basal till dataset: **a)** geochemistry: copper concentration by inductively coupled plasma–mass spectrometry (ICP-MS); **b)** mineralogy: gold grains; **c)** pebble lithologies: sedimentary pebbles plotted with known sedimentary bedrock sources (Massey et al., 2005). Glacial transport is generally to the northwest in the north, and slightly more northerly in the south. Digital elevation model from Canadian digital elevation data (GeoBase®, 2007).

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