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

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Till in situ is exposed at a

**Highland Valley mine and** 

accessible. In the example

## **SUMMARY**

argeted Geoscience Initiative 4 is a 5-year federal program t 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 heav mineral geochemical anomalies back to the original buried

as indicators of buried mineralization. Pilot studies at the Woodjam district and Gibraltar and Highland Valley mines type (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**

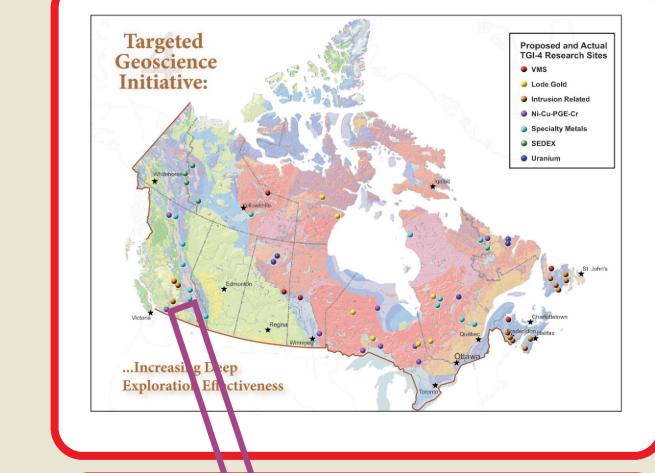
The initial studies could not have been undertaken without the support of GSC TG Villeneuve, N. Rogers, C. Hutton and C. Bjerkelund from the Geological Survey of Canada provided the Program and Project support to enable the fieldwork to be

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

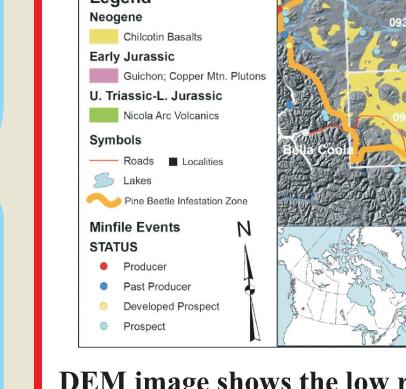
A review by Alex Zagorevski improved the content and presentation of information

Mineral exploration at Highland Valley continues for deep deposits (September 20



arguted Geoscience Initiative 4: 2011 study sites

Legend Neogene



**DEM** image shows the low relief Interior Plateau compared with mountain ranges to west and east. The abundance of base- and precious metal mineral showing around the periphery of the plateau (coloured dots) can 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 Ar porphyry deposit metallotect is also shown.

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

innovative changes in technology to improve the effectivenes in exploration for covered or deep deposits.

renewed (TGI4) with the objective of improving deep mineral exploration effectiveness, in established and geoscience program which will provide industry with the techniques that will result in more effective targeting of

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

### Current Situation:

Canada's reserves of metals have been declining for 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, educing the investment risk and cost through smarter

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

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

**Ouestion:** Do trees or surficial sediments display disting 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, Mount Polley) and of its potential fo Woodiam) which are obscured by **I** glacial deposits and unmineralized Tertiary basalt flows.

# Methodologies

Drift Prospecting and Ice-flow History

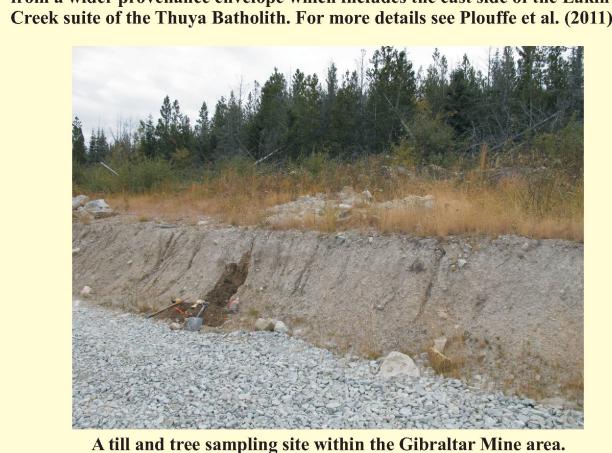
was left following the glaciation which hides prospective geology in a vast sediments resulting from the erosion of the mineralization might be geochemically enriched in a suite of elements or might contain minerals indicative of porphyry mineralization. The objectives of this activity are to determine 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

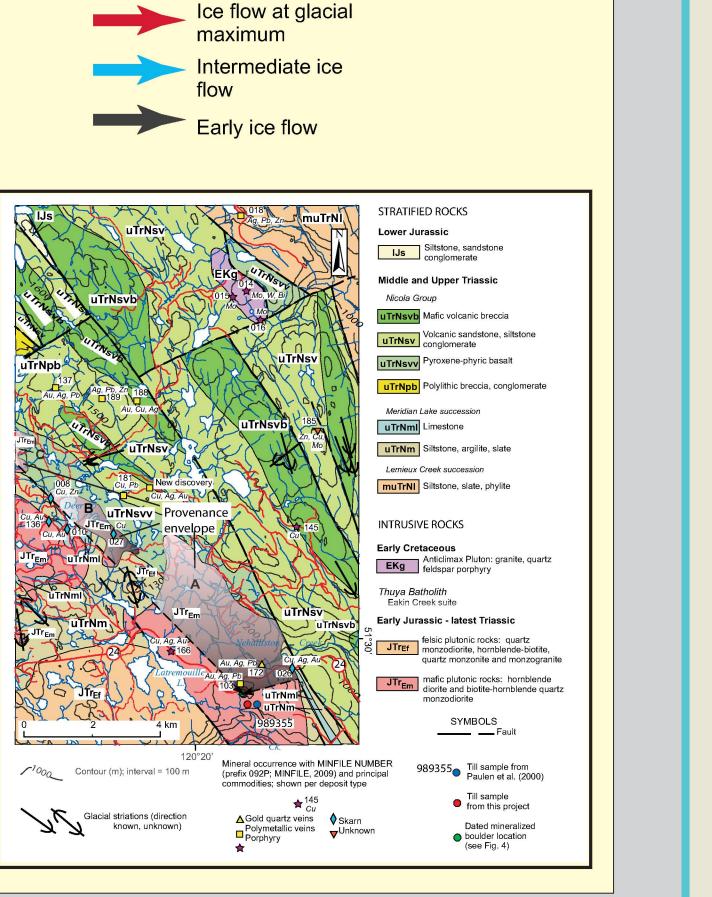
The map on the right, from the Bonaparte Lake region, illustrates ar example of the recently reconstructed ice-flow history of the Bonaparte Lake map area. It shows that at the onset of the last glaciation, ice was flowing to the west and southwest from an ice source region located in the Cariboo Mountains. 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

outcrop (e.g. striations) scales.

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



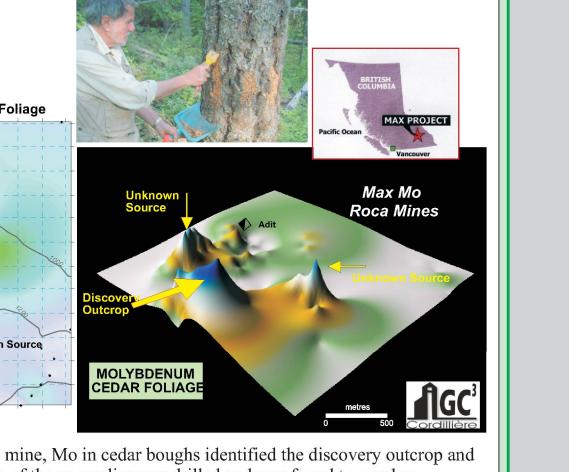
Optimally, tree and till sample site locations are the same.



### Biogeochemistry and Identification of Anomalies Metals are absorbed from soil, from groundwater, and locally

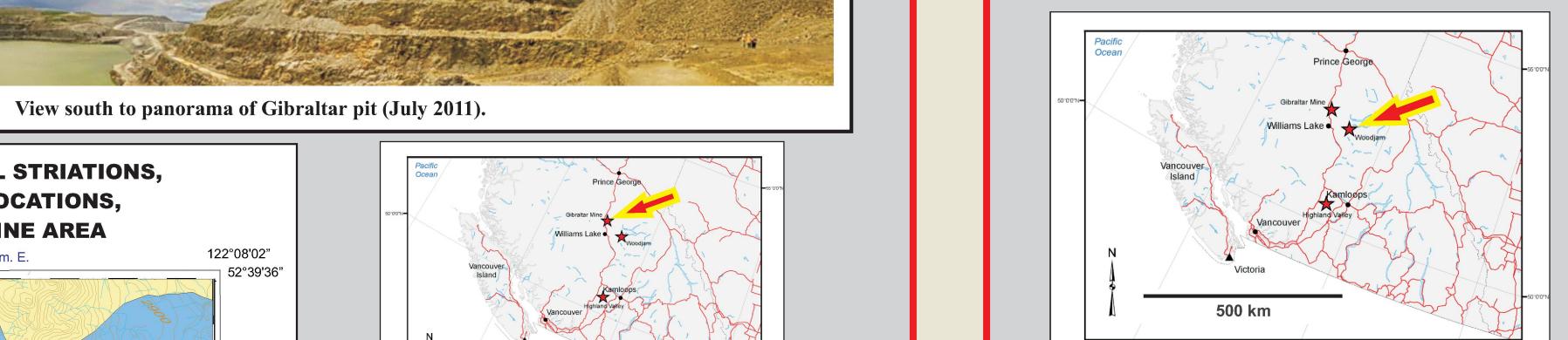
from bedrock where roots penetrate into, and locally through many cubic metres of the cover to bedrock faults, joints and cleavage planes. The metal content measured in the plants therefore integrates the geochemical signature of a large volume of all soil horizons, the contained groundwater, and bedrock 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).

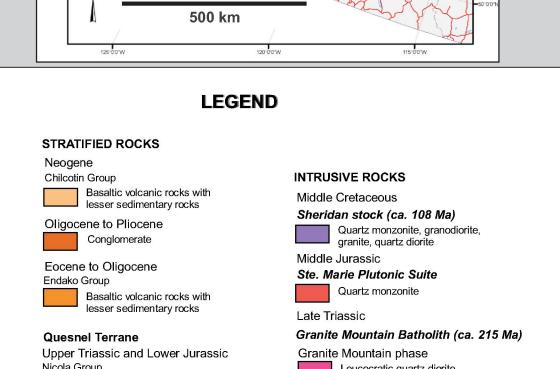
The sampling plan in Interior BC includes collections of bark from Engelmann spruce and lodgepole pine as available from the vicinity of the mine and to a distance of 10 km from the mine. A typical sample site includes one till sample and at least one, and preferably the two targeted tree species depending 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



neralization, alteration and style of quartz veining similar to that at the discovery outcrop. (See Thompson and Dunn, 2009: Biogeochemical signatures of the area around the MAX molybdenum mine, southern British Columbia Geological Survey of Canada, Current Research no. 2009-2, 20 pages).

## Gibraltar Mine

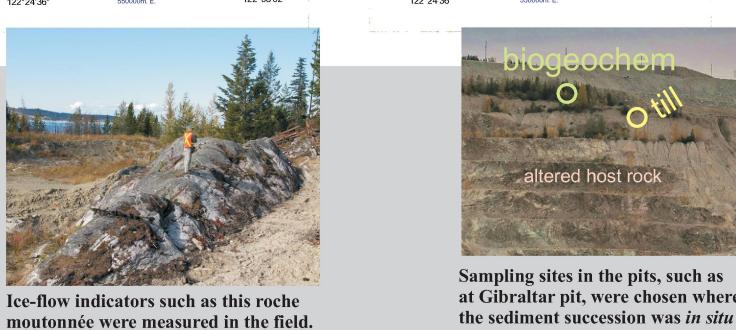




Leucocratic quartz diorite Volcanic sandstone-siltstone and northern border phase Cache Creek Terrane Carboniferous - Lower Jurassic Southern border phase Cache Creek Complex Undivided marine sedimentary and

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: <sup>c</sup>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



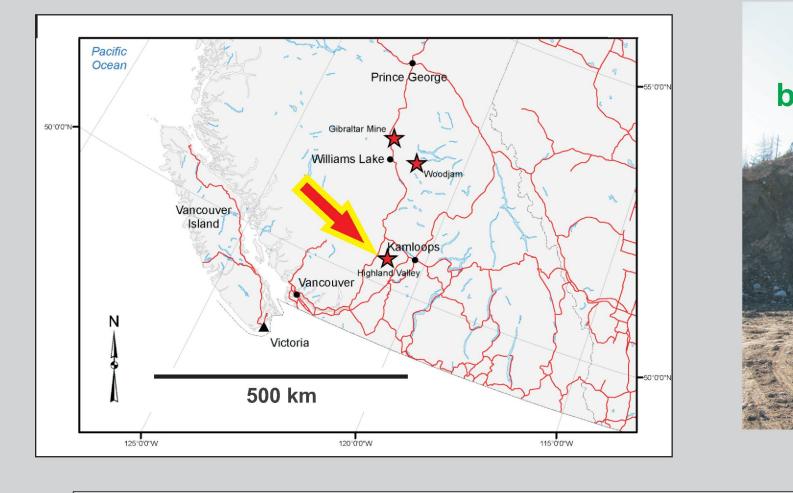
Chilcotin Group basalt.

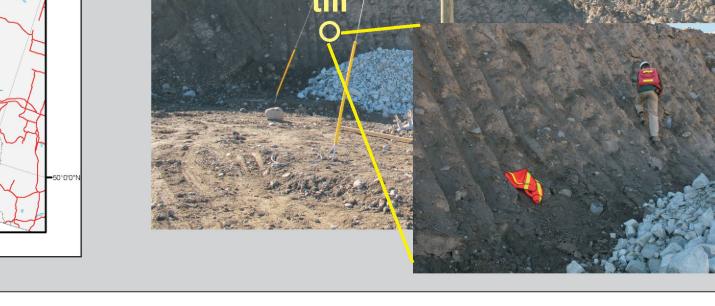
### Woodjam District A large (ca. 10 kg bag on left) and small (ca. 2 Effects on till composition caused by kg) till samples were collected at every changes in ice-flow direction and sour sampling site. The large sample is processed area are tested by till samples collected at for indicator minerals and the small one for different stratigraphic levels. Bedrock Geological Map of the Woodjam District and 2011 Sampling Sites Chilcotin Group: vesicular, olivine-plagioclase-phyric basalt medium-grained, equigranular to weakly megacrystic hornblende fine-grained hornblende-pyroxene diorite variably-altered aphanitic groundmass. hornblende-pyroxene-plagioclase porphyry andesite with sharp upper and lower contacts with volcanic sandstone to mudstone nits; local monomictic breccia sub-units plagioclase-rich sandstone to mudstone; locally bedded and laminated matrix- to clast-supported polymictic breccia to plagioclase- and plagioclase- and pyroxene-phyric andesite, basalt, and rare mudstone, sandstone and hornblende-phyric dacite; locally interbedded with laminated mudstone to sandstone pyroxene-plagioclase porphyry andesite dyke coarse-grained plagioclase porphyry andesite (a.k.a. "turkey track unit"); trachytic texture defined by an alignment of plagioclase crystals; local chlorite filled amygdales; peperite facies at the upper and lower contacts of unit medium-grained plagioclase-pyroxene porphyritic andesite; local chlorite-filled amygdales; peperite facies at the upper and coarse-grained plagioclase-pyroxene porphyritic andesite; peperite facies at the upper contacts of unit matrix-supported polymictic breccia to sandstone; contains angular to subround clasts of fine-grained plagioclase porphyry andesite unit and of plagioclase- and pyroxene porphyry andesite and basalt; thin- to thick-bedded; locally interbedded with mudstone Geology modified from: Blackwell, J., Lesage, G., Skinner, T., Eckfeldt, M., Hamilton, J Hertel, J., Laird, B., Madsen, J., Rainbow, A., Sherlock, R., Sepp, M. 2010. Geology of the Woodjam property core area; Woodjam Property mapping 2010 interpretation. Gold Fields internal document. 1:10,000 scale.

were sampled if present at the sampling site.

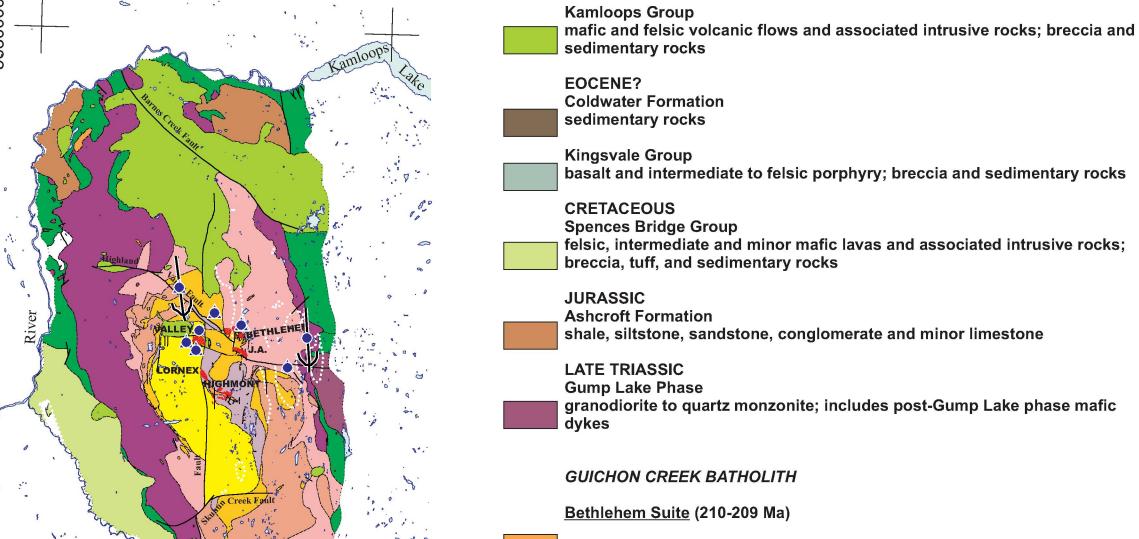
# Highland Valley District







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





post-Bethsaida phase quartz porphyry and aplitic dykes ethsaida Phase : quartz monzonite to granodiorite Skeena Sub-phase: intermediate in composition and

texture between Bethsaida and Bethlehem phases Bethlehem Phase: granodiorite Highland Valley Suite (ca. 211 Ma)

Chataway Phase: granodiorite Guichon Phase: fine- and medium-grained granodiorite

Border Phase: mafic quartz diorite to granodiorite **UNASSIGNED INTRUSIONS** Coyle Stock: diorite to quartz monzonite, local alaskite

Geological base map modified from. McMillan, W.J., Anderson, R.G., Chen, R., and Chen, W., 2009. Geology and mineral occurrences (MINFILE), the Guichon Creek Batholith and Highland Valley porphyry copper district, British Columbia, Geological Survey of Canada, Open File 6079.

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deposits; a new TGI4 activity in the southern This publication is available from the Geological Survey of Canada Books

Canada, Open File 7081, poster.

It can also be downloaded free of charge from GeoPub

Ilimits for some dyke swarms

mafic, intermediate and uncommon felsic flow rocks and breccia; associated

volcano-sedimentary rocks and minor limestone









and tree cover had survived.