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Discovering buried copper porphyry mineralization: geochemistry and indicator minerals in till

A. Plouffe and T. Ferbey

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Discovering buried copper porphyry mineralization: geochemistry and indicator minerals in till

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Publications in this series have not been edited; they are released as submitted by the author.

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ABSTRACT

Till orientation surveys at Gibraltar Mine (copper-molybdenum porphyry), Mount Polley Mine (copper-gold porphyry) and the Woodjam prospect (copper-gold porphyry) in south central British Columbia have defined geochemical and mineralogical indicators of porphyry mineralization dispersed within till deposits. These indicators are more abundant near mineralization than in surrounding regions which include higher copper values in the clay-sized fraction (<0.002 mm) and elevated chalcopyrite and gold grains counts in the sand-sized fraction of till. The regional distribution of these indicators are dispersed in the direction of former glacial flow. The reconstructed ice-flow history includes two dominant phases of ice movement: a first phase of westerly to southwesterly glacier movement which occurred at the onset of the last glaciation when ice flowed from the Cariboo Mountains and, a second phase of northwesterly glacier movement related to the formation of an ice divide at last glacial maximum, around the 52° north latitude. Using copper and copper-gold porphyry indicator minerals identified as part of the orientation surveys, we test the potential of copper porphyry mineralization in the region of two Late Triassic to Early Jurassic intrusions (Thuya and Takomkane batholiths) that have potential to host porphyry mineralization. A previous regional till sampling survey completed in this region revealed copper enrichment and elevated gold grain counts in till at the northern end of the Thuya batholith and along the western margin of the Takomkane batholith. The region with elevated gold grain counts in till (> 66 gold grains / 10 kg) in the northern sector of the Thuya batholith is aerially extensive (ca. 10 x 20 km or 200 km^2) representing one of the largest known gold grain dispersal trains in till in Canada most likely derived from multiple mineralized bedrock sources. A limited number (n=57) of archived heavy mineral (>3.2 s.g.) samples were reprocessed for porphyry copper indicator minerals. Chalcopyrite was identified in nineteen till samples (up to 11 grains per 10 kg) in the same two areas (west of the Takomkane and north of the Thuya batholiths) which suggests that both areas have potential to host copper-gold porphyry mineralization.

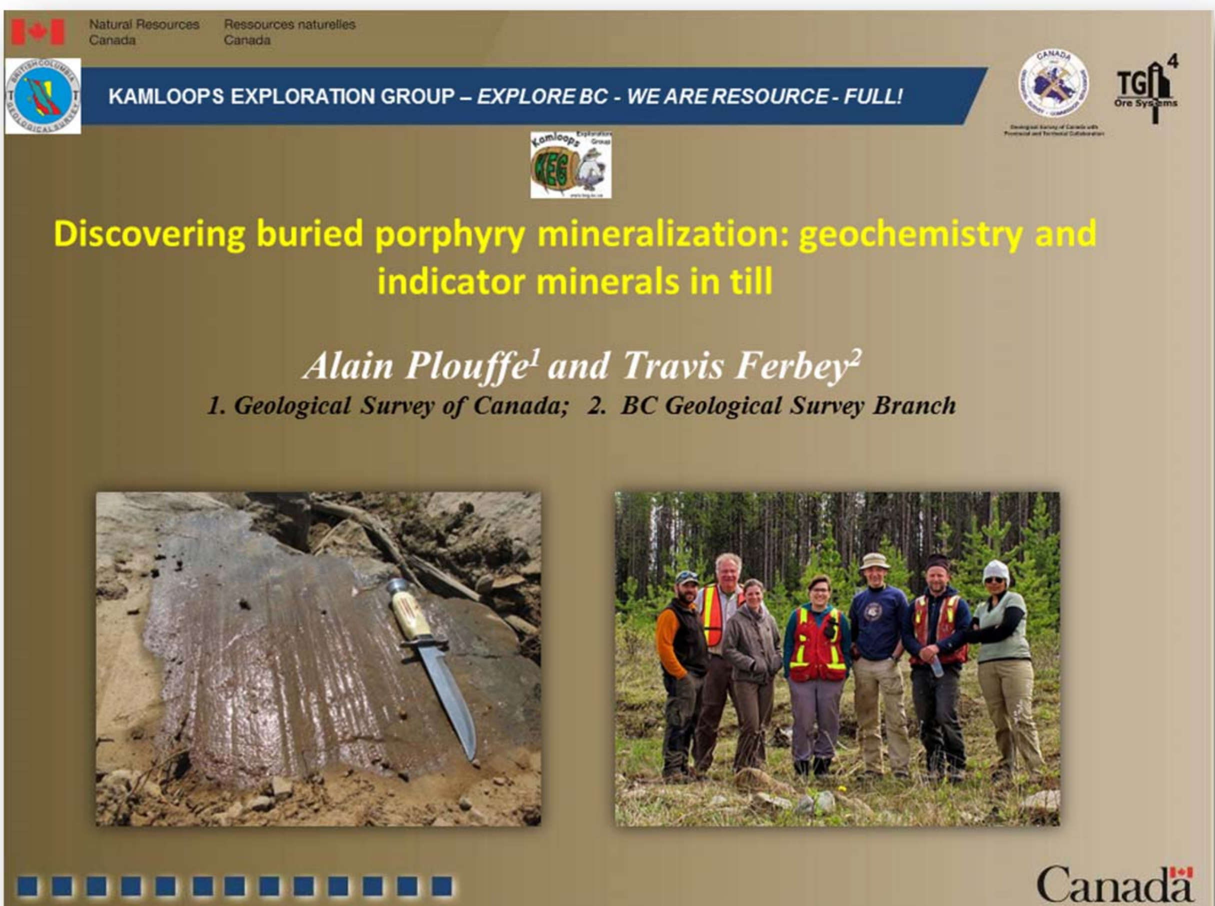
INTRODUCTION

The 27th Kamloops Exploration Group (KEG) Conference and Trade Show was held on April 8th and 9th 2014, in Kamloops British Columbia, attracting over 500 registrants. The goal of the conference is to gather technical presentations, posters and commercial exhibits to facilitate exchange on all aspects of mineral exploration in British Columbia.

This Open File contains the slides and descriptive notes of a technical presentation given at KEG on till geochemistry and mineralogy near copper porphyry mineralization. The purpose of the presentation is to demonstrate key indicators of porphyry mineralization that we have identified in till (copper content of the clay-sized fraction, chalcopyrite and gold grain counts) and that these indicators can serve to define porphyry mineral exploration targets in a prospective geological setting. This research is being conducted as part of the Targeted Geoscience Initiative – 4 involving the collaboration of the Geological Survey of Canada (GSC; Natural Resources Canada) and the British Columbia Geological Survey (British Columbia Ministry of Energy and Mines).

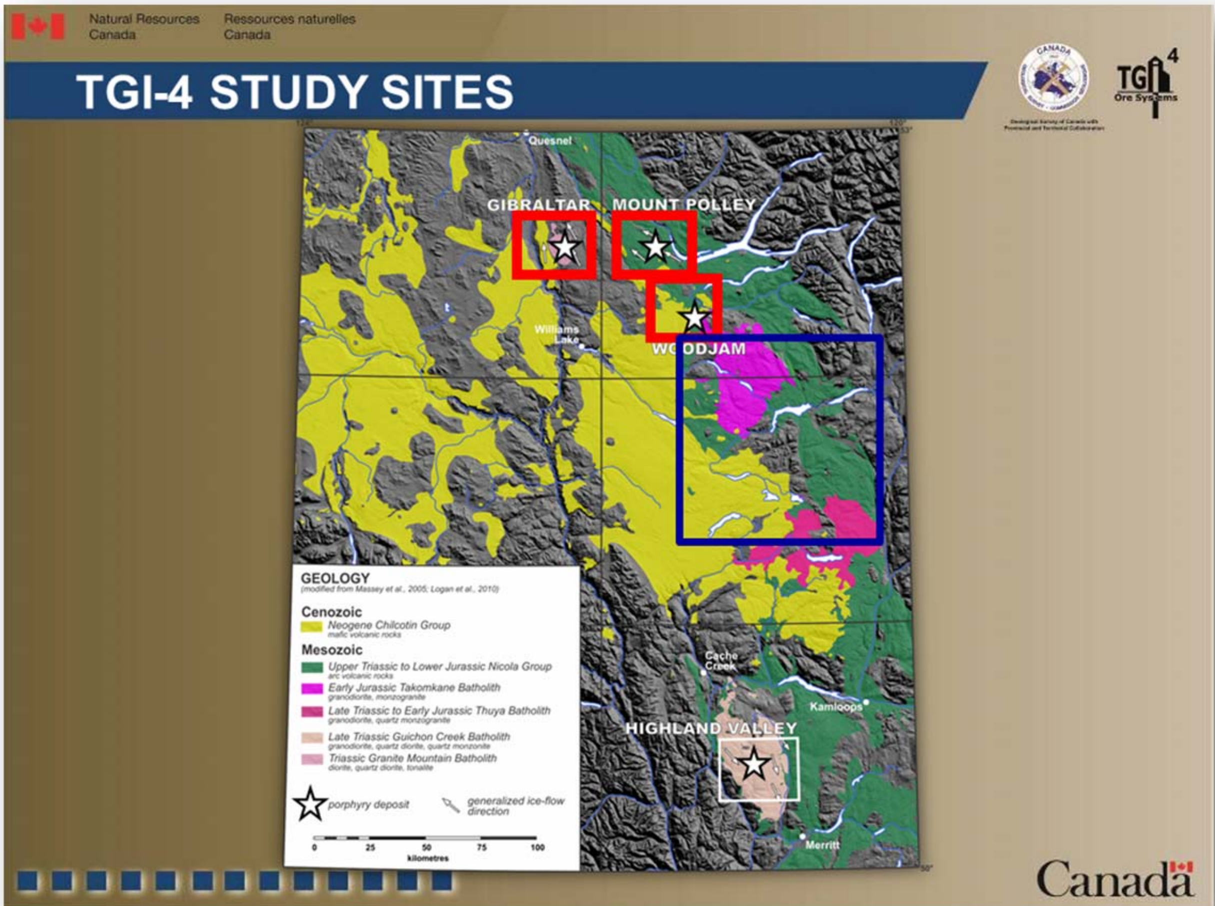
Preliminary results from this project have been disseminated in Current Research papers and Open Files reports: (Plouffe et al., 2011a, 2012, 2013a, b, 2014; Anderson et al., 2012a, b, c; Ferbey et al., 2014; Hashmi et al., 2014).

Slide 1



Title of the presentation, authors and their affiliations.
Photograph on the right: 2012 field crew. From left to right: D. Sacco, R.G. Anderson, K.-L. Robillard, N. Evanoff, A. Plouffe, T. Ferbey, and S. Hashmi.
Photograph on the left: Glacial striations on an outcrop of Nicola Group volcanic rocks 4 km northwest of Mount Polley Mine. Striations are oriented 120-300°. Knife for scale is 24 cm.

Slide 2



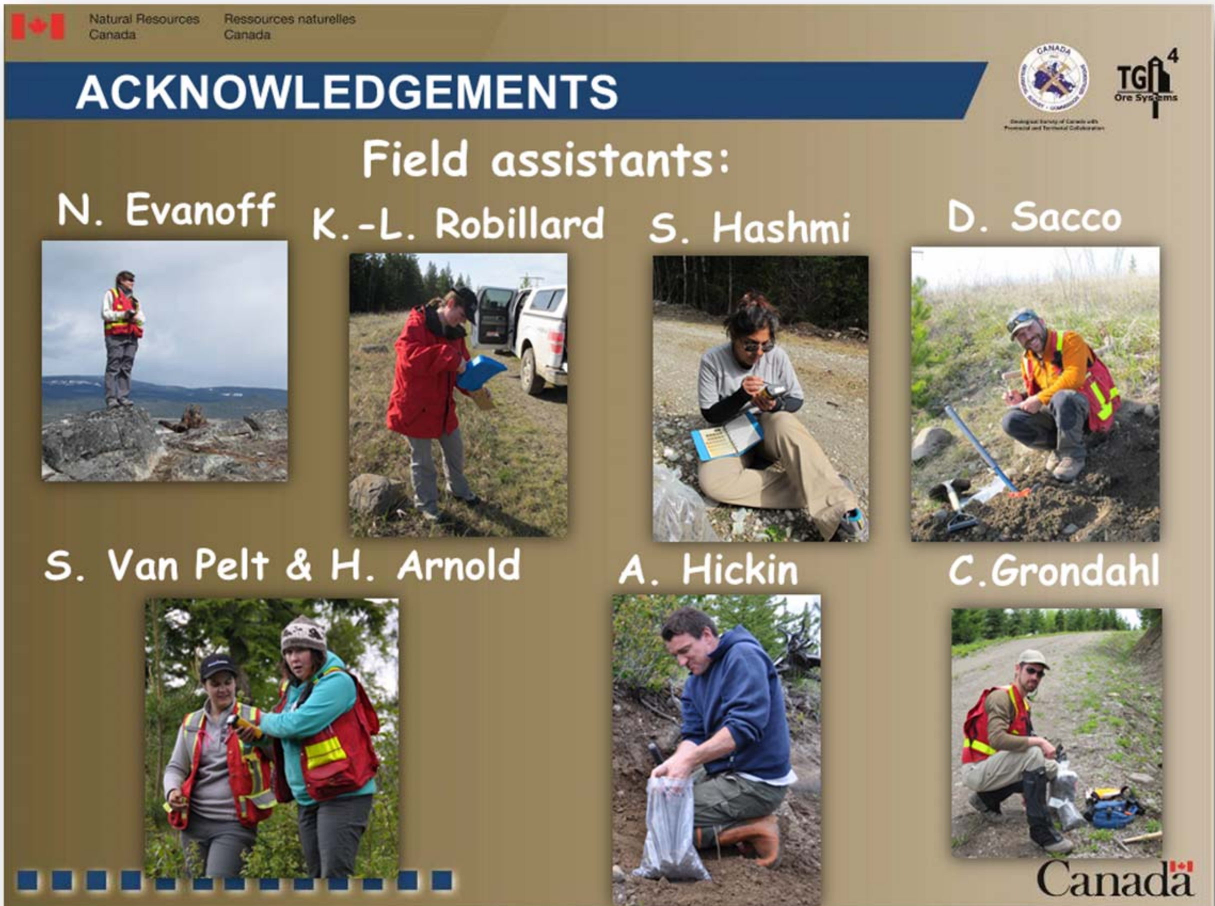
Till orientation surveys were completed at four sites: Highland Valley Copper Mine, Gibraltar Mine, Mount Polley Mine and the Woodjam prospect (white stars). Results from three of those four sites are presented here: Gibraltar Mine (copper-molybdenum porphyry), Mount Polley Mine (copper-gold porphyry), and the Woodjam prospect (copper-gold porphyry). These three sites are located with red boxes which also define the extent of till sampling. The study sites are depicted on a generalized and simplified geological map draped on a digital elevation model produced from Shuttle Remote Topographic Mission (SRTM) data (http://eros.usgs.gov/). The depicted bedrock units include the Late Triassic to Early Jurassic intrusive rocks which are known to be prospective for copper porphyry mineralization (McMillan and Panteleyev, 1995; McMillan et al., 1995; Logan and Mihalynuk, 2014), the Upper Triassic to Lower Jurassic Nicola Group volcanic and associated sedimentary rocks which define the Quesnel Terrane, and the Neogene Chilcotin Group mafic volcanic rocks which cover and mask underlying geological units and therefore, hinder mineral exploration over a large part of the Interior Plateau of British Columbia.

This presentation focusses on key geochemical and mineralogical indicators of copper porphyry mineralization identified in till at Gibraltar and Mount Polley mines, and the Woodjam prospect. Using those indicators, we test the potential of copper porphyry mineralization in the northern sector of the Bonaparte Lake map area (NTS 092P) (blue box above) where there are two Late Triassic to Early Jurassic intrusions (Thuya and Takomkane batholiths) that are prospective for copper porphyry mineralization. Archived till samples collected as part of a previous GSC project (Plouffe et al., 2009, 2010) within this region of interest were utilized for this purpose.
The till orientation surveys followed the field and analytical guidelines suggested by Spirito et al. (2011). Geochemical and mineralogical analytical methods applied to the till samples are summarized in Plouffe et al. (2013a). Indicator minerals analyses followed the protocols outlined in Plouffe et al. (2013c).

Slide 3

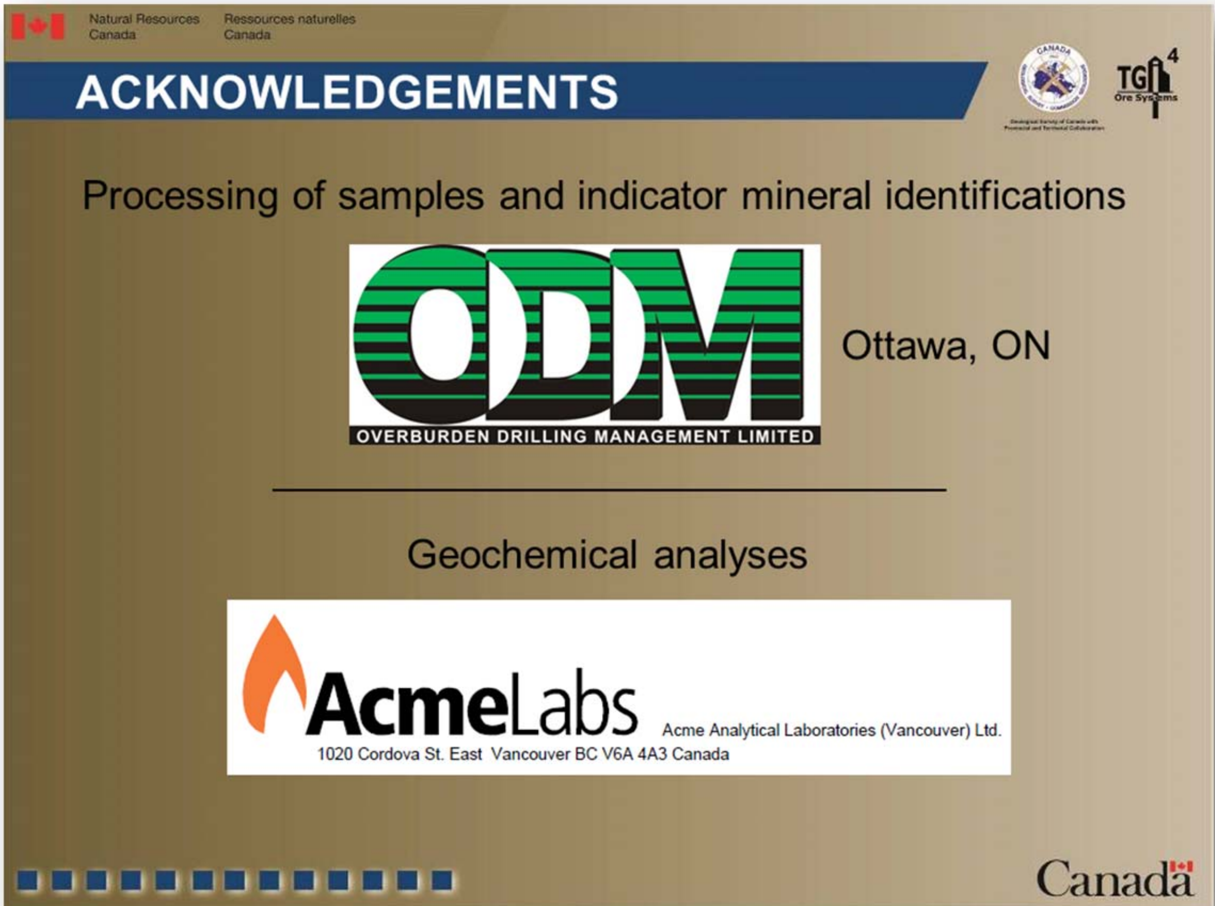
The research in this presentation would not have been possible without the support of the companies involved at each of the four study sites: Taseko Mines Limited (Gibraltar Mine), Gold Fields and Consolidated Woodjam Copper Corporation (Woodjam prospect), Teck Resources Limited (Highland Valley Copper Mine) and Imperial Metals Corporation (Mount Polley Mine). All individuals listed on this slide are acknowledged for being supportive of our project, for participating in enlightened geological discussions, for touring us in the field or at the mine site, and for ensuring our safety while at the mine or project site.

Slide 4



H. Arnold, N. Evanoff, C. Grondahl, S. Hasmi, A. Hickin, K.-L. Robillard, D. Sacco, and S. Van Pelt provided capable field assistance.

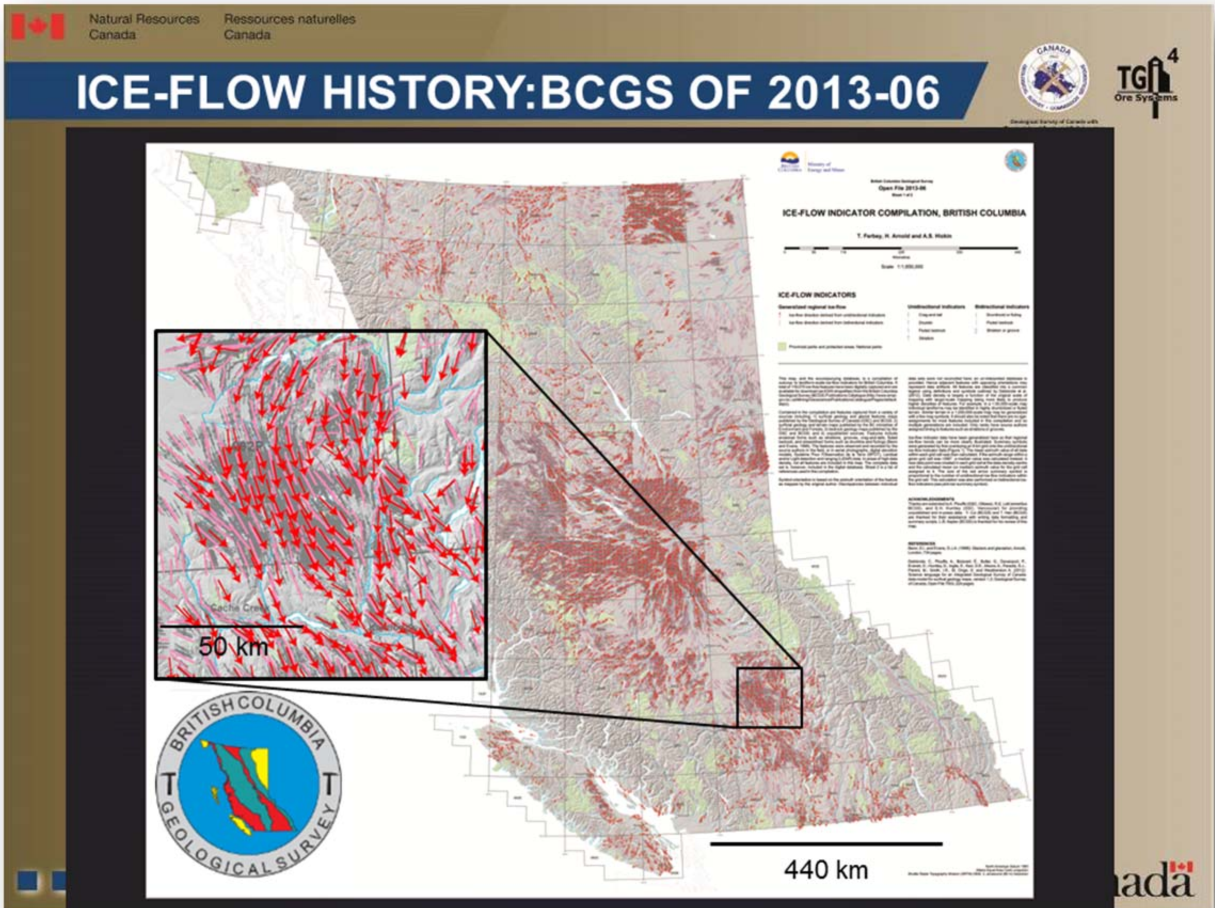
Slide 5



Heavy mineral separations and identifications on the sand-sized fraction of till were performed by Overburden Drilling Management Ltd. (ODM Ltd.) in Ottawa, ON. Geochemical analyses on the clay-sized fraction of till were completed at Acme Analytical Laboratories, a division of the Bureau Veritas Commodities Canada Limited, in Vancouver, BC. Both commercial laboratories are acknowledged for their professional services.

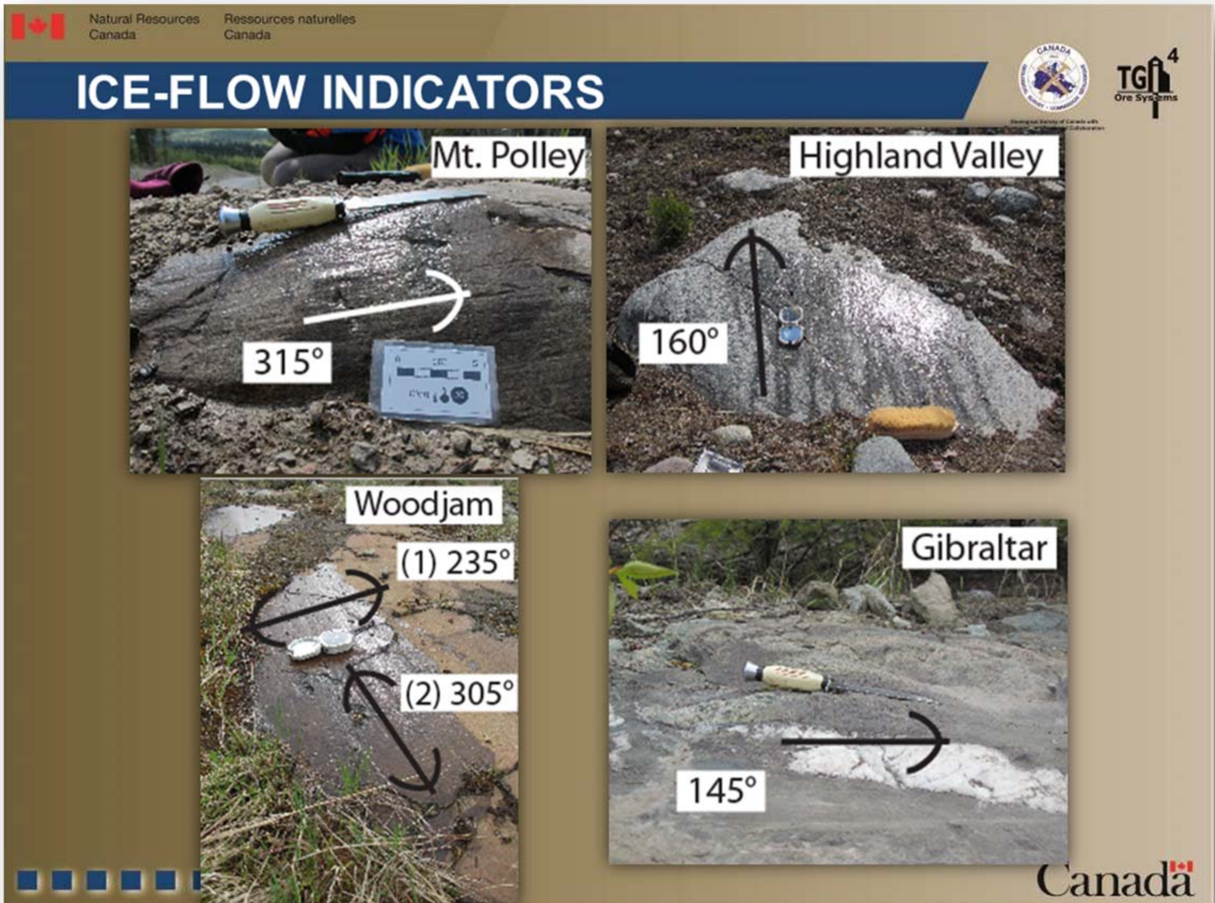
ICE-FLOW HISTORY

Slide 6



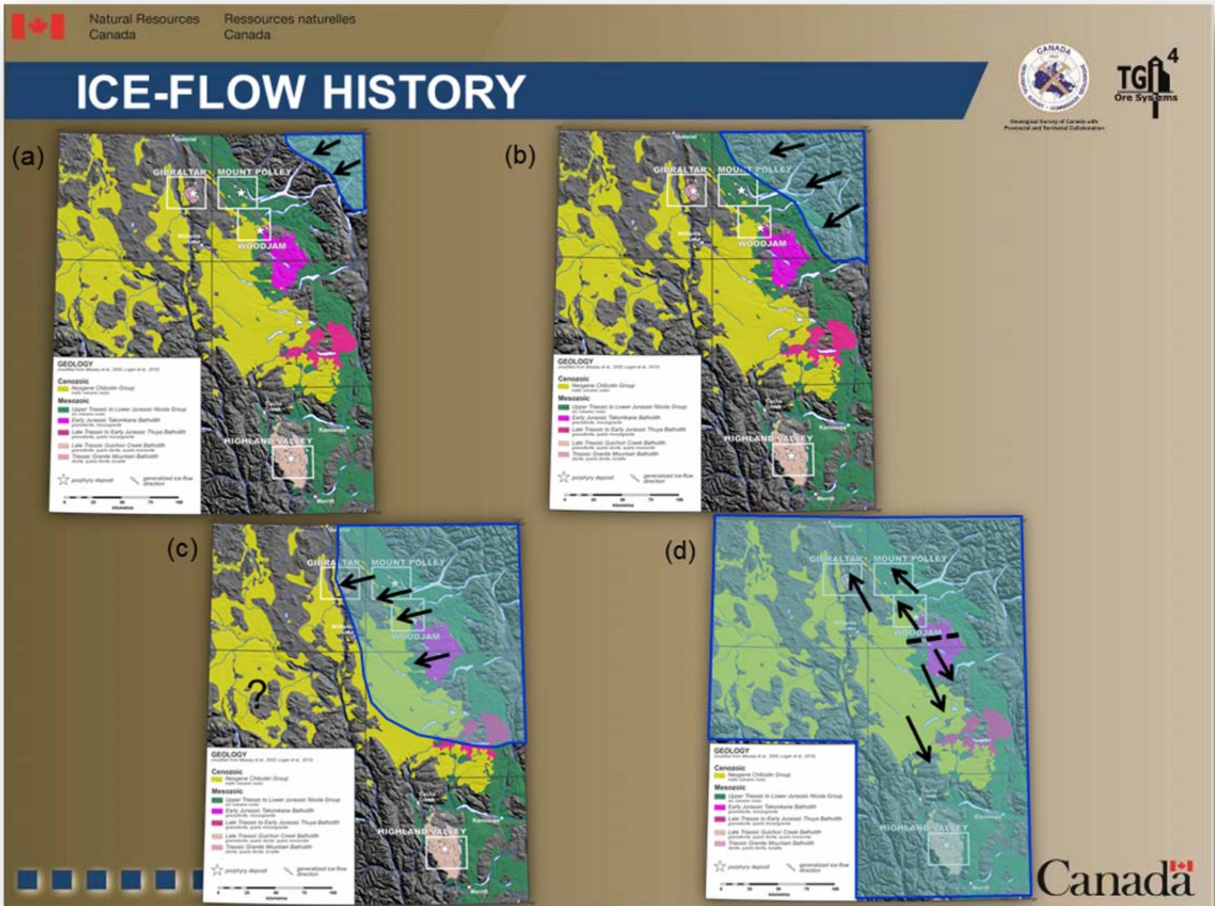
The history of ice-flow movements responsible for detrital glacial transport needs to be established for the interpretation of till geochemistry and mineralogy. Ice-flow movements in south central British Columbia have been interpreted in a number of papers and surficial geology maps (e.g. Fulton, 1967, 1975; Tipper, 1971a; Lian and Hicock, 2000; Bednarski, 2009a, b, 2010a, b; Huscroft, 2009a, b; McCuaig, 2009; Plouffe, 2009a, b, c, d; Plouffe et al., 2011b). In addition, as depicted on this slide, ice-flow indicators have been compiled from surficial geology maps for British Columbia by Ferbey et al. (2013). As an example, the region northwest of Kamloops is enlarged to show the drumlins and flutings (grey symbols) and the reconstructed generalized ice-flow (pink and red symbols). These data are the starting point for the reconstruction of the ice-flow histories at each study site.

Slide 7



To further detail local ice-flow history, glacial striations were measured on a number of bedrock outcrops at all study sites. Examples of striations are shown on this slide. In rare instances, two phases of ice movement were identified and their chronology could be established based on cross-cutting relationships. For example, on an outcrop of Chilcotin basalt, in the region of the Woodjam prospect, grooves oriented 055° – 235° contain, and therefore are cross-cut by younger striations 125° – 305°.

Slide 8

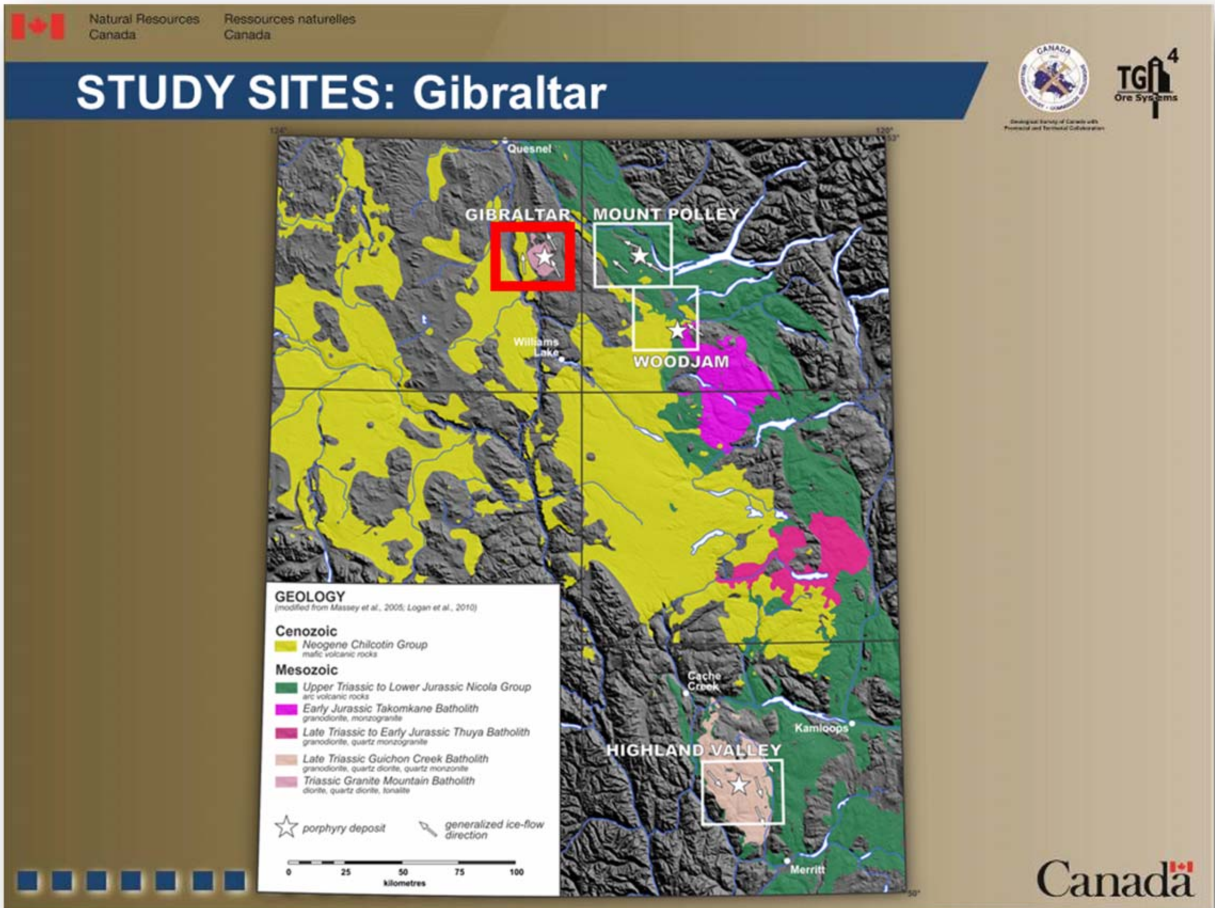


The regional ice-flow history for the southern sector of the Cordilleran Ice Sheet, which covered the southern Interior Plateau of British Columbia, is presented here. The configuration of the ice sheet margin is based on previous studies (Tipper, 1971a, b; Plouffe et al., 2011b; Anderson et al., 2012b) and augmented with our field observations.

At the onset of the last glaciation (Late Wisconsinan) in this part of British Columbia, glaciers first formed in the Cariboo Mountains (a and b in slide above). Valley glaciers coalescing into piedmont glaciers expanded westerly and southwesterly onto the Interior Plateau (c in slide above). At this stage, glaciers advanced westerly at least as far as the Gibraltar Mine region where striations and rat-tails indicative of westerly ice movement have been measured. There was likely a concurrent easterly advance of glaciers from the Coast Mountains onto the Interior Plateau but the position of the ice front at that time is uncertain, hence the question mark on the Interior Plateau in (c). At glacial maximum, an ice divide formed around the 52° north latitude from which ice was flowing to the northwest and southeast (d). The net results is that glacial dispersal at Gibraltar and Mount Polley mines and the Woodjam prospect was controlled by at least two vectors of ice flow: a first one to the west-southwest and a second one to the northwest.

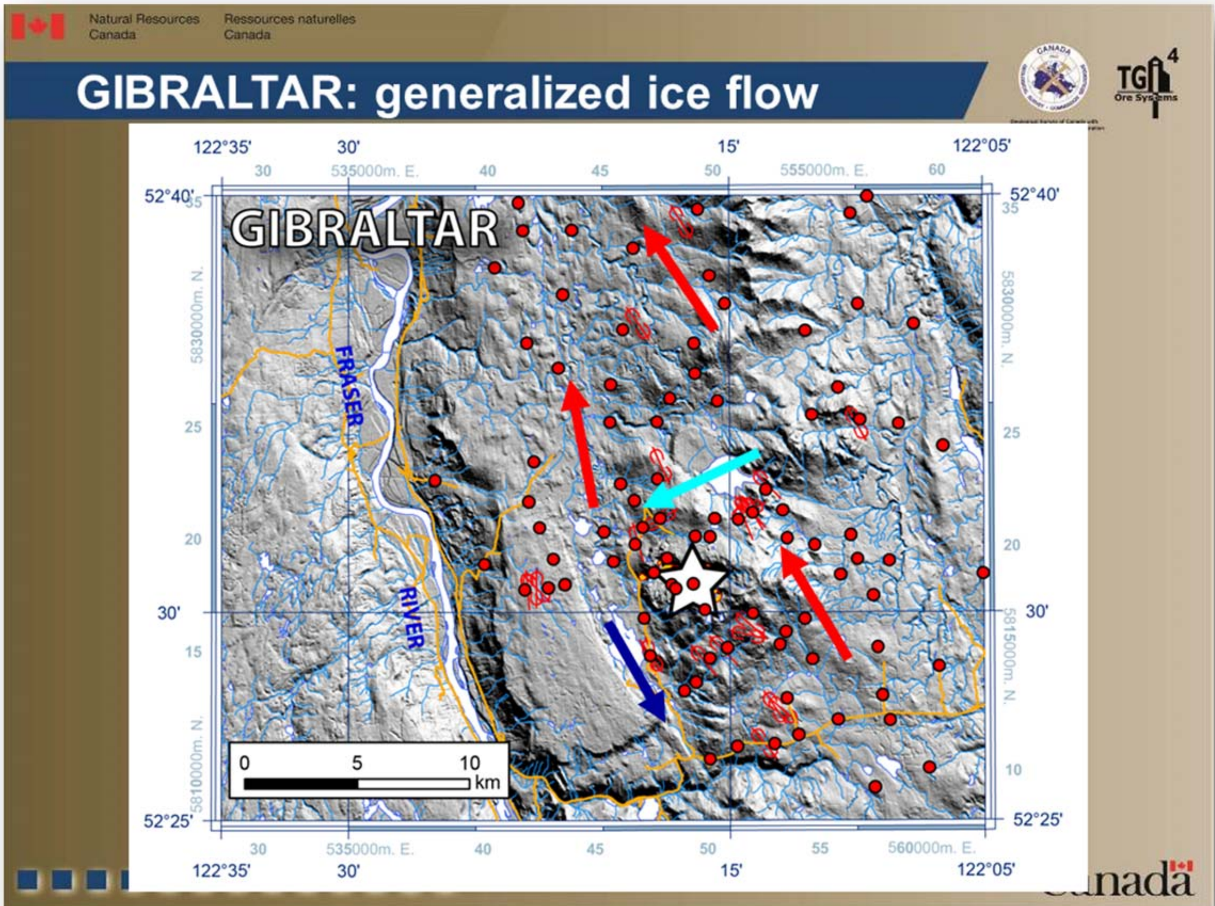
GIBRALTAR MINE

Slide 9



An overview of the results at Gibraltar mine are first presented.

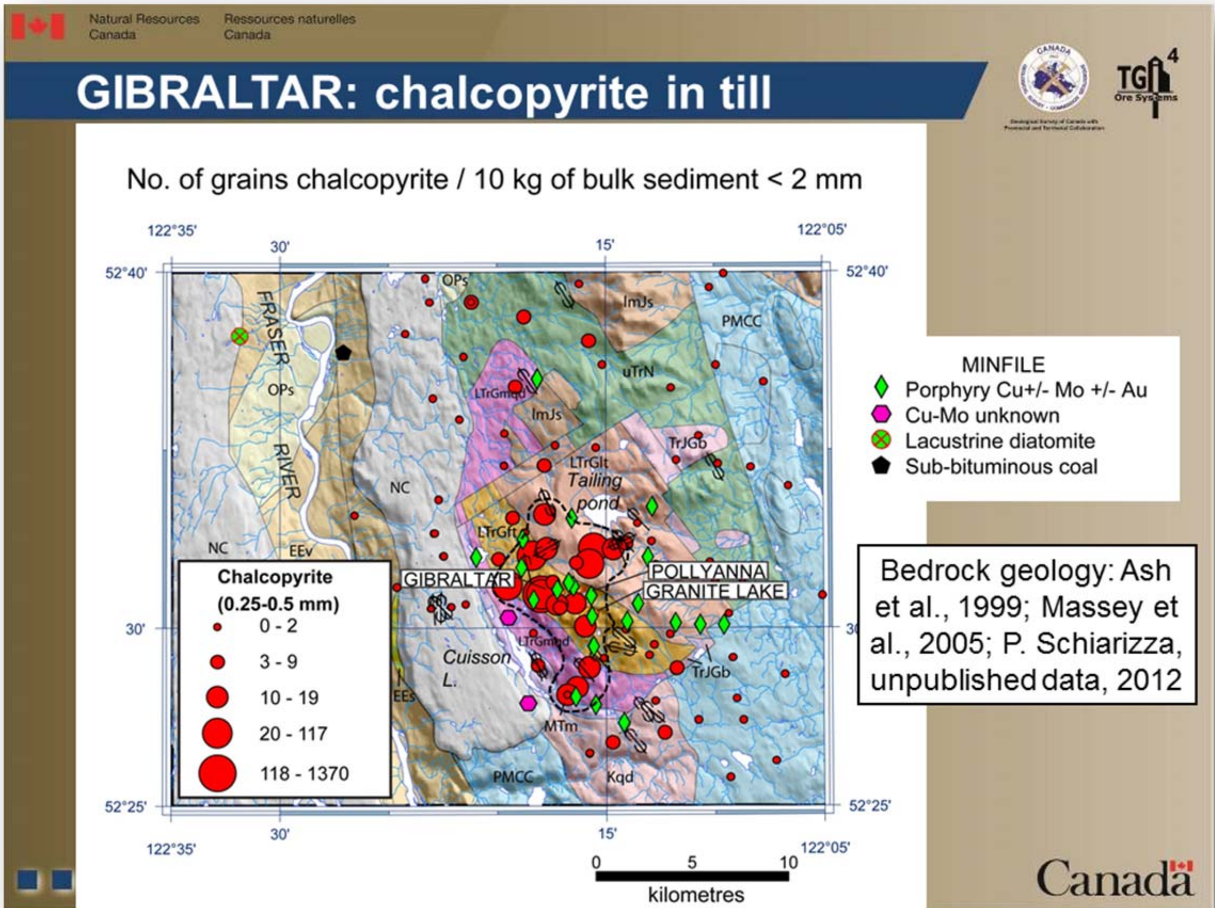
Slide 10



Till sample locations (red dots) are depicted on a shaded digital elevation model produced from SRTM data (http://eros.usgs.gov/). Till samples were collected in road accessible areas within a 10 km radius from the Gibraltar Mine site (white star).

The Gibraltar Mine region was under the influence of the aforementioned southwesterly (pale blue arrow) and northwesterly ice movements (red arrows). In addition, evidence of southeastward ice movement was identified in a single outcrop four kilometres southwest of the mine (dark blue arrow) (Plouffe et al., 2013a). The southeastward flow could be related to the migration of the ice-divide north of Gibraltar Mine or most likely, to a local readjustment of the ice profile during ice retreat because it was only identified in this region and not at any of the other study sites (Plouffe et al., 2013a). Consequently, glacial dispersal in the Gibraltar Mine region was controlled by multiple phases of ice movements: to the southwest, northwest and southeast.

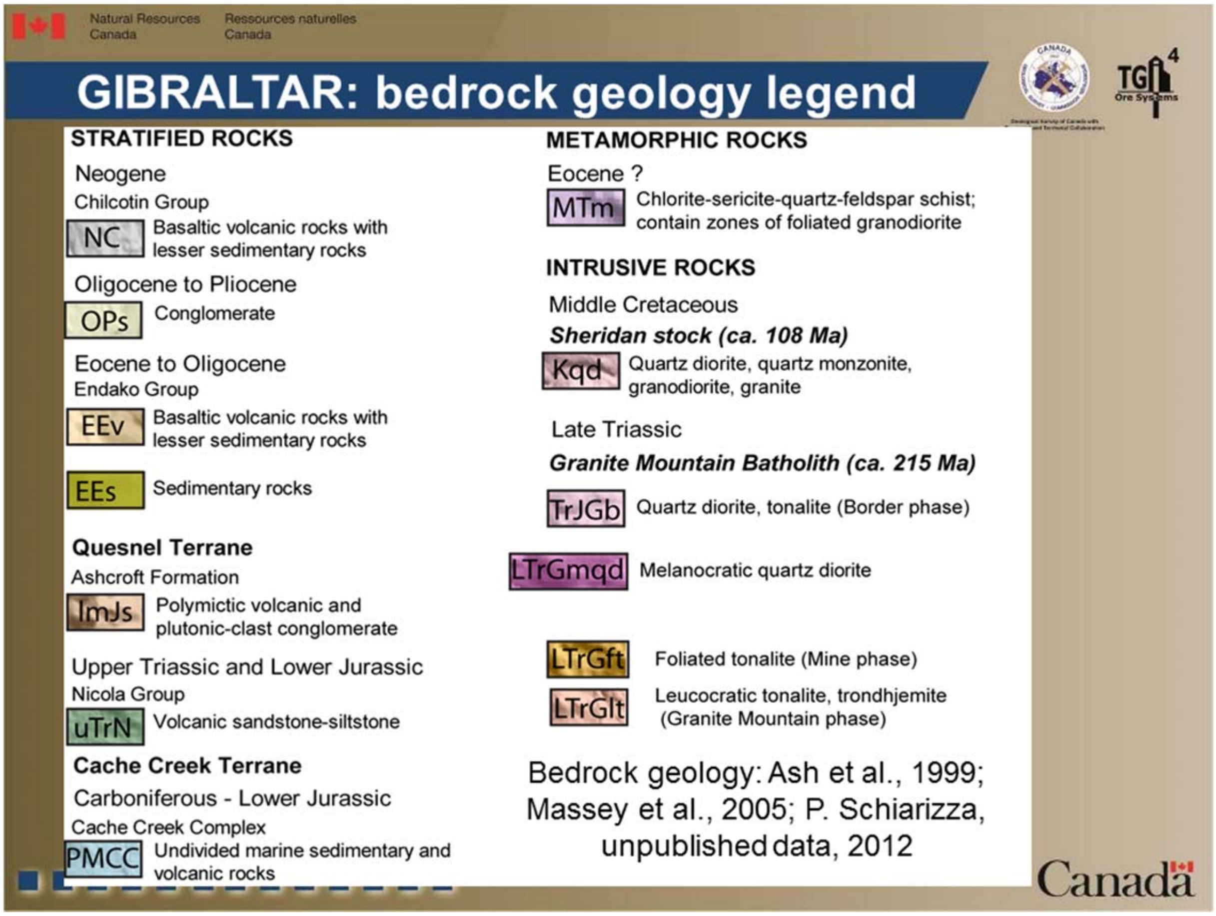
Slide 11



This slide depicts the number of chalcopyrite grains in till identified in the 0.25-0.5 mm size fraction with a s.g. >3.2. The counts are normalized to 10 kg samples of bulk till (< 2mm). Results are depicted on bedrock geology mapped by Ash et al. (1999), Massey et al. (2005) with unpublished data from P. Schiarizza. The bedrock geology legend is shown in slide 12. Gibraltar, Pollyanna, and Granite Lake represents the three pits at Gibraltar Mine.

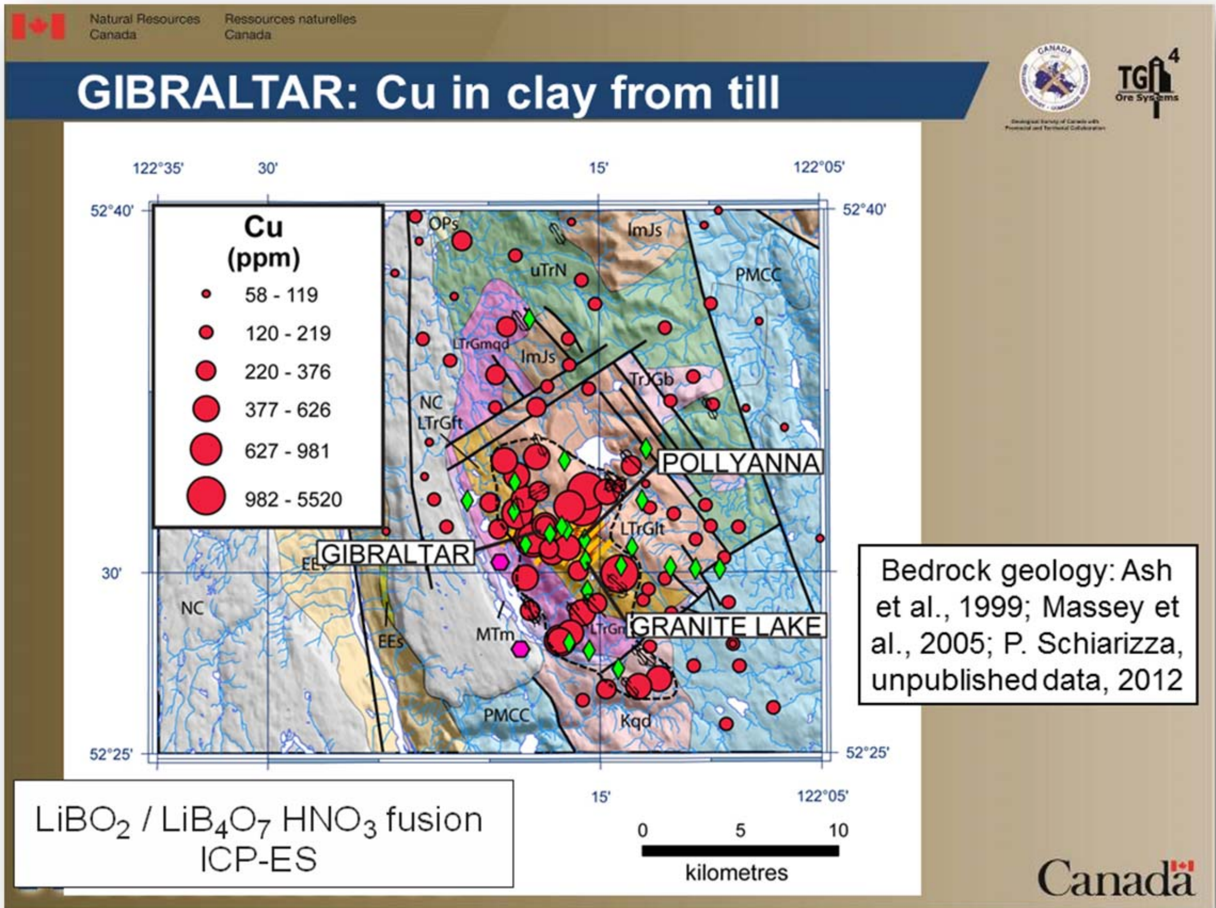
As demonstrated by Plouffe et al. (2013a), the number of chalcopyrite grains in till is more elevated (≥10 grains / 10 kg) to the west, north and south of the mine (outlined with a dash line) compared to the surrounding region.

Slide 12



Bedrock geology legend of the Gibraltar Mine region.

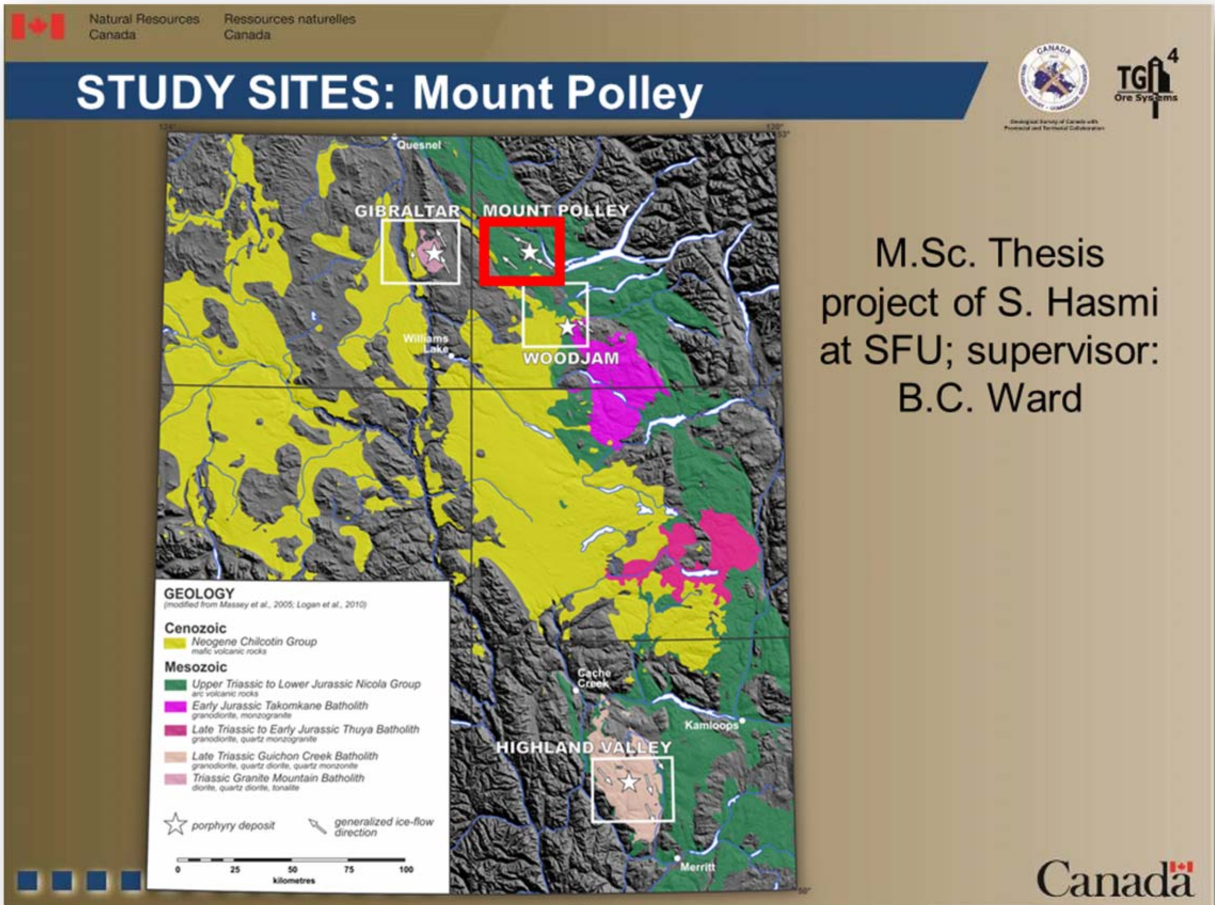
Slide 13



Similarly, the copper content of the clay-sized fraction of till (<0.002 mm) is elevated (≥377 ppm) west, north and south of the mine (outlined with a dash line), compared to the rest of the area (Plouffe et al., 2013a) . The copper was determined by inductively coupled plasma-emission spectrometry (ICP-ES) analysis after a lithium borate – lithium tetraborate fusion (at 980°C), and dissolved in 5% HNO_3. All other copper determinations in this report were completed by the same analytical method. The distribution of chalcopyrite grains and copper content of the clay-sized fraction of till reflects a combination of multiple ice-flow directions which have dispersed mineralized debris to the southwest, northwest and southeast and multiple mineralized bedrock sources. In other words, chalcopyrite and copper in till might be derived from the economic mineralization at the mine but also from the cluster of known sub-economic porphyry occurrences (green diamonds), all contributing to the regional enrichment in till.

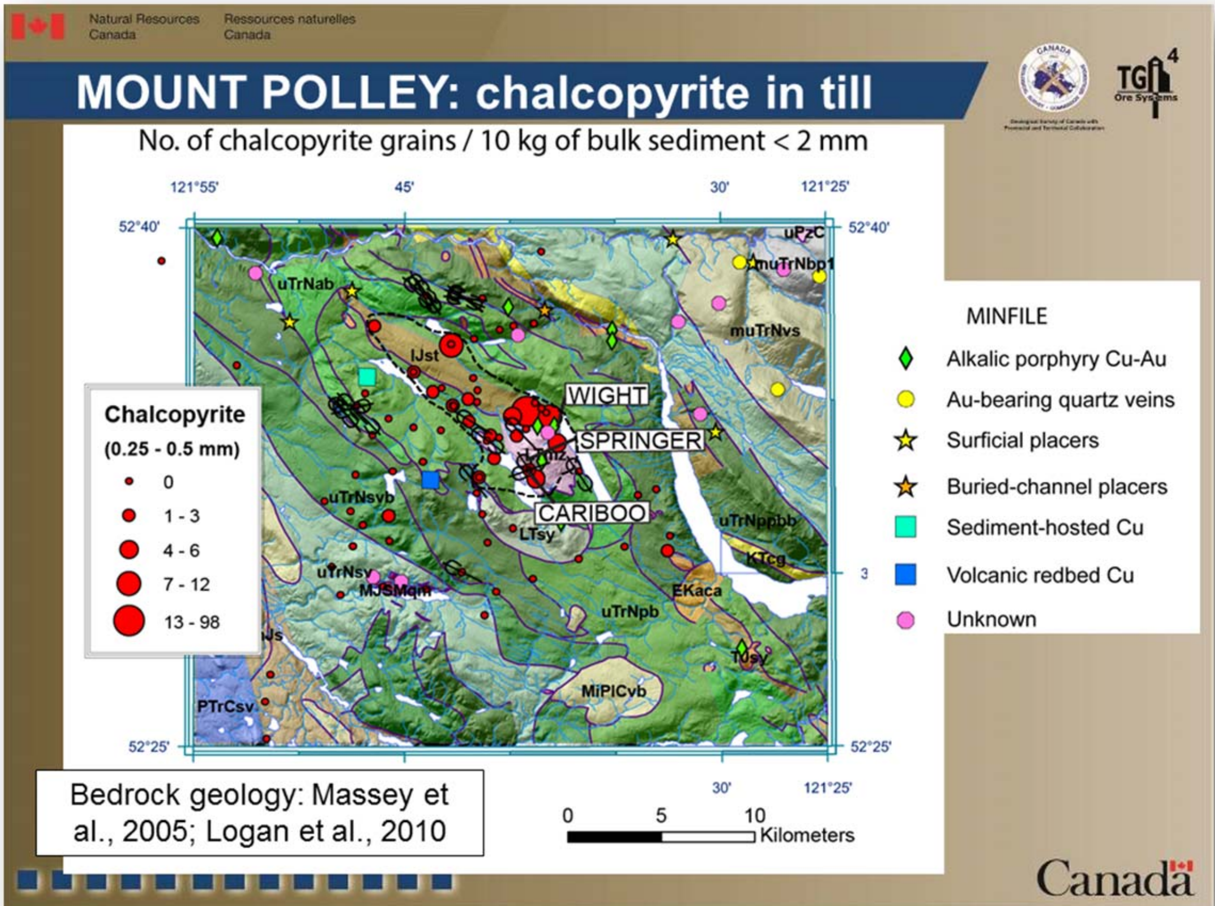
MOUNT POLLEY MINE

Slide 14



The study of glacial dispersal at Mount Polley is part of a M.Sc. thesis project undertaken by S. Hashmi at Simon Fraser University under the supervision of B.C. Ward (Hashmi et al., 2014).

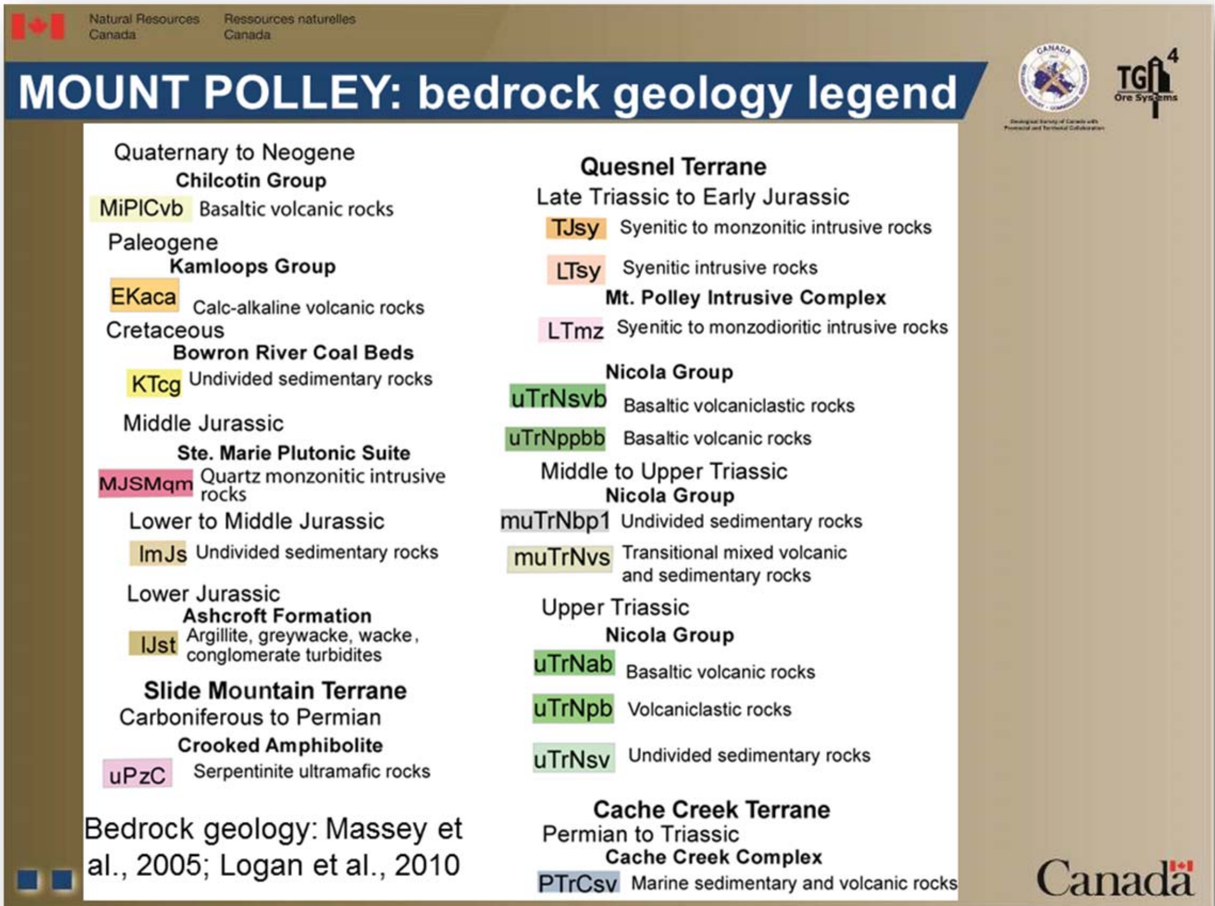
Slide 15



The distribution of chalcopyrite grains in till in the Mount Polley area is depicted on the bedrock geology from Massey et al. (2005) and Logan et al. (2010). Location of the Wight, Springer and Cariboo pits is indicated. The bedrock geology legend is depicted in slide 16.

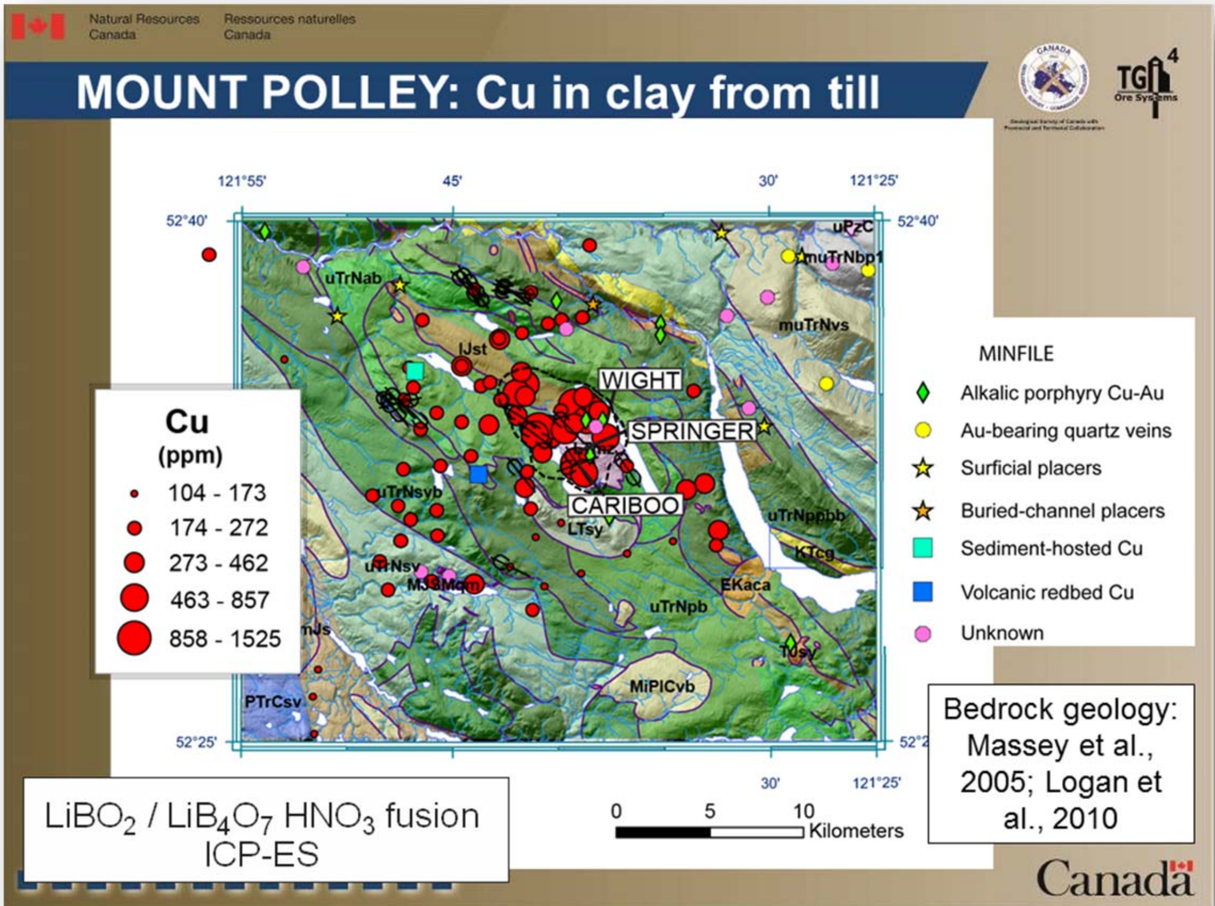
There is a large number of chalcopyrite grains (≥ 7 grains / 10 kg) in till at less than one kilometre from Mount Polley Mine. Furthermore, all samples with more than 1 grain of chalcopyrite are located to the southwest and northwest of the mine (outlined with a dash line). With two exceptions, the regional samples do not contain chalcopyrite. The distribution of chalcopyrite in till in the Mount Polley area is interpreted to reflect glacial transport to the southwest and northwest from the mineralization.

Slide 16



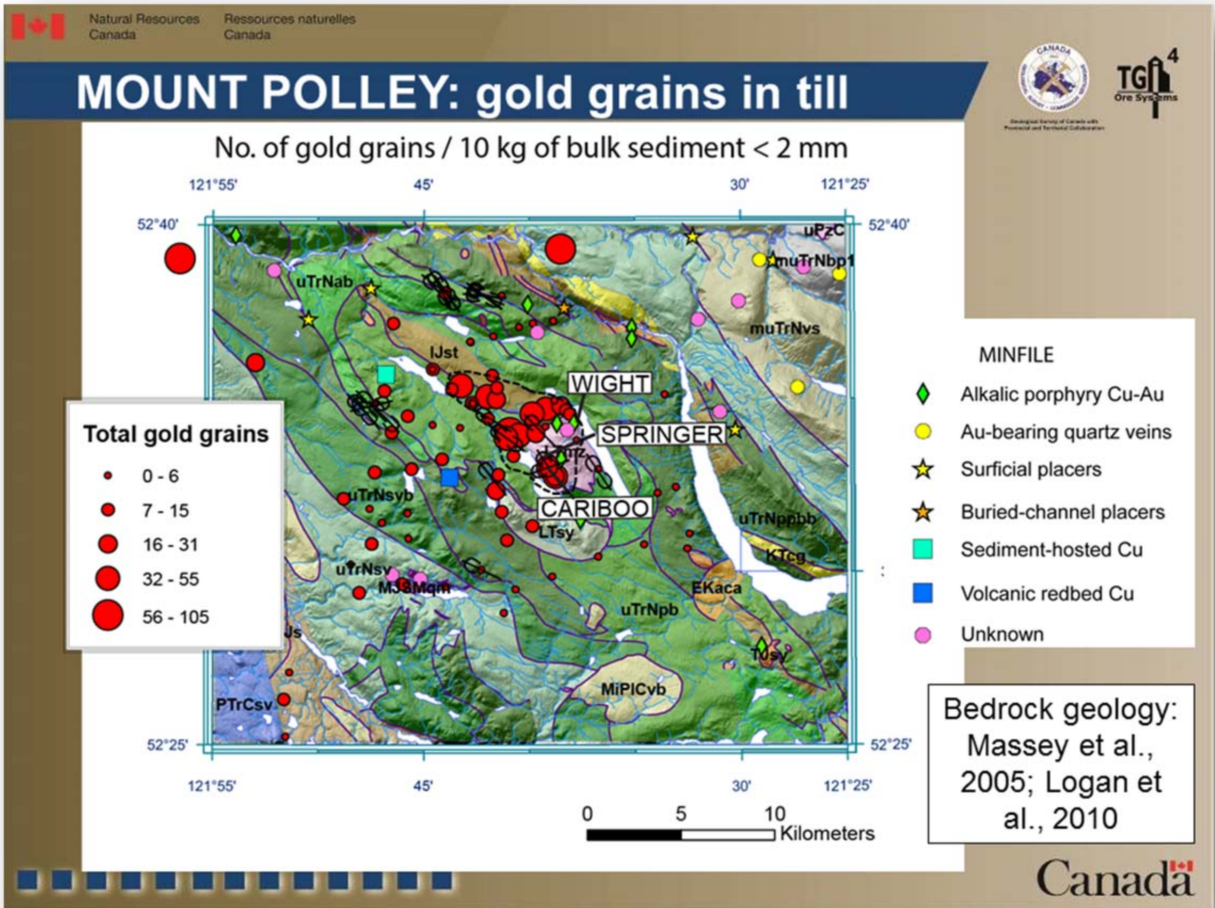
Bedrock geology legend for the Mount Polley Mine area.

Slide 17



Similarly, all till samples with ≥463 ppm copper in the clay-sized fraction (<0.002 mm) are located to the northwest of Mount Polley Mine (outlined with a dash line) which is attributed to glacial transport (Plouffe et al., 2013a).

Slide 18

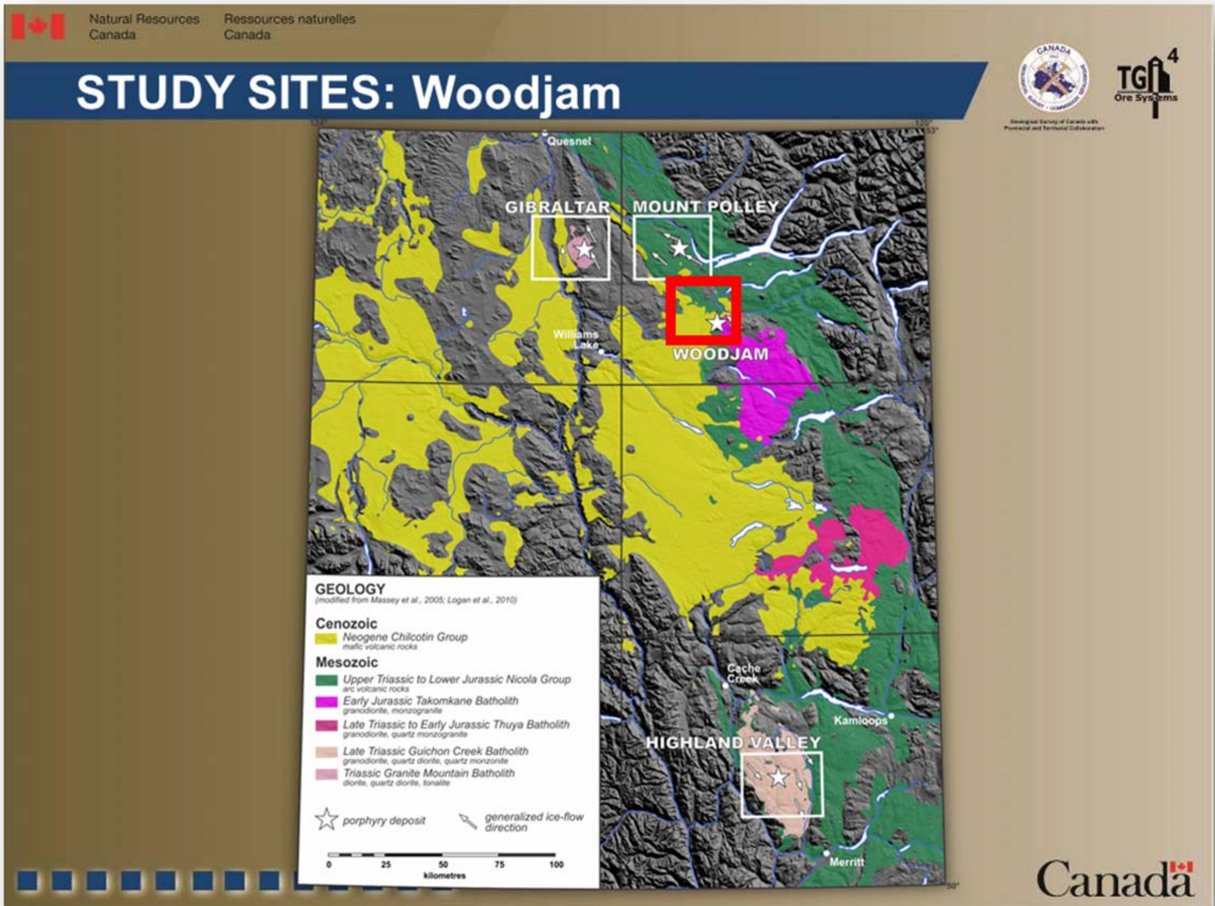


In addition to chalcopyrite and copper, there is a gold grain enrichment (≥32 gold grains / 10 kg) in till at Mount Polley (outlined with a dash line) compared to regional samples which typically contain less than 32 grains of gold / 10 kg. The gold grain enrichment outlined with a dash line extend to the northwest of the mine reflecting glacial transport. Within this area, gold grains vary in size from 4 to 250 µm (Hashmi et al., 2014) most likely reflecting the fine grained nature of gold at Mount Polley dominantly present as inclusions in pyrite (Rees, 2013).

One sample collected in the north central part of the study area contains 105 gold grains / 10 kg. The gold in this sample is derived from an unknown source which could be placer gold (Plouffe et al., 2013a; Hashmi et al., 2014). Indeed, placer deposits in this region are hosted in sand and gravel units that stratigraphically underlie till of the last glaciation. Therefore, placer deposits might have been eroded by ice during the last glaciation. Additional detailed study on the shape and the composition of the gold grains recovered from till could serve to define the potential source of gold (see for examples Grant et al., 1991; Nikkarinen, 1991; Youngson and Craw, 1999; Chapman and Mortensen, 2006; McClenaghan and Cabri, 2011).

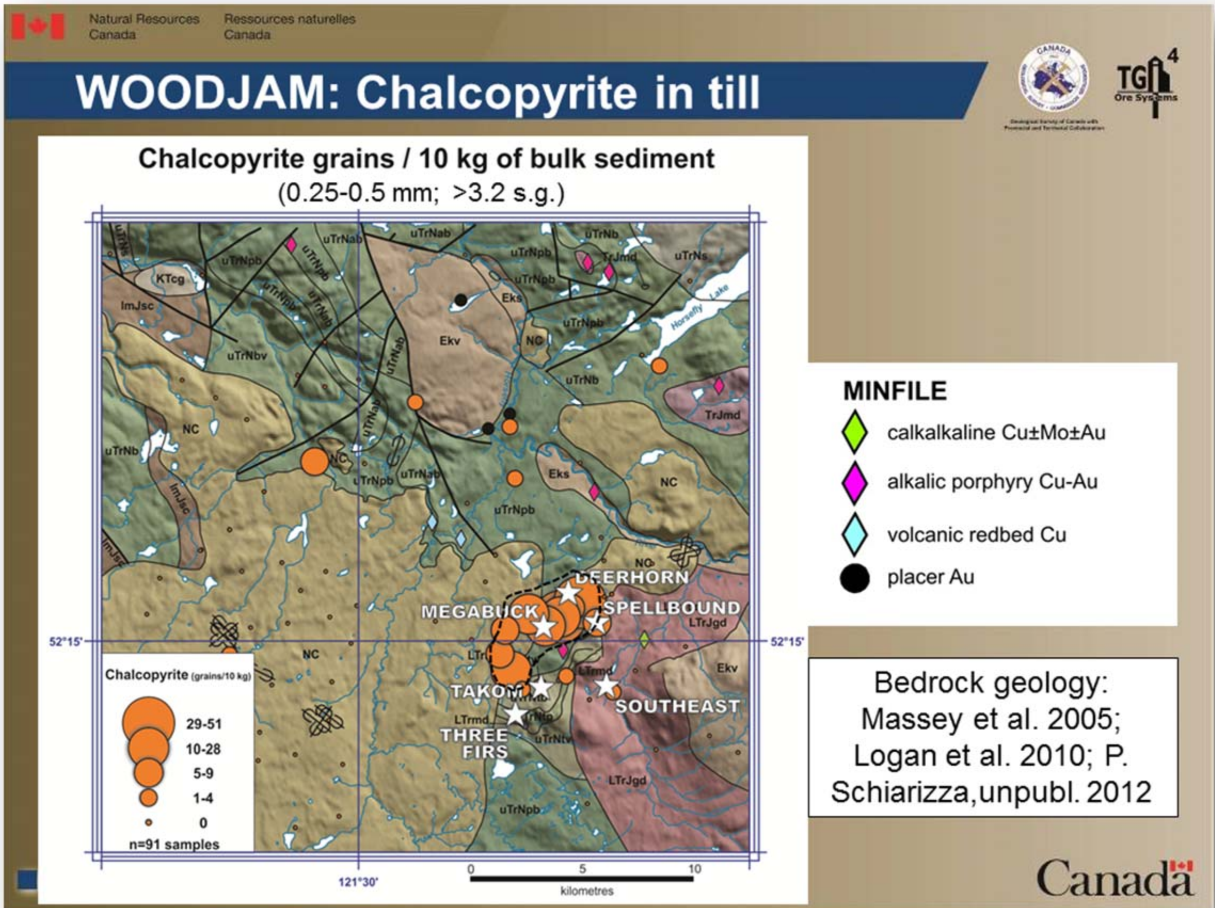
WOODJAM PROSPECT

Slide 19



The third study site, the Woodjam Prospect, is located to the southeast of Mount Polley at the northern extent of the Takomkane batholith (red box above).

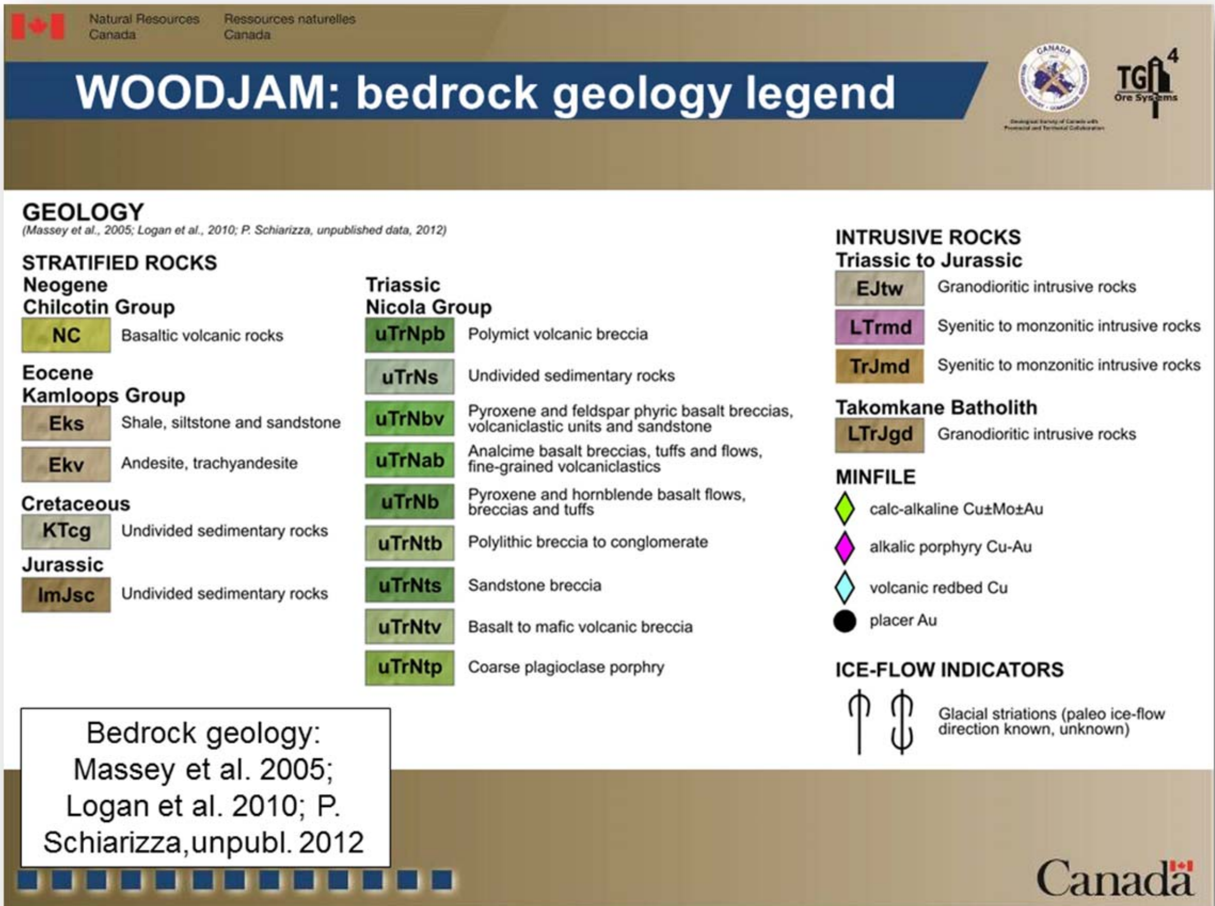
Slide 20



The number of chalcopyrite grains (0.25 – 0.5 mm; s.g. >3.2) in till normalized to 10 kg of bulk sediment <2 mm is depicted on a bedrock geology map from Massey et al. (2005), Logan et al. (2010) with unpublished data from P. Schiarizza. Six known mineralized zones at Woodjam are indicated: Megabuck, Deerhorn, Spellbound, Takom, Southeast, and Three Firs. The bedrock geology legend is depicted in slide 21.

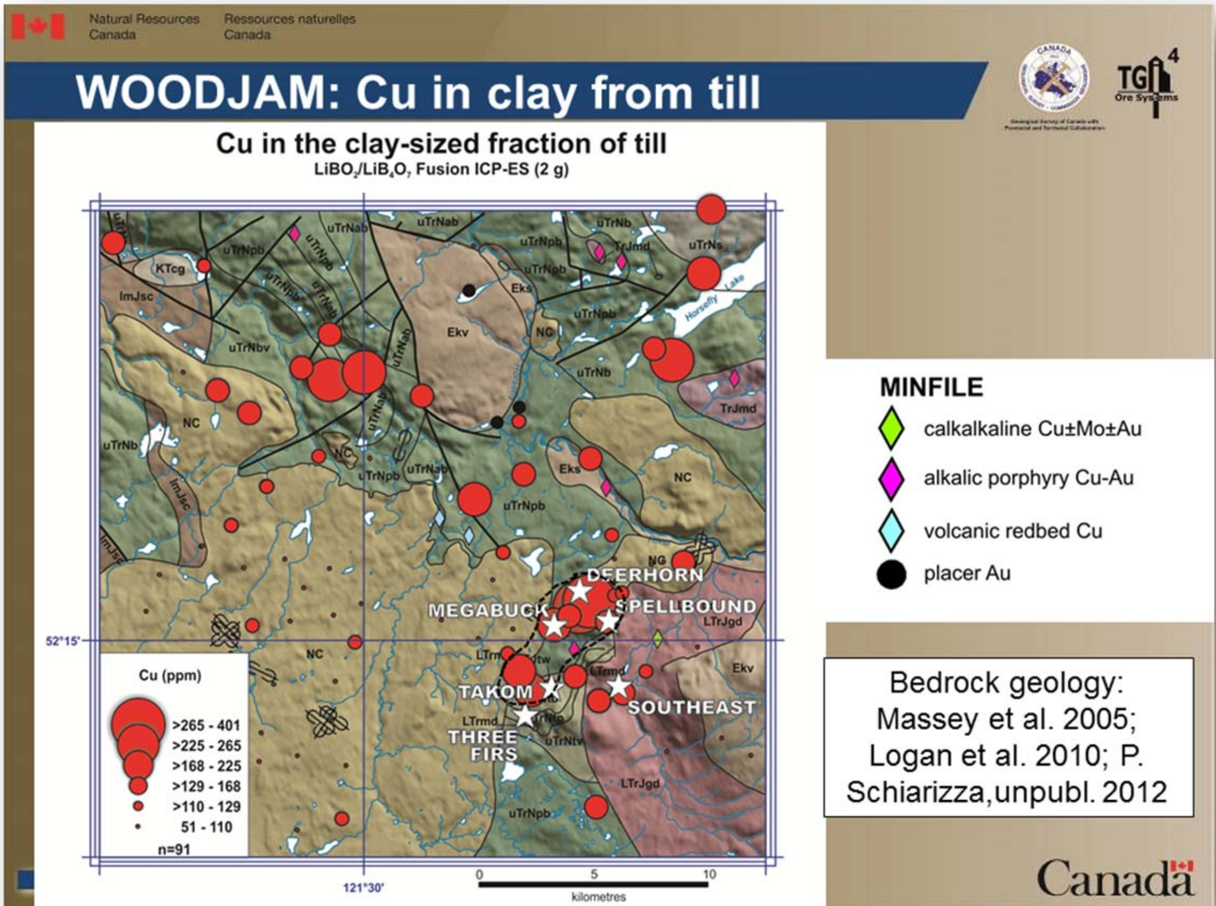
All samples with ≥10 grains of chalcopyrite per 10 kg of till are located at less than two kilometres from the known mineralized zones. At this sampling scale, there is no indication of detrital glacial transport in the down-ice directions, i.e. southwest and northwest. The absence of till samples in the region west and southwest of Woodjam is attributed to the presence of a thick cover of sand and gravel and associated diamictons likely deposited from ice stagnation during deglaciation. Till could not be sampled at surface in these areas.

Slide 21



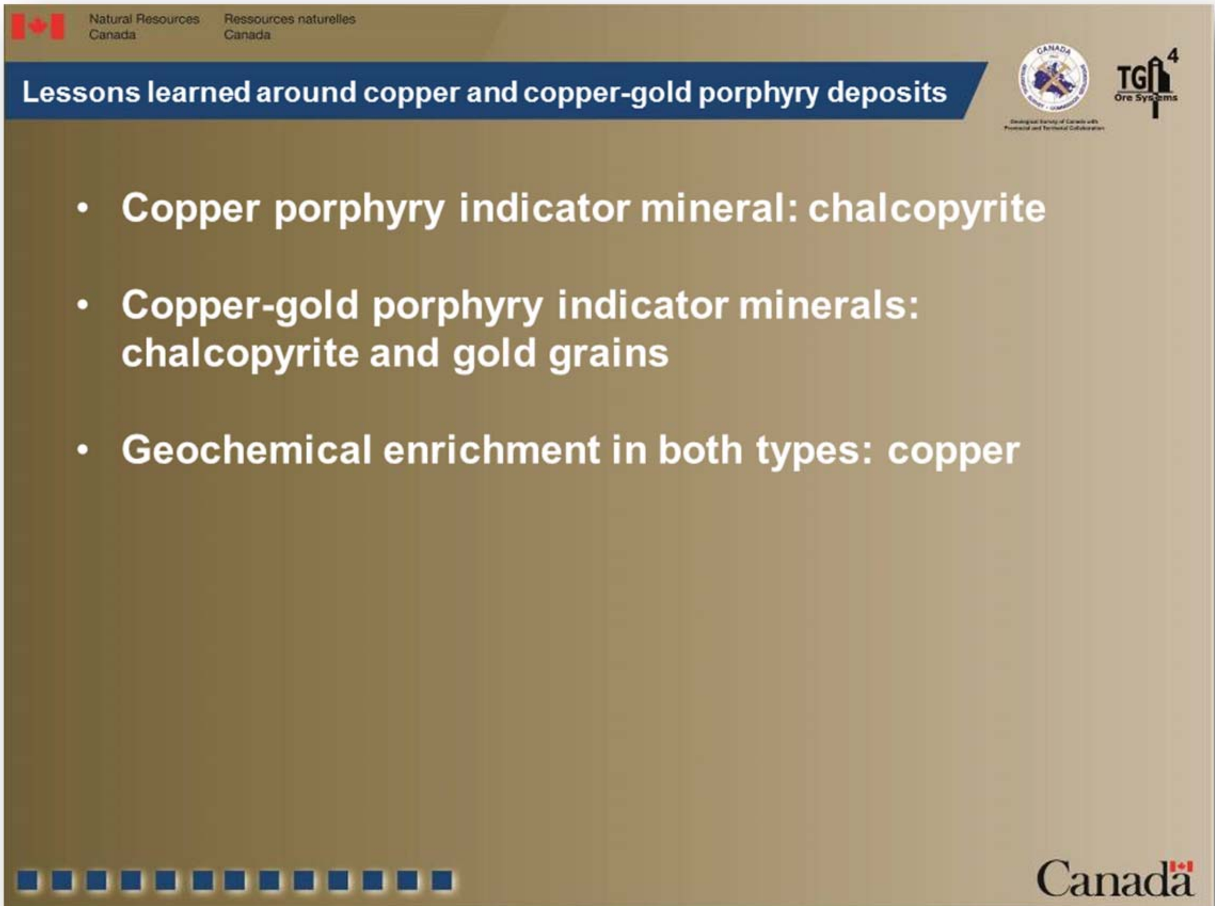
Bedrock geology legend of the Woodjam prospect region.

Slide 22



As for the other study sites, copper is enriched (≥265 ppm) in the clay-sized fraction of till near mineralization at Woodjam (outlined with a dash line). Two till samples west of the large unit of Kamloops Group volcanic rocks (Ekv) in the northwest sector of the study area contain more than 225 ppm copper which is elevated compared to rest of the regional samples. The source of copper in those two samples is unknown but could be related to native copper occurrences reported in the area (T. Schroeter, pers. comm., 2013).

Slide 23

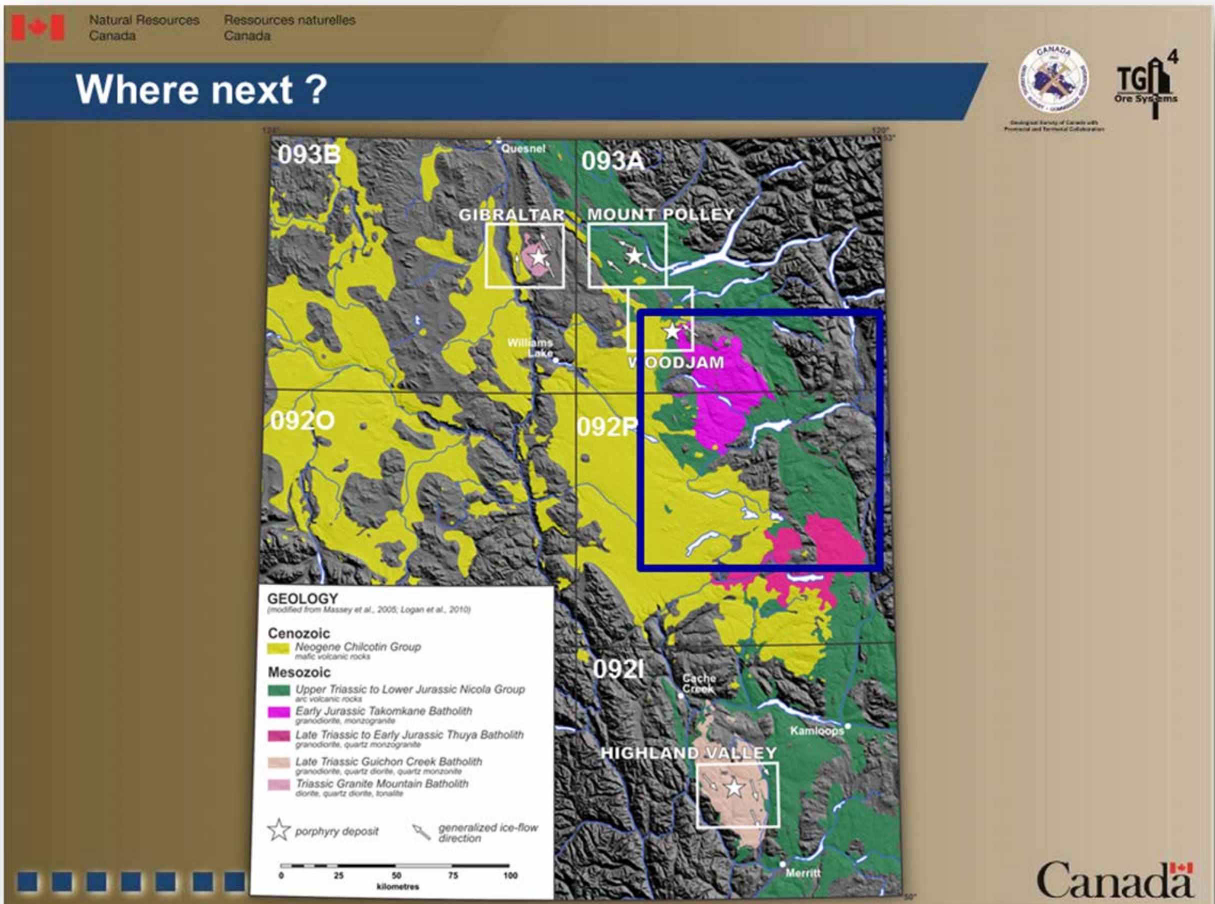


Based on the orientation surveys completed at Gibraltar (copper-molybdenum porphyry) and Mount Polley (copper-gold) mines and the Woodjam (copper-gold porphyry) prospect, key geochemical and mineralogical indicators have been identified in till that can be linked to copper and copper-gold porphyry mineralization. Those include two indicator minerals, chalcopyrite and gold grains, and one trace metal, copper. Chalcopyrite grains are enriched in till near copper and copper-gold porphyries compared to surrounding background regions. In addition, gold grains are enriched in till near copper-gold porphyry mineralization. As part of our study on till composition near copper porphyry mineralization, other indicator minerals (e.g. epidote) and elemental enrichment (e.g. gold, molybdenum, lead and zinc) have been identified in addition to chalcopyrite, gold grains and copper (e.g. Ferbey and Plouffe, 2014; Hashmi et al., 2014; Plouffe et al., 2014). Our till mineralogy study at three copper porphyry test sites presented here builds on similar studies reported for the giant Pebble porphyry copper-gold-molybdenum deposit in Alaska, USA (Anderson et al., 2011; Kelley et al., 2011; Eppinger et al., 2013) and the Quebrada-Blanca porphyry copper deposit located in an unglaciated region of Chile (Averill, 2011).

Results from our orientation surveys at the three study sites depict a range of copper, chalcopyrite, and gold grains that might be expected in specific size and density fractions in till near copper porphyry mineralization, including anomalous amounts in samples that were intentionally collected near known mineralization. On the other hand, samples collected down-ice from known mineralization can still contain a significant amount of a given mineral or element but not reach the levels observed near mineralization. For example, at Mount Polley, till samples containing one to three chalcopyrite grains per 10 kg and collected > 2 km from the mine are significant because most till samples in this region do not contain chalcopyrite. In other words, in a regional data set on till composition, any amounts of copper, chalcopyrite and gold grains above the regional levels can be significant and potentially be reflective of copper and/or copper-gold porphyry mineralization.

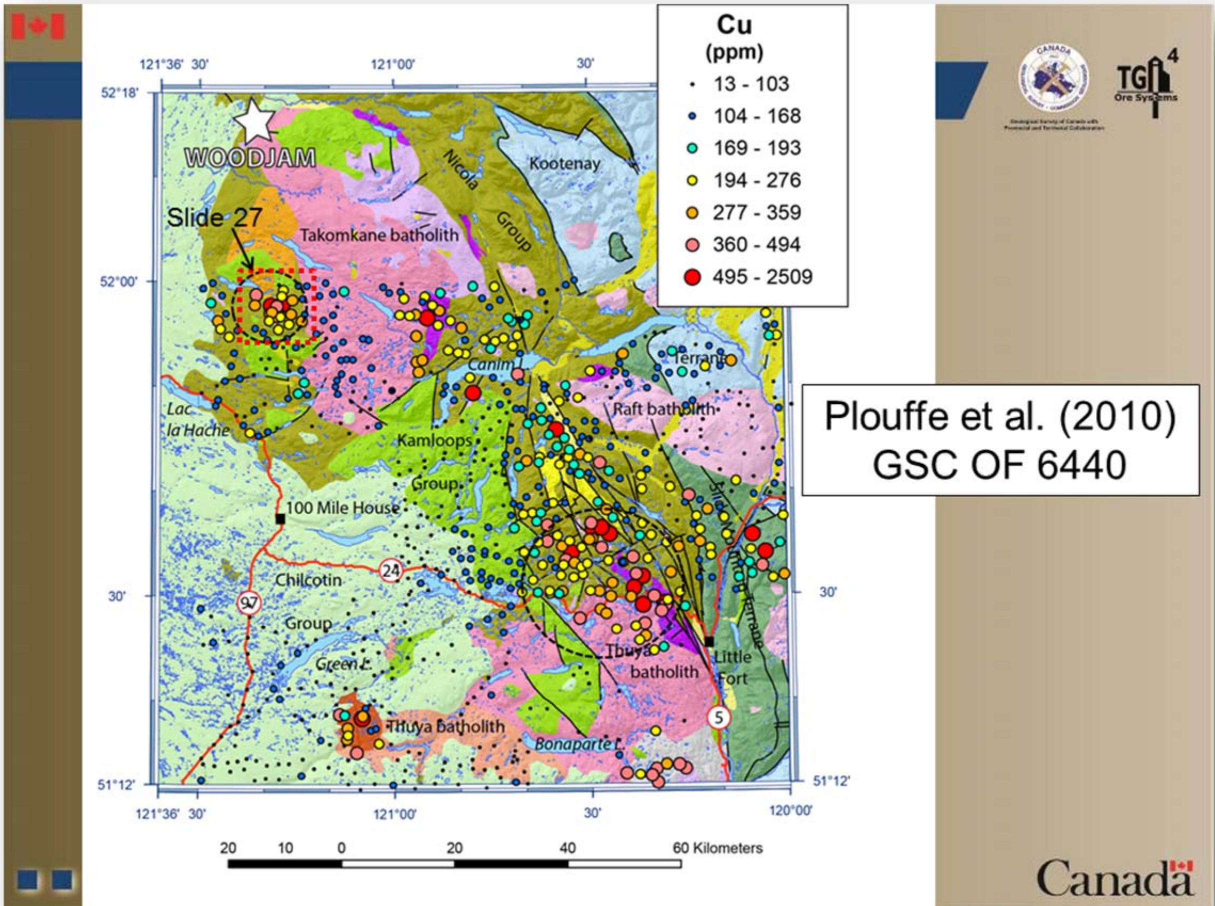
COPPER-GOLD PORPHYRY POTENTIAL NEAR THE THUYA AND TAKOMKANE BATHOLITHS

Slide 24



To test our model of porphyry indicators in till, we have selected the region of the Thuya and Takomkane batholiths where a recent regional data set on till geochemistry and mineralogy exists (Plouffe et al., 2009, 2010, 2011b) which was acquired during the Mountain Pine Beetle Program of the Geological Survey of Canada (Haggart et al., 2011). Fifty-seven archived heavy mineral concentrates (0.25 – 0.5 mm; >3.2 s.g.) from this past project were selected for detailed copper porphyry indicator mineral analyses at ODM Ltd. The selected samples are from areas with and without potential for copper porphyry mineralization based on geology (i.e. proximity to a Late Triassic – Early Jurassic intrusion), till geochemistry (Plouffe et al., 2010) and till gold grain content (Plouffe et al., 2009).

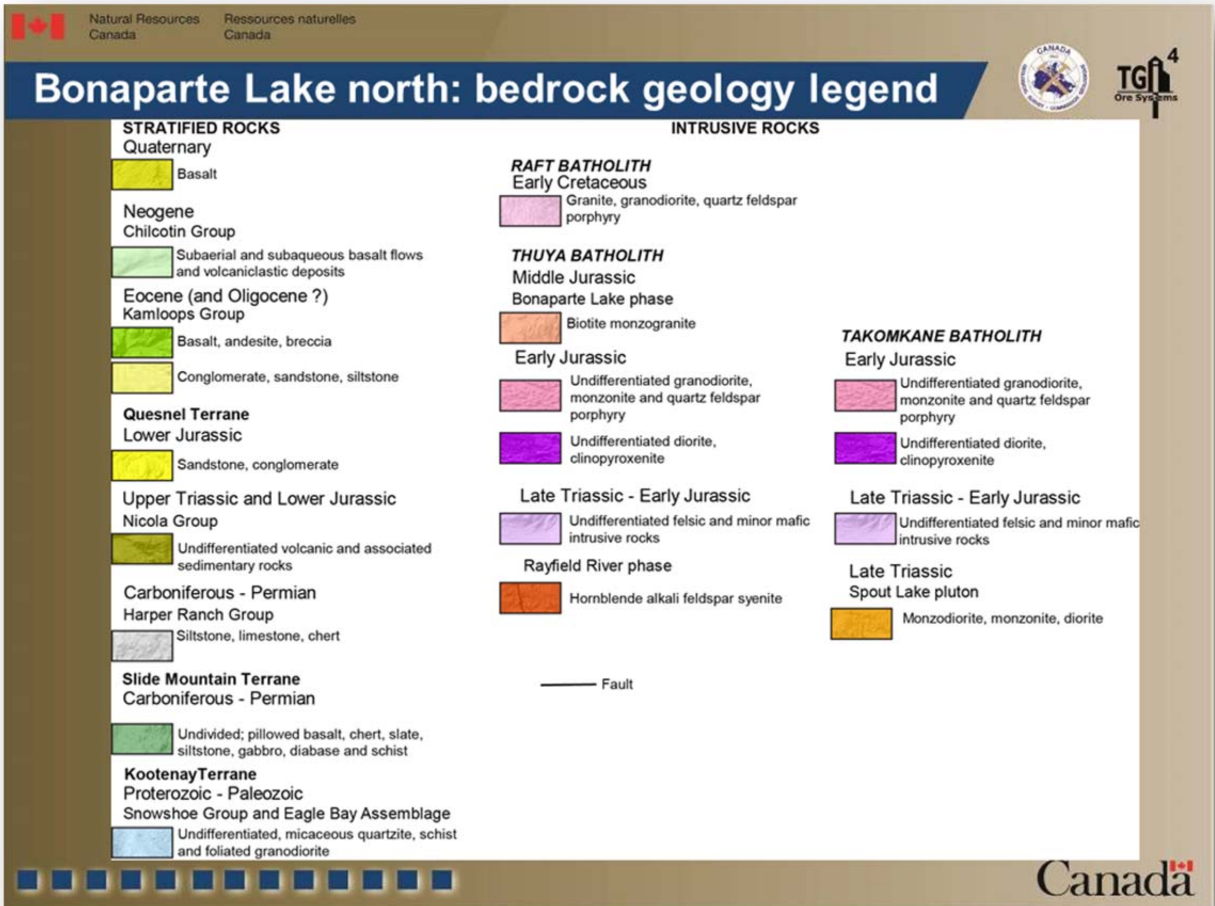
Slide 25



The copper content of the clay-sized fraction of till is depicted on a generalized bedrock geology map which includes the Takomkane and Thuya batholiths south of the Woodjam prospect (located with a white star). The bedrock geology was simplified from Campbell and Tipper (1971), Schiarizza et al. (2002a, b, c; 2009a, b), Schiarizza and Boulton (2006a, b) Schiarizza and Bligh (2008), and Anderson et al. (2010), and was based on the compilation presented in Plouffe et al. (2011b). The bedrock geology legend is depicted in slide 26.

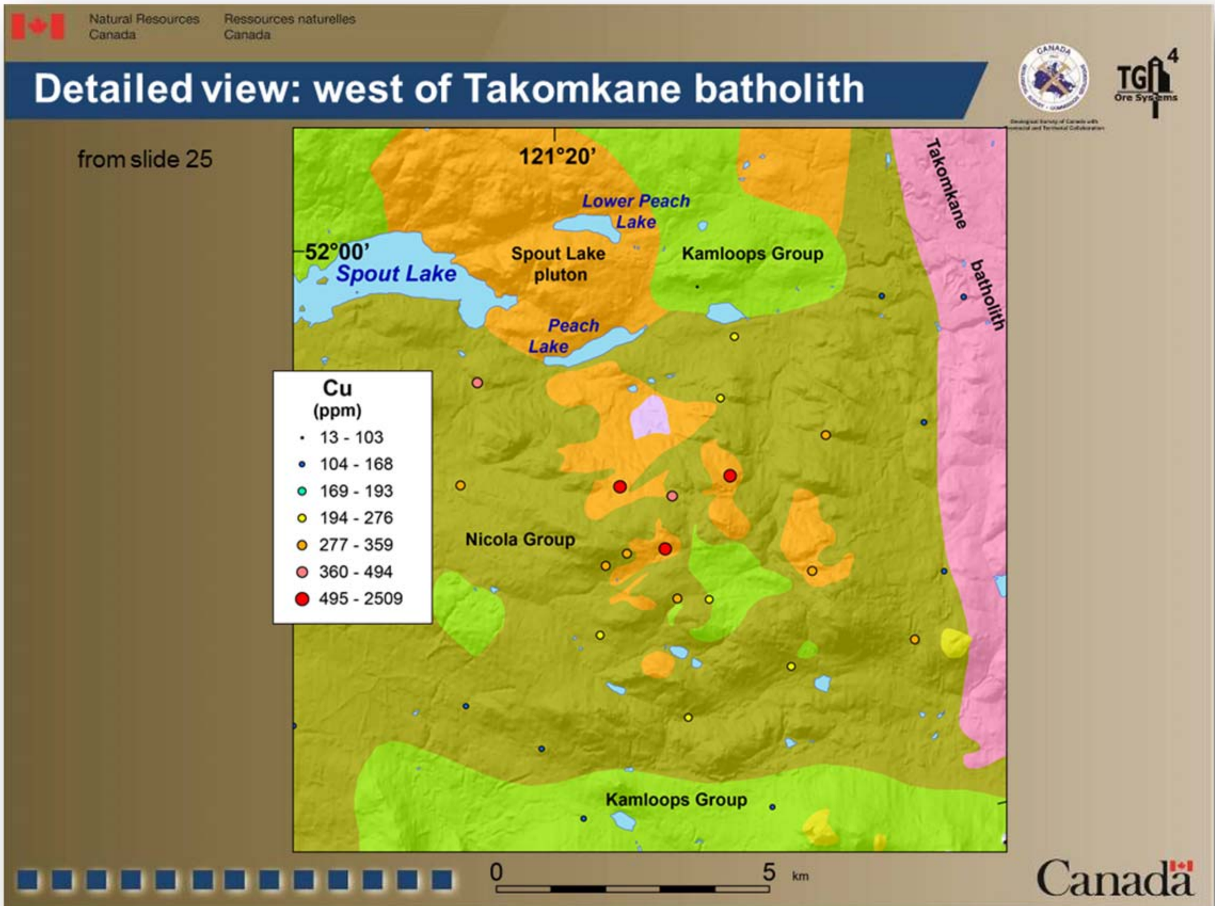
In the above slide, two areas (outlined with a black dash line) contain a number of till samples with elevated copper content (≥ 360 ppm): at the northern end of the Thuya batholith and along the western margin of the Takomkane batholith which includes areas of inrusive rocks of the Late Triassic Spout Lake pluton. The region at the western margin of the Takomkane batholith is shown in more details in slide 27.

Slide 26



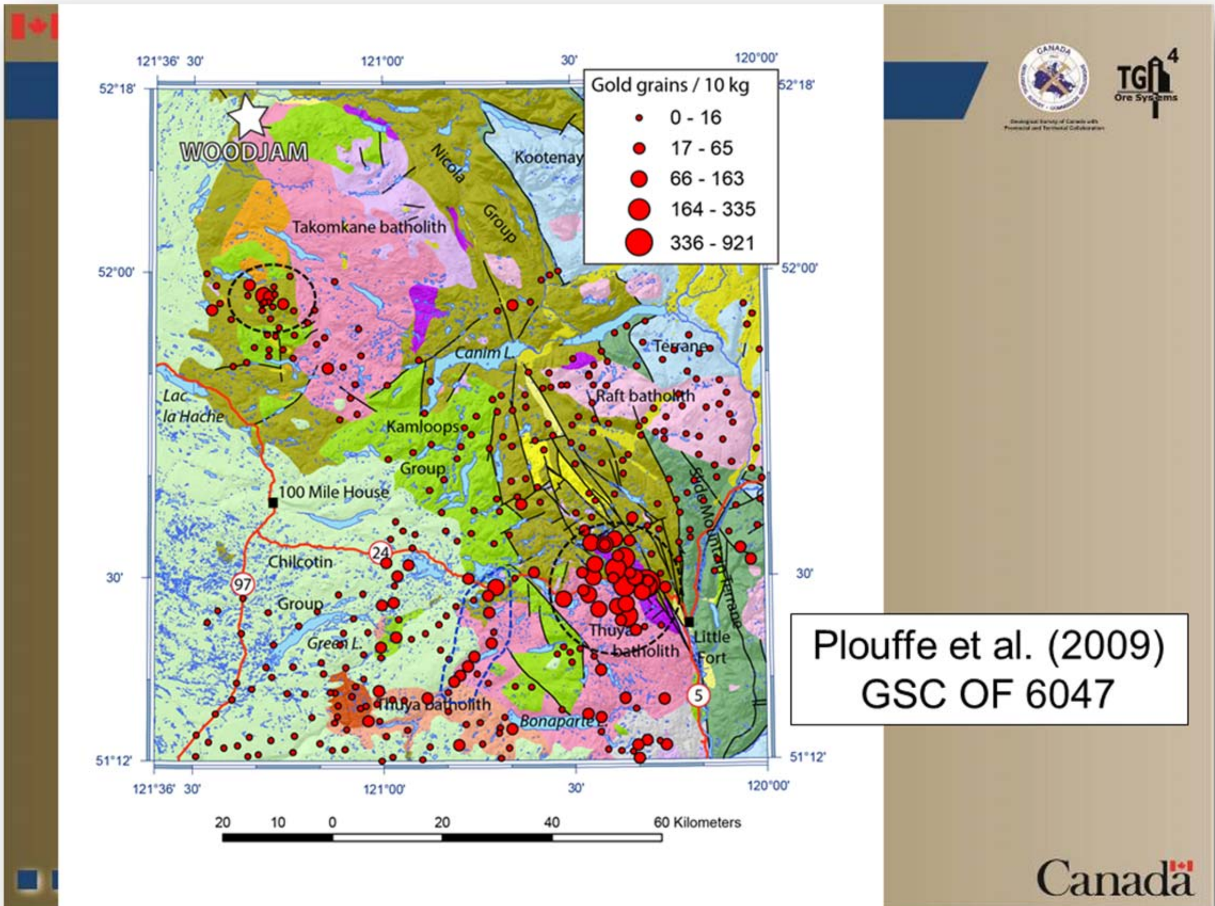
Bedrock geology legend for the region of the Thuya and Takomkane batholiths.

Slide 27



Detailed view of the till copper content in the Spout Lake region. See slide 25 for location.

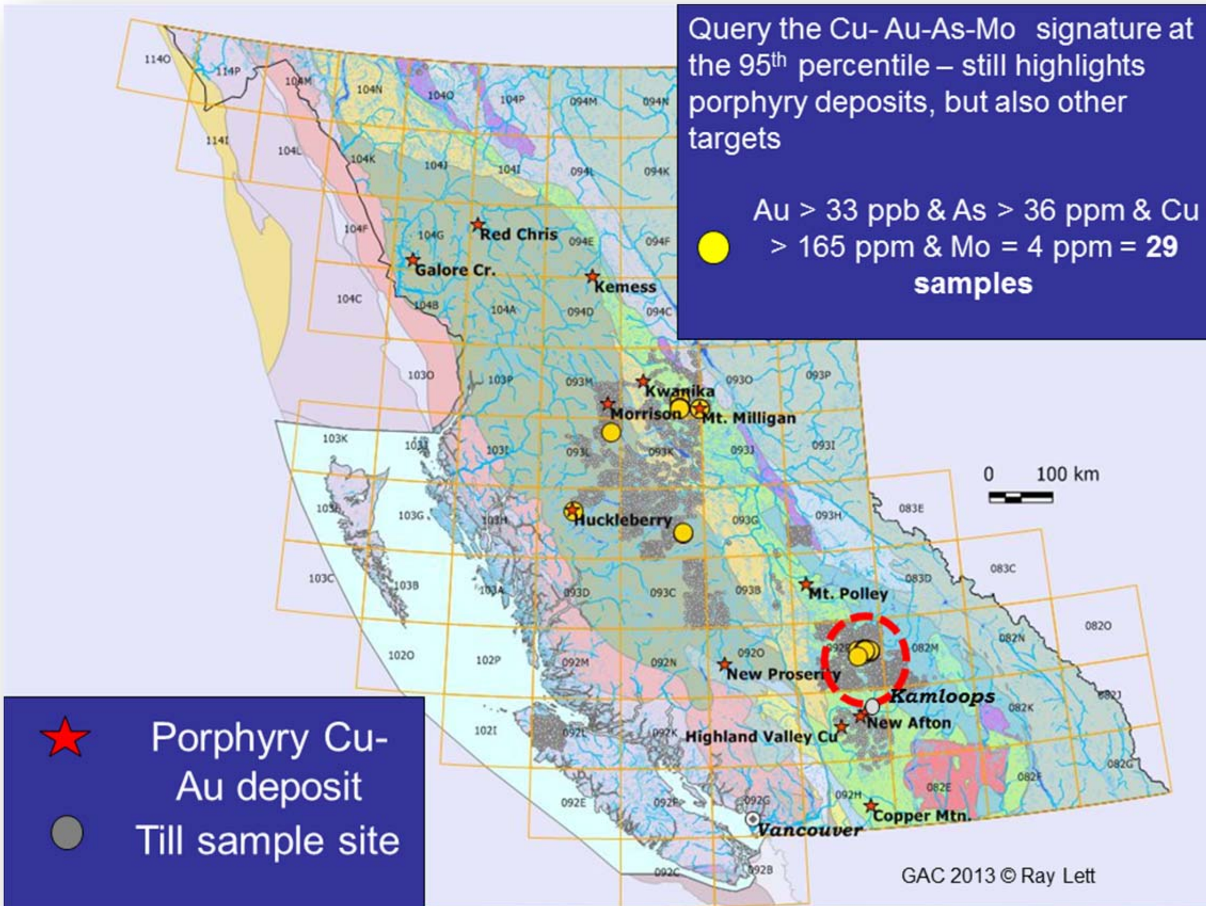
Slide 28



The gold grain content of till (gold grain counts normalized to 10 kg of bulk sediment <2mm) is depicted on the same bedrock geology map.

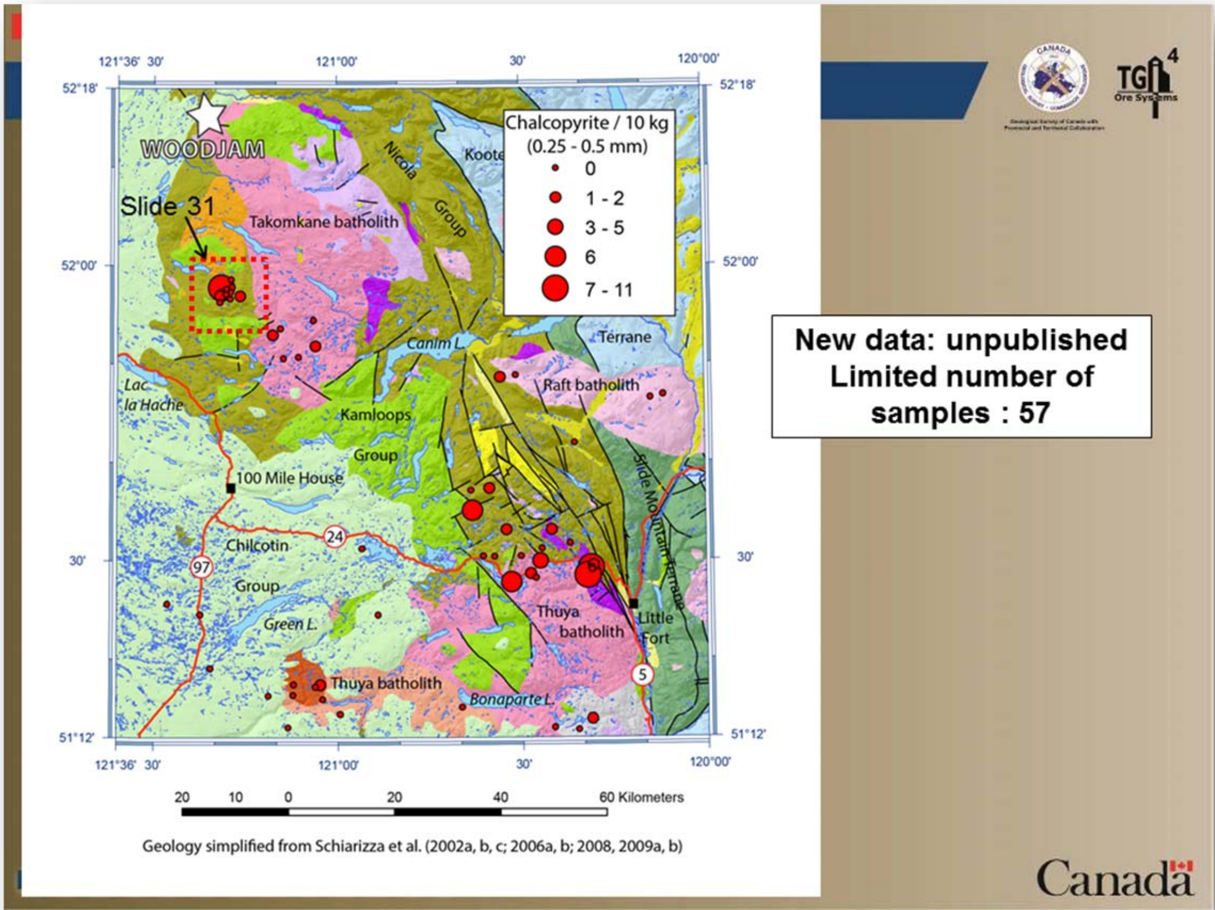
Till samples with more than 66 gold grains are present at the northern end of the Thuya batholith, in an area of approximately 10 by 20 km (200 km^2) (outlined with a black dash line). The size of this region with elevated gold grain content in till is significant when compared with two gold grain dispersal trains in Ontario which are considered amongst the largest in Canada (Averill, 2013; Morris, 2014). The first one is from the Ti-pa-haa-kaa-ning (TPK) gold property which consists of two zones (one 5 x 5 km with > 8 gold grains and a second one 5 x 8 km with >73 grains per sample) (Morris, 2014) and the second one from the Rainy River gold deposit which is a 3 x 15 km dispersal train with >11 gold grains / 7.5 kg (Averill, 2013). Note that Morris (2014) did not normalized gold grain counts to bulk sediment processed which could potentially affect the extent of glacial dispersal at TPK. Furthermore, along the western margin of the Takomkane batholith, four till samples contain ≥17 gold grains (outlined with a black dash line) where the copper content of till is ≥ 360 ppm (see slide 25). A number of samples located along the northwestern margin of the Thuya batholith contain ≥17 gold grains (outlined with a blue dash line). However, this region is not characterized with elevated copper content in till (see slide 25).

Slide 29



In his analysis of the British Columbia till geochemistry database, Lett (2013) demonstrated that known porphyry deposits such as Mount Milligan (copper-gold) and Huckleberry (copper-gold) are defined by elevated Au (>33 ppb), As (>36 ppm), Cu (>165 ppm) and Mo (>4 ppm) content in the silt plus clay-sized fraction (>0.063 mm) of till. On the other hand, other porphyry deposits (e.g. Morrison, New Afton, Highland Valley Copper) are not characterized by this same elevated multi-elemental association in till. It could be that the enrichment for one or more of those elements (Au, As, Cu, and Mo) in the mineralization at those sites is not significant enough to create the multi-element geochemical enrichment in till. Furthermore, if the mineralization was protected from glacial erosion (e.g. mineralization only occurs at depth in bedrock or is covered by pre-glacial sediments) its geochemical enrichment would not be reflected in till (Plouffe et al., 2012).
Nevertheless, even at a provincial scale, the region at the northern end of the Thuya Batholith (outlined with a red dash line) represents a potential copper-gold porphyry mineral exploration target defined by a number of till samples with elevated amounts of Au, As, Cu and Mo.

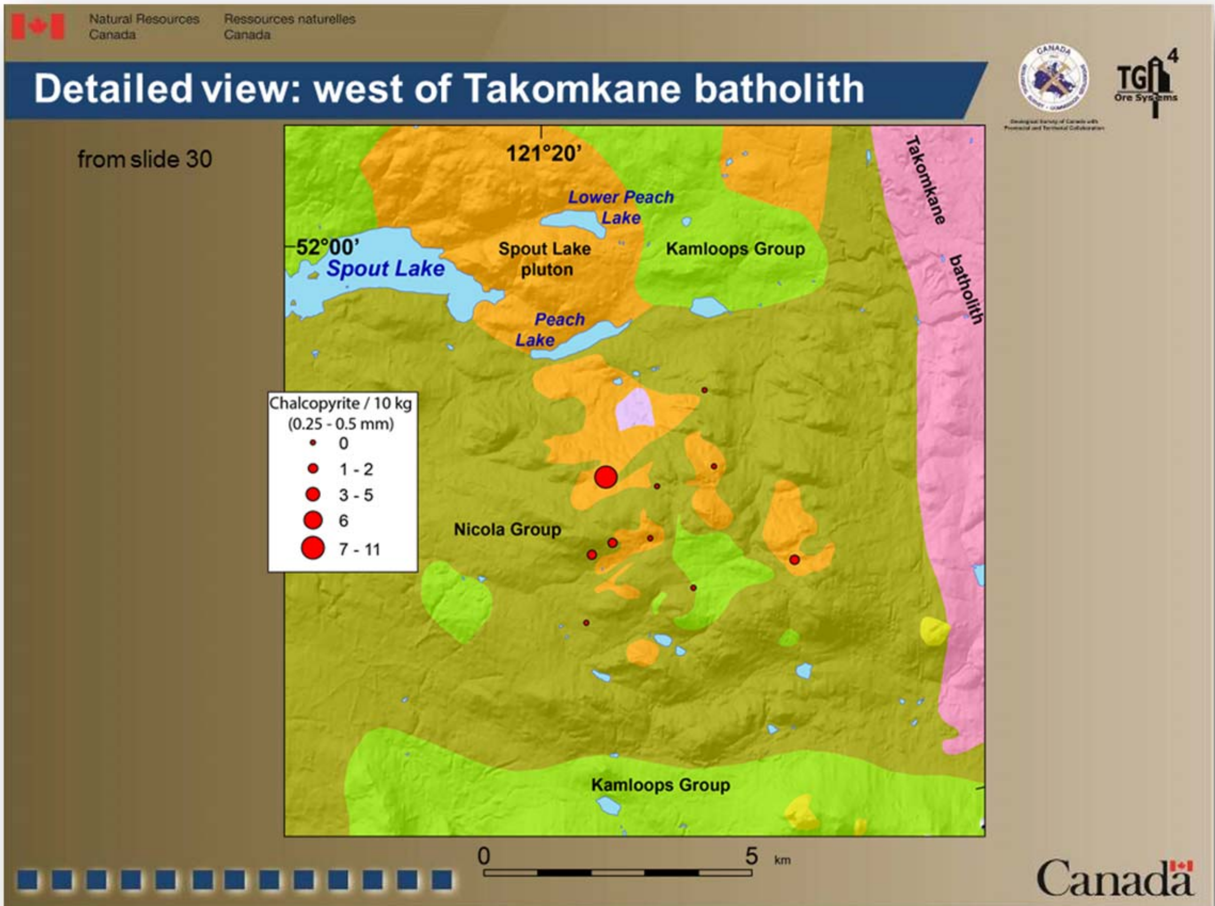
Slide 30



Fifty seven archived heavy mineral concentrates from till samples obtained in the northern sector of the Bonaparte Lake map area were re-processed for porphyry indicator minerals including chalcopyrite grain counts. Results are presented in Table 1. All samples with more than 3 chalcopyrite grains per 10 kg are located near the northern end of the Thuya batholith. In addition, one sample with 8 chalcopyrite grains per 10 kg is from the western margin of the Takomkane batholith and is underlain by the Spout Lake pluton (slide 31).

We postulate that based on the mineralogical and geochemical indicators of porphyry mineralization identified in till, the region at the northern end of the Thuya batholith and along the western margin of the Takomkane batholith (Spout Lake pluton) might have potential for copper-gold porphyry-style mineralization. Indeed, a number of mineral occurrences with chalcopyrite and variable amounts of gold associated to the Spout Lake pluton and Takomkane batholith have been described by Schiarizza and Bligh (2008) and Schiarizza et al. (2009a). At the northern extent of the Thuya batholith, Schiarizza and Israel (2001) have described a number of base and precious metal occurrences including platinum mineralization, metalliferous skarns, veins and shear-related gold showings, and porphyry-style copper occurences. The extensive gold grain anomaly in till in this region (slide 28) might result from the glacial erosion of multiple gold bearing bedrock sources. The chalcopyrite grains in till are likely derived from known and unknown copper occurrences.

Slide 31



Detailed view of the chalcopyrite grain content of till in the Spout Lake region. See slide 30 for location.

Table 1. Chalcopyrite grain counts in till; (0.25-0.5 mm; s.g. >3.2)

				Chalcopyrite grains	
Sample	Easting*	Northing*	Table Feed (kg)	Counts	Normalized counts (/10kg)
07BJB-003	687670	5678854	8.1	1	1
07BJB-006	685163	5676740	10.8	0	0
07BJB-008	680666	5676993	9.2	0	0
07BJB-033	687094	5707872	14.7	1	1
07BJB-036	677032	5708231	14.5	3	2
07BJB-037	675307	5705865	13.3	1	1
07BJB-038	671720	5704130	13.5	8	6
07BJB-041	666246	5708811	11	0	0
07BJB-076	662999	5680214	15.5	0	0
07BJB-088	676282	5705093	12.4	0	0
07BJB-091	686061	5705874	13	12	9
07BJB-097	646692	5697230	14	0	0
07PMA-A075A-01	630222	5675508	11.8	0	0
07PMA-A154A-01	615237	5686313	18.2	0	0
07PMA-A162A-01	631074	5683634	15.5	0	0
07PMA-A164A-01	630995	5681604	16.5	0	0
07PMA-A166A-01	626357	5681383	18	0	0
07PMA-A202A-01	635147	5683327	22.6	0	0
07PMA-A203A-01	636136	5683683	20.3	2	1
07PMA-A205A-01	636684	5681000	16.5	0	0
07PMA-A236A-01	606906	5698277	20.6	0	0
07PMA-A239A-01	613059	5696379	22.6	0	0
07PMA-C009A-01	640044	5678288	15.2	0	0
08BJB-014	682885	5730760	8.1	0	0
08BJB-049	677234	5710607	6.6	0	0
08PMA-A026A-01	619288	5756615	6.2	1	2
08-PMA-A033A-01	615883	5756845	8.4	1	1
08-PMA-A037A-01	617412	5756044	11.5	0	0
08-PMA-A038A-01	615430	5755340	8.1	0	0

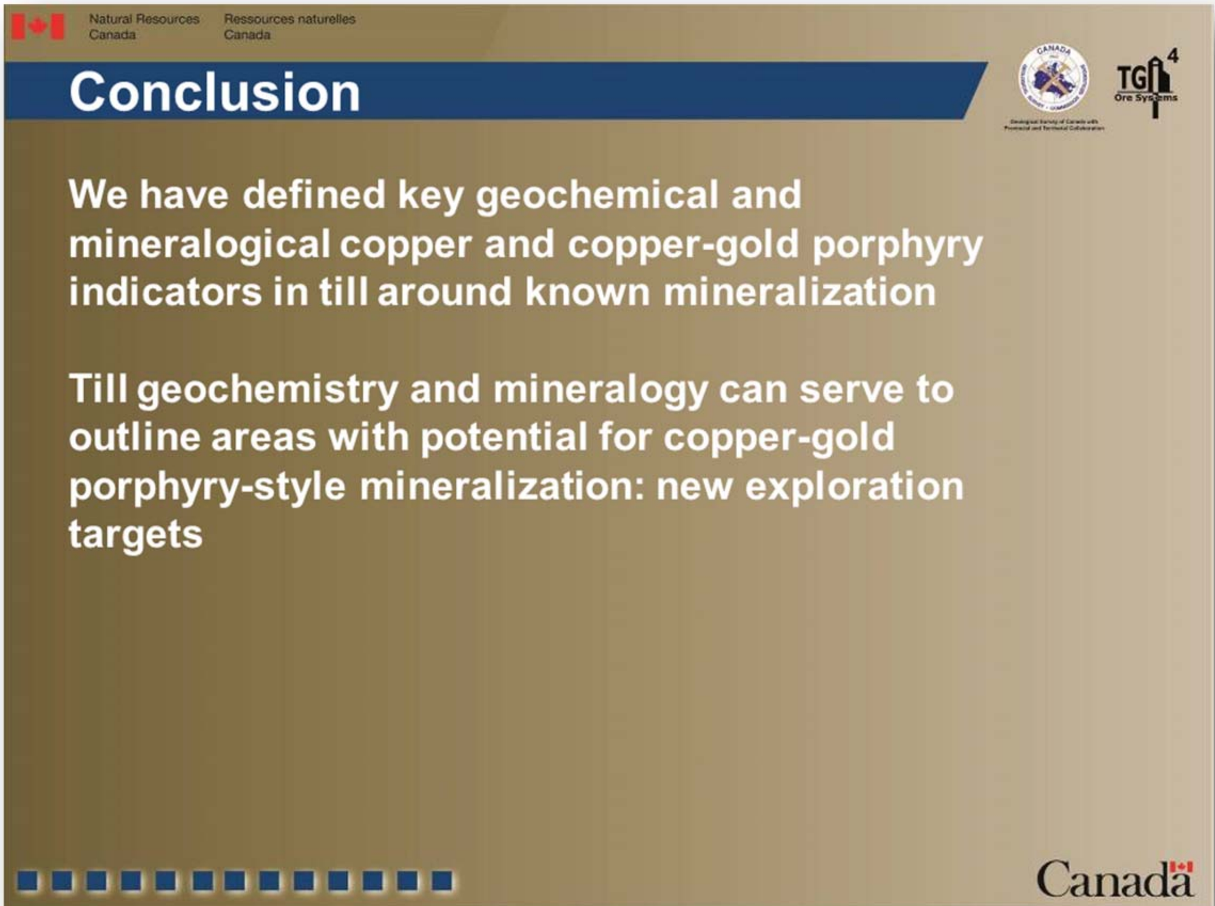
Table 1. (Cont'd) Chalcopyrite grain counts in till; (0.25 – 0.5 mm; s.g. >3.2)

				Chalcopyrite grains	
Sample	**Easting***	**Northing***	**Table Feed (kg)**	**Counts**	**Normalized counts (/10kg)**
08-PMA-A059A-01	616688	5757921	10.5	0	0
08-PMA-A066A-01	617534	5759739	12.5	0	0
08-PMA-A078A-01	633182	5752453	12	0	0
08-PMA-A083A-01	626973	5750711	11.9	0	0
08-PMA-A088A-01	625558	5749447	13.7	2	1
08-PMA-A090A-01	627713	5745100	12	0	0
08-PMA-A092A-01	616587	5756948	8.8	0	0
08PMA-A093A-01	615502	5756614	9.9	1	1
08PMA-A098A-01	617741	5758323	9.4	0	0
08PMA-A099A-01	615725	5758067	10.14	8	8
08PMA-A101A-01	686654	5707285	6.6	7	11
08PMA-A102A-01	686688	5707395	6.5	0	0
08PMA-A103A-01	686768	5706981	8.8	0	0
08PMA-A104A-01	682534	5711886	9.9	0	0
08PMA-A105B-01	679019	5714296	8.3	1	1
08PMA-A121A-01	668477	5742696	10.8	2	2
08PMA-A134A-01	630492	5745429	9.9	0	0
08PMA-A137A-01	633699	5747503	12	1	1
08PMA-A187A-01	671395	5743157	10.7	0	0
08PMAC-108A-01	699248	5740398	8.6	0	0
08PMAC-114A-01	696894	5739745	6.1	0	0
08PMA-J068A-01	667055	5721647	6.1	1	2
08PMA-J088A-01	663579	5721145	12.2	0	0
08PMA-J105A-01	643291	5709610	7.6	0	0
08PMA-J154A-01	663979	5717392	11.1	6	5
08PMA-J171A-01	670460	5713970	6.5	1	2
08PMA-J177A-01	668405	5708828	5.9	0	0
08PMA-J178A-01	673384	5709085	9.2	0	0

*Easting and northing: UTM zone 10, NAD 83.

CONCLUSION

Slide 32



The till orientation surveys completed at three sites with copper porphyry mineralization (Gibraltar Mine, Mount Polley Mine and the Woodjam prospect) have served to define key geochemical and mineralogical indicators of porphyry mineralization in till. These include: elevated amounts of copper in the clay-sized fraction and large number of chalcopyrite (0.25 – 0.5 mm and >3.2 s.g. fraction). At Mount Polley, gold grains (4 to 250 µm) are another indicator of mineralization given the nature of the copper-gold porphyry mineralization. These indicators are more elevated in till near mineralization compared to surrounding regions. Furthermore, they can now serve to define regions with potential for porphyry-style mineralization. Using a published till geochemistry and mineralogy data set (Plouffe et al., 2009, 2010) and new porphyry indicator mineral analyses, we are suggesting that two areas might have potential for porphyry-style or other type of copper-gold mineralization: at the northern end of the Thuya batholith and along the western margin of the Takomkane batholith in an area underlain by the Spout Lake pluton.

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