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The search for surficial expressions of buried Cordilleran porphyry deposits; a new TGI4 activity in the southern Canadian Cordillera

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Geological Survey of Canada with Provincial and Territorial Collaboration

SUMMARY

Targeted Geoscience Initiative 4 is a 5-year federal program to provide public geoscience knowledge coverage to improve deep mineral exploration effectiveness. In southern British Columbia, the focus is on porphyry base- and precious metal districts.

The objective is inter-jurisdictional and preliminary activities will focus federal and provincial survey activities in the sampling of tree bark, which provides natural probes into the subsurface, and, of glacial till derived from eroded bedrock and mineral deposits. The first stage comprised pilot studies at the Woodjam district, and Gibraltar and Highland Valley mines in autumn 2011. The determination of complex ice-flow directions from map- to outcrop-scale ice movement indicators help trace till and heavy mineral geochemical anomalies back to the original buried deposits.

The studies helped test the sampling media (tree bark and till) as indicators of buried mineralization. Pilot studies at the Woodjam district and Gibraltar and Highland Valley mines type areas include 47 till samples and 41 biogeochemical sample sites (66 samples). Results from these samples, expected in mid-2012, will help test and improve these technologies and demonstrate how analysis of the same sediments that hinder surface mineral exploration can help pinpont buried mineral deposits and increase the effectiveness of deep mineral exploration.

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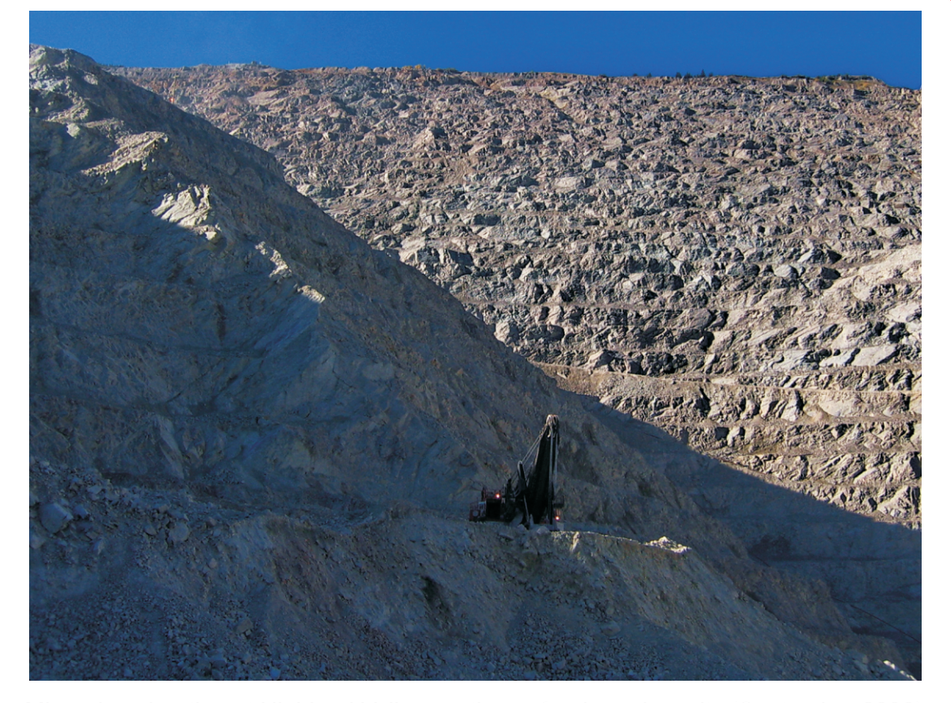
ACKNOWLEDGEMENTS

The initial studies could not have been undertaken without the support of GSC TGI4 project personnel and extraordinary mineral and mining company support. M. Villeneuve, N. Rogers, C. Hutton and C. Bjerkelund from the Geological Survey of Canada provided the Program and Project support to enable the fieldwork to be undertaken.

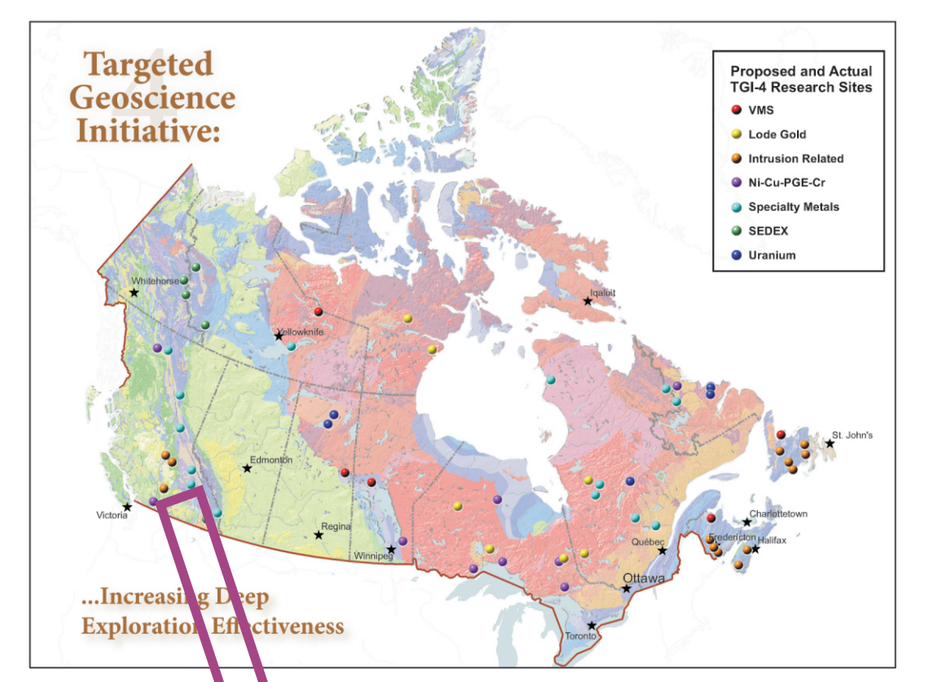
The cooperation, support and assistance of: John Fleming (Gibraltar Mines Ltd); Tom Schroeter (Fjordland Exploration Inc.), Ross Sherlock, John Hertel, J. Blackwell, and Amelia Rainbow (Gold Fields Exploration); and, Gerald Grubisa, Chris LeClair, Mathieu Veillette, and Ron Grayden (Teck Highland Valley Copper Partnership) facilitated the success of our scoping studies at Gibraltar Mine, the Woodjam District and the Highland Valley District. Assistance by volunteer Valerie Cameron was invaluable.

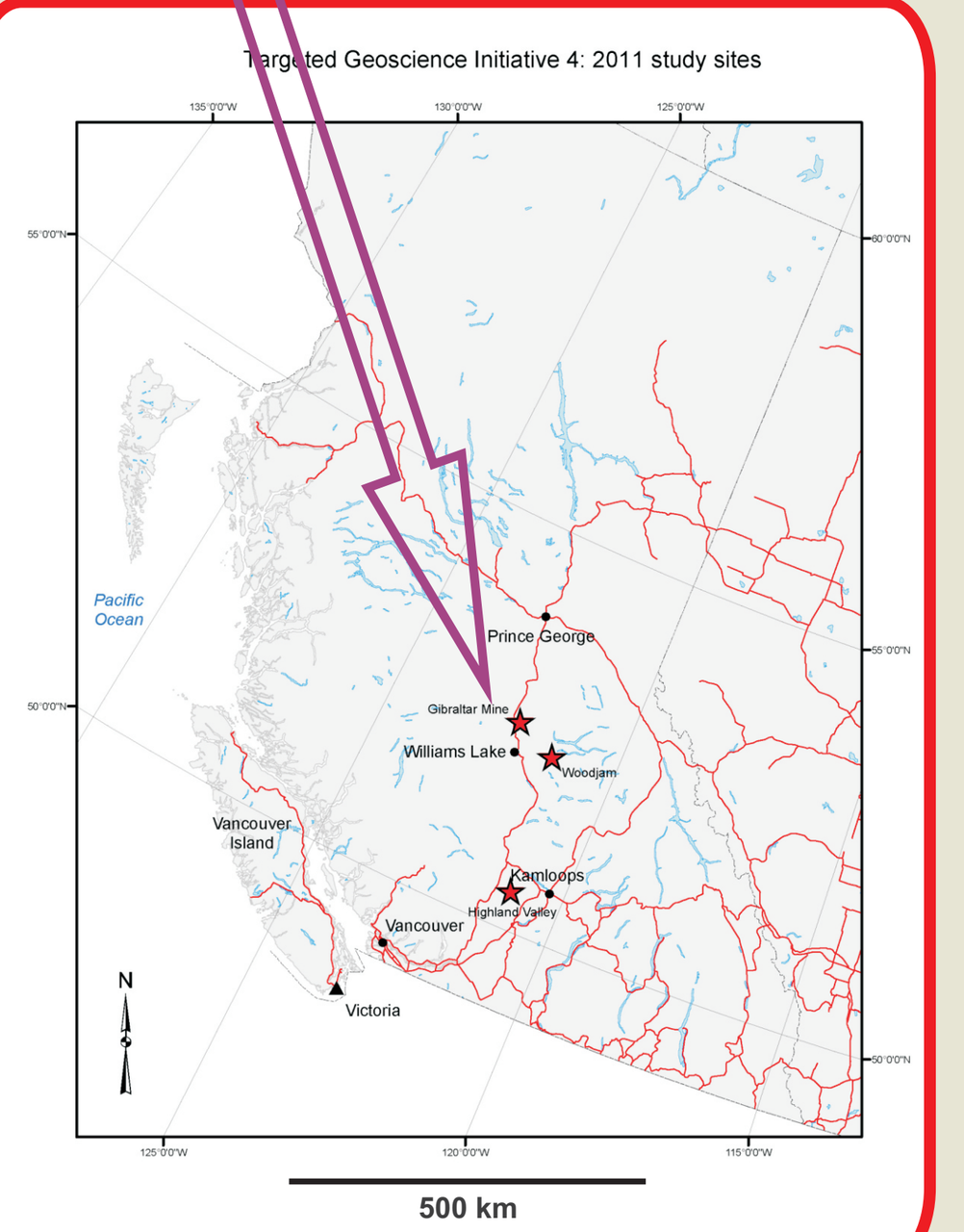
Work on preparing the sample maps by Neil Rogers and support for printing the poster by Tracy Barry are greatly appreciated.

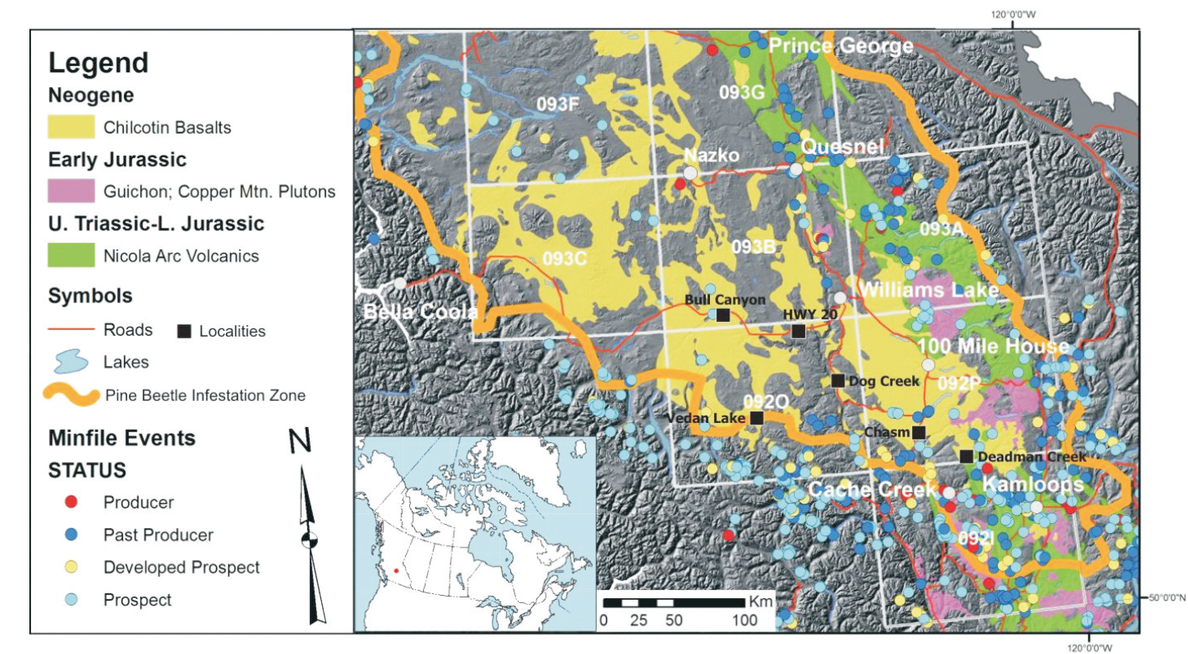
A review by Alex Zagorevski improved the content and presentation of information on this poster.



Mineral exploration at Highland Valley continues for deep deposits (September 2006).







DEM image shows the low relief Interior Plateau compared with mountain ranges to west and east. The abundance of base- and precious metal mineral showings around the periphery of the plateau (coloured dots) can be attributed to good exposure of basement rocks. In contrast, the apparent dearth of mineral showings in Interior Plateau may be due to glacial deposits and Tertiary basalt cover. The plutono-volcanic Nicola Arc porphyry deposit metallotect is also shown.

A New Federal Program – Targeted Geoscience Initiative 4 (TGI4): Increasing Deep Exploration Effectiveness

The mineral exploration industry continues to seek innovative changes in technology to improve the effectiveness in exploration for covered or deep deposits.

The Federal Targeted Geoscience Initiative has been renewed (TGI4) with the objective of improving deep mineral exploration effectiveness, in established and emerging mining camps. TGI-4 is a collaborative federal geoscience program which will provide industry with the next generation of geoscience knowledge and innovative techniques that will result in more effective targeting of buried mineral deposits.

Its approach is to define the geoscience knowledge and information gaps that exist in seven main ore systems, including intrusion-related (porphyry) systems, the focus of activities in British Columbia, New Brunswick and Nova Scotia. The TGI4 mandate "Public geoscience in support of deep exploration" is in response to the need expressed by the mineral exploration industry for publically accessible research to improve technologies for effective targeting of buried mineral deposits.

Current Situation:

* Canada's reserves of metals have been declining for more than 28 years.
* There is an increasing rarity of surface discoveries leading to a need to explore deeper to find new resources.

The TGI4 framework focuses on:

* Developing more robust exploration vectors that can more effectively identify buried fertile mineral systems, reducing the investment risk and cost through smarter targeting;
* Developing new and improved geoscience knowledge and techniques to better understand, model and detect Canada's major mineral systems;
* Training and mentoring students in order to increase the number of highly qualified personnel available to the mineral industry.

Program Design - Ore System Approach:

* TGI4 is a knowledge-based, thematic program that uses the best examples of ore systems across Canada.
* Projects and activities are not centred in a geographic region, but instead integrate data and knowledge from multiple mining camps across Canada.
* Scientific hypotheses underpin the program and define the critical knowledge gaps within ore systems.

Hypothesis: The compositions of trees and surficial sediments are influenced by underlying mineral deposits.

Issue: The elements and components in trees and surficial sediments which are indicative of the underlying fertile mineral deposits need to be identified. Identifying the components to look for in trees and sediments and the areas in which they occur will help find buried mineral deposits and increase the effectiveness of deep mineral exploration.

Question: Do trees or surficial sediments display distinct enrichment in chemical components that could be linked to buried mineral deposits and how can we identify them?

In British Columbia, the Interior Plateau physiographic region is an ideal study area to develop new technologies for deep exploration because it is underlain by well known porphyry deposits (e.g., New Afton, Highland Valley, Gibraltar, and Mount Polley) and of its potential for further porphyry deposits (e.g., Woodjam) which are obscured by glacial deposits and unmineralized Tertiary basalt flows.

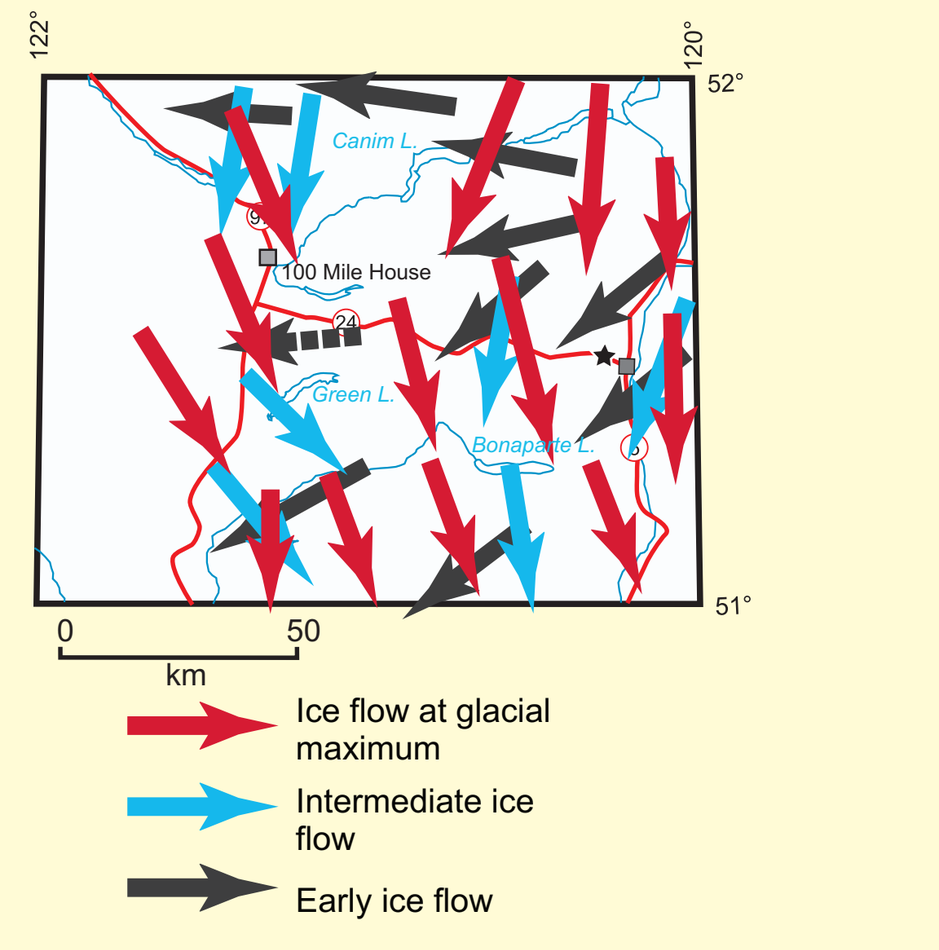
Methodologies

Drift Prospecting and Ice-flow History

The southern sector of the Cordillera was completely covered by the Cordilleran Ice Sheet during the last glacial maximum (Late Wisconsinan Fraser Glaciation). An extensive cover of unconsolidated glacial sediments was left following the glaciation which hides prospective geology in a vast sector of the Interior Plateau.

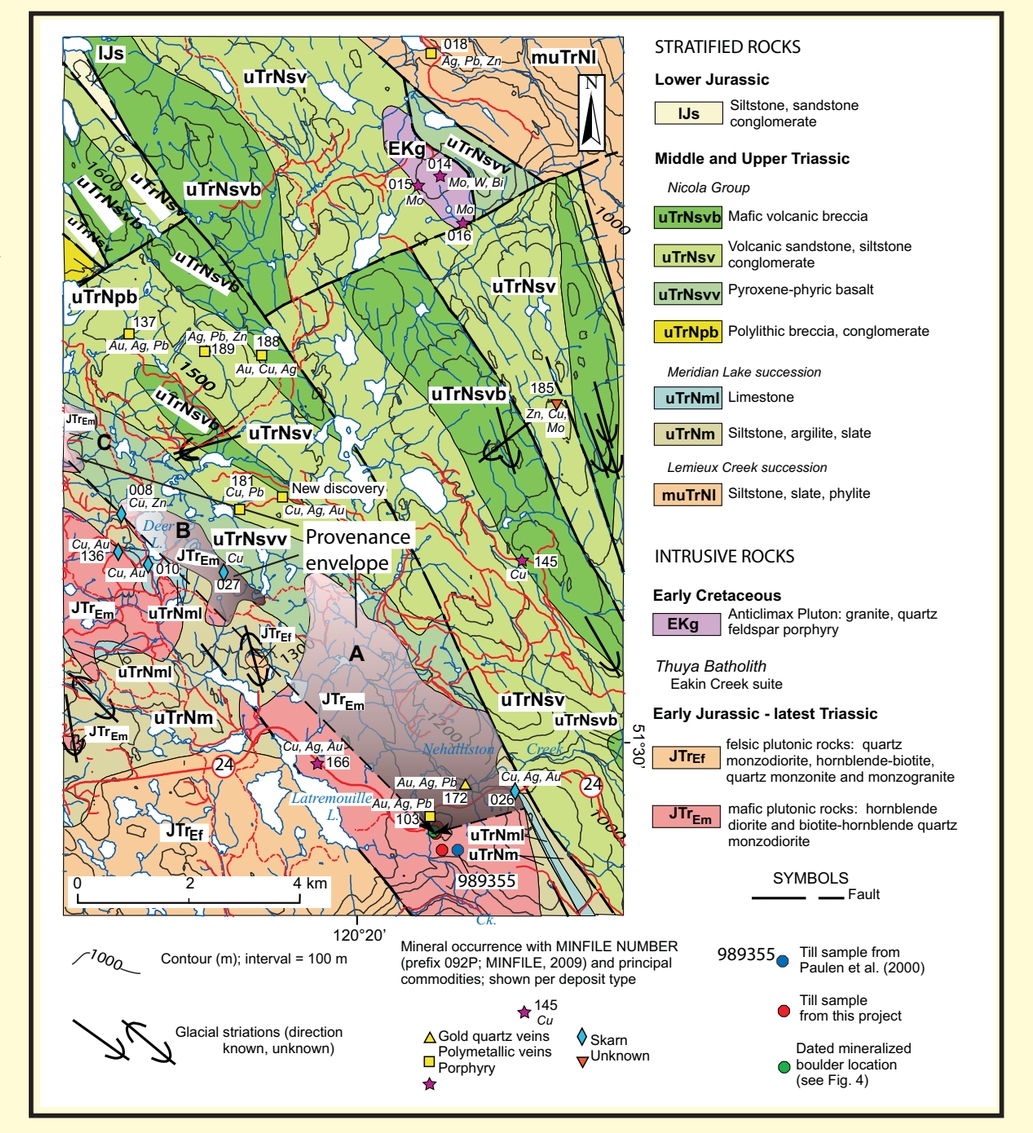
Porphyry deposits were eroded by glaciers during the last glaciation if they were not protected by rocks or unconsolidated sediments. The glacial sediments resulting from the erosion of the mineralization might be geochemically enriched in a suite of elements or might contain minerals indicative of porphyry mineralization. The objectives of this activity are to determine which elements and minerals are enriched in till (glacial sediment directly deposited by glaciers) and are indicative of fertility, and to what distance from the bedrock source can the enrichment in till be detected. The success of this approach is largely based on the reconstruction and interpretation of the ice-flow history which represents the vectors towards the bedrock source region. For each study site, the ice-flow history will be reconstructed from surficial geology maps produced as part of this project which will include ice-flow indicators at the landform (e.g. drumlin) to the outcrop (e.g. striations) scales.

The map on the right, from the Bonaparte Lake region, illustrates an example of the recently reconstructed ice-flow history of the Bonaparte Lake map area. It shows that at the onset of the last glaciation, ice was flowing to the west and southwest from an ice source region located in the Cariboo Mountains. Later, at glacial maximum, glaciers were flowing generally to the south from an ice divide located near the 52° latitude. Evidence of glacial transport to the west related to the ice advance from the Cariboo Mountains and to the south was identified by Plouffe et al. (2011). One of the objective of this activity will be to determine if the ice movement to the west impacted the regions of the Gibraltar Mine and Woodjam district.



EXAMPLE FROM BONAPARTE LAKE AREA

The new interpretation of the ice-flow history outlined above has served to better define the provenance envelope of mineralized felsic intrusive boulders in the Little Fort area (Figure on the right). Without the recently reconstructed ice-flow history, the bedrock source of the boulders was thought to be to the north-northwest. The new model indicates that the boulders can be derived from a wider provenance envelope which includes the east side of the Eakin Creek suite of the Thuya Batholith. For more details see Plouffe et al. (2011).



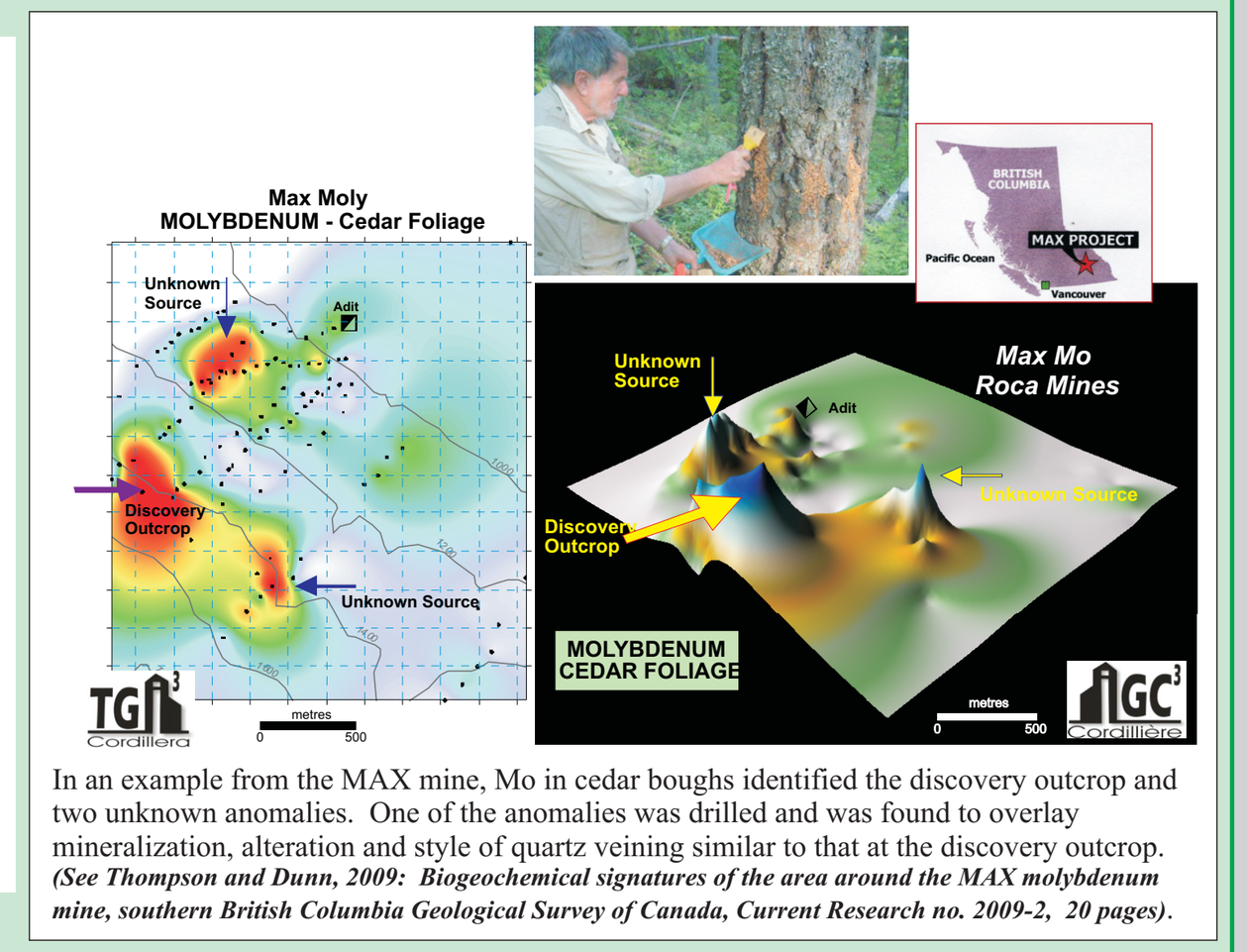
A till and tree sampling site within the Gibraltar Mine area. Optimally, tree and till sample site locations are the same.

Biogeochemistry and Identification of Anomalies

Metals are absorbed from soil, from groundwater, and locally from bedrock where roots penetrate into, and locally through many cubic metres of the cover to bedrock faults, joints and cleavage planes. The metal content measured in the plants therefore integrates the geochemical signature of a large volume of all soil horizons, the contained groundwater, and bedrock that is covered by only a few metres of overburden.

Depth of root penetration is not critical for a biogeochemical response, because local conditions may be favourable for elements to migrate upward from considerable depth in solution, by diffusion, in electrochemical cells, and possibly by seismic pumping. Further details are found in Dunn (2007).

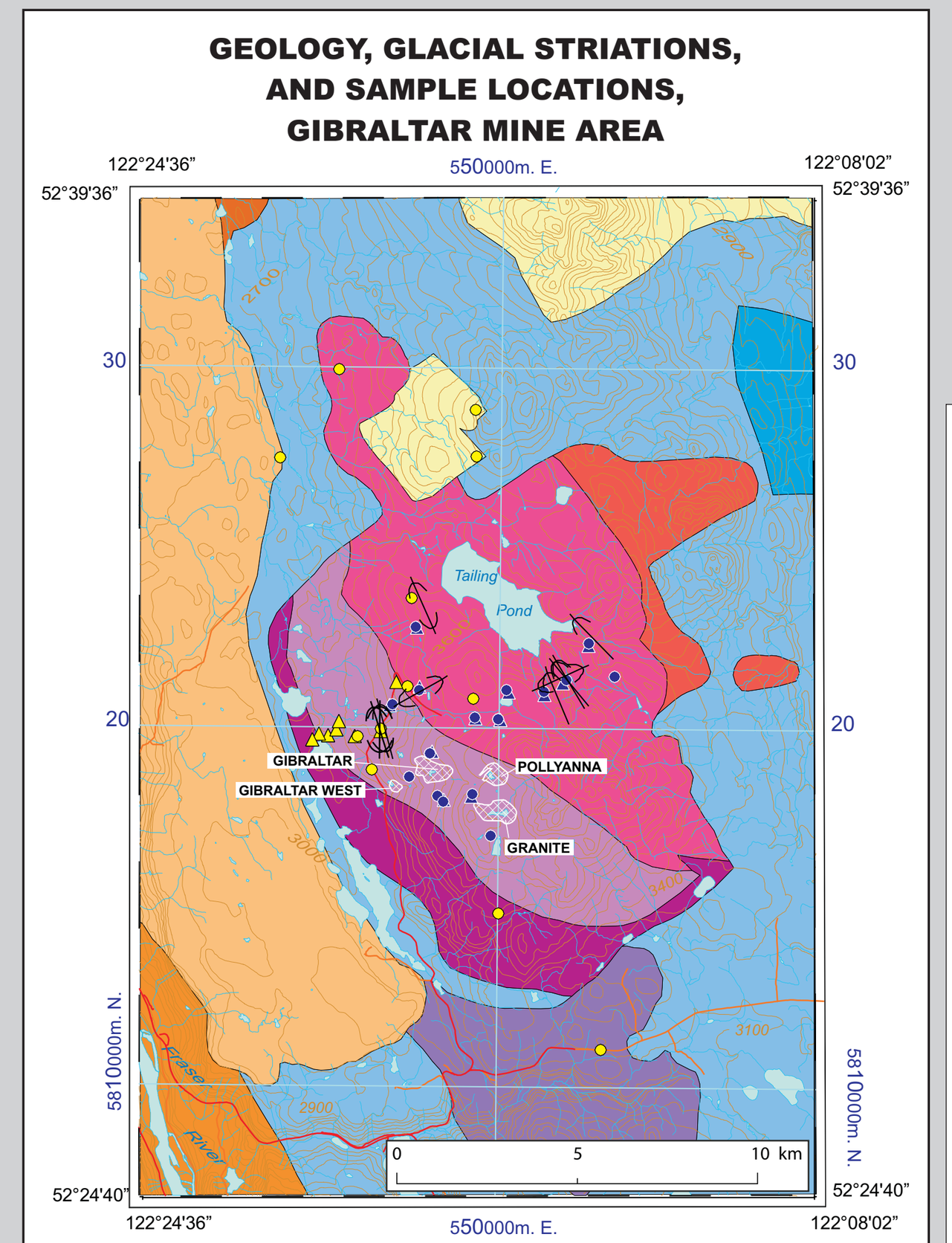
The sampling plan in Interior BC includes collections of bark from Engelmann spruce and lodgepole pine as available from the vicinity of the mine and to a distance of 10 km from the mine. A typical sample site includes one till sample and at least one, and preferably the two targeted tree species depending on the type of vegetation present. Consequently, the tree and till sample spacing will generally be similar. Duplicate samples are collected as part of the sampling protocol. The bark samples will be prepared, interspersed with biogeochemical standard samples, and all analyzed for 53 elements.

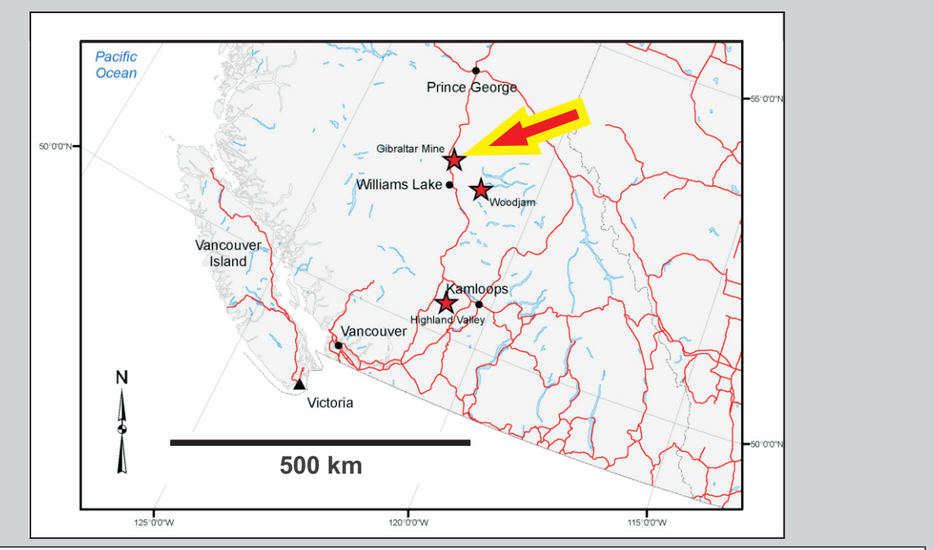


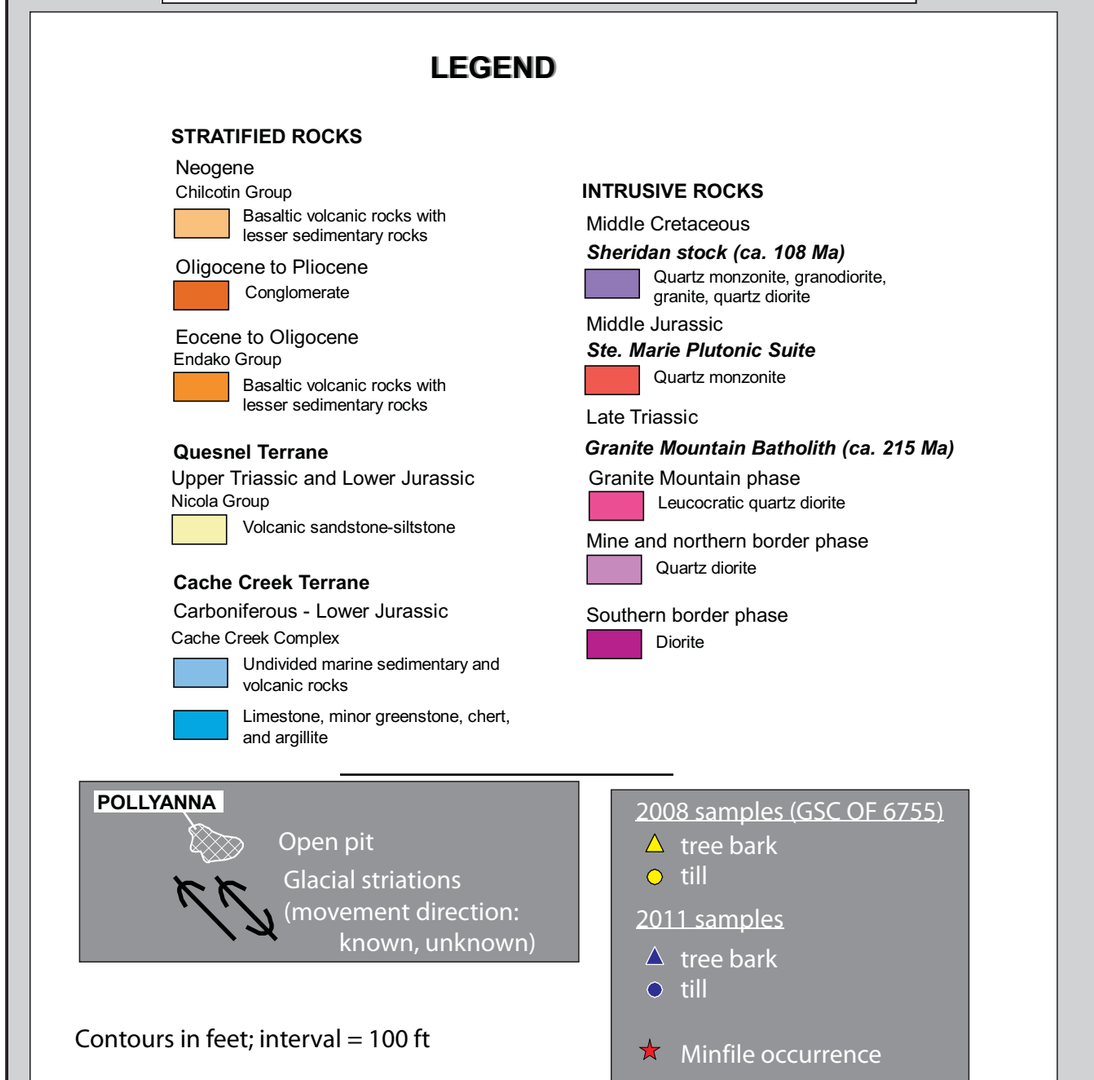
Gibraltar Mine

View south to panorama of Gibraltar pit (July 2011).

GEOLOGY, GLACIAL STRIATIONS, AND SAMPLE LOCATIONS, GIBRALTAR MINE AREA



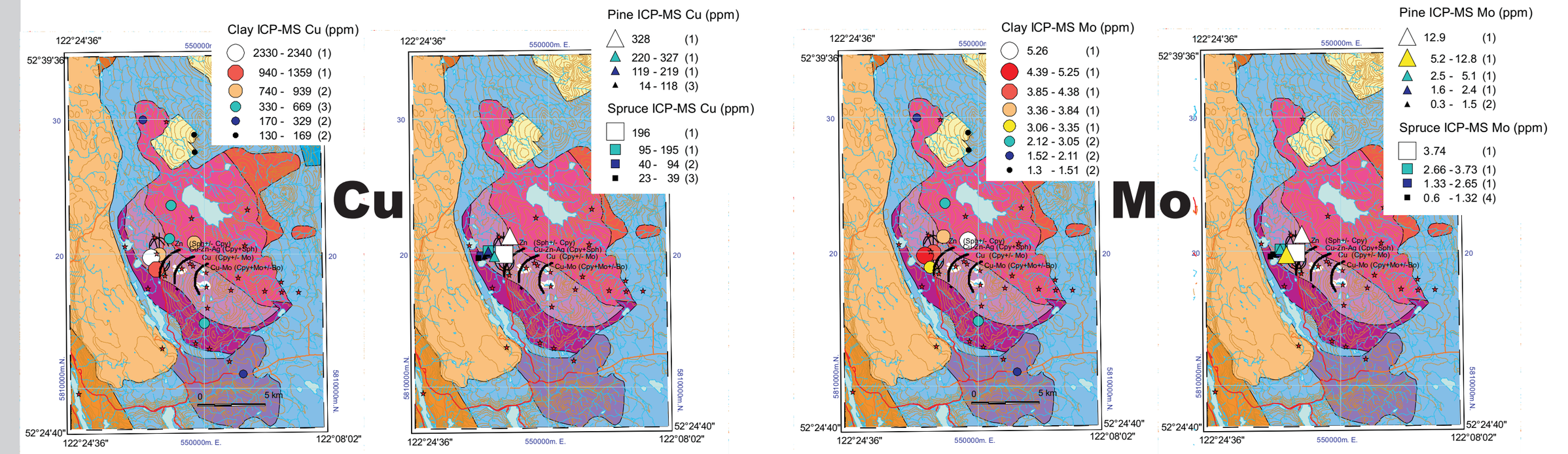


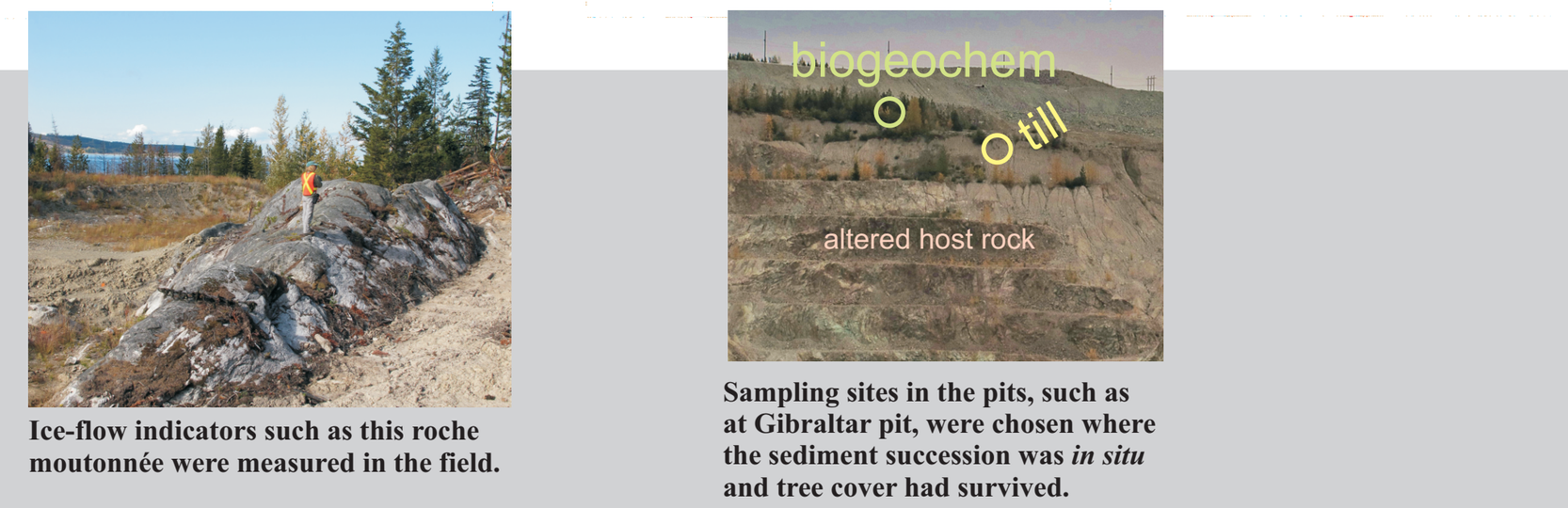


Contours in feet; interval = 100 ft

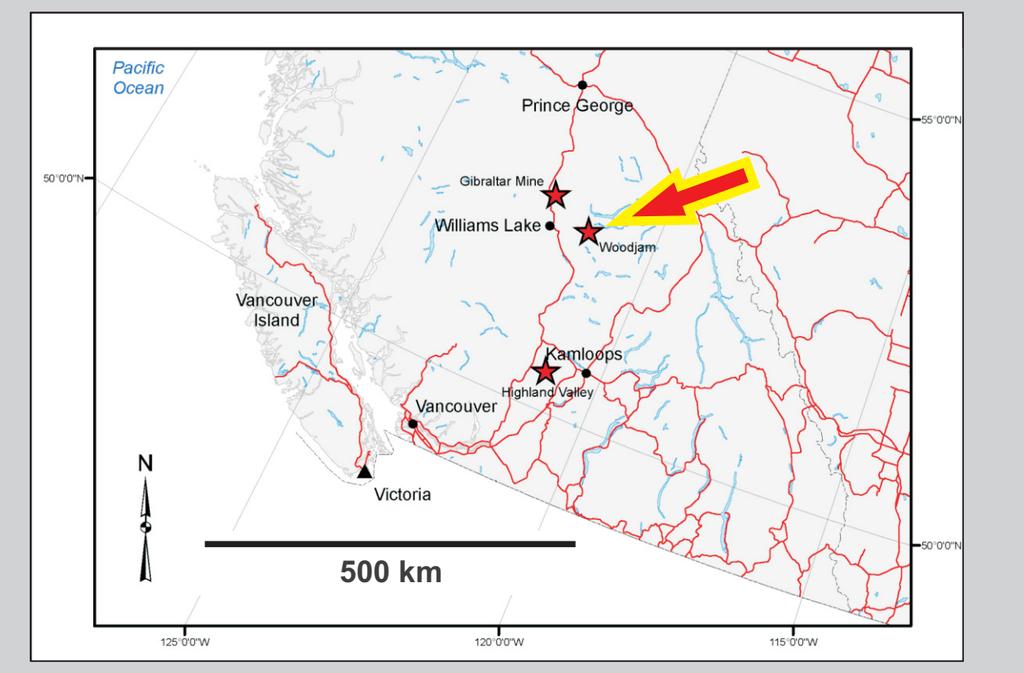
Geology from : Ash, C. H., Panteleyev, A., MacLellan, K. L., Payne, C. W., and Rydman, M. O., 1999. Geology of the Gibraltar Mine area (93B/6&9); British Columbia Ministry of Energy and Mines, Open File 1999-7, scale 1:50 000.

A pilot study conducted in the Gibraltar Mine area (Plouffe et al., 2008, GSC Open File 6755) showed:
* Cu and Mo values for coarse and clay till fractions and for pine and spruce bark significantly above background values
* an increase in Cu and Mo abundances in clay fraction and tree bark consistent with zonations reported in the mine area (see maps below).
The locations of the 2008 sample sites and those collected in 2011 are shown in the map above.

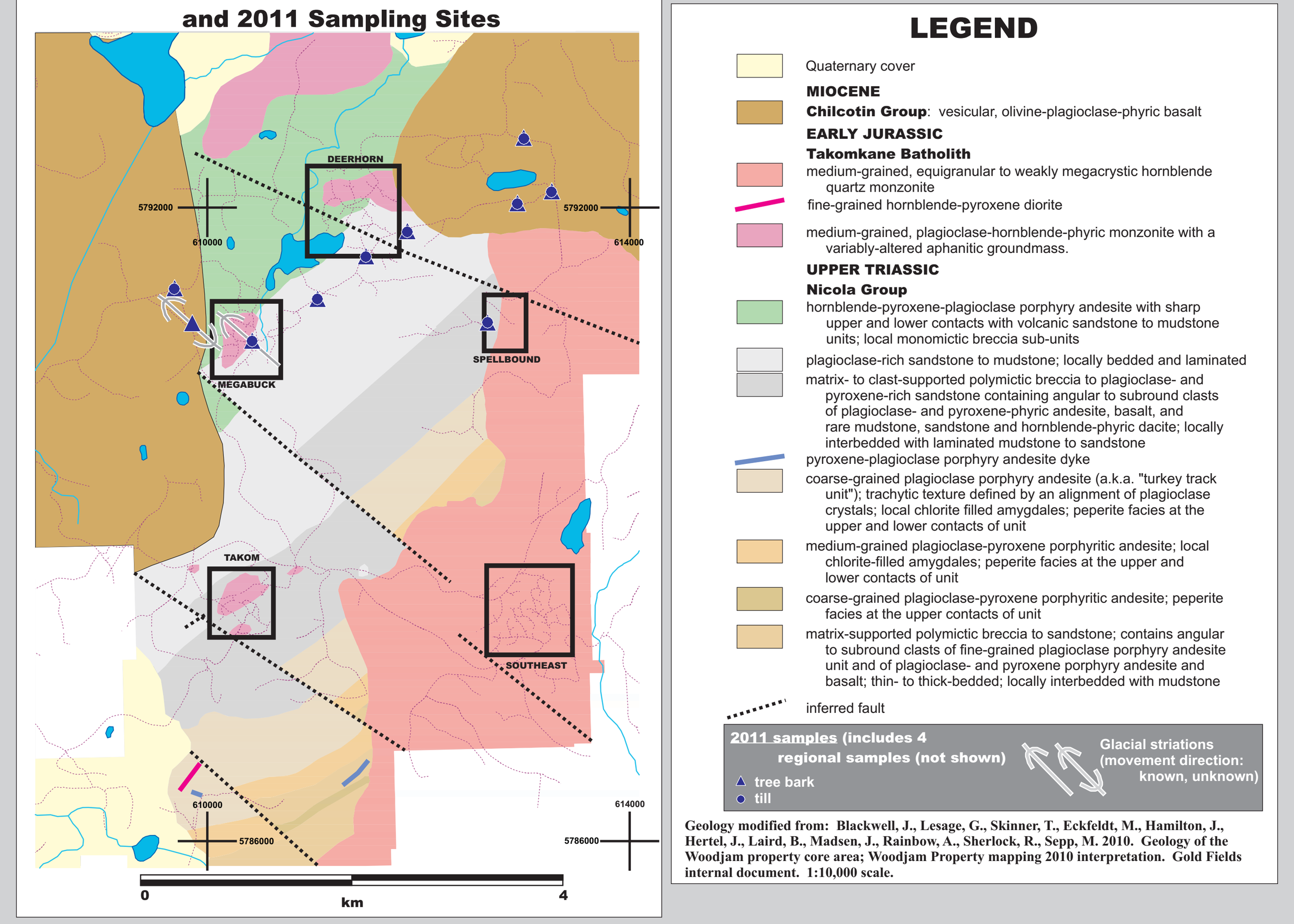

Clay ICP-MS Cu (ppm)
2330 - 2340 (1)
940 - 1359 (1)
740 - 939 (2)
330 - 669 (3)
170 - 329 (2)
130 - 169 (2)
Pine ICP-MS Cu (ppm)
328 (1)
220 - 327 (1)
119 - 219 (1)
14 - 118 (3)
Spruce ICP-MS Cu (ppm)
196 (1)
95 - 195 (1)
40 - 94 (2)
23 - 39 (3)
Cu
Clay ICP-MS Mo (ppm)
5.26 (1)
4.39 - 5.25 (1)
3.85 - 4.38 (1)
3.36 - 3.84 (1)
3.06 - 3.35 (1)
2.12 - 3.05 (2)
1.52 - 2.11 (2)
1.3 - 1.51 (2)
Pine ICP-MS Mo (ppm)
12.9 (1)
5.2 - 12.8 (1)
2.5 - 5.1 (1)
1.6 - 2.4 (1)
0.3 - 1.5 (2)
Spruce ICP-MS Mo (ppm)
3.74 (1)
2.66 - 3.73 (1)
1.33 - 2.65 (1)
Mo



Woodjam District

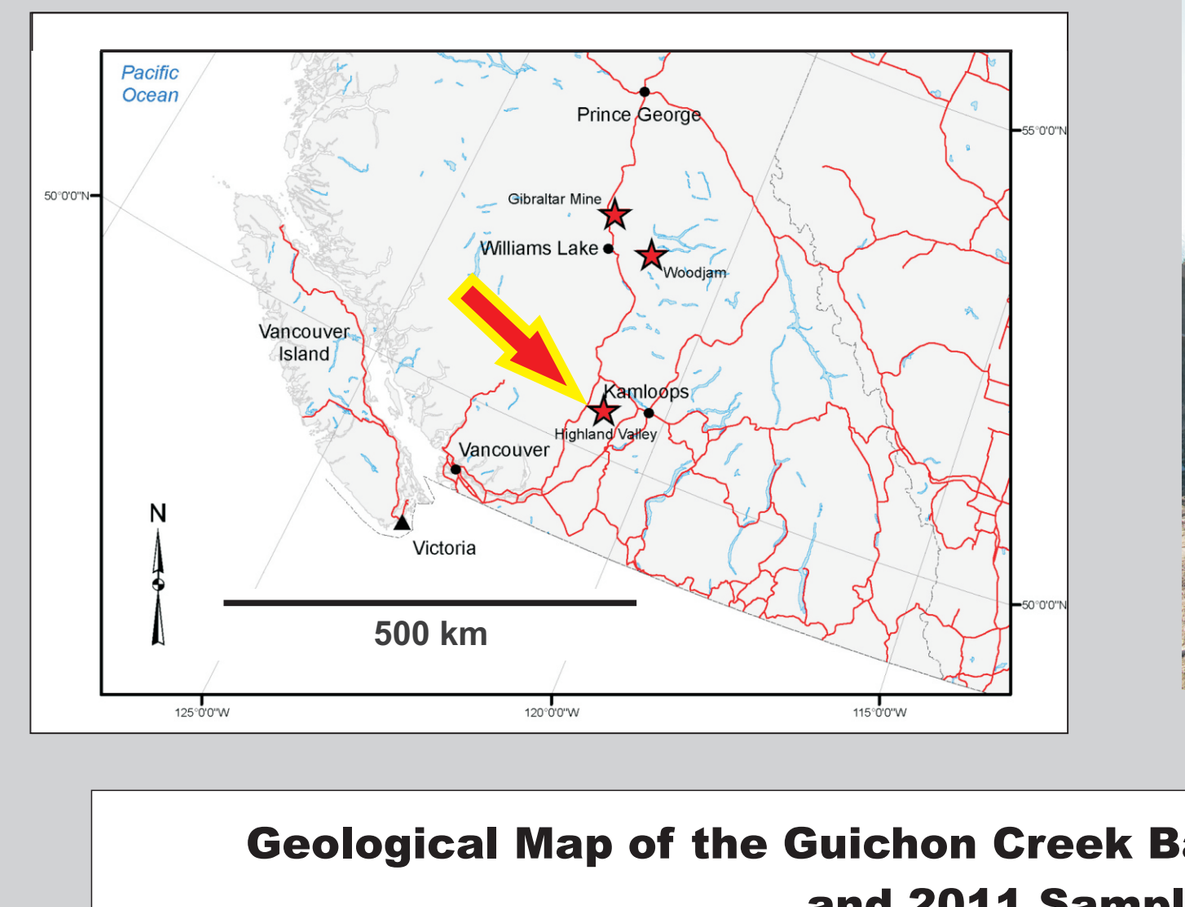


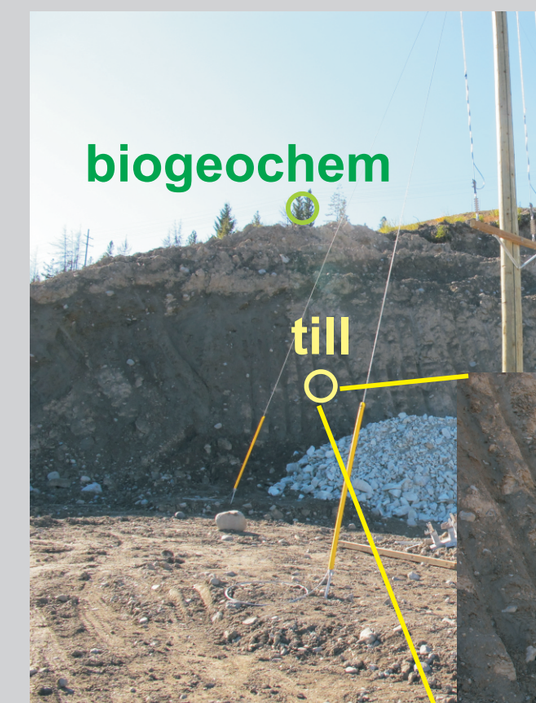
Bedrock Geological Map of the Woodjam District and 2011 Sampling Sites



Highland Valley District

View west to panorama of Valley Pit (July 2011). Pre-glacial sediment succession (in brown) visible on right hand side of pit.





Geological Map of the Guichon Creek Batholith, Highland Valley District and 2011 Sampling Sites