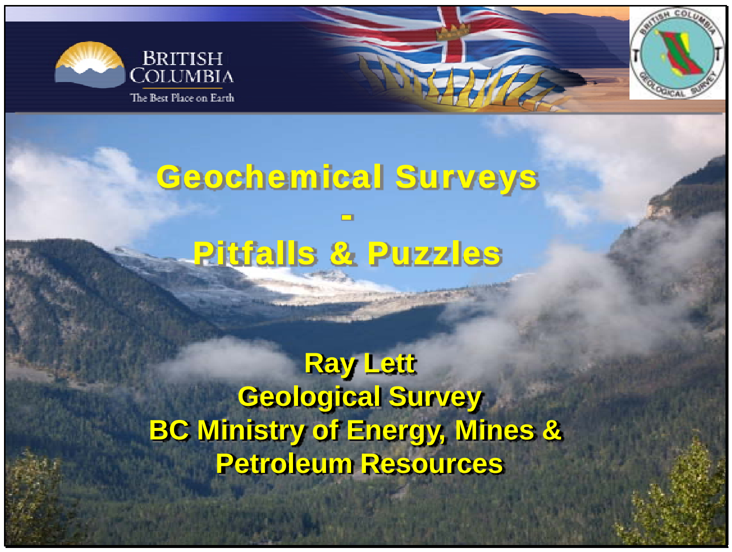
Ministry of Energy
Mines and Petroleum
Resources

GEOCHEMICAL SURVEYS – PITFALLS AND PUZZLES

Ray Lett

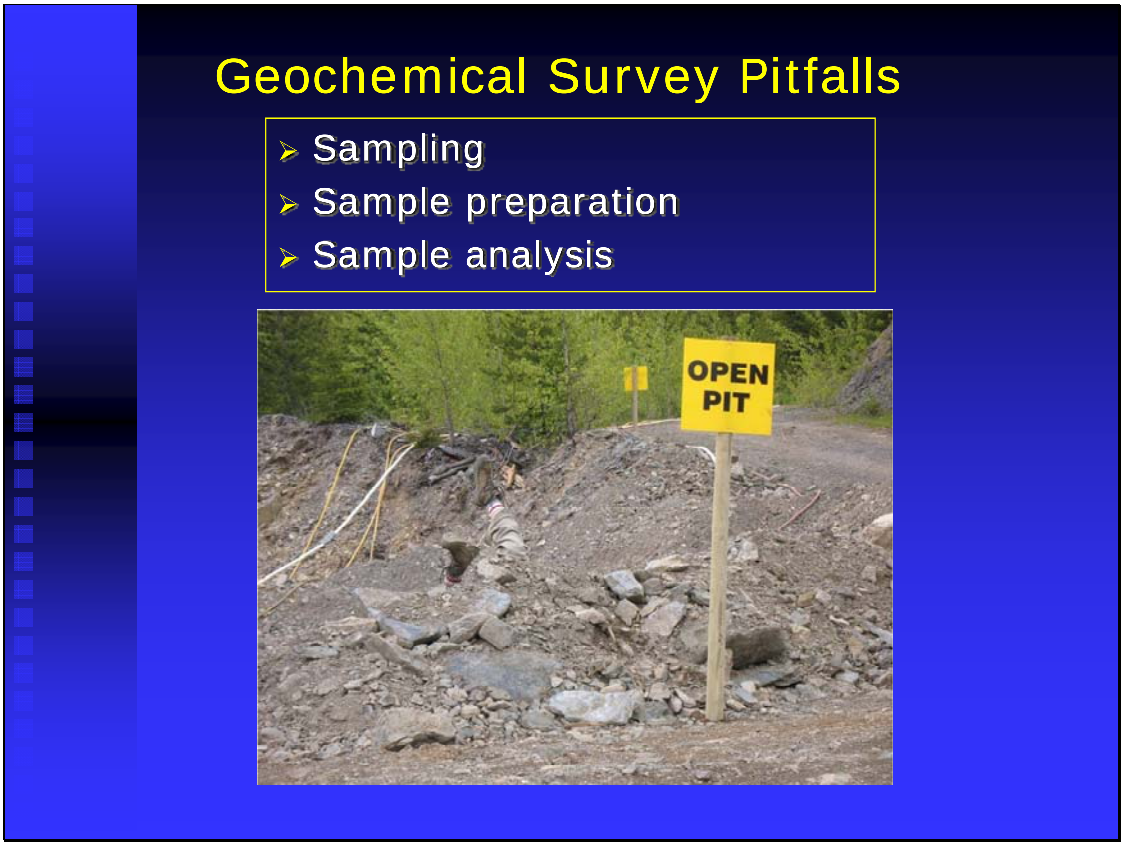
Geofile

Slide 1



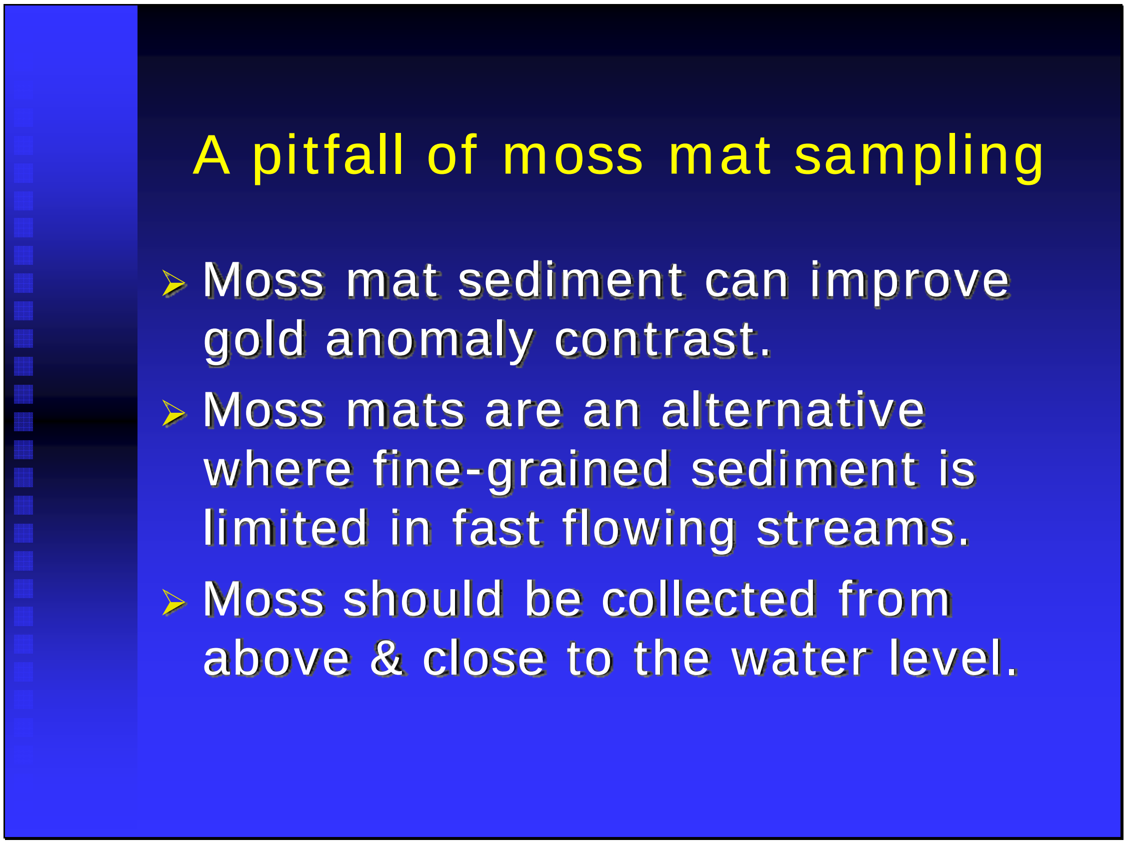
This talk will illustrate some geochemical survey pitfalls, a few puzzles (at least to the author) and a brief review of the current GSB Geochemical program.

Slide 2



There are always the pitfalls of poor sampling technique, absence of any field data describing the sample collected, contamination during sampling and sample preparation and an unsuitable analytical method chosen for a survey that will make interpreting geochemical survey data difficult. There are also the obvious pitfalls during fieldwork that should be avoided.

Slide 3

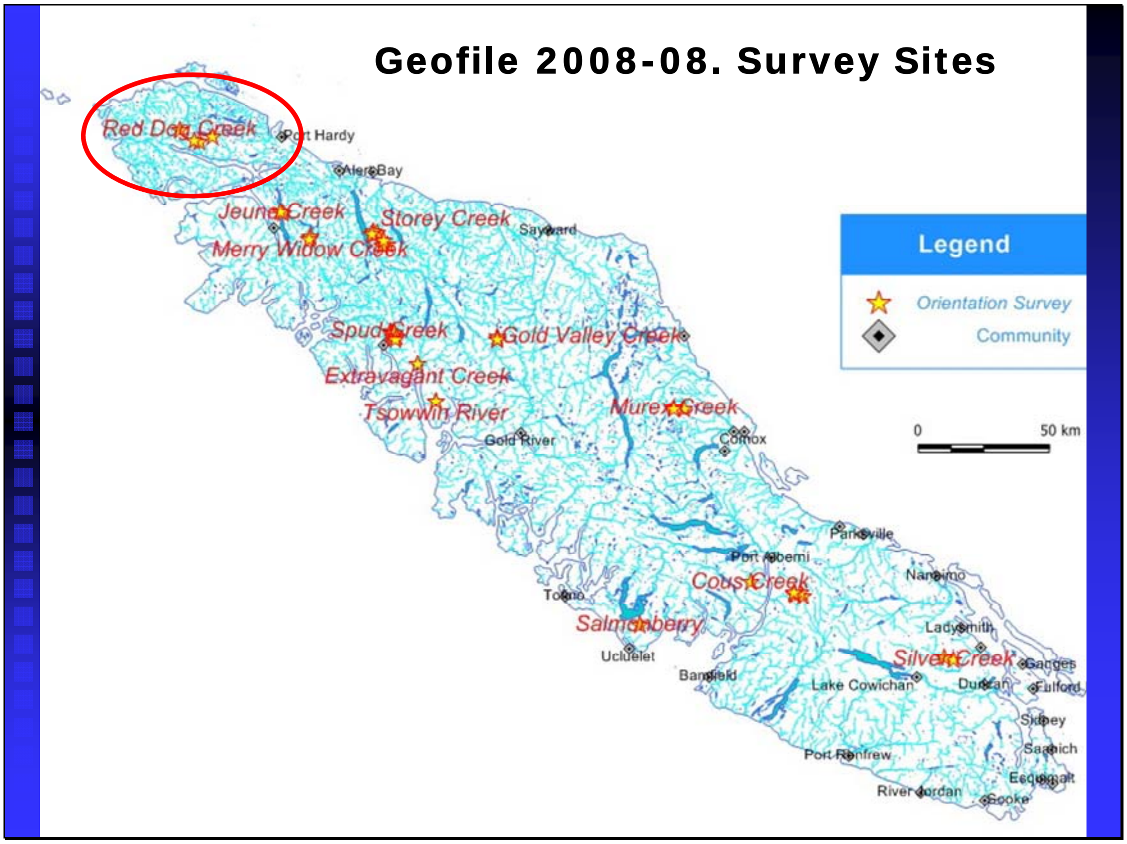


A regional survey with a sampling density between 1 /10 km^2 to 1 /15 km^2 will outline bedrock geology that has an elevated trace element geochemical background. This sample density is generally too low to detect all of the exposed mineral occurrences that would be revealed by the stream geochemistry as an obvious anomaly. However, there have been recent BC examples where the routine RGS has been successful as the primary exploration tool. A routine geochemical survey can be improves by adjusting sample density so that the sampling will better detect mineralization or by using a different sample types. Lake sediments are an obvious example to deal with areas where there are few streams, but many lakes. Moss mat sediment was introduced in the early 1990's to solve the problem of sampling fast flowing mountain streams on Vancouver Island where fine grained sediment was depleted from the stream bed load. Moss mat sediment can improve gold anomaly contrast because the moss captures fine-grained sediment and heavy mineral from the suspended sediment at periods of high water flow (e.g. Spring runoff). It is important that live moss mats are collected from boulders and logs close to the stream water level.

Slide 4

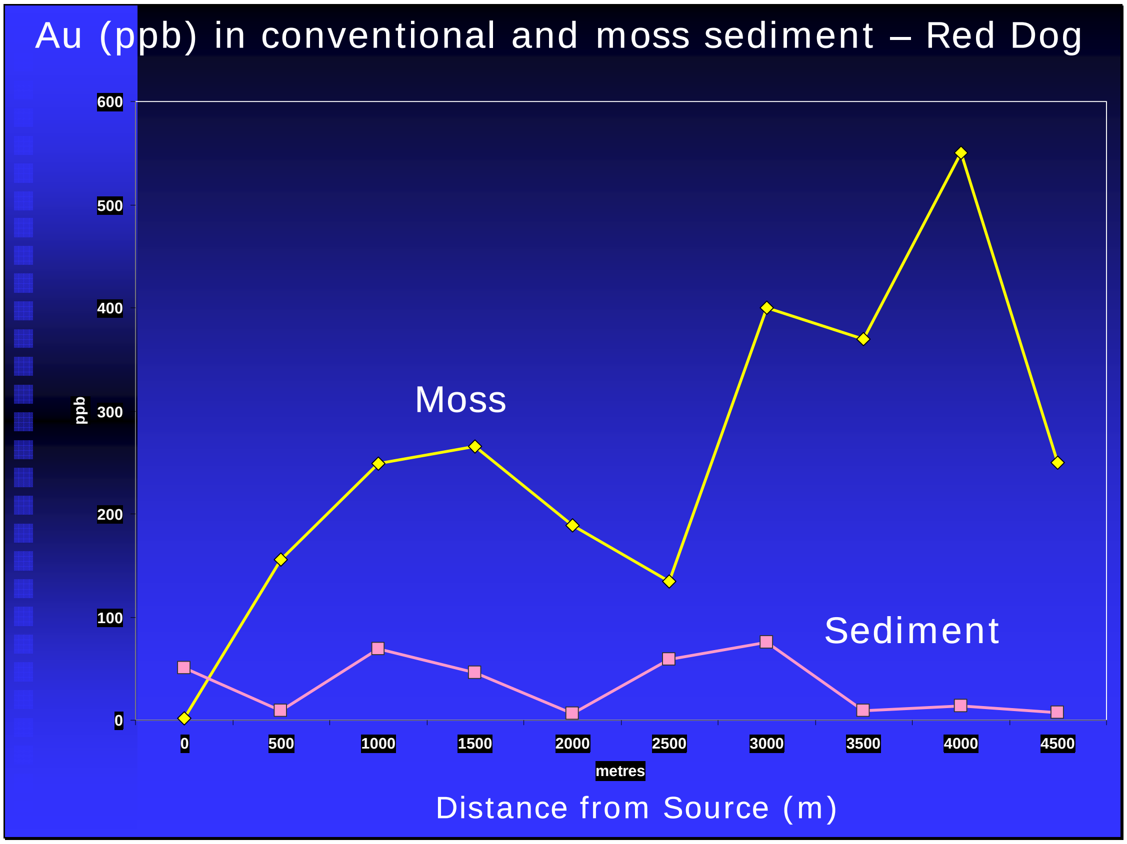
This slide shows moss sediment sampling in the Lillooet area – Thanks to Garret Larcroux of the Ts'kw'aylaxw First Nation for assistance with sampling.

Slide 5



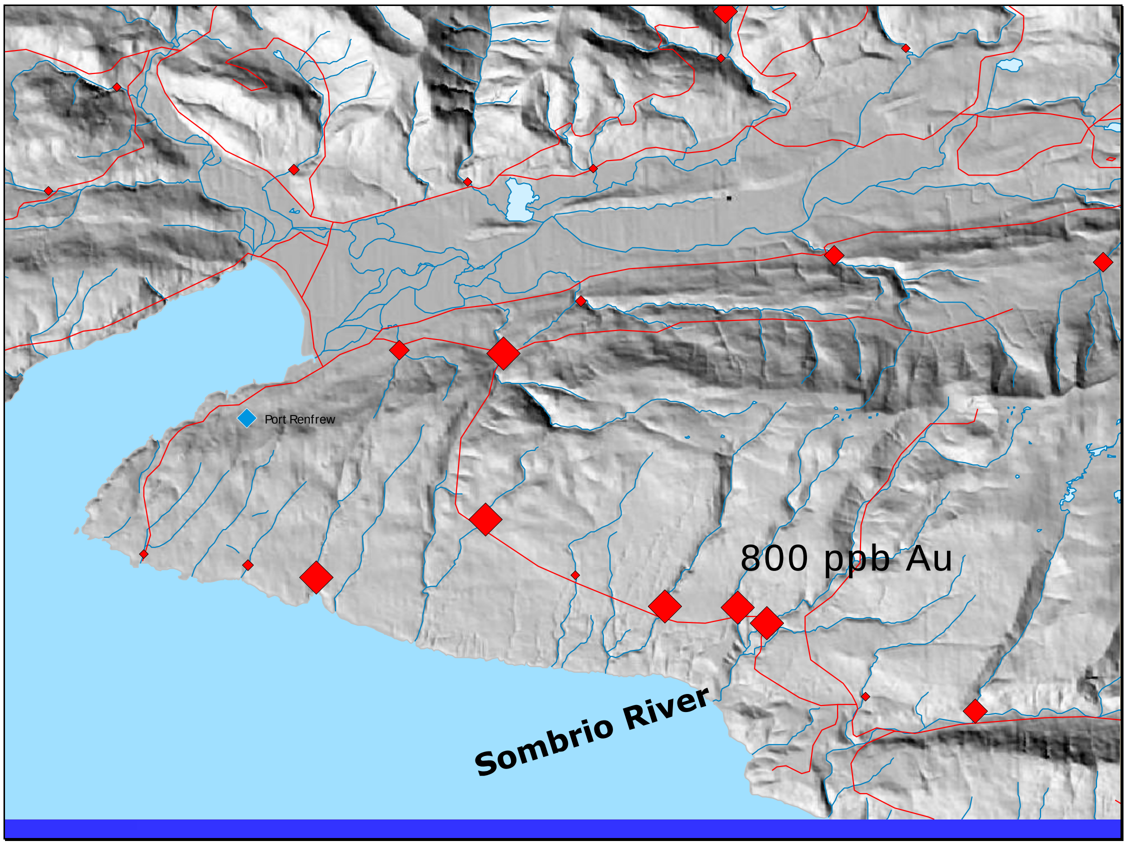
This side shows the locations of the geochemical orientation surveys on Vancouver Island, including the Red Dog property documented in BC Geological Survey Geofile 2008-08. Drainage from the Red Dog Cu-Mo-Au-Ag sub-economic porphyry deposit at the north end of Vancouver Island illustrates the difference between the behavior of Au in stream versus moss sediments. The creek has a 150 m vertical drop over the 3.7 km reach of the channel where moss and sediment samples were taken.

Slide 6



The profile of shows that Au values are below 100 ppb in stream sediment from the channel for 4.5 km, but significantly increase to almost 600 ppb in the moss sediment with a peak at about 3 km downstream from the an area where this most likely Cu-Au sulphide mineralization.

Slide 7

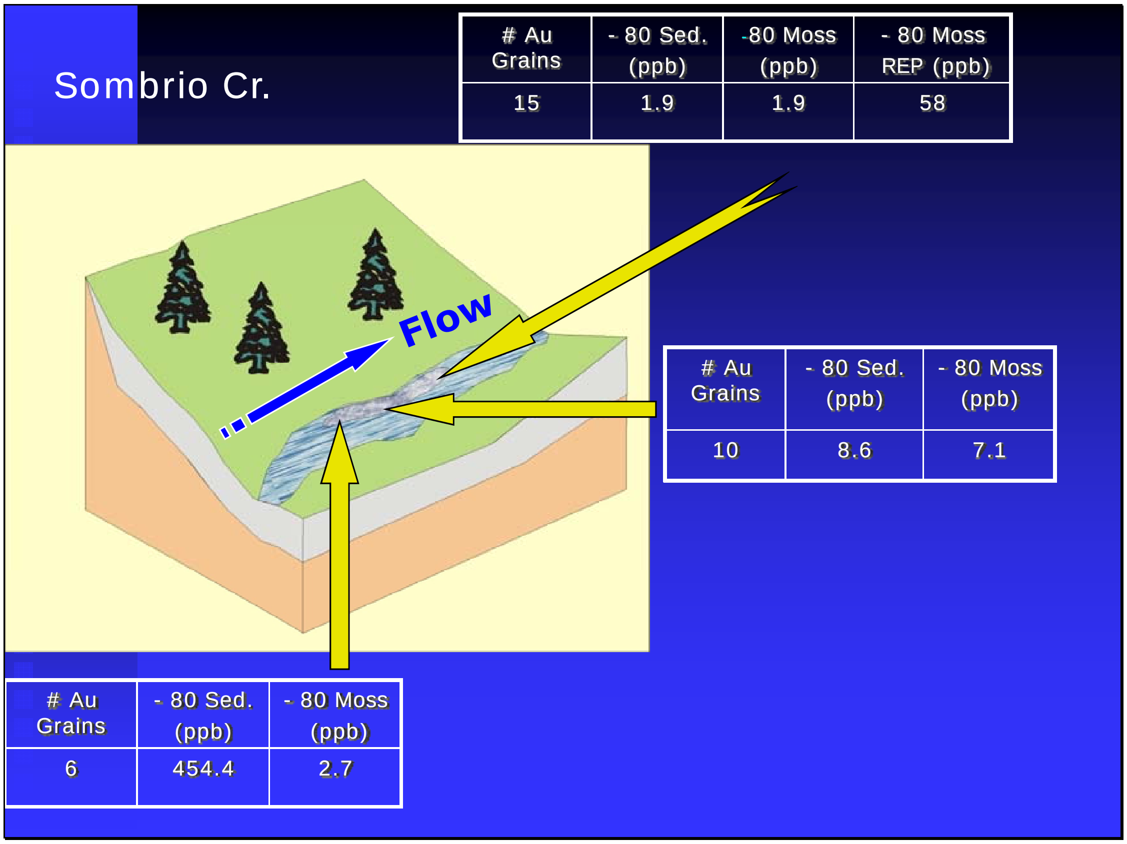


Slide 7 illustrates another example to compare the distribution of Au in conventional stream sediment to Au in moss sediment and Au in heavy mineral concentrates along a bar in Sombrio River west of Victoria on Vancouver Island, British Columbia. Stream flow is south to the sea from rocks forming the Pacific Rim Leach River complex. The map identifies the site and shows the Au value detected in sediment collected during a previous BC Geological Survey regional survey.

Slide 8

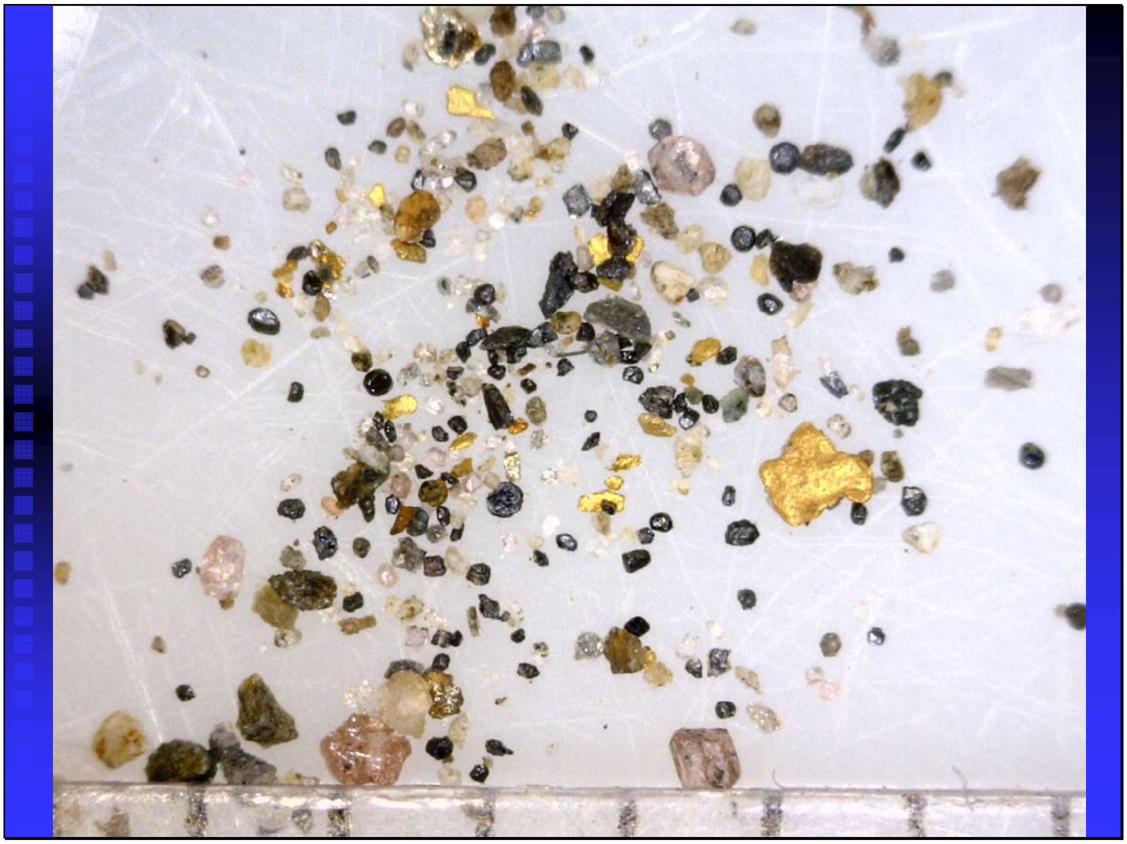
Slide 8 shows the Sombrio Creek gravel bar where samples were collected. There are three sites where a heavy mineral bulk sediment and conventional stream sediment where collected from the upstream end, midpoint and tail of the bar at about 10 to 15 m intervals marked by A, B and C on the slide. Bulk samples were from shallow (10-15 cm depth) pits in the bar. The moss sediment was collected close to the creek bank (but about 5-10 cm about the present water level) on the right of the slide (hidden by the trees). Credit to Zoe Sandwith for this photograph showing the bar upstream from the BC Highway 14 road bridge.

Slide 9



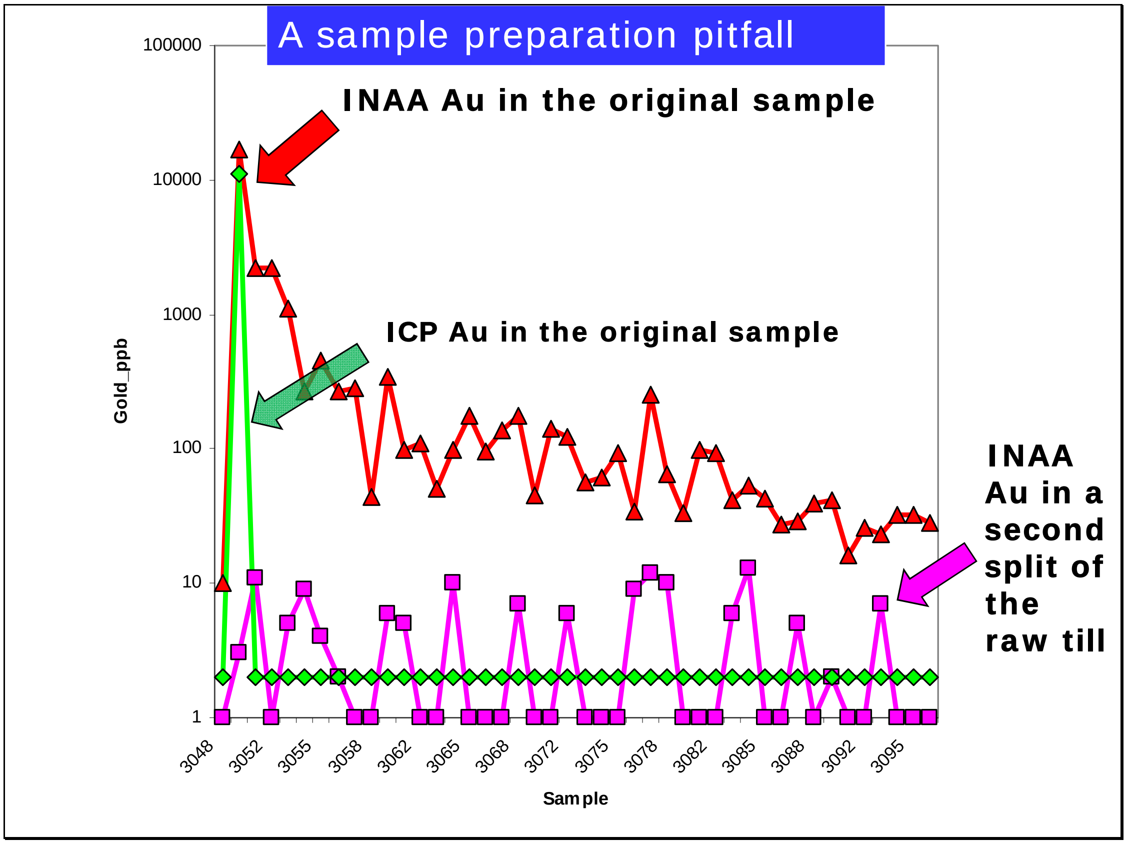
Slide 9 shows that the highest Au value from the Sombrio Creek bar is in the - 80 mesh fraction of the stream sediment and not in the - 80 mesh fraction of the moss sediment as might be expected from the Red Dog example. This difference may reflect that the moss collected from close to the creek bank was infrequently submerged in the creek water floe and therefore had less chance to capture Au from the suspended sediment. The Au grains show a progressive increase in number from the upstream end of the bar to the bar tail. The study illustrates that a single sediment sample from a large gravel bar may not be sufficient to detect anomalous Au because the erratic distribution of Au in the sediment. Also, moss sediment must be carefully collected to make sure it has sufficient contact with the water.

Slide 10



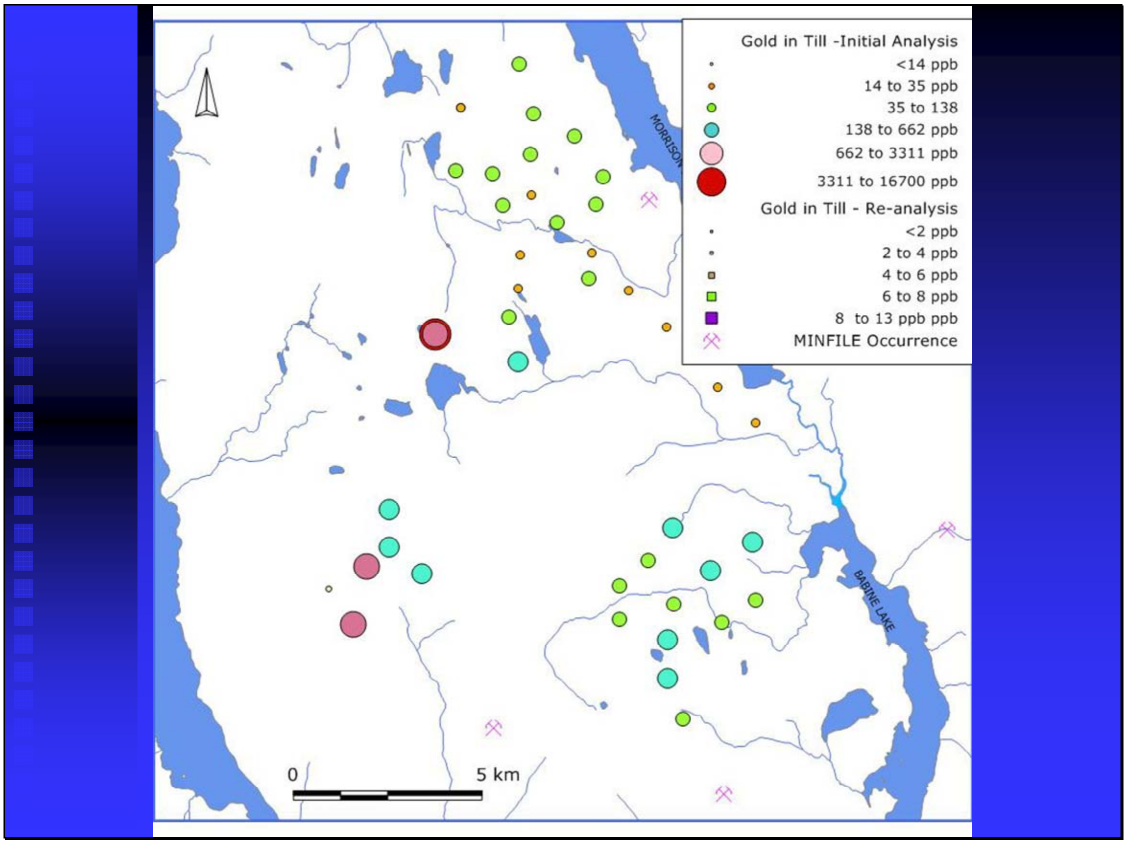
This slide shows Au and other mineral grains in the heavy mineral concentrate made from the bar point B bulk sediment sample (- 2mm fraction). Most of the grains are rounded and have a range of sizes.

Slide 11



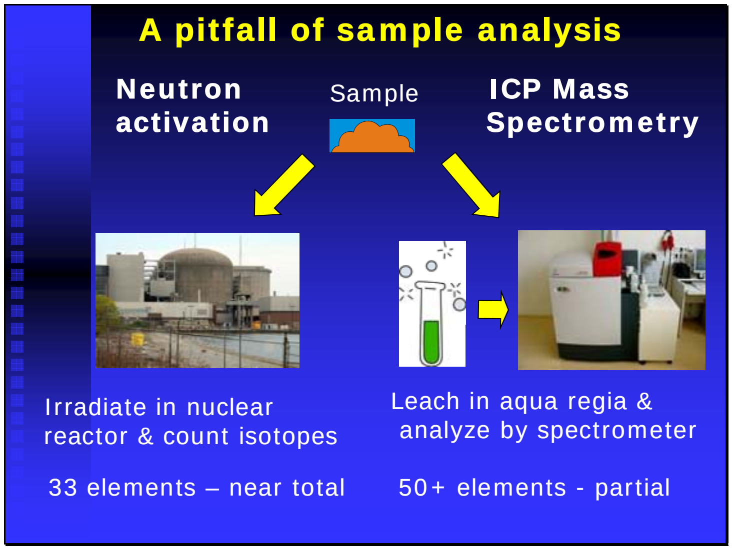
Slide 11 shows a hazard of the poor preparation of till samples collected from a regional survey in the Babine Lake area, central BC. An instrumental neutron activation (INAA) analysis of the – 63 micron till samples from Babine Lake till survey produced some spectacular Au results (over 10 ppm) that, if published, had the potential of stimulating a staking rush to the area. The INAA Au levels were confirmed by an aqua regia-ICP (inductively coupled plasma emission spectroscopy) analysis (1 ppm detection limit) of a split of the prepared till sample so the quality of the analysis appeared acceptable. Also, only Au appeared to reach such high levels compared to other elements. Contamination of the sieve with Au bearing rock during preparation at a commercial laboratory was most likely the reason for the high values because two independent methods reported a similar Au content. Also, the Au values decreased sharply from a peak along an exponential decay curve through the sequence of samples sieved for analysis. Having suspected contamination a second sample of the archived raw bulk till was prepared by the BC Geological Survey, analysed by INAA and found to contain less than 20 ppb in the – 63 micron fraction. The risk of a sample preparation problem can be reduced by keeping a “witness” split of the sample separate from that sent for analysis and carefully examining quality control and the reported data for inconsistencies.

Slide 12



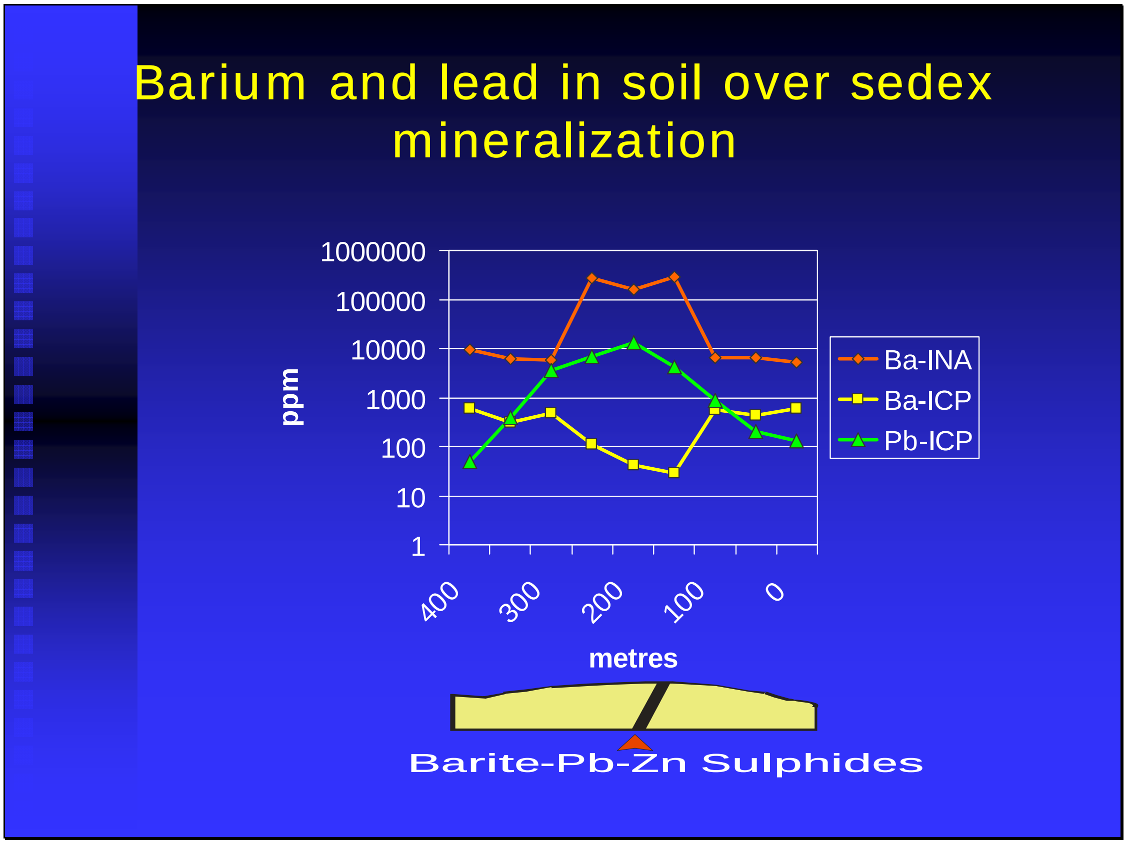
Slide 12 shows the distribution of Au values in the till if they had been released to the public. The “Gold in till – Re-Analysis” in the legend shows the range of values after preparation of a second samples from the bulk till and analysis for Au by INAA. All of the high Au values shown on the map would have disappeared because the maximum value shown in the legend is now 13 ppb.

Slide 13



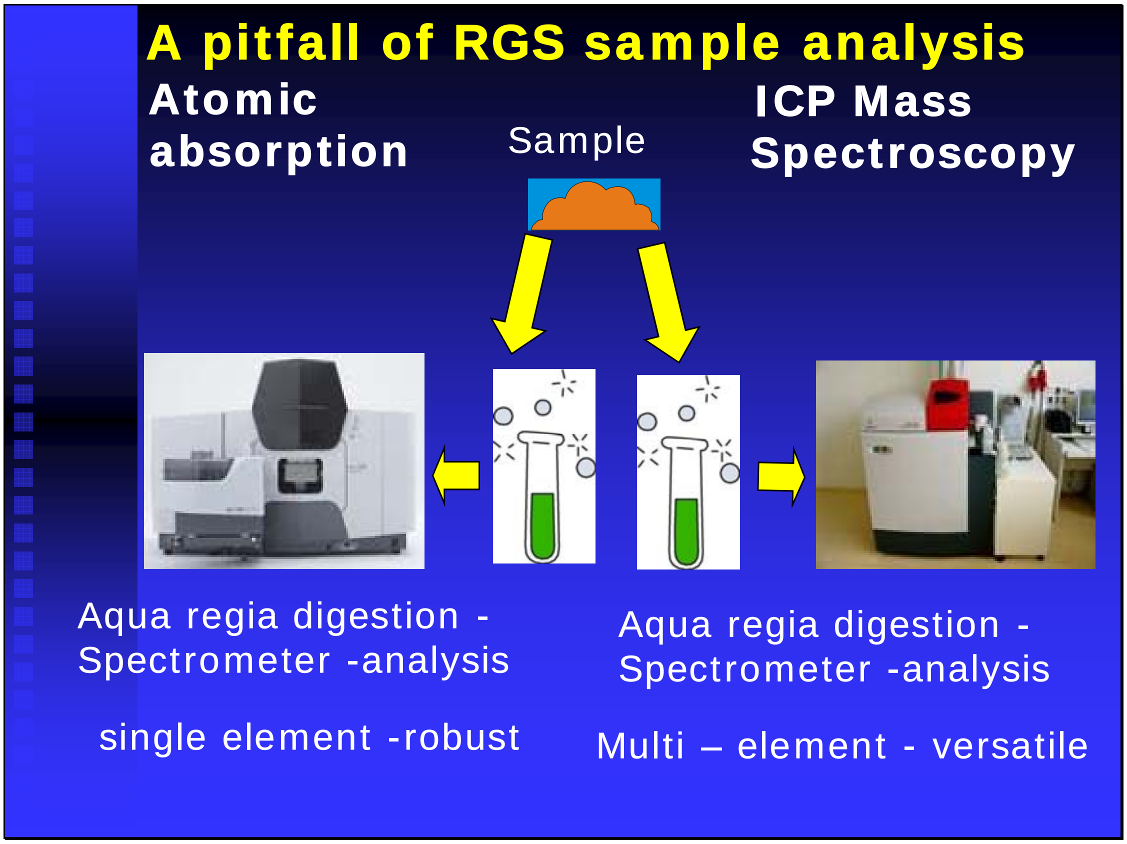
Using an unsuitable analytical method can lead to problems in a geochemical survey. Slide 13 illustrates a difference between instrumental neutron activation analysis (INAA) and aqua regia digestion followed by inductively coupled plasma mass spectroscopy (aqua regia-ICPMS). INAA is non-destructive and reports near-total element abundances in all minerals forming the sample whereas aqua regia will only measure a varying fraction of the total amount of an element in a sample depending on a mineral solubility in the nitric-hydrochloric acid leach. For many elements (e.g. W, Cr, Zr) commonly found in refractory minerals (e.g. chromite) aqua regia-ICPMS is a partial analysis. For other elements present in sulphide the method is near-total. Hence, an appreciation of sample mineralogy and the aim of the survey are important when selecting the analytical method.

Slide 14



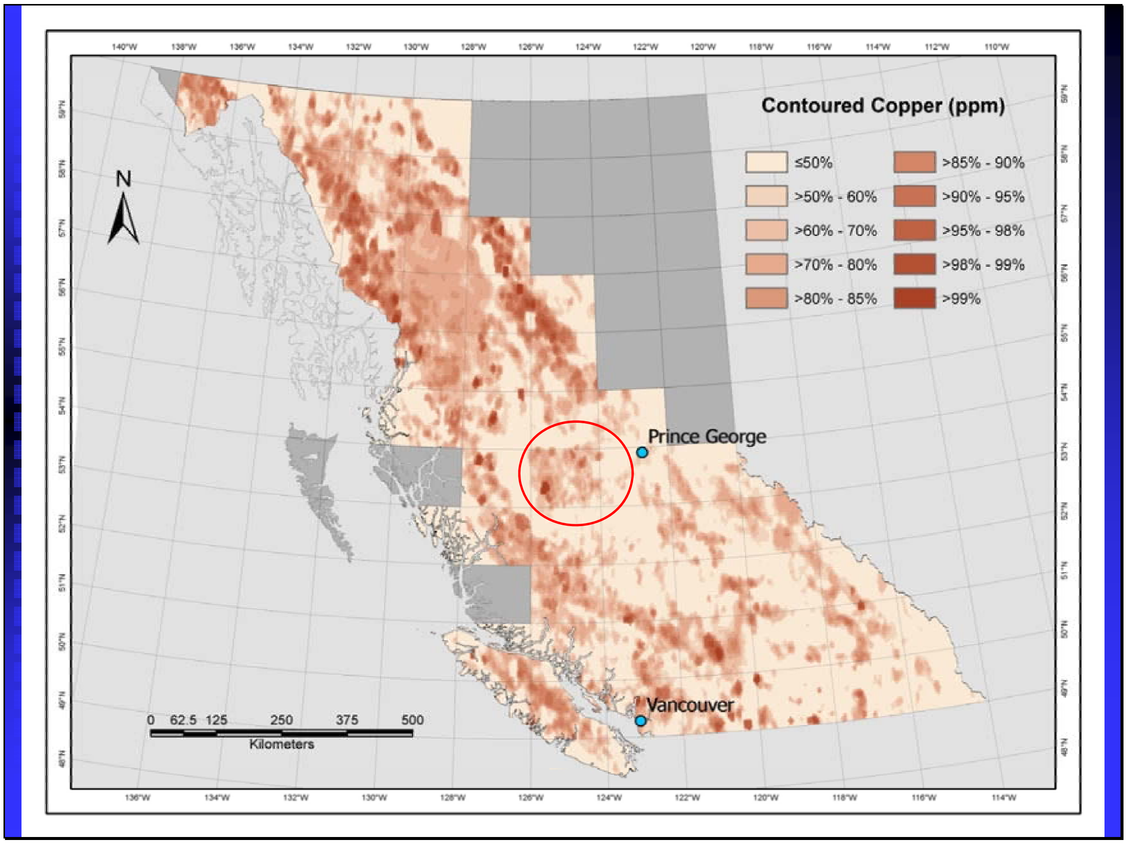
Slide 14 compares the results of an INAA and aqua regia-ICP analysis of soil samples collected over a lead-zinc sulphide lens containing barite. The difference between the aqua regia-ICP (partial) Ba and the INAA Ba (near total) indicates that barite is abundant in the soil. The low Ba values in the soil by aqua regia-ICP may also reflect a suppression effect from the high sulphate liberated by the sulphide dissolution that would enhance $BaSO_4$ precipitation from the digestion solution.

Slide 15



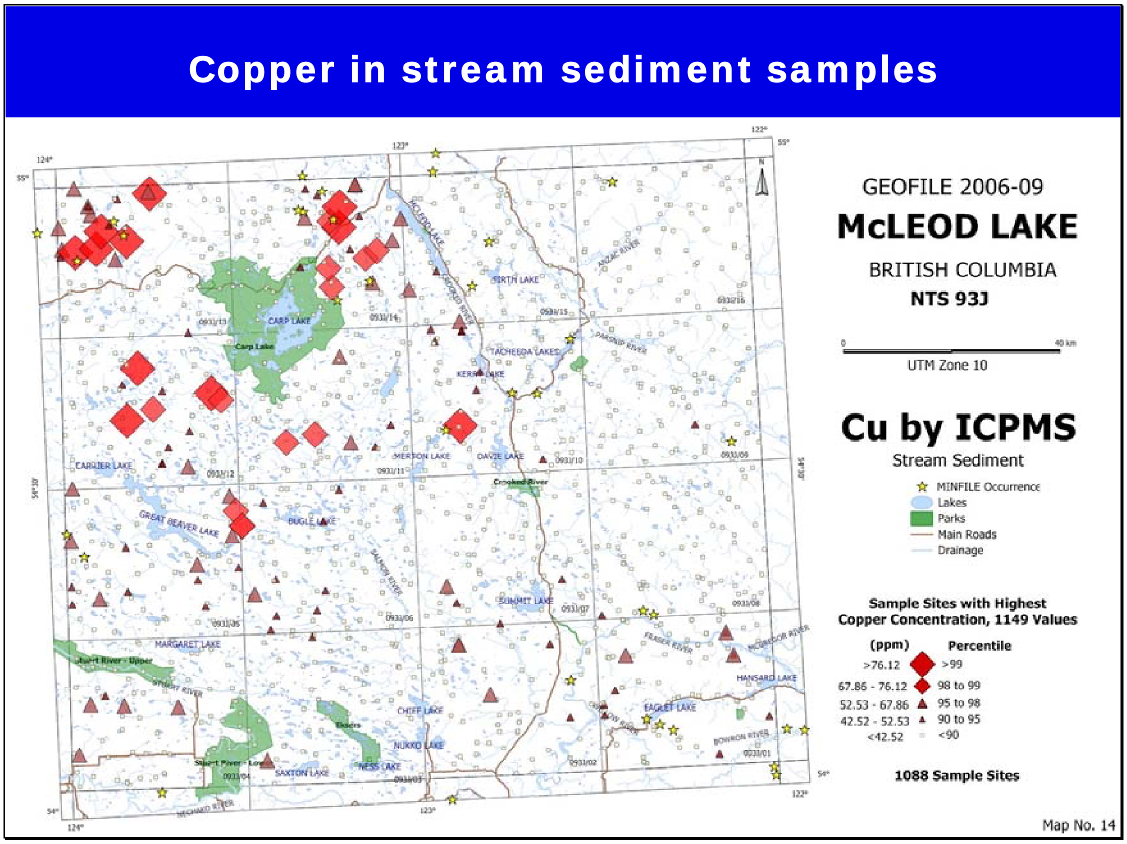
Slide 15 illustrates two common methods used for trace element analysis of sediment samples collected during regional geochemical surveys (RGS) typical of those carried out by the BC Geological Survey, Geological Survey of Canada and Geoscience BC. An earlier analytical method used to detect element in RGS samples was an aqua regia digestion of the sediment followed by atomic absorption spectrophotometry. (AAS). This method is robust , but can only determine on element at a time. A more recent method is an aqua regia digestion followed by inductively coupled plasma mass spectroscopy (ICP-MS). This is multi-element and therefore more efficient and can measure elements to a lower detection limit. Both methods will only measure part of the total amount of an element in a sample depending on a mineral solubility in the nitric-hydrochloric acid leach. Results of the two methods should be very similar, but there will be differences in the amount of metal liberated depending on the conditions of the digestion.

Slide 16



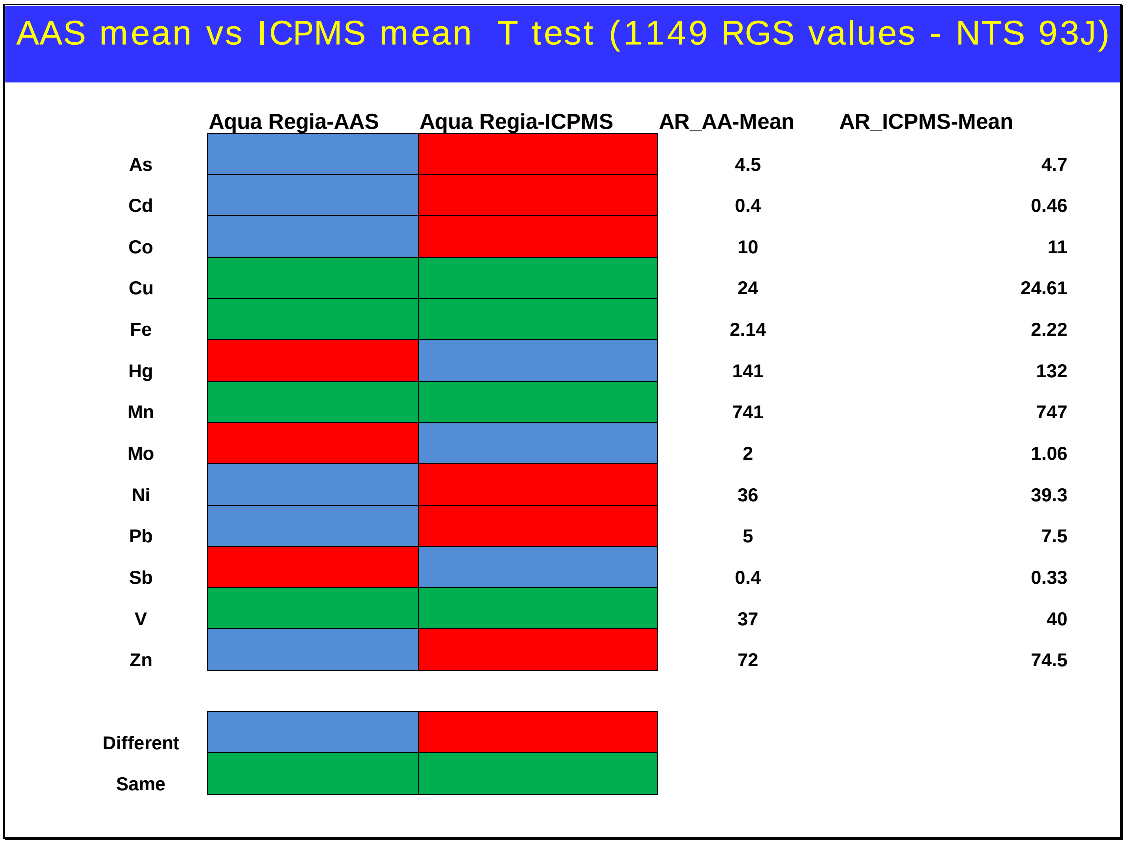
While a difference in the results produced by the two methods (i.e. Aqua regia-AAS versus aqua regia-ICPMS) may have little effect on exploration geochemistry where the object is to identify anomalous values, it can be more obvious when regional survey data is contoured. This shows the contoured RGS copper in BC – note the edge effect along a map sheet boundary.

Slide 17



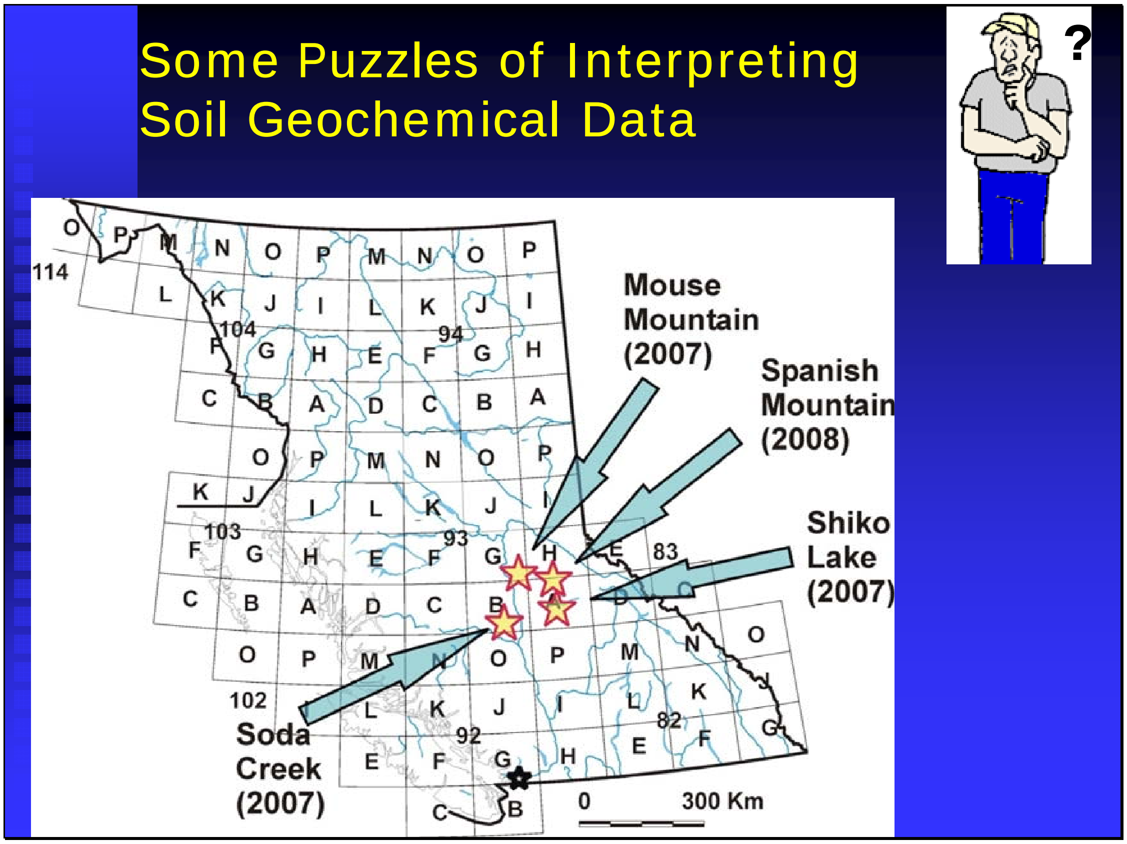
Slide 17 shows the distribution of copper in the archived stream sediment samples from the McLeod Lake map sheet that were analysed by an aqua regia digestion – ICPMS. The samples were originally analysed for Cu in 1985 by aqua regia digestion – AAS.

Slide 18



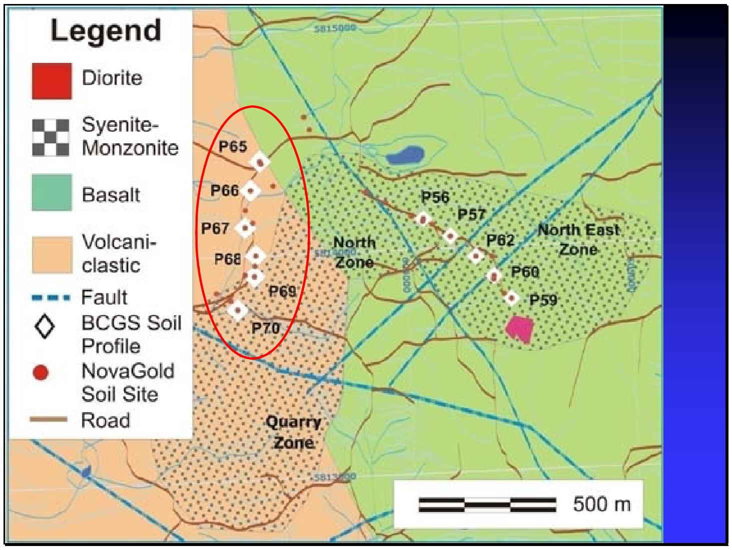
Slide 18 summarises the results of a statistical t test applied to mean values for elements determined first by aqua regia –atomic absorption and later by aqua regia-ICPMS. All values except for Fe log transformed before the t test was applied and also tested to determine if the distributions had equal or unequal variance. Red to blue indicates difference (red higher than blue) and green indicates no difference at the 0.05 probability level. Note that although some of the means are apparently identical the t test shows that statistically the means are different. The same differences could influence merged survey data if the RGS samples from one map sheet were analysed by aqua regia-ICPMS and samples from an adjacent sheet analysed by aqua regia-AAS.

Slide 19



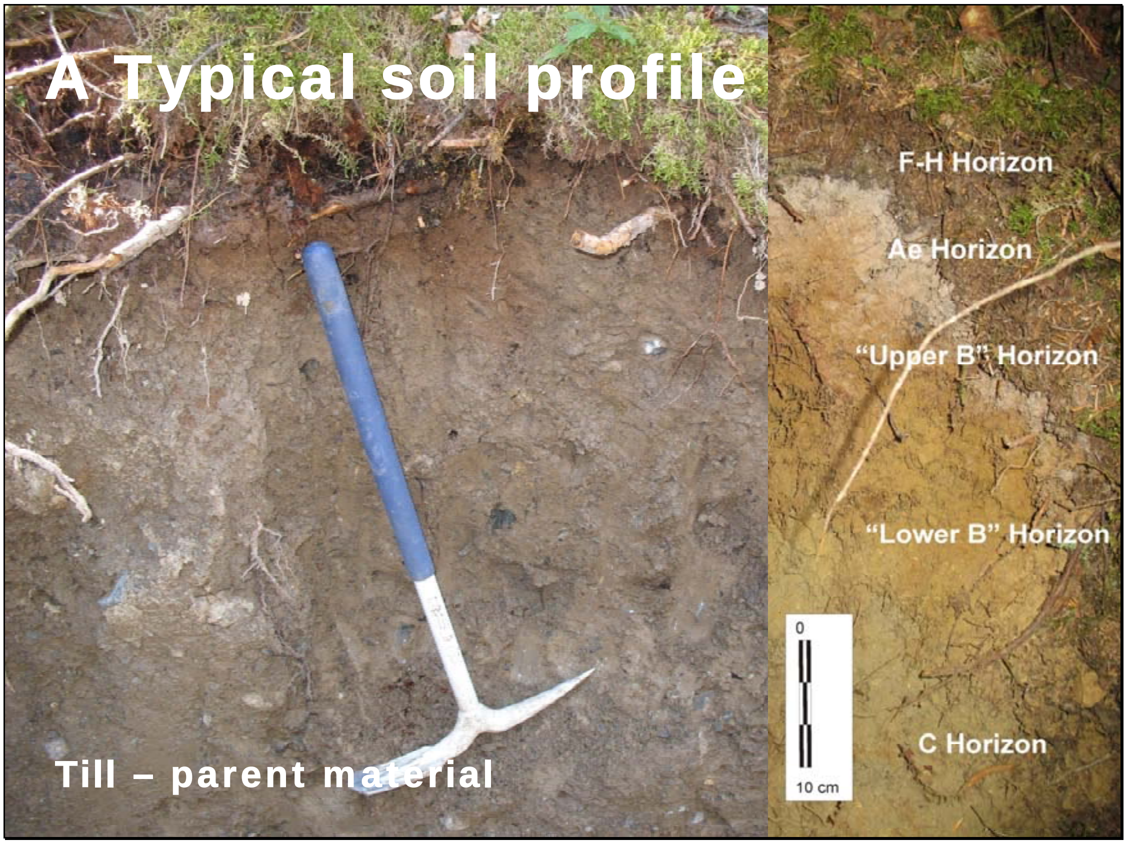
Moving on to some questions asked by geochemists trying to interpret soil geochemical data. Selecting the optimum soil horizon for sampling to give maximum anomaly contrast for ore indicator and pathfinder elements is often a puzzle and can be illustrated by an orientation survey carried out over the Shiko Lake Cu-Au porphyry property. This orientation is among several studies undertaken in 2007 by the BC Geological Survey to try and better understand the soil and till geochemical expression of drift covered porphyry Cu-Au mineralization using conventional (e.g. Aqua regia-ICPMS) and a less conventional, partial extraction method (e.g. Mobile metal ion (MMI from X-ray labs, Toronto), (Enzyme leach, Bioleach, SGH from Actlabs, Ancaster, Ontario).

Slide 20



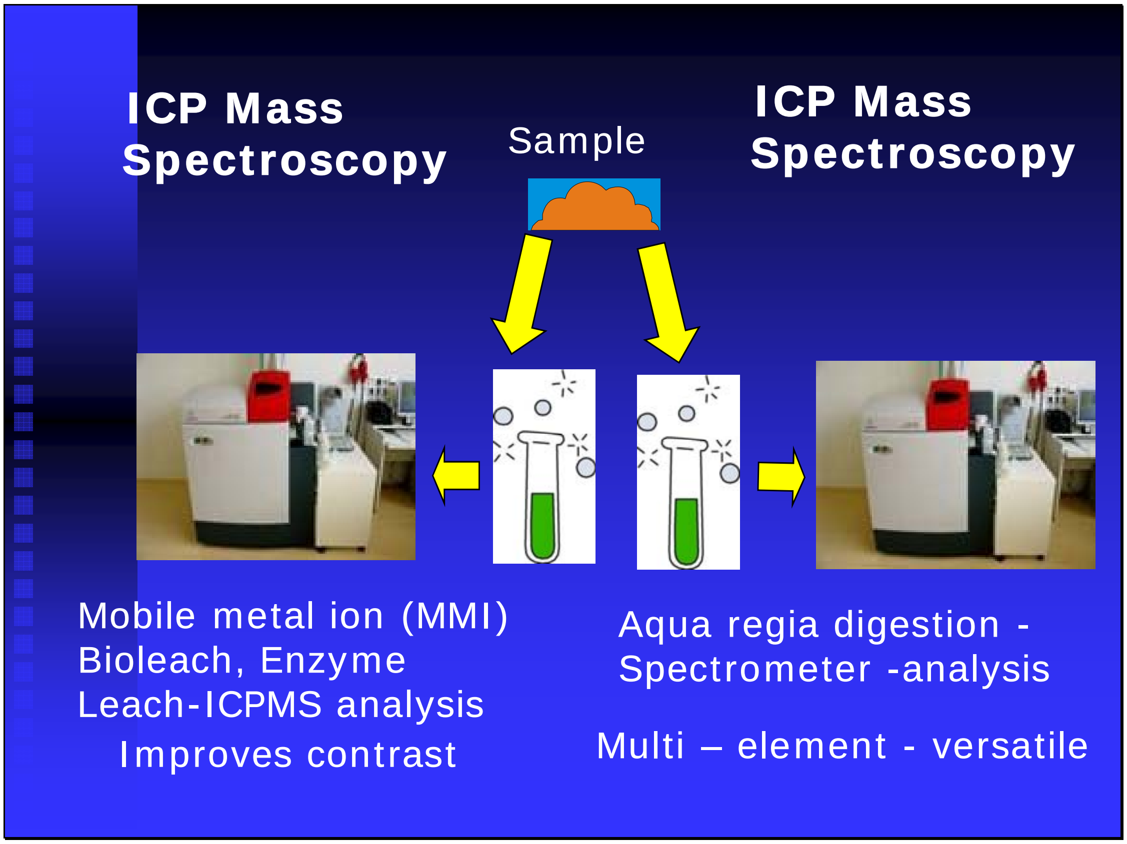
Slide 20 summarises the geology of the Shiko Lake property near Quesnel Lake, BC. A complex syenite-monzonite-diorite intrusive into Nicola basalt and volcaniclastic rocks is been mineralized with Cu and Fe sulphides and with Au. There are also alternation envelopes around the intrusive. The Mount Polley Cu-Au mine is about 8 km to the north of the property. Previous exploration by several mining companies most recently has involved overburden drilling and IP surveys. Results of detailed GSB soil sampling along a north to south traverse will be shown in the next slides.

Slide 21



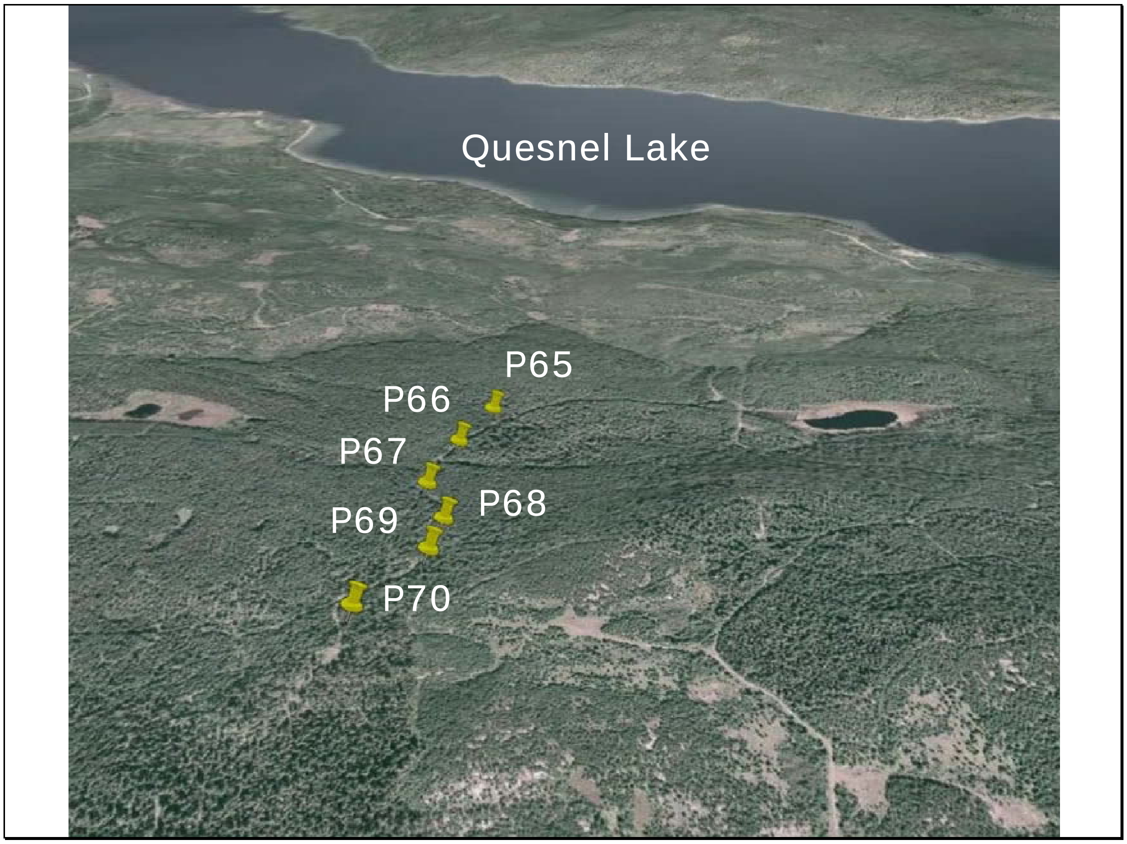
Side 21 is of a till exposure (ice transported minerals and rock fragment forming a compact, unsorted glacial deposit) and of more a detailed profile with the A, B and C soil horizons identified. Material was taken from the F-H, “upper” B, and “lower” B and C horizon each down soil profiles to establish the geochemical changes and element variations with depth and to try and replicate routine sampling carried out by exploration companies.

Slide 22



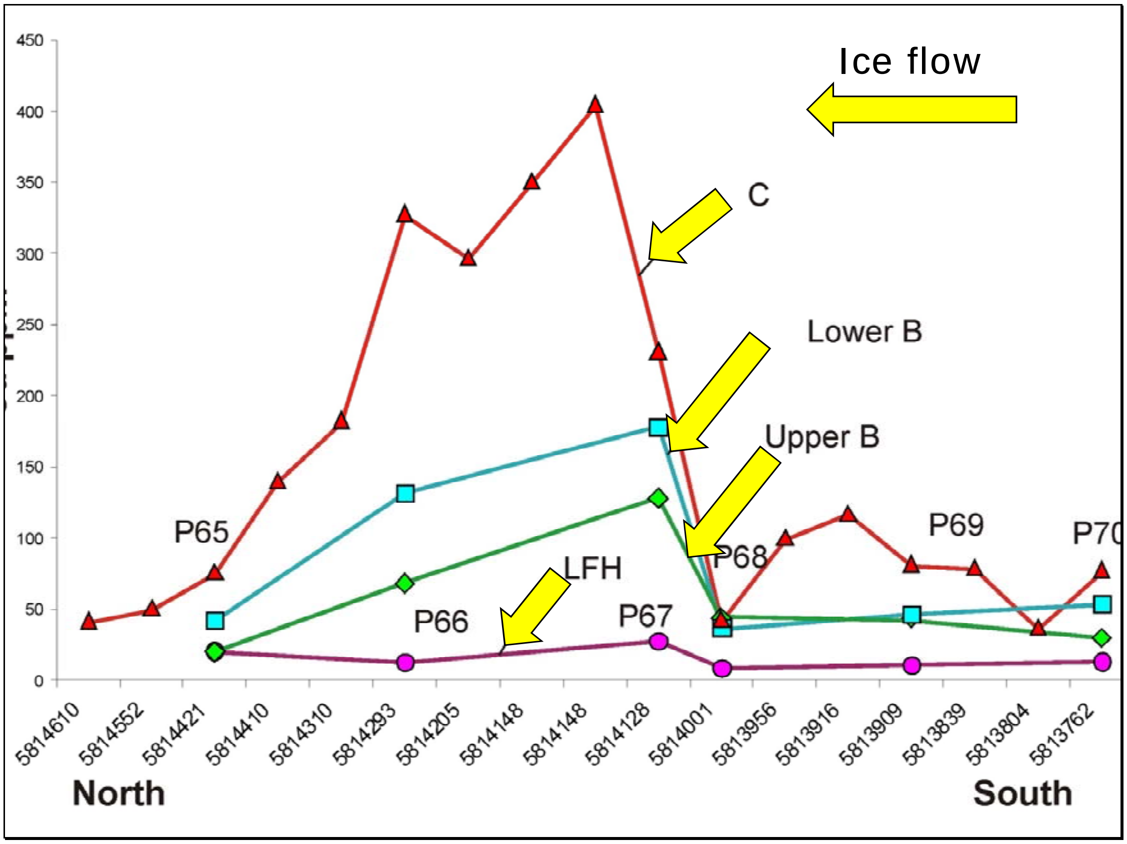
Sample analysed for a range of elements by aqua regia digestion followed by inductively coupled plasma mass spectroscopy and by INAA. Several partial extraction techniques such as MMI, Bioleach and Enzyme Leach were also used to try and improve anomaly contrast. B soil samples were also analysed for loss on ignition, for pH and for soil gas hydrocarbons (SGH).

Slide 23



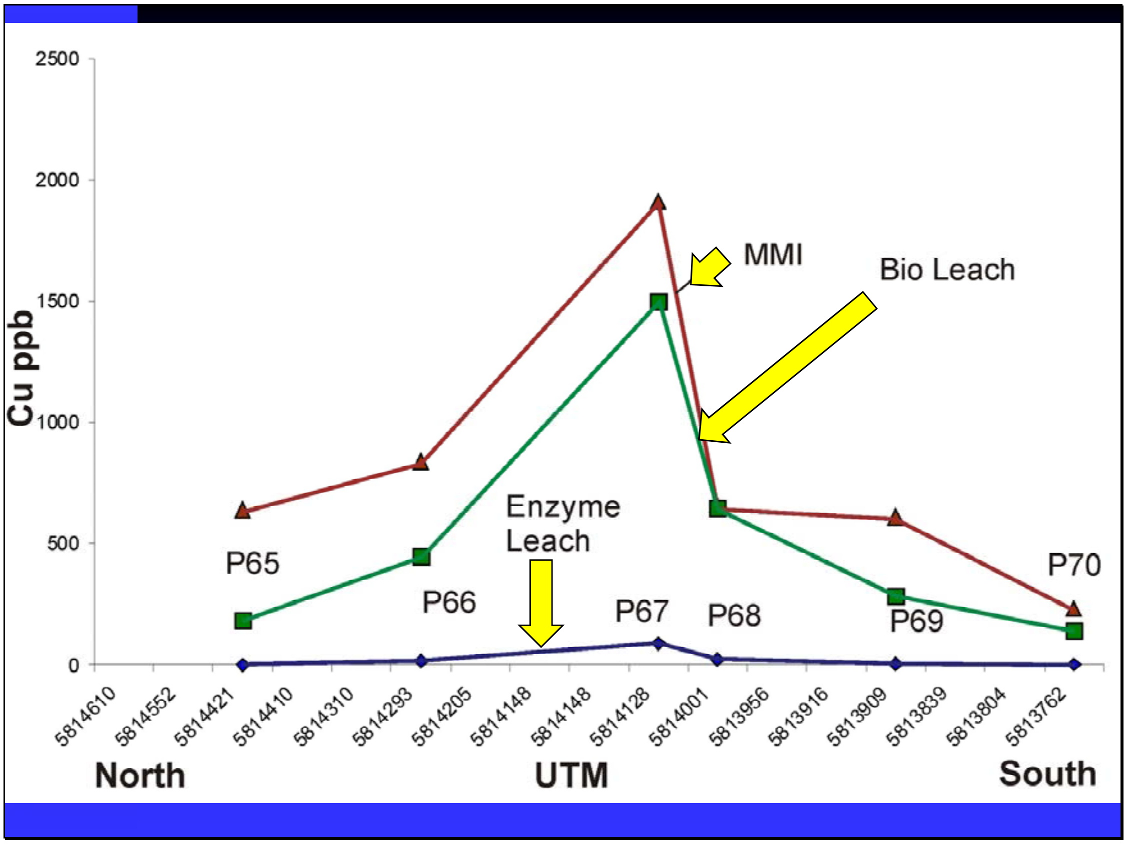
Slide 23 is a view north towards Quesnel lake close to the North Cu-Au mineralized to give a better appreciation of the terrain and ice-flow features (ice flow is from the south east to North West). The view shows the detailed soil profile locations.

Slide 24



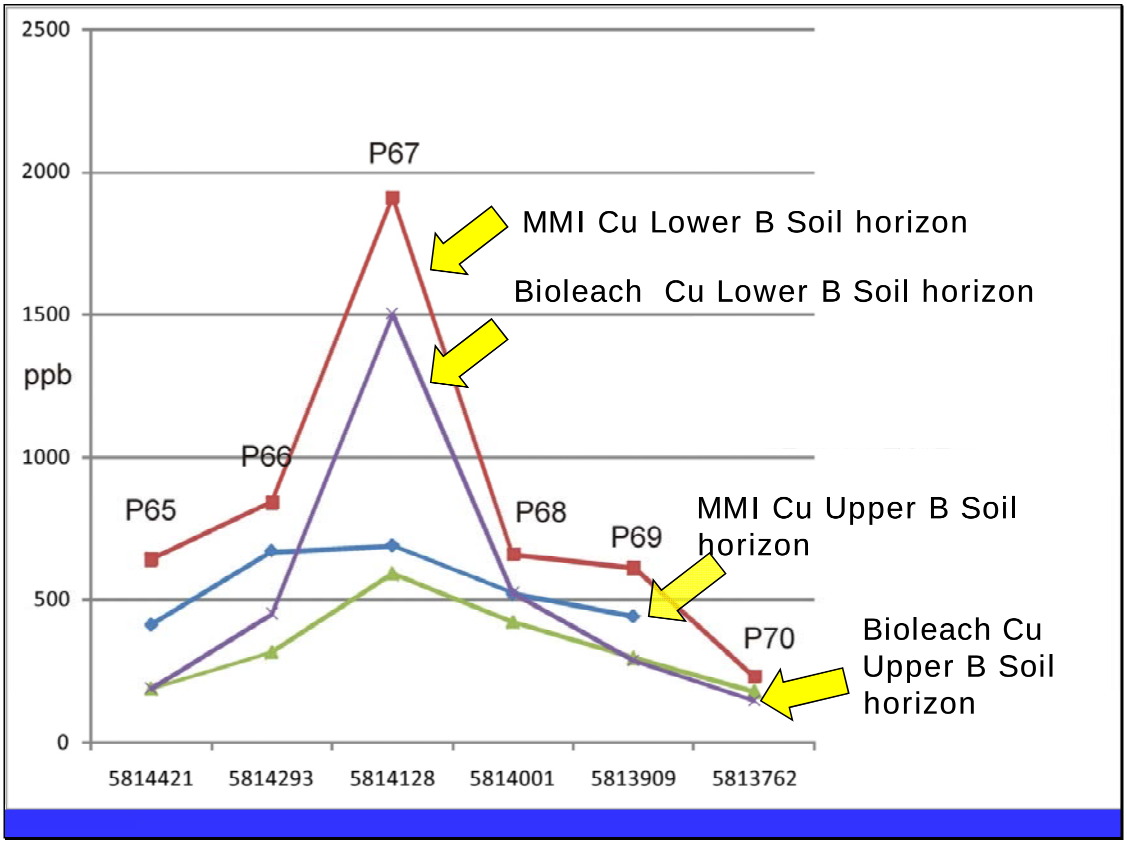
Slide 24 shows the variation of Cu by aqua regia-ICPMS in samples from different soil horizons along the profile crossing part of the North mineralized zone. The C Survey values have been merged with those for a previous overburden drilling program to better define the variation of metal along the traverse. Copper anomaly contrast is greatest in the C soil horizon compared to the B and F- H horizons and this may partly reflect analysis of the – 63 micron fraction compared to the – 0.177 mm fraction used for the B horizon samples. The asymmetric profile shape suggests a glacial transport of material from south to north. There is a contact between basalt and volcaniclastic rock under about 4 m of till between P67 and P68 close to where diamond drilling intersected about 5% disseminated pyrite plus anomalous Cu and Au values.

Slide 25



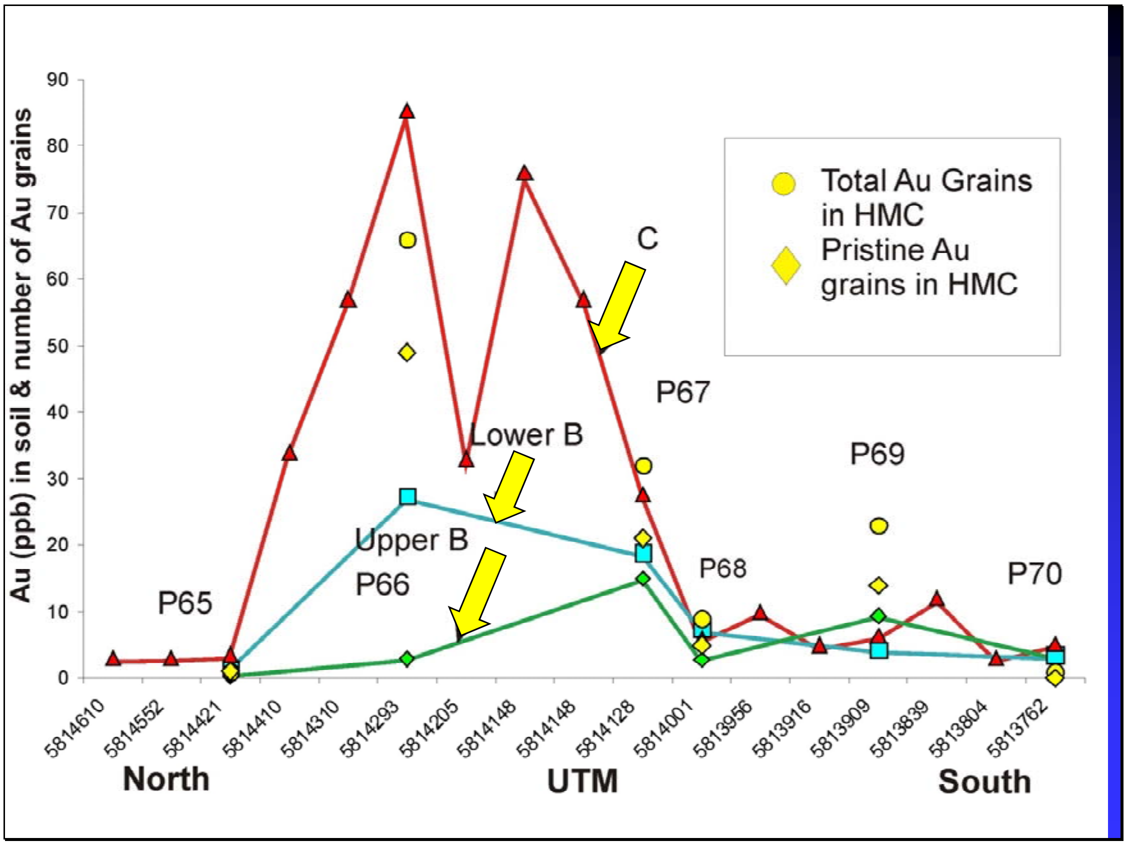
Slide 25 shows mobile metal ion (MMI), Bioleach & Enzyme Leach Cu in the lower B soil horizon across the NW zone. The peak is centered over Profile 67. Analyses are from lower B soil horizon samples. The profile is similar to that for aqua regia-ICPMS copper, but contrast is improved using the partial extractions.

Slide 26



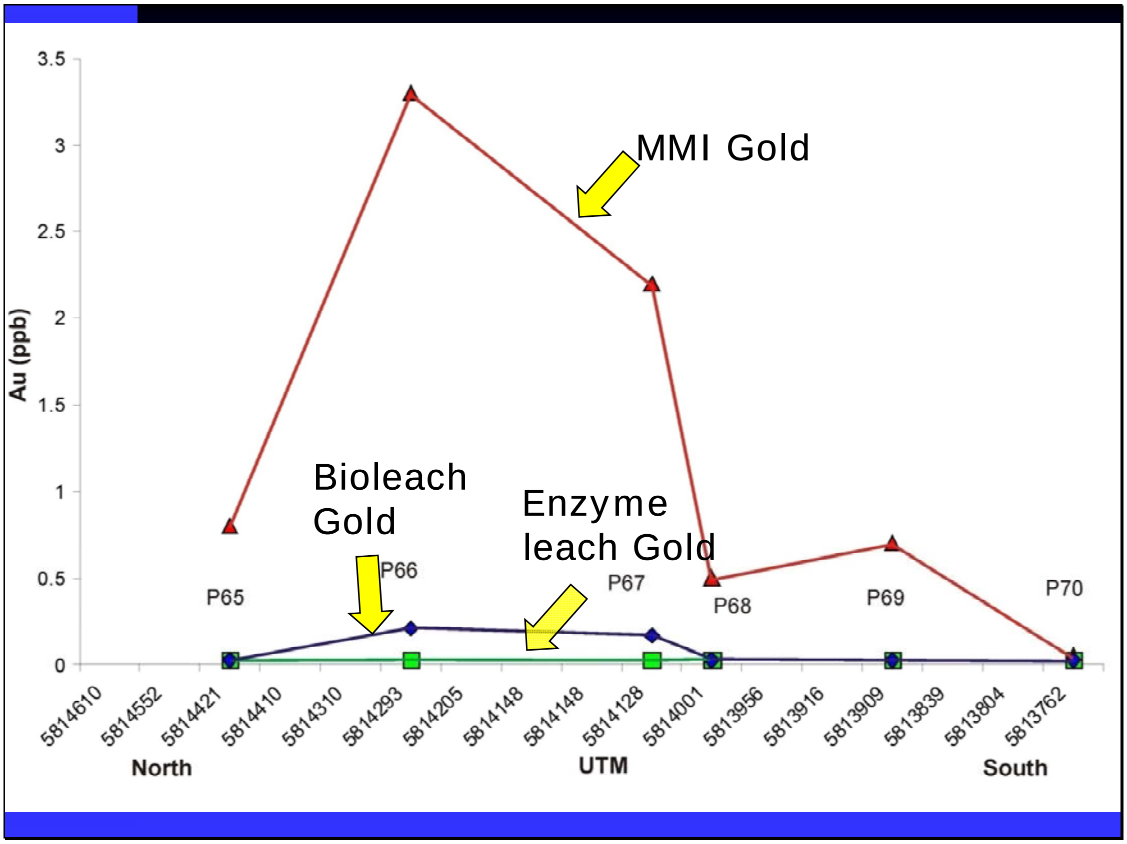
Slide 26 shows the variation of Cu by MMI & Bioleach in the upper B horizon compared to the lower B. Note there is a similarity between results for each method and the difference between the response at the two depths. Contrast is clearly improved by using samples from the lower B soil horizon.

Slide 27



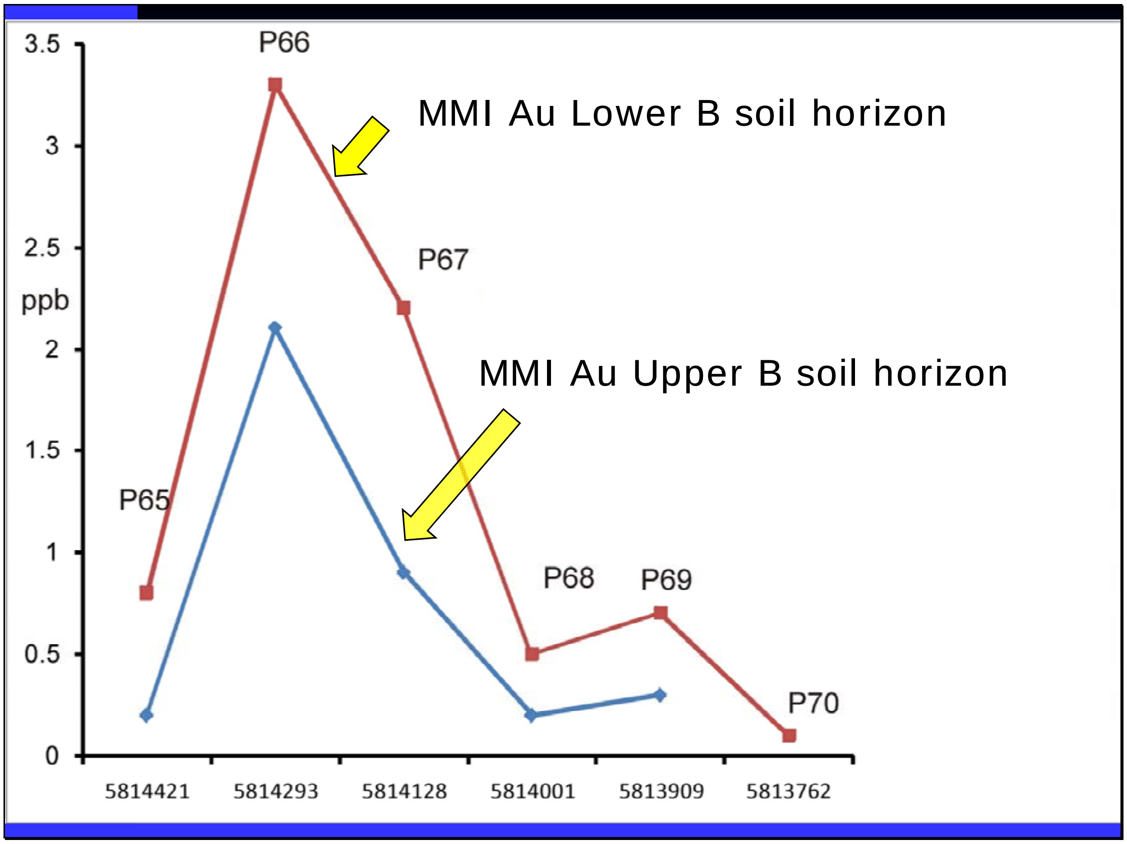
Slide 27 shows the variation of Au by aqua regia-ICPMS in different soil horizons and the number of Au grains isolated from the heavy mineral fraction of the C soil horizon. The variation of Au along the traverse is more erratic than that of Cu and the Au anomaly peak with the greatest number of pristine Au grains (local source) is displaced north from the Profile 67 Cu peak.

Slide 28



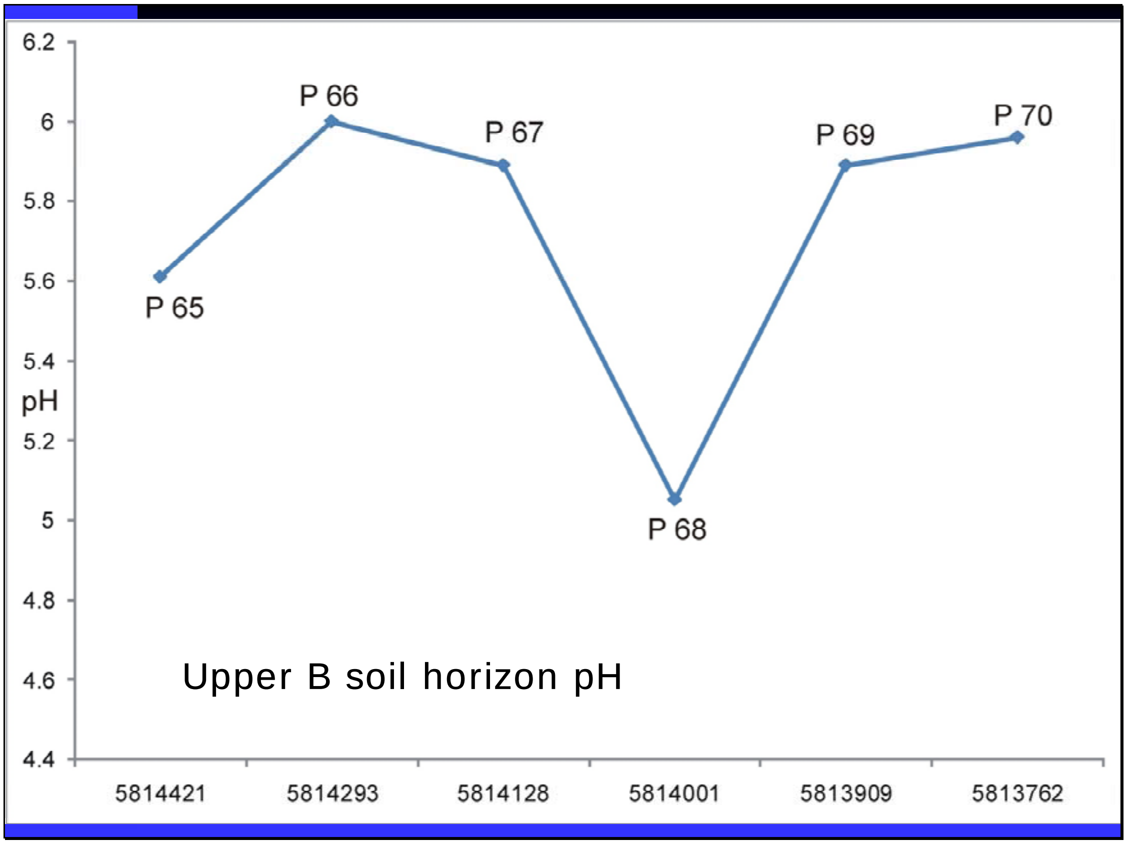
Slide 28 shows the distribution of Au by Mobile Metal ion (MMI), Bioleach and Enzyme Leach. Clearly MMI enhances Au anomaly contrast compared to other leaches with a sharp peak over profile P66.

Slide 29



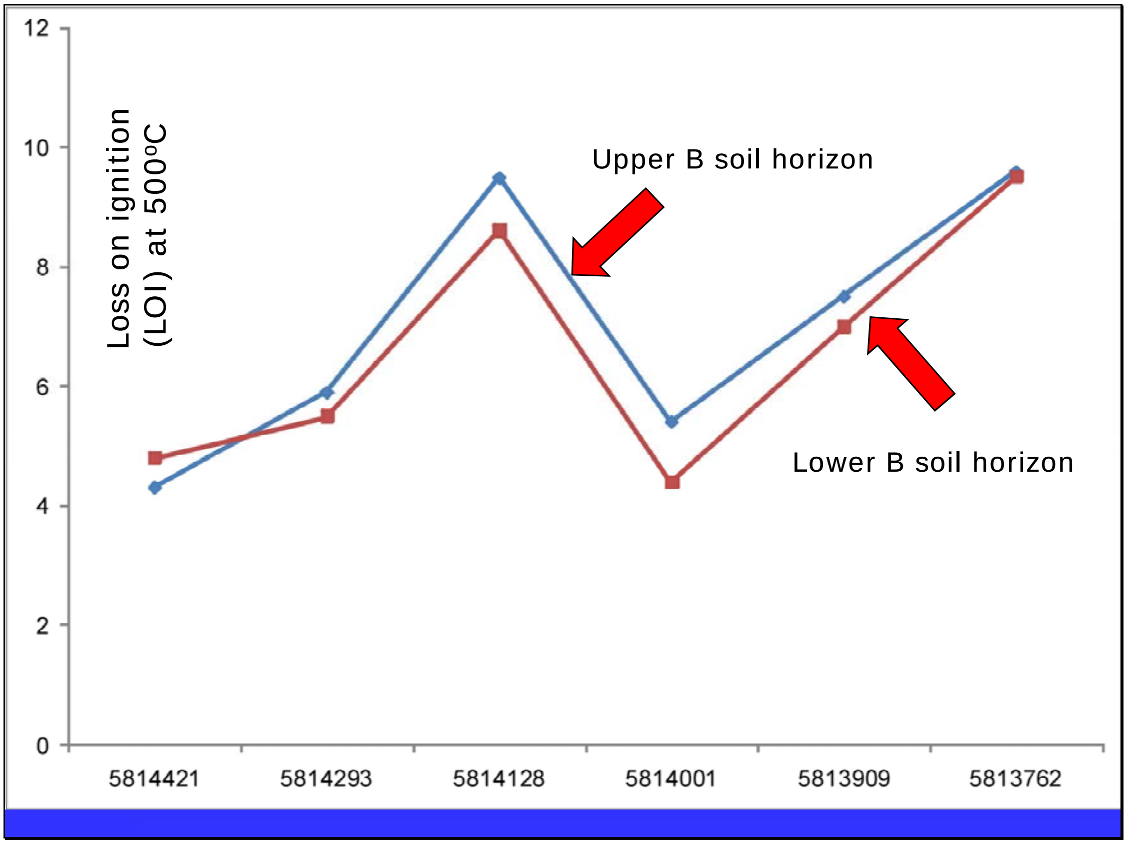
Slide 29 shows the variation of Au by MMI in “upper” B and “lower” B soil samples. The MMI gold peaks in the two horizon are at the same point along the traverse, but contrast is improved by analysis of the “lower” B. Samples. A t test applied to MMI determined Au in the “upper” B compared to the “lower” B horizon shows that there is no statistical difference between the means of the two populations. This slide illustrates that care with soil sampling is needed to avoid variations in anomaly contrast from horizon to horizon.

Slide 30



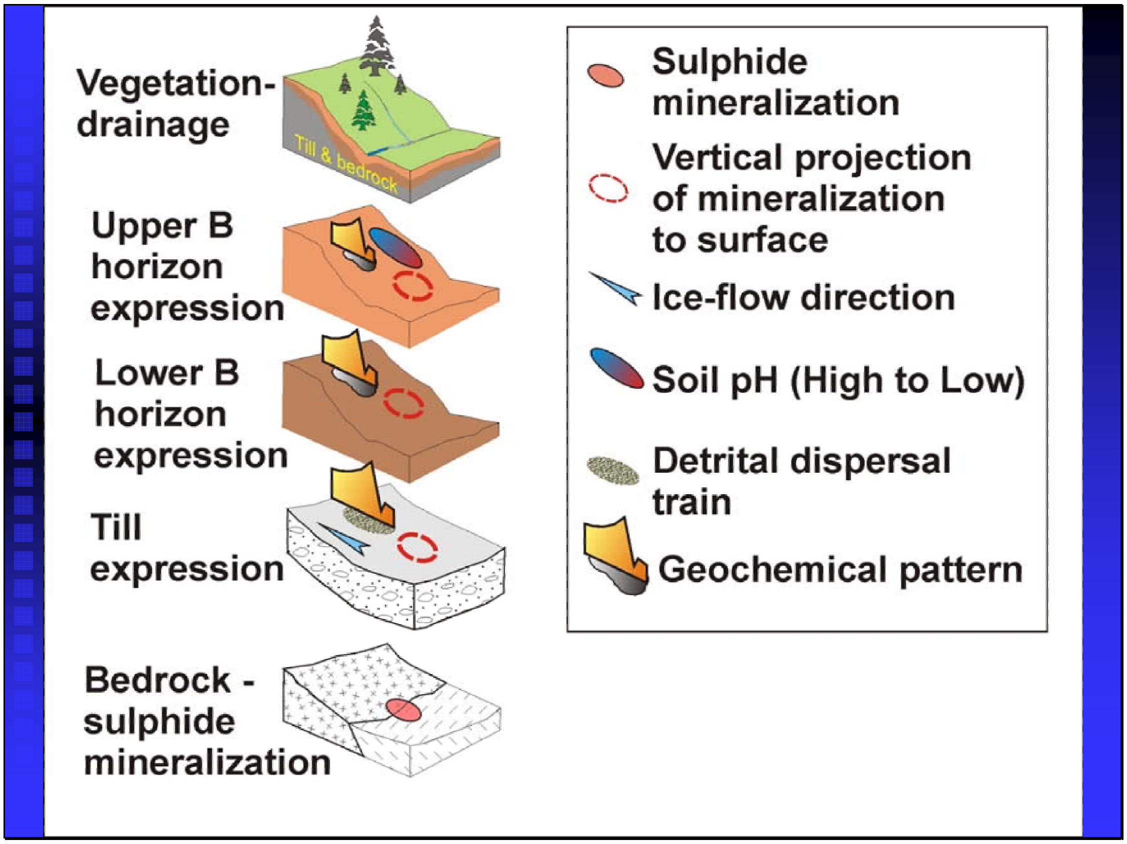
Slide 30 shows pH in the “upper” B horizon along the same traverse as Cu and Au. There is a sharp decrease in soil pH at P68.

Slide 31



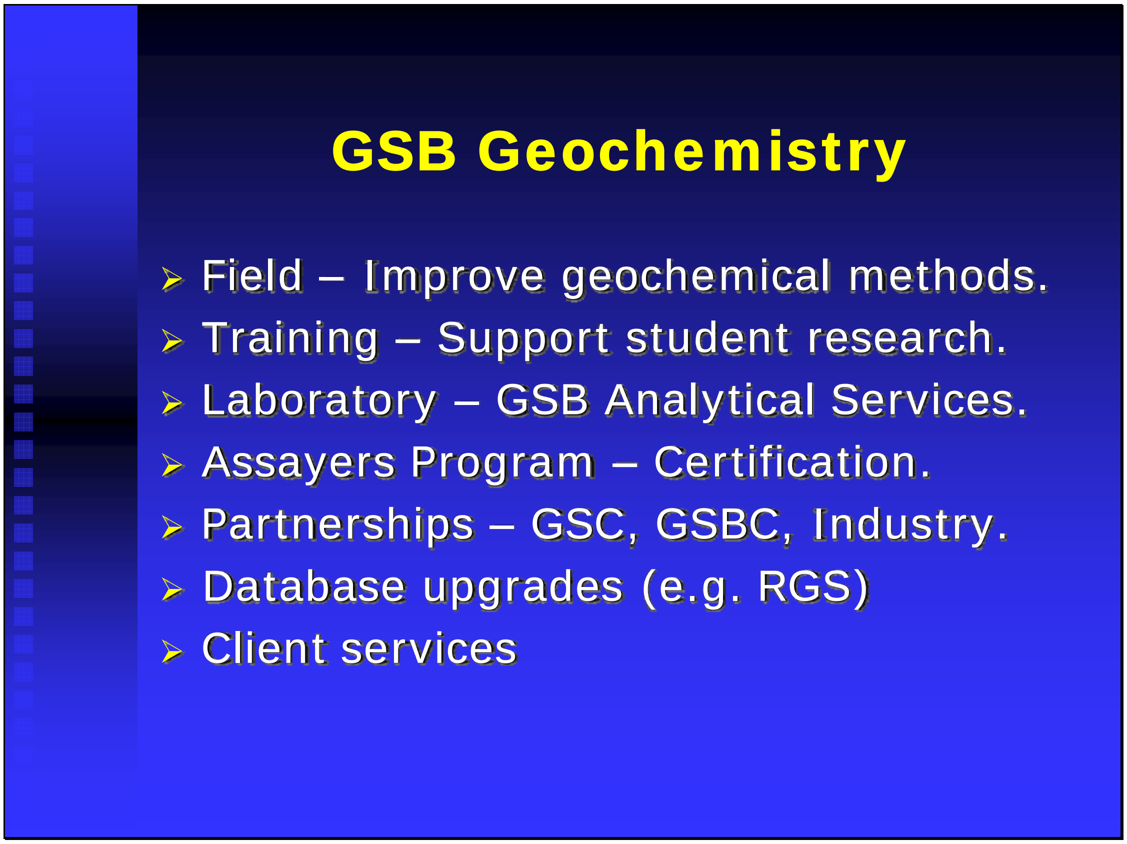
Slide 31 shows loss on ignition at 500°C (LOI) along the traverse. There is a low LOI value at P68 that appears similar to the variation in pH and Cu and Au determined by MMI and Bioleach. Organic matter or clay mineral content could influence soil pH and the geochemistry of the metals.

Slide 32



Slide 32 attempts to summarise the variation of Cu and Au in the soil with a simple model. The model shows the relationship between the bedrock source of the metal, the vertical projection of the mineralization to surface to the surface and displaced (due to ice transported material containing mineralized bedrock) till-soil geochemical patterns in the different horizons. The model speculates that soil pH has influenced geochemical anomaly contrast.

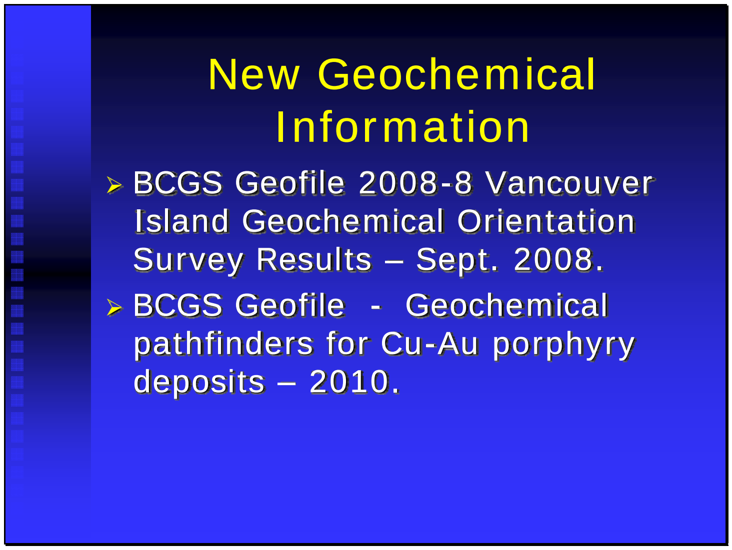
Slide 33



Slide 33 Summarizes the BC Geological Survey Geochemical program including:

- Field research to improve geochemical exploration techniques used by industry.
- Training of students in field sampling and advising on student project research.
- Providing geochemical analytical services (sample preparation & QC) in support of GSB bedrock mapping, mineral deposit and till survey projects.
- Delivering the BC Certified Assayers Program i.e. examination & certification of assayers in BC as required by the MEMPR Act.
- Partnerships include sample analysis funded by the GSC and support to Geoscience BC and GSC regional geochemical surveys by supplying standard reference materials.
- Database upgrades include updates to the BC regional geochemical survey database with Geoscience BC data.
- Client services – trying to answer your many questions.

Slide 34



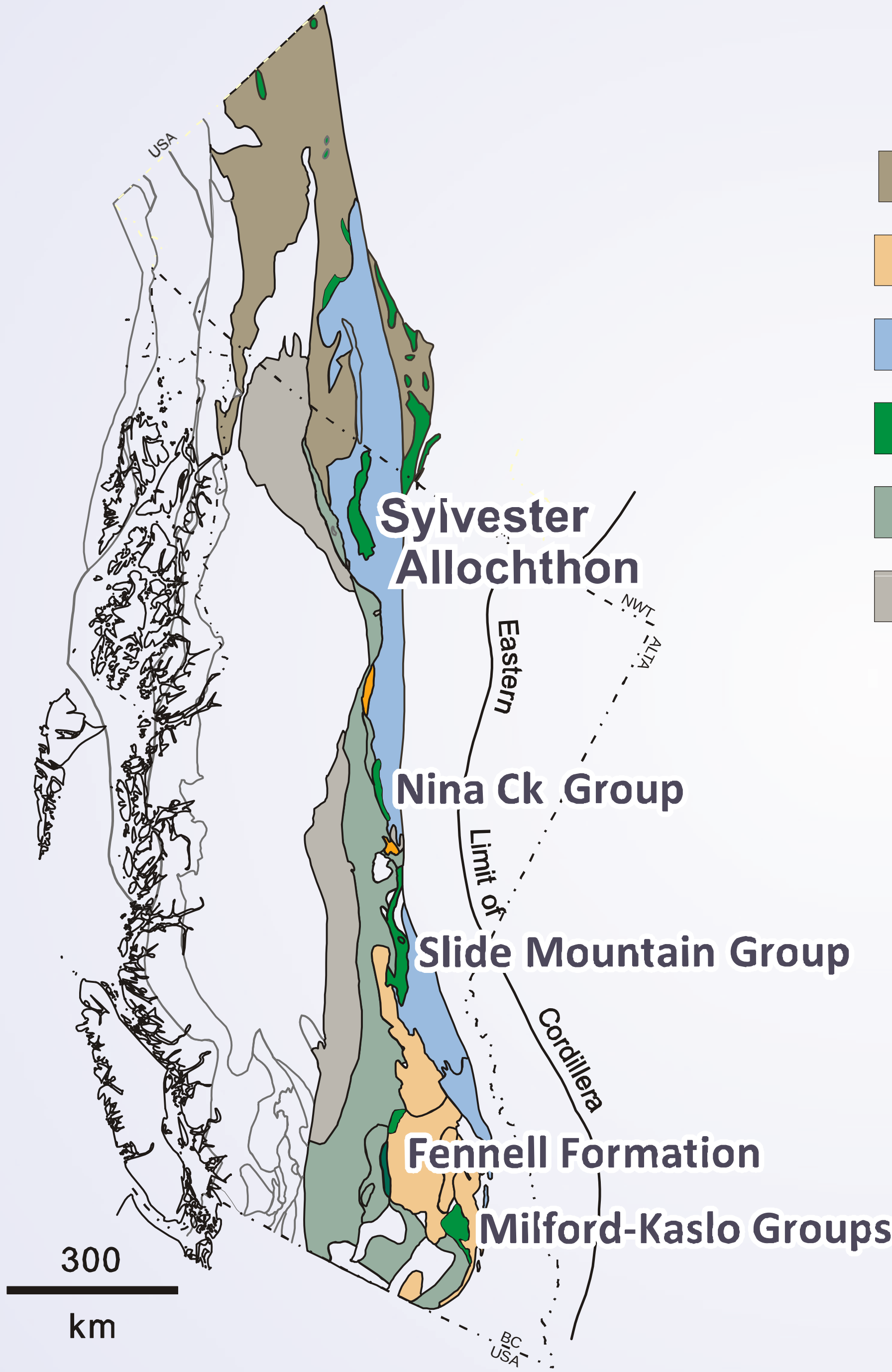
And, finally, the release of new geochemical information.

The Wingdam Conglomerate:
Geological Setting,
Detrital Zircon Geochronology and Regional Significance

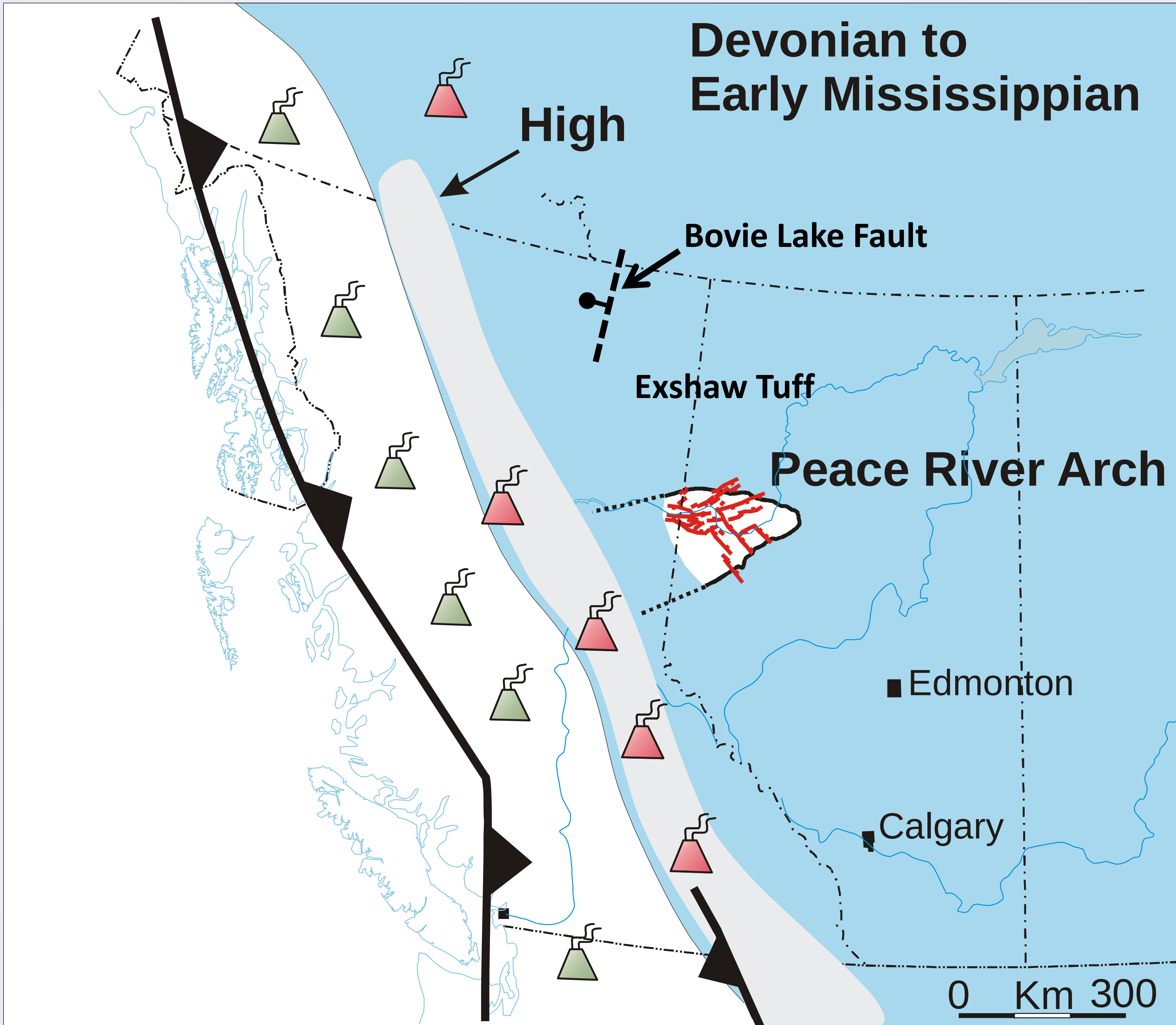
Filippo Ferri
Resource Development and Geoscience Branch,

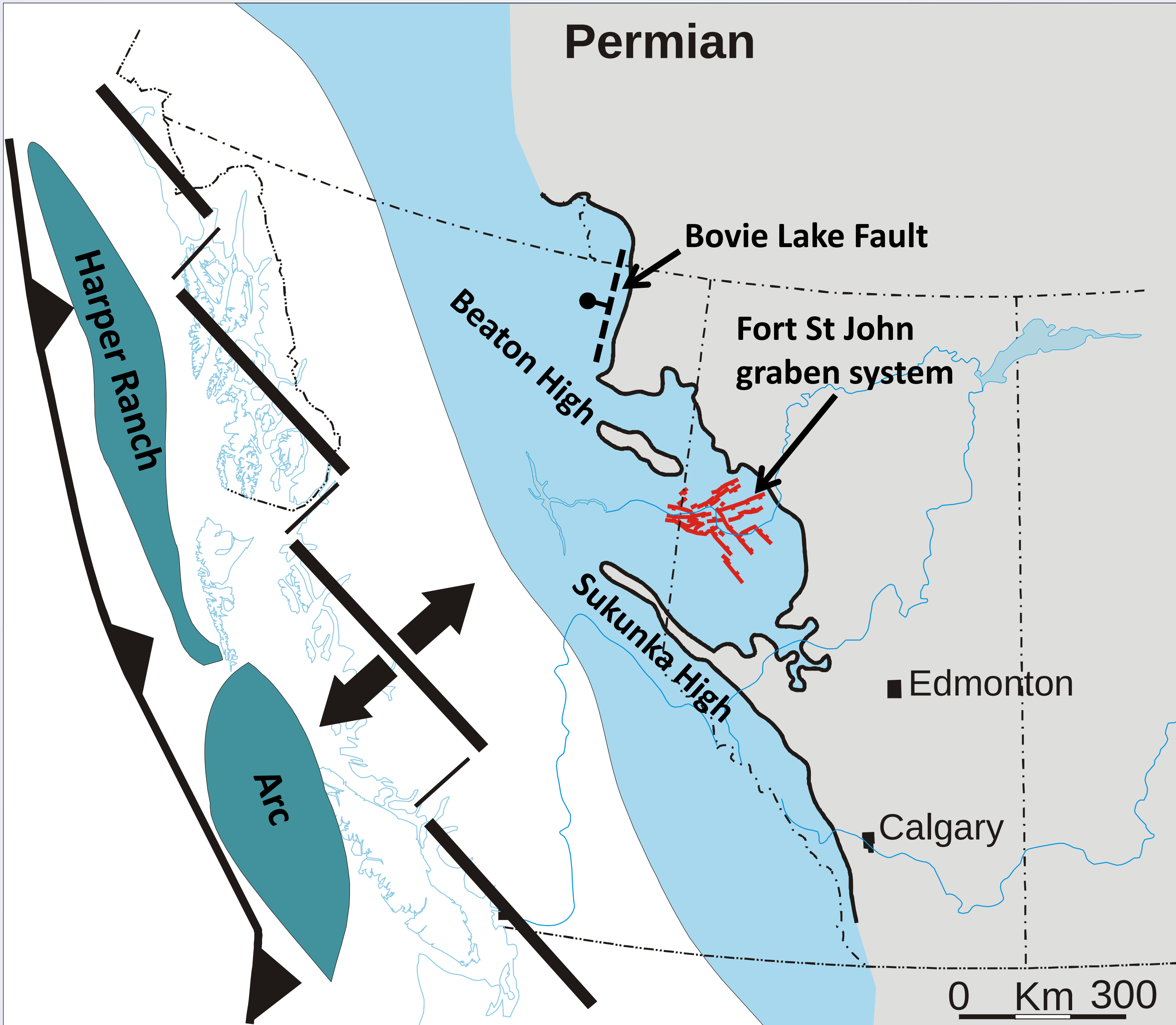
Jim Logan
Geological Survey Branch,

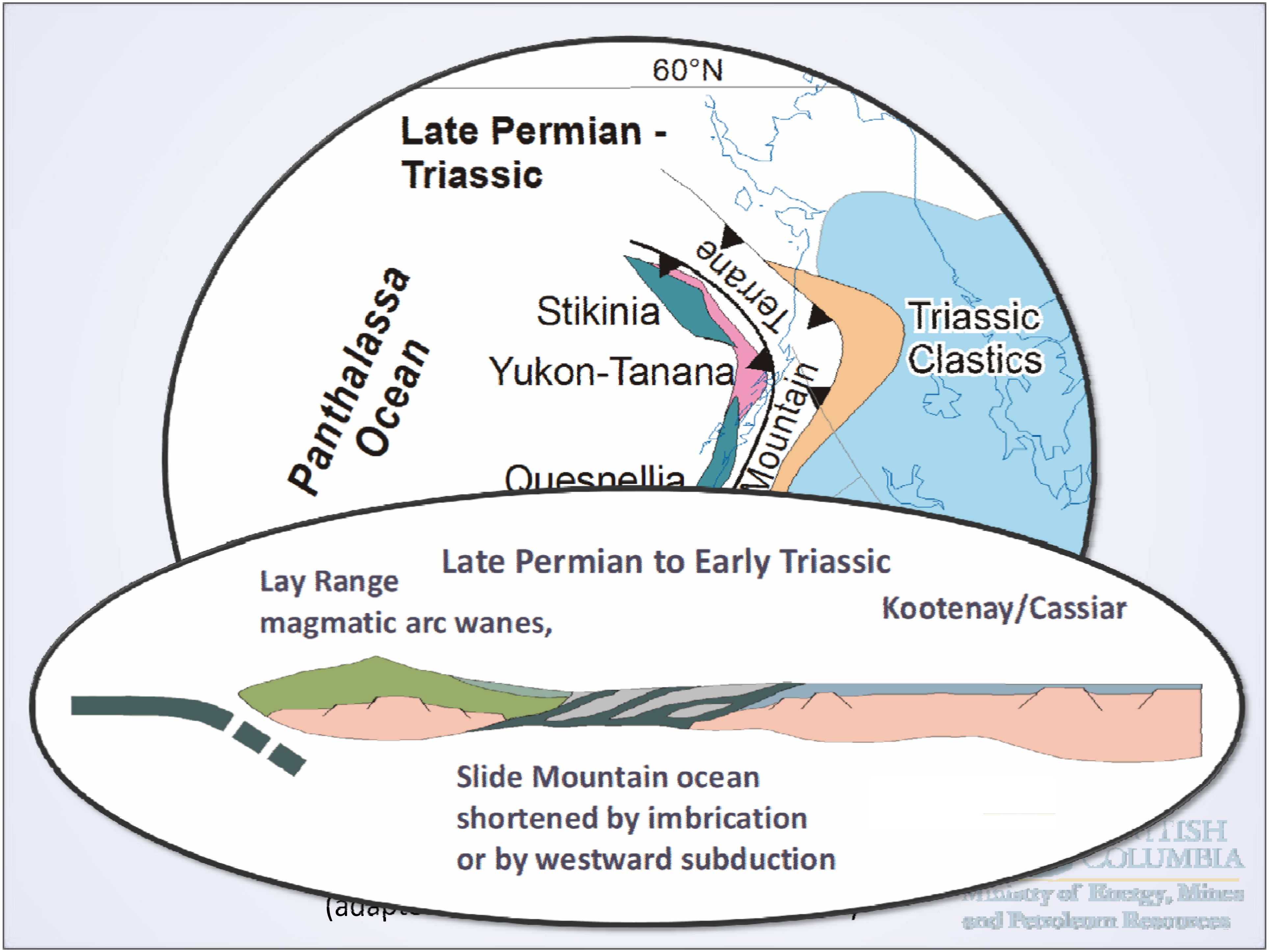
Ministry of Energy, Mines and Petroleum Resources



Slide Mountain Terrane is a Late Paleozoic back-arc basin between the Ancestral North American margin and a mid to Late Paleozoic arc system

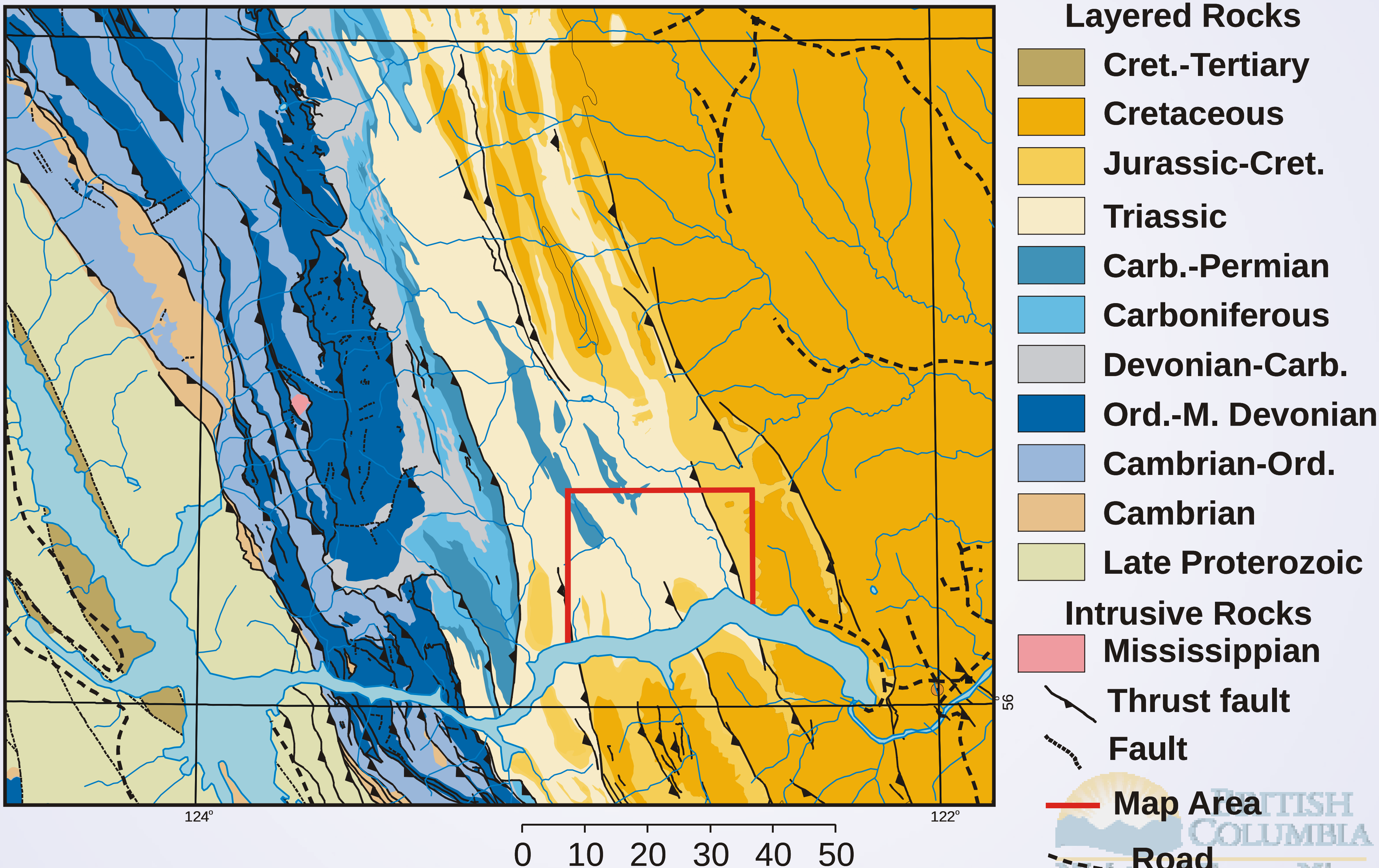

Devonian to
Early Mississippian
High
Bovie Lake Fault
Exshaw Tuff
Peace River Arch
Edmonton
Calgary
0 Km 300


Permian
Bovie Lake Fault
Fort St John graben system
Beaton High
Harper Ranch
Sukunka High
Arc
Edmonton
Calgary
0 Km 300

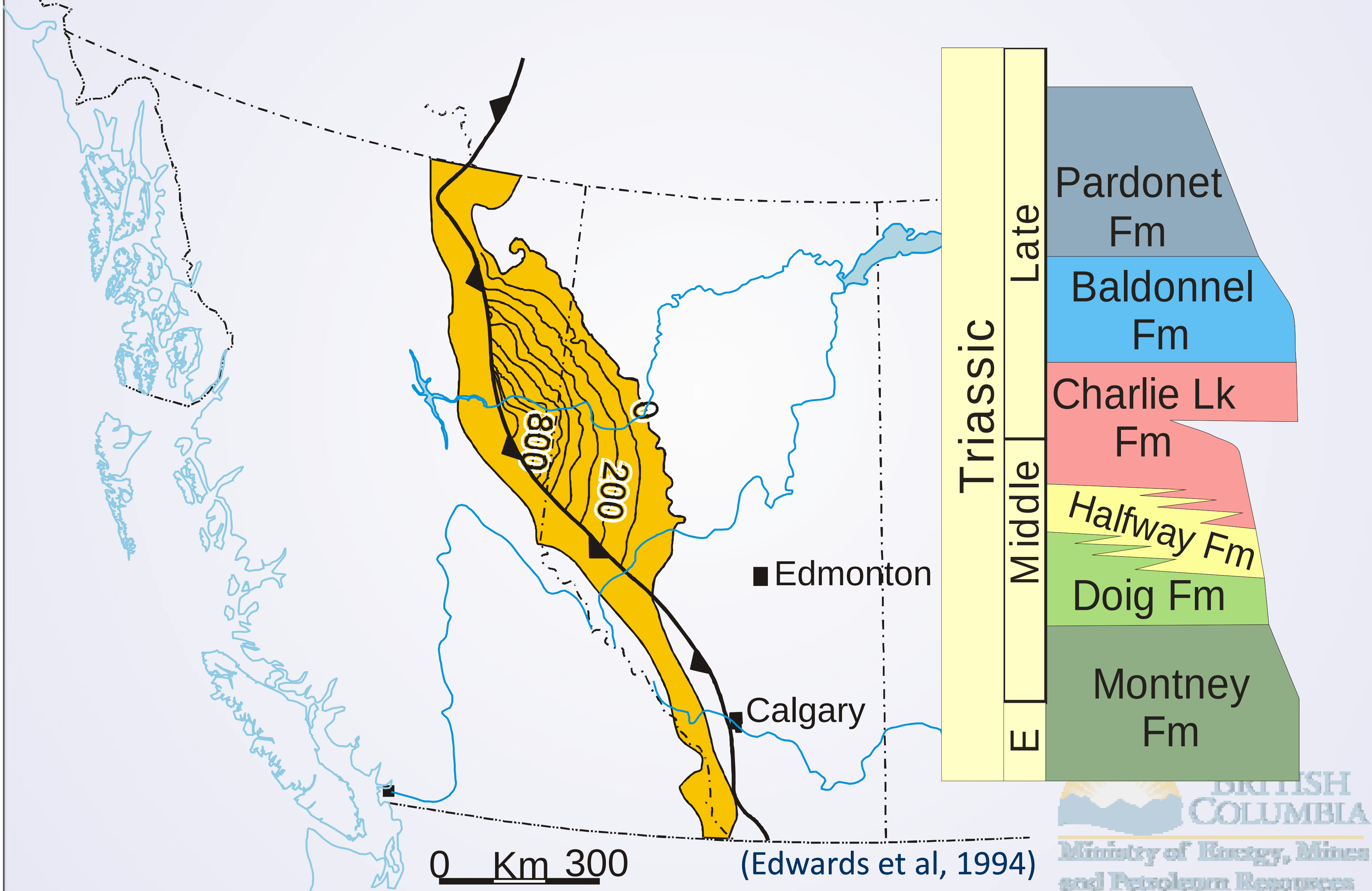


60°N
Late Permian - Triassic
Panthalassa Ocean
Stikinia
Yukon-Tanana
Quesnellia
Terrane
Mountain
Triassic Clastics
Late Permian to Early Triassic
Lay Range
magmatic arc wanes,
Kootenay/Cassiar
Slide Mountain ocean
shortened by imbrication
or by westward subduction

Halfway River Map area; 94B

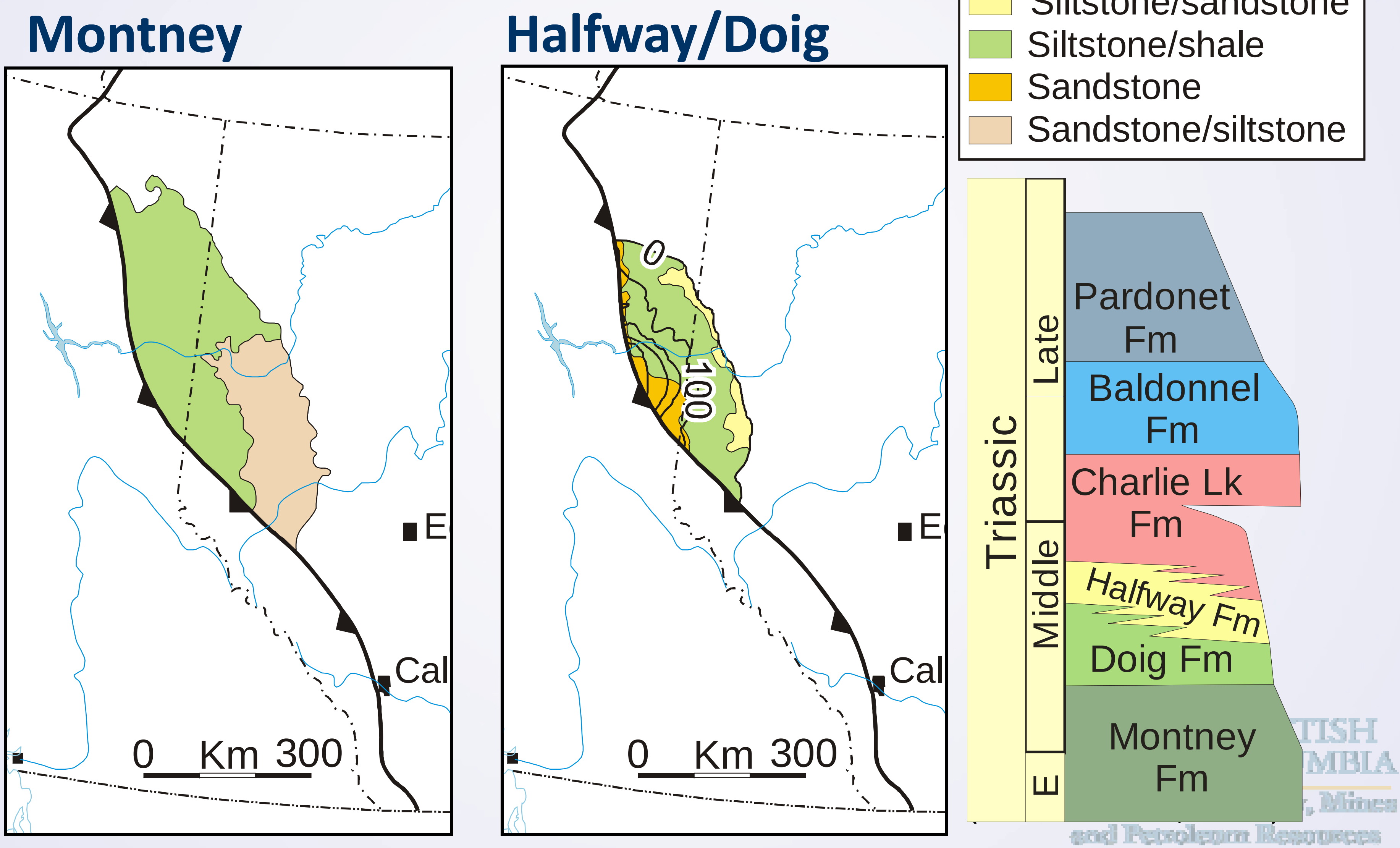


Triassic – Western Canada Sedimentary Basin



(Edwards et al, 1994)

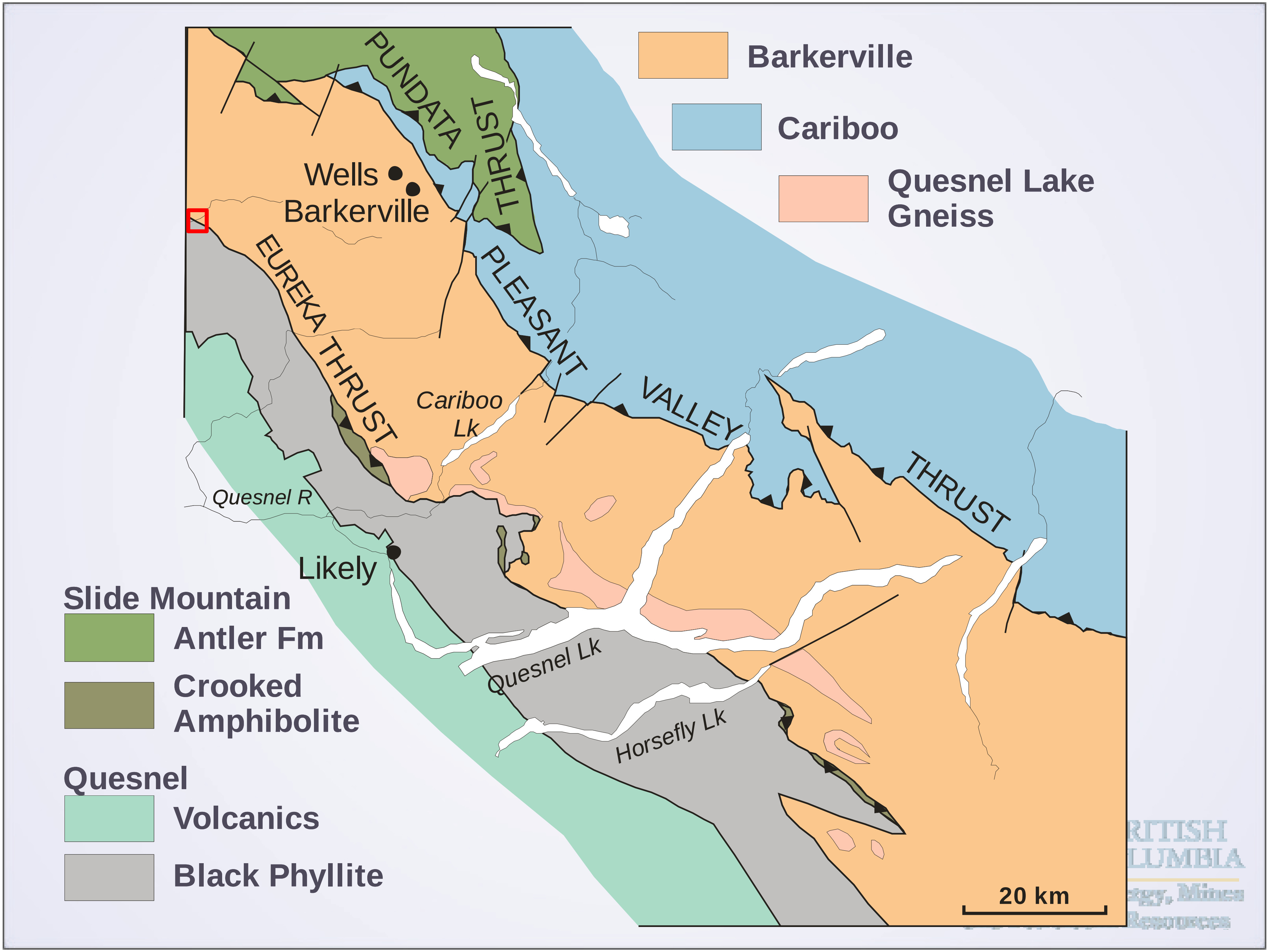
Early to Middle Triassic clastic succession



Southern Canadian Cordillera

Ancestral North America
Fold and Thrust
Cariboo
Kootenay

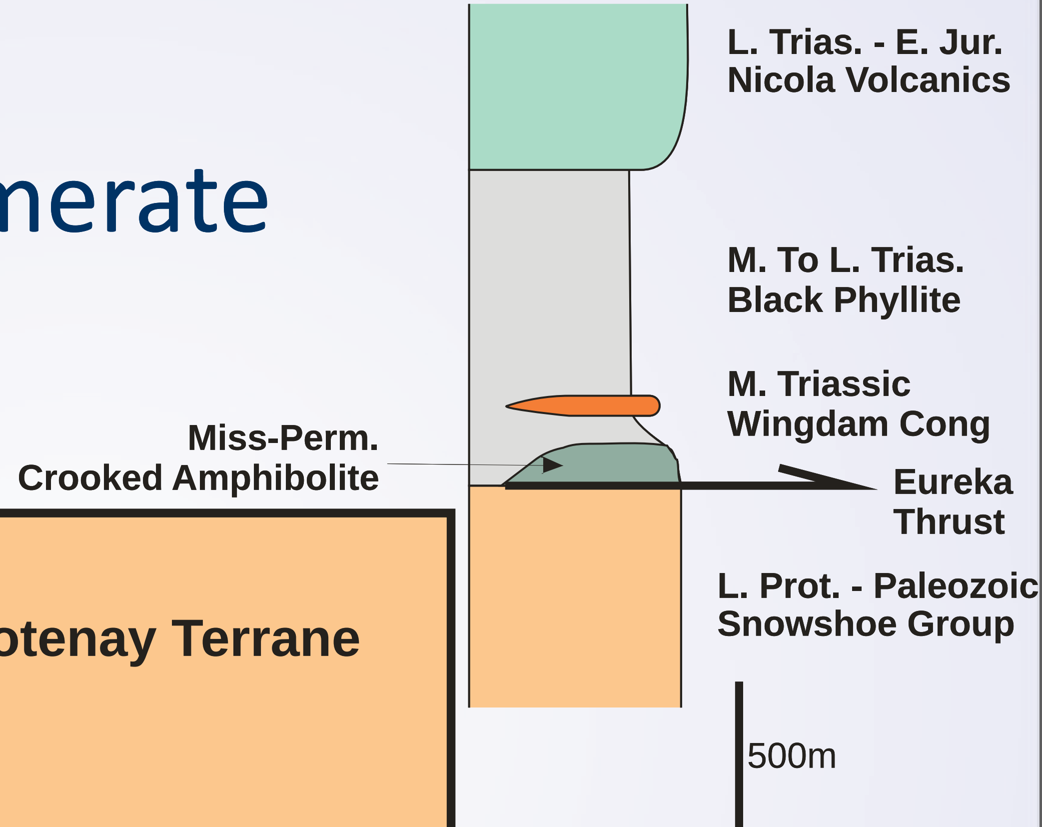
Slide Mountain
Quesnel
Cache Creek

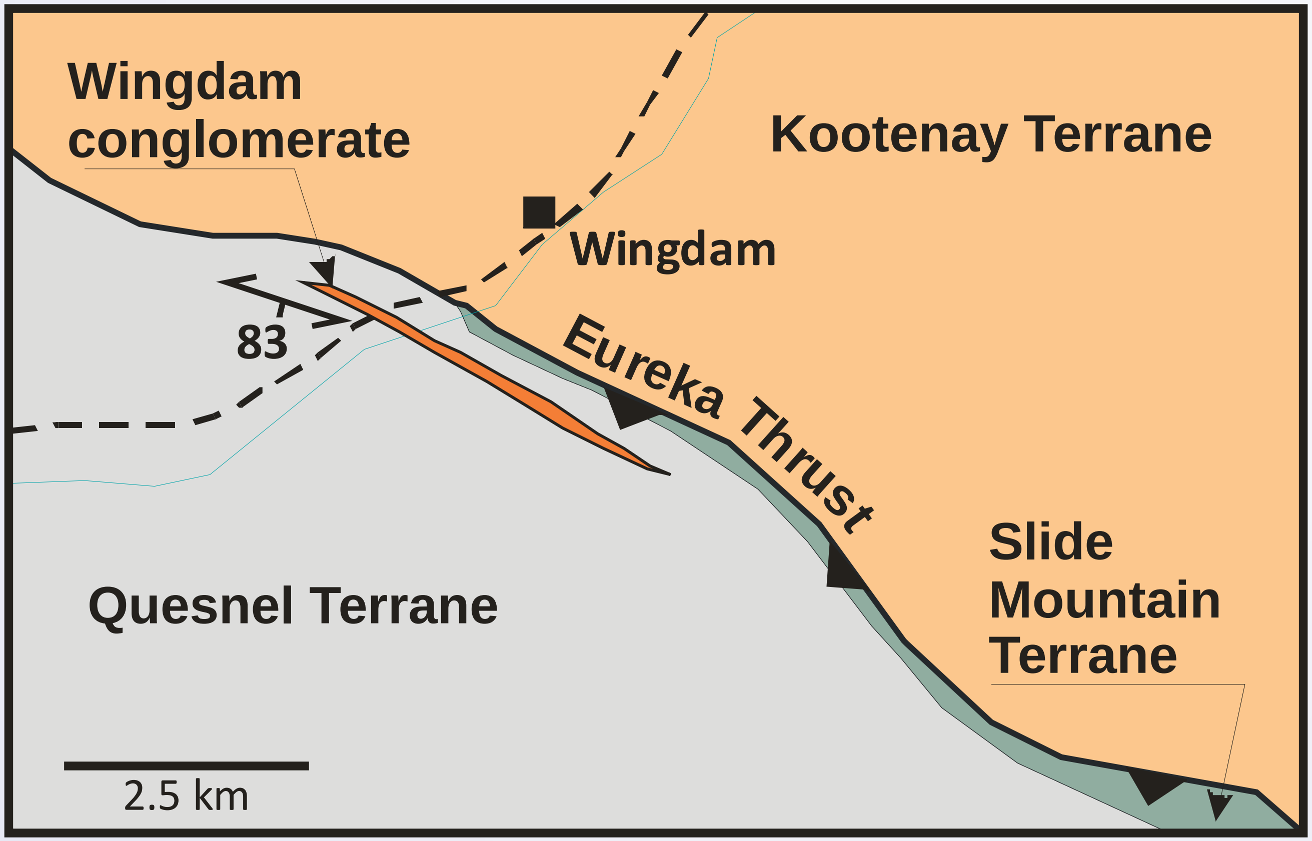

Barkerville
Cariboo
Quesnel Lake
Gneiss
Slide Mountain
Antler Fm
Crooked
Amphibolite
Quesnel
Volcanics
Black Phyllite
PUNDATA
THRUST
Wells
Barkerville
EUREKA
THRUST
PLEASANT
VALLEY
THRUST
Cariboo
Lk
Quesnel R
Likely
Quesnel Lk
Horsefly Lk
20 km

Wingdam conglomerate

- First described by Struik (1988)
- McMullin et al., (1990) first detailed its significance
- Similar quartz-rich clastics described from the base of the Black Phyllite along the length of its exposure
- Erosional nature of basal Triassic Black Phyllite contact noted by Struik, Campbell and others
- These and other arguments have been used to support pre-Jurassic deformation

Wingdam Conglomerate



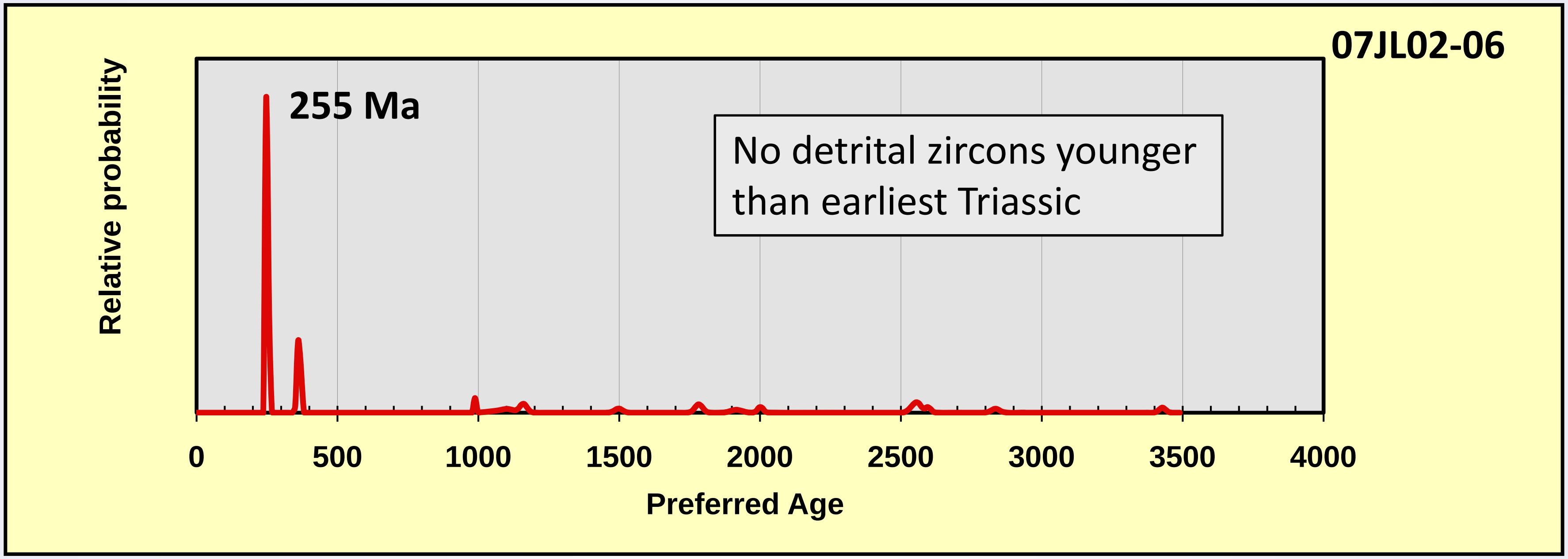


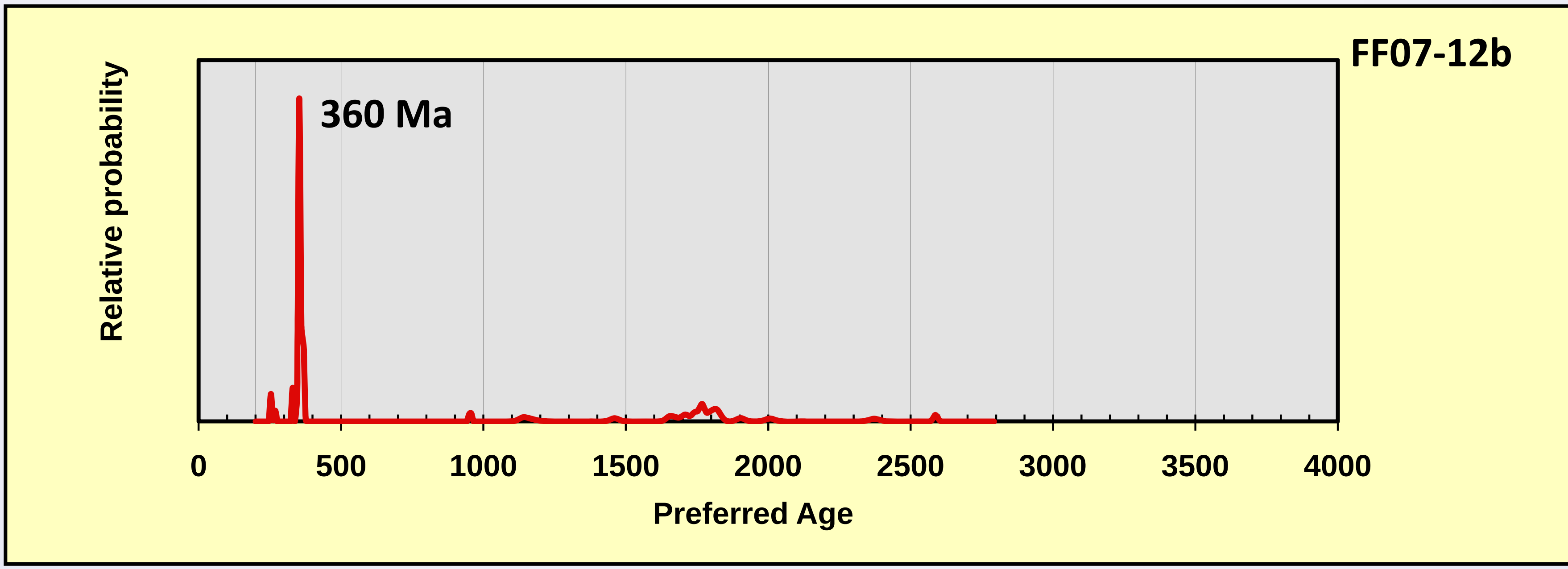
Middle Triassic conodont assemblages from lower Black Phyllite

Gneiss clasts

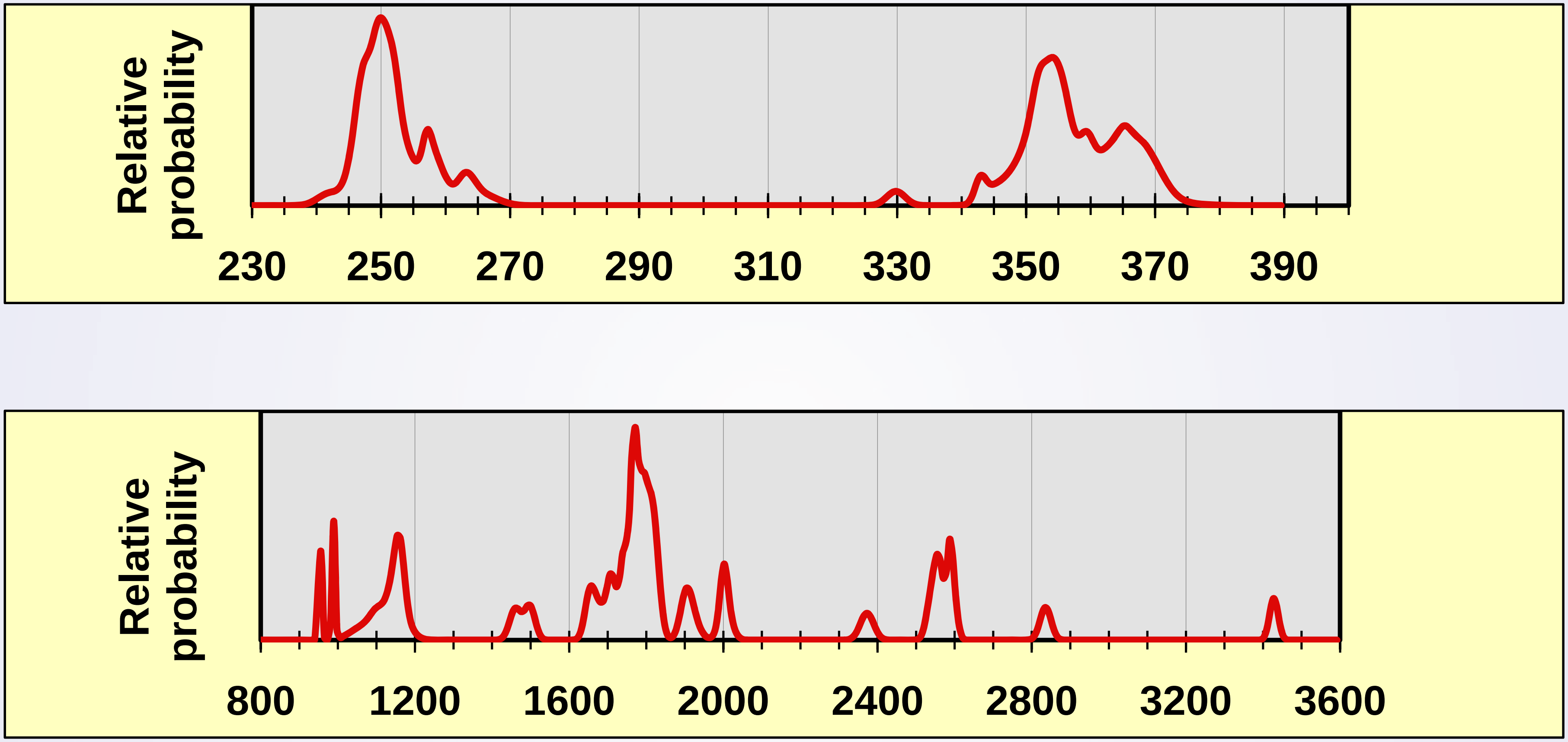
British Columbia Ministry of Energy, Mines and Petroleum Resources

Detrital Zircon Geochronology for the Wingdam Conglomerate



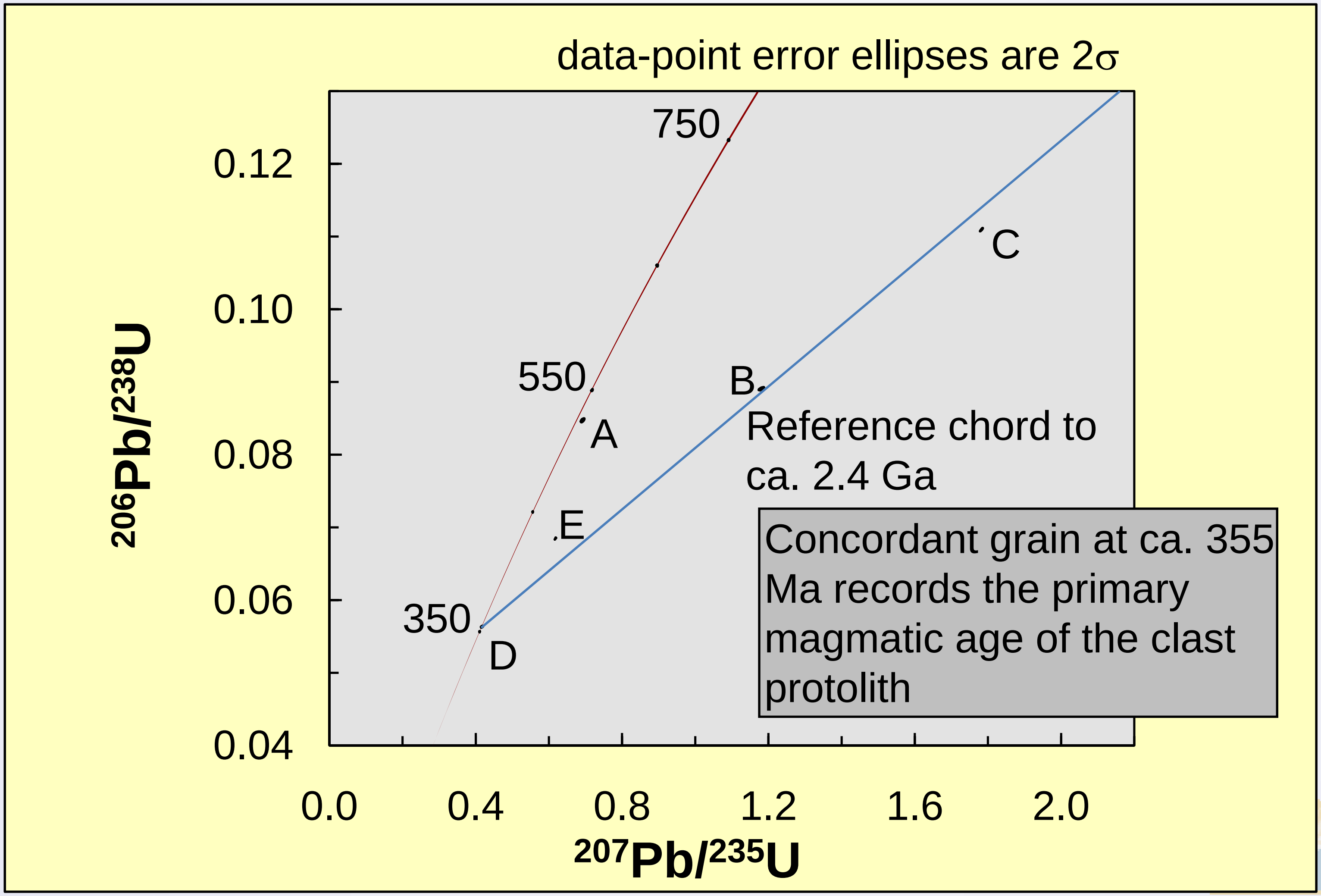


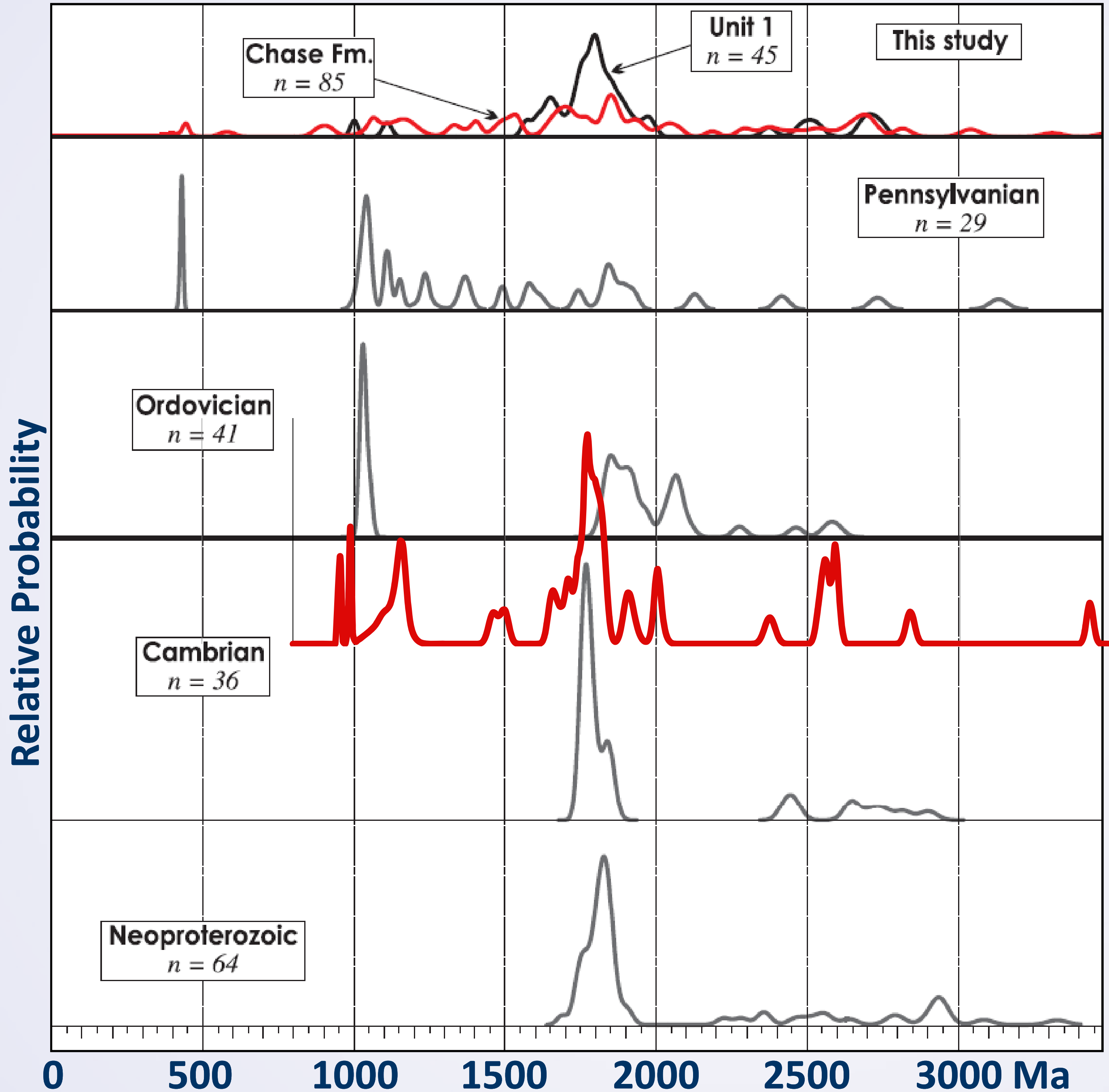
Wingdam detrital zircon geochronology (continued)



Combined data for samples 07JL02-06 and FF07-12b

Geochronology of gneiss clast in Wingdam conglomerate



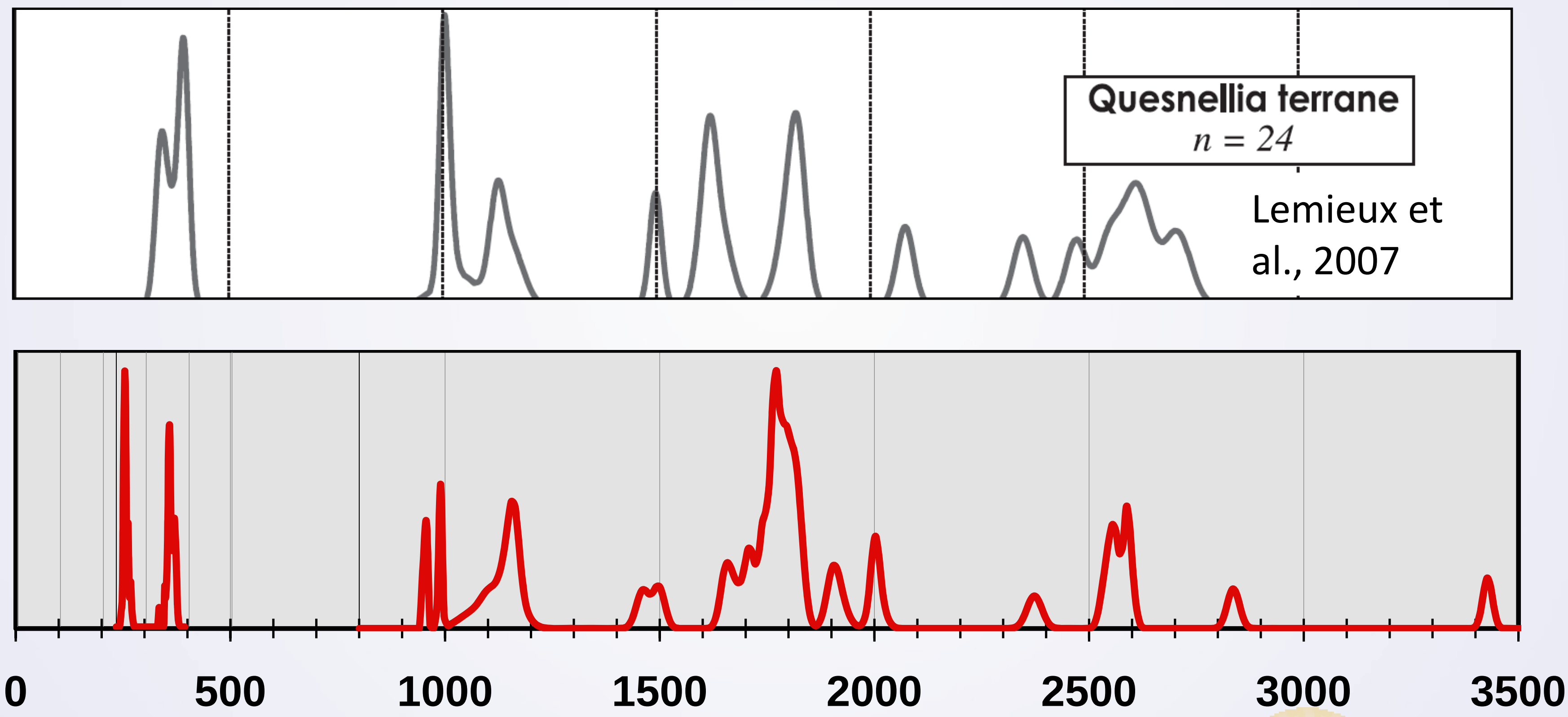


Lemieux et al., 2007

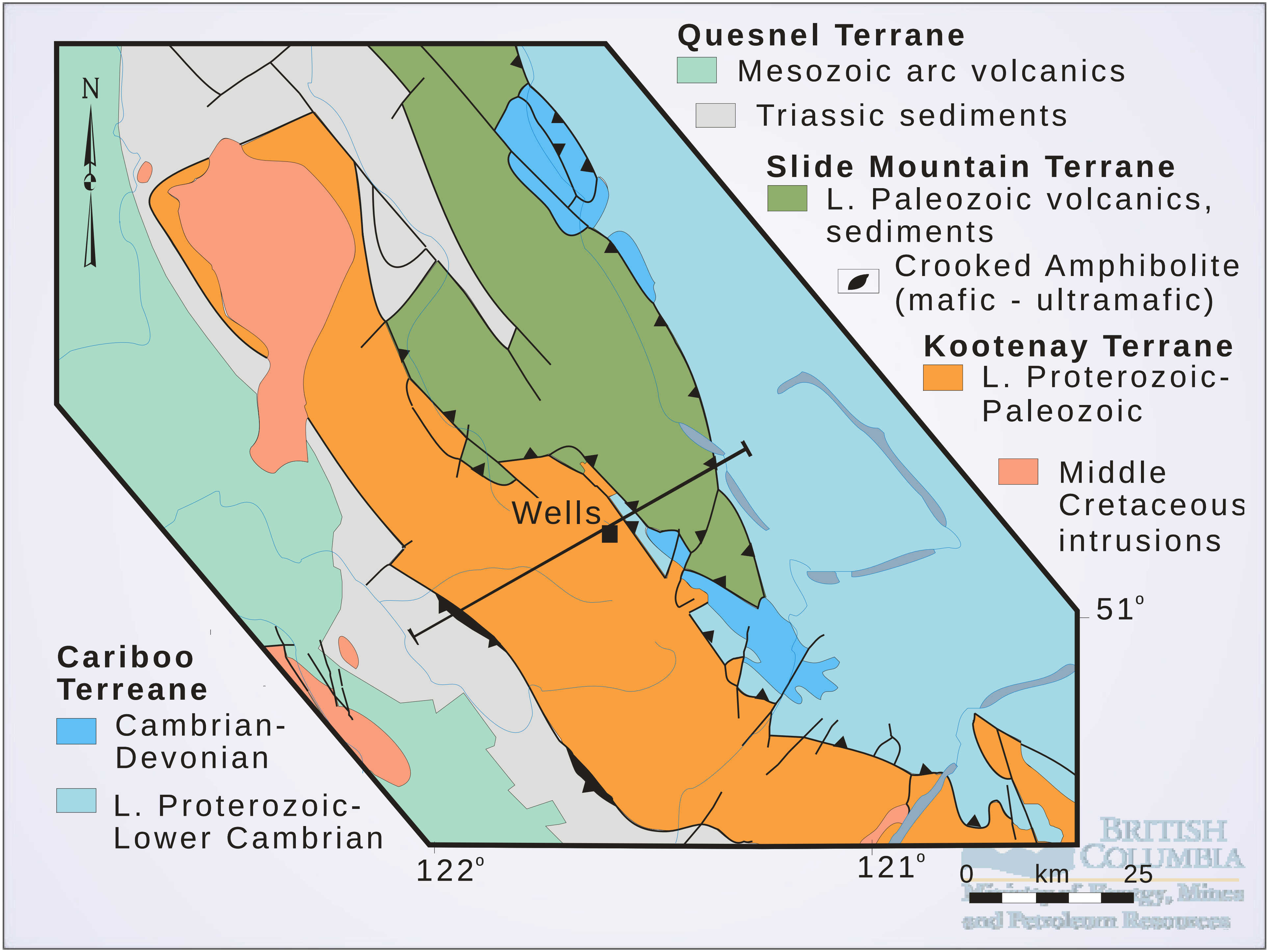
Detrital zircon spectra;
Southern Canadian
Cordillera
Ross and Gehrels, 1998

BRITISH COLUMBIA
Ministry of Energy, Mines
and Petroleum Resources

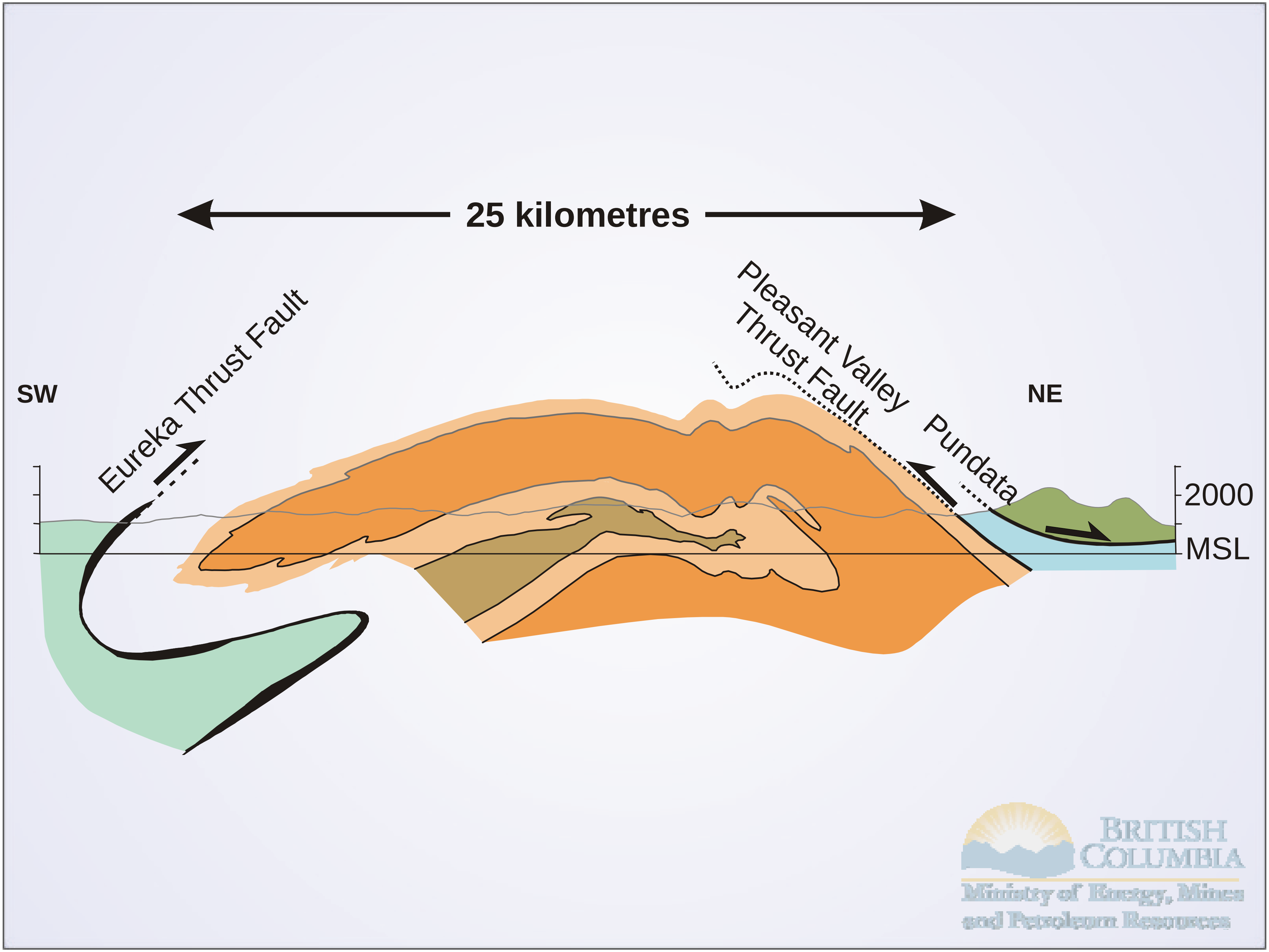
Detrital zircon spectra of Mount Roberts Formation, southern Quesnel Terrane



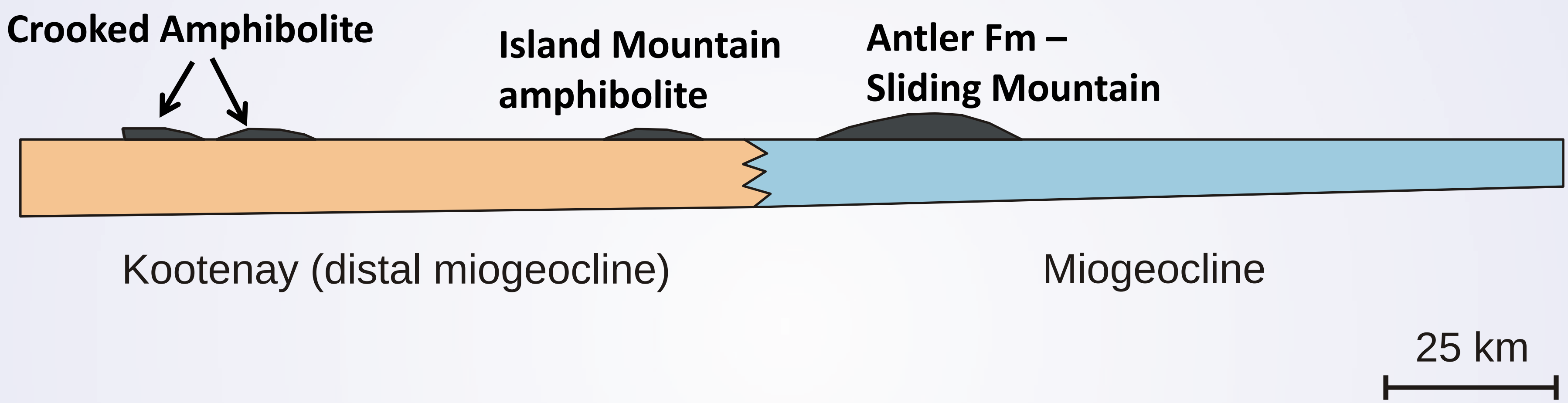
British Columbia
Ministry of Energy, Mines and Petroleum Resources



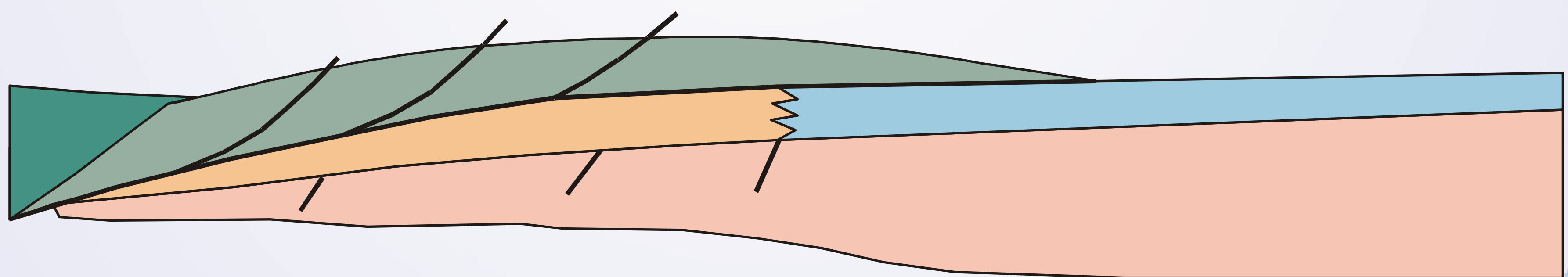
Quesnel Terrane
Mesozoic arc volcanics
Triassic sediments
Slide Mountain Terrane
L. Paleozoic volcanics, sediments
Crooked Amphibolite (mafic - ultramafic)
Kootenay Terrane
L. Proterozoic-Paleozoic
Middle Cretaceous intrusions
Cariboo Terrane
Cambrian-Devonian
L. Proterozoic-Lower Cambrian
N
Wells
51°
122°
121°
0 km 25
British Columbia
Ministry of Energy, Mines and Petroleum Resources

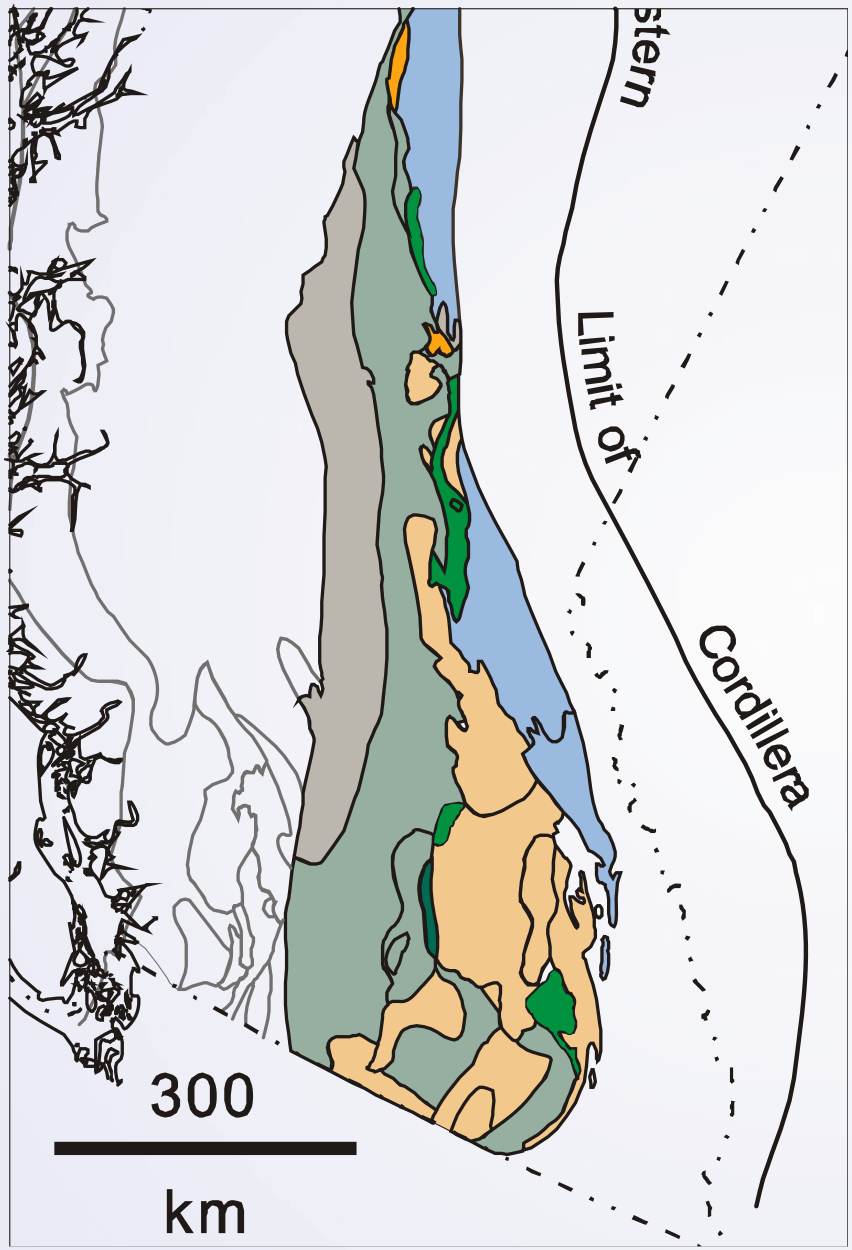

25 kilometres
SW
NE
Eureka Thrust Fault
Pleasant Valley
Thrust Fault
Pundata
2000
MSL
British
Columbia
Ministry of Energy, Mines
and Petroleum Resources

Amount of obduction



Latest Permian to Middle Triassic





Yukon-Tanana
Kootenay
Cassiar
Slide Mountain
Quesnel
Cache Creek

Conclusions

- Detrital zircon geochronology of the Wingdam conglomerate is compatible with it being sourced from Kootenay and Harper Ranch rocks
- Clast composition also suggests the Slide Mountain as a source

Also:

- The Crooked amphibolite is an erosional remnant of the Slide Mountain Terrane below the Triassic black phyllite
- The black phyllite sits unconformably on Kootenay and Crooked amphibolite rocks
- Wingdam conglomerate is a product of this unconformity
- Obduction of the Slide Mountain Terrane onto Kootenay rocks in Late Permian to Early Triassic times (Sonoman Orogeny) was the ultimate cause of these relationships
- Kootenay rocks most likely underlie much of the Quesnel Terrane

British Columbia
Ministry of Energy, Mines and Petroleum Resources

BRITISH COLUMBIA

Ministry of Energy, Mines and Petroleum Resources

MINEovation and Efficiencies with

MapPlace.ca

BCGS Open House
November 13, 2009

ph (250) 952-0386
Larry.Jones@gov.bc.ca

BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources

Outline

- MapPlace as a World Leader
  - Geoscience Databases
- MINEovative Application Examples

1. **Data Integration & Efficiencies**
   - ARIS & MapBuilders
   - MINFILE & Property File
   - RGS, MTO
2. **Visualization & Interactive Tools**
   - Google Earth Display
   - Publication Application
   - Exploration Assistant Tools
   - MapPlace2Go
3. **Where to Next**

BRITISH COLUMBIA GEOLOGICAL SURVEY

Geological Survey Branch

- Established in 1895
- Responsible for producing and housing geoscience information about mineral resources and mineral potential.
- Systematic inventory, assessment and archiving of the complex geology of BC.

MapPlace.ca

BC Geology on MapPlace.ca

Some GSB Database Milestones

1895 Establishment of Bureau of Mines

1947 Assessment Reports filing MTA Regs

1982-84 Open House (Roundup), new MINFILE

1985-95 Mineral Development Agreements

1989 90 Staff, MDO Van., Surficial etc, National Accords

1995 Ward's Paperless Office / MapPlace

2000 Geofiles, Web development, GIS

MapPlace: BCYCM Award; Public Service Award 2001

2005 MTO, GeoscienceBC

2007 25K Assessment Reports scanned

Key Activities

Mapping and Deposit Models

Confidential Expertise

- Industry Clients
- General Public

Advise Government

- Land-use planning
- First Nations consultation

Data Custodian

- MapPlace, BCGeoMap, ARIS, MINFILE

Monitor Industry Activity

- Regional geologist reports

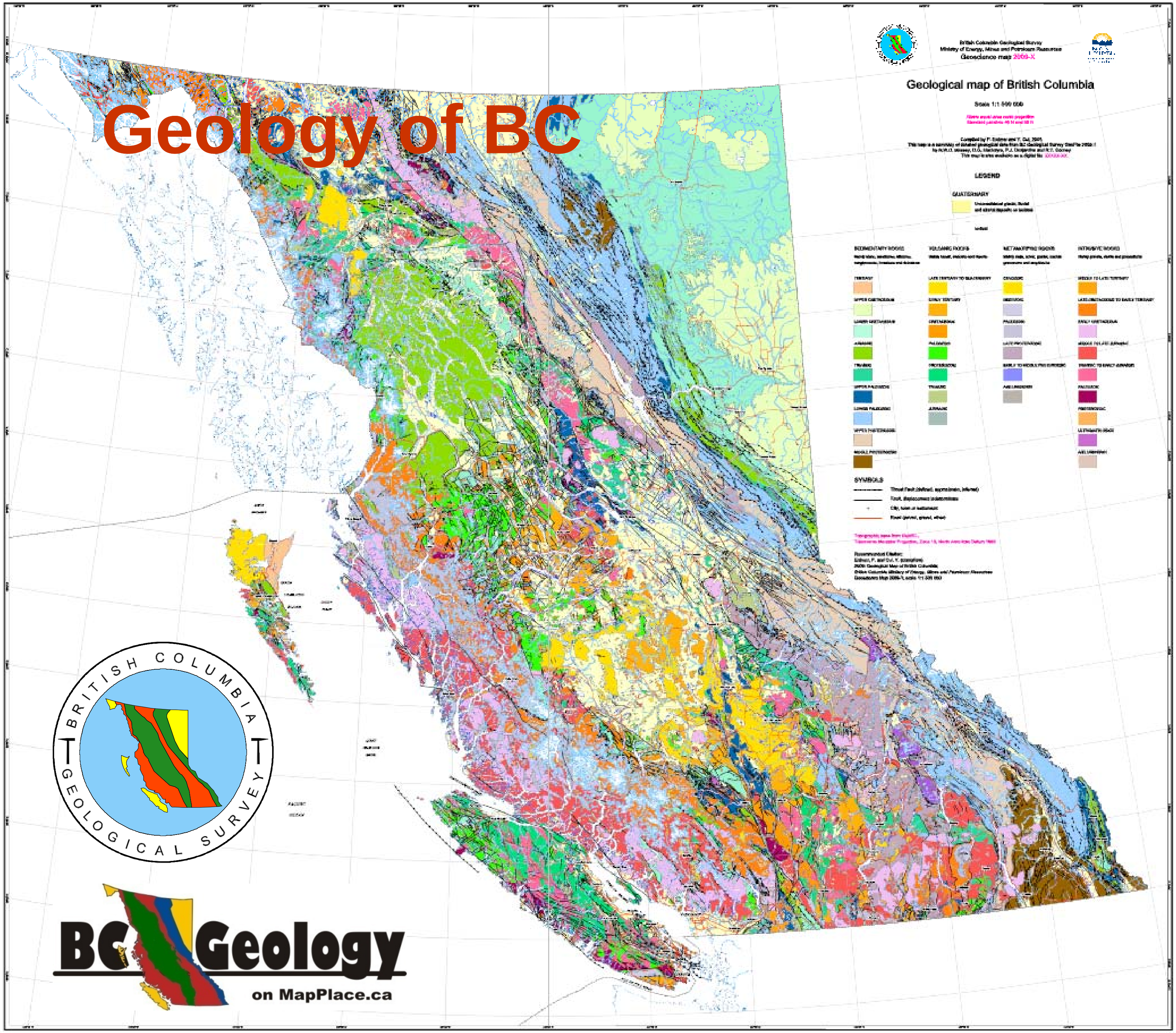
Clients

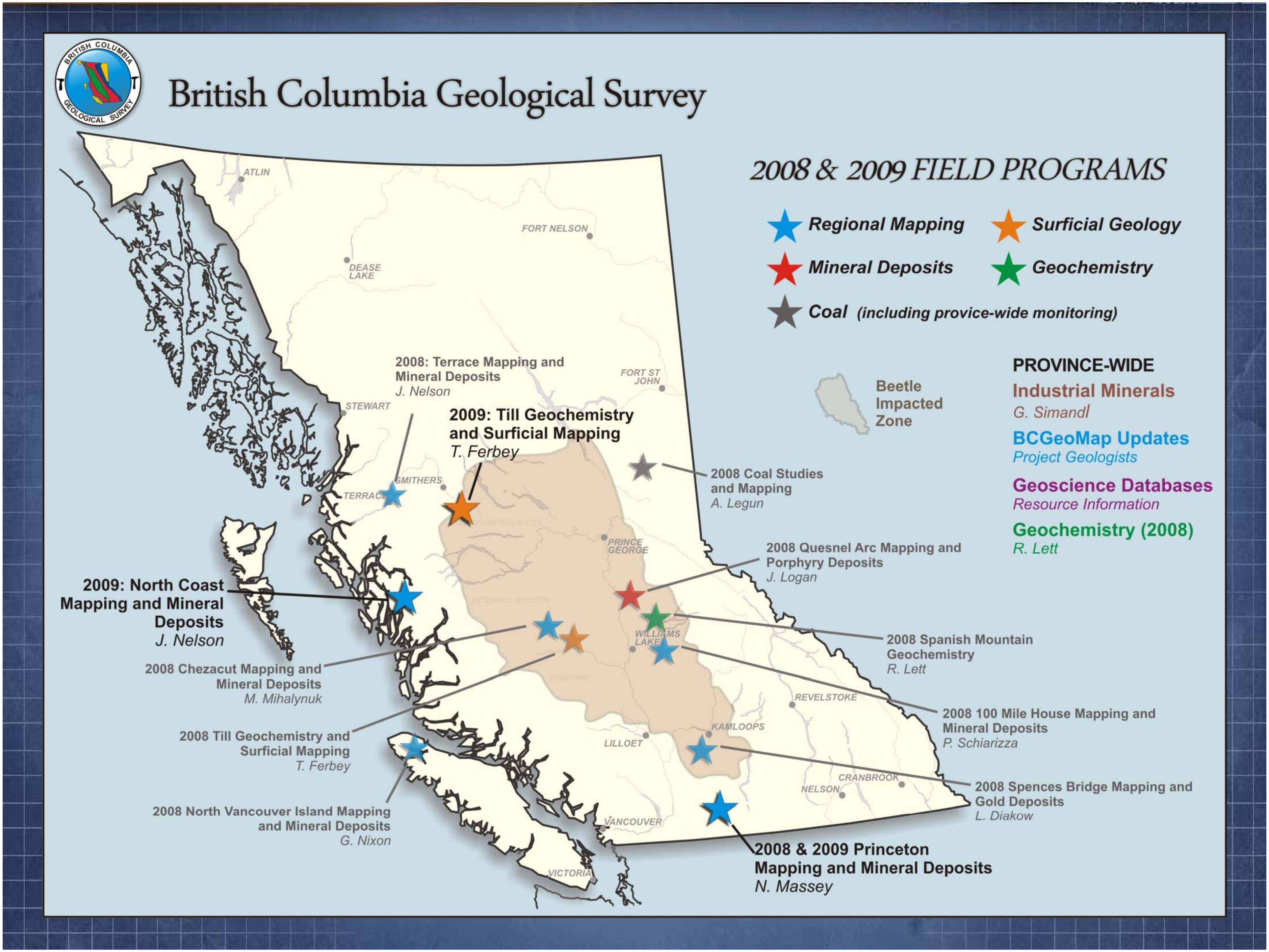
Mining Industry
Governments

Resource Assessment
Aboriginal Relations
Gold Commissioner
Land-use Branch
Permitting

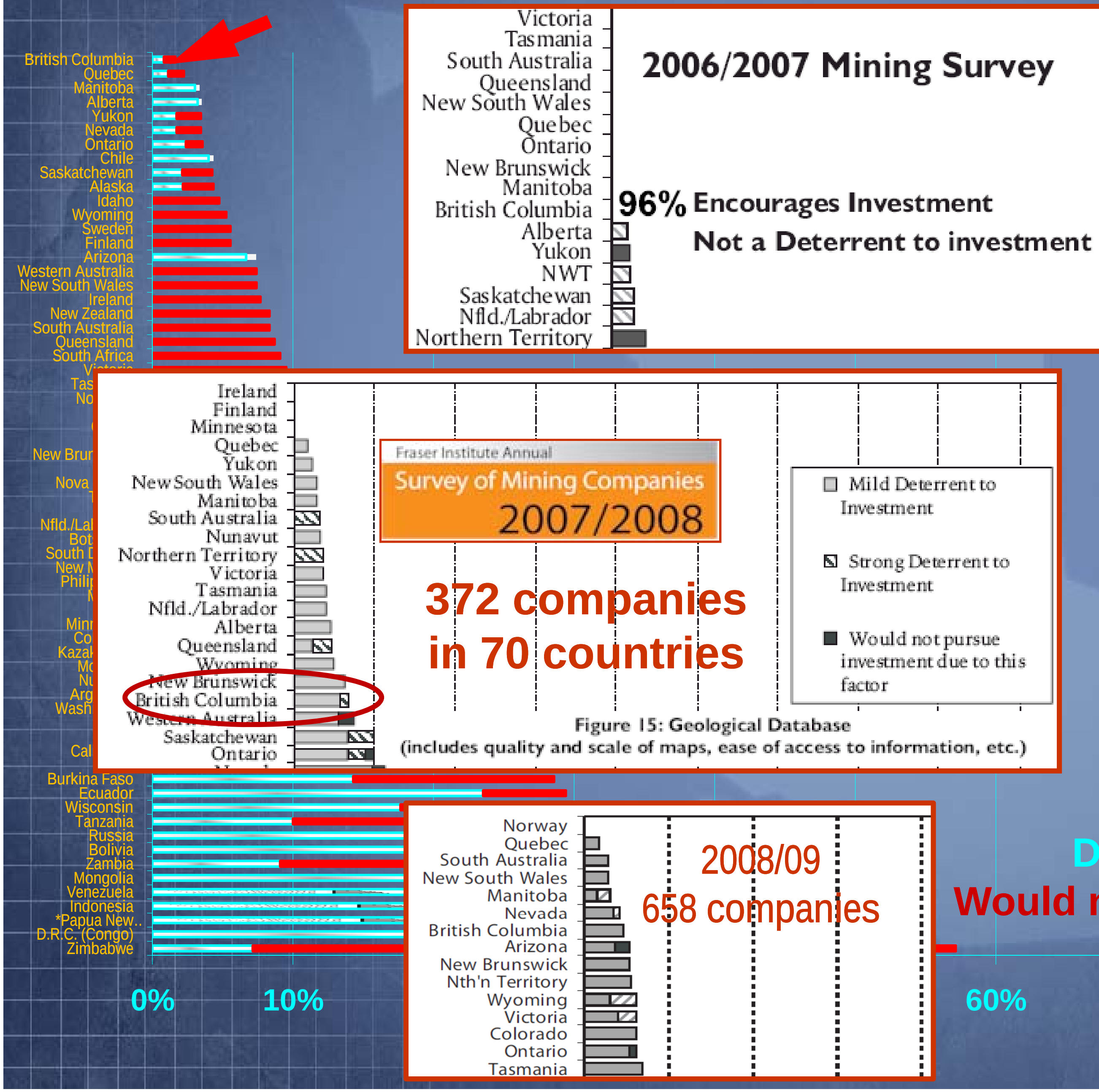
First Nations
Communities
Public
Universities
Investors
Consultants
Students
Business
Insurance Companies
Search and Rescue
Legal
Real Estate
Environmental Groups

Geology of BC




British Columbia Geological Survey
2008 & 2009 FIELD PROGRAMS
Regional Mapping
Surficial Geology
Mineral Deposits
Geochemistry
Coal (including provice-wide monitoring)
PROVINCE-WIDE
Industrial Minerals
G. Simandl
BCGeoMap Updates
Project Geologists
Geoscience Databases
Resource Information
Geochemistry (2008)
R. Lett
Beetle Impacted Zone
ATLIN
FORT NELSON
DEASE LAKE
FORT ST JOHN
STEWART
SMITHERS
TERRACE
PRINCE GEORGE
WILLIAMS LAKE
REVELSTOKE
KAMLOOPS
LILLOET
CRANBROOK
NELSON
VANCOUVER
VICTORIA
2008: Terrace Mapping and Mineral Deposits
J. Nelson
2009: Till Geochemistry and Surficial Mapping
T. Ferbey
2008 Coal Studies and Mapping
A. Legun
2008 Quesnel Arc Mapping and Porphyry Deposits
J. Logan
2009: North Coast Mapping and Mineral Deposits
J. Nelson
2008 Spanish Mountain Geochemistry
R. Lett
2008 Chezacut Mapping and Mineral Deposits
M. Mihalynuk
2008 100 Mile House Mapping and Mineral Deposits
P. Schiarizza
2008 Till Geochemistry and Surficial Mapping
T. Ferbey
2008 Spences Bridge Mapping and Gold Deposits
L. Diakow
2008 North Vancouver Island Mapping and Mineral Deposits
G. Nixon
2008 & 2009 Princeton Mapping and Mineral Deposits
N. Massey

Quality of geological database



THE FRASER INSTITUTE

Annual Survey of Mining Companies 2005/2006
64 jurisdictions

Deterrent to investment
Would not pursue exploration

MapPlace.ca

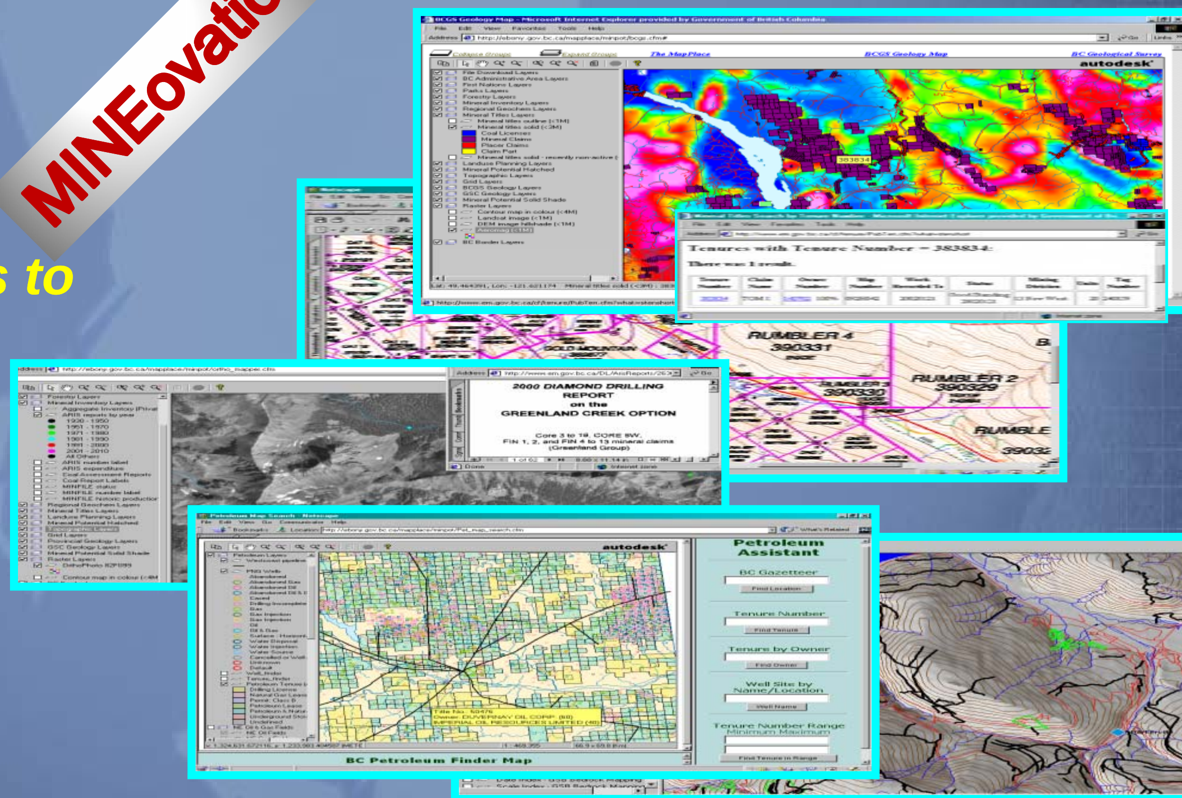
Delivering Geoscience Data

MINEovation

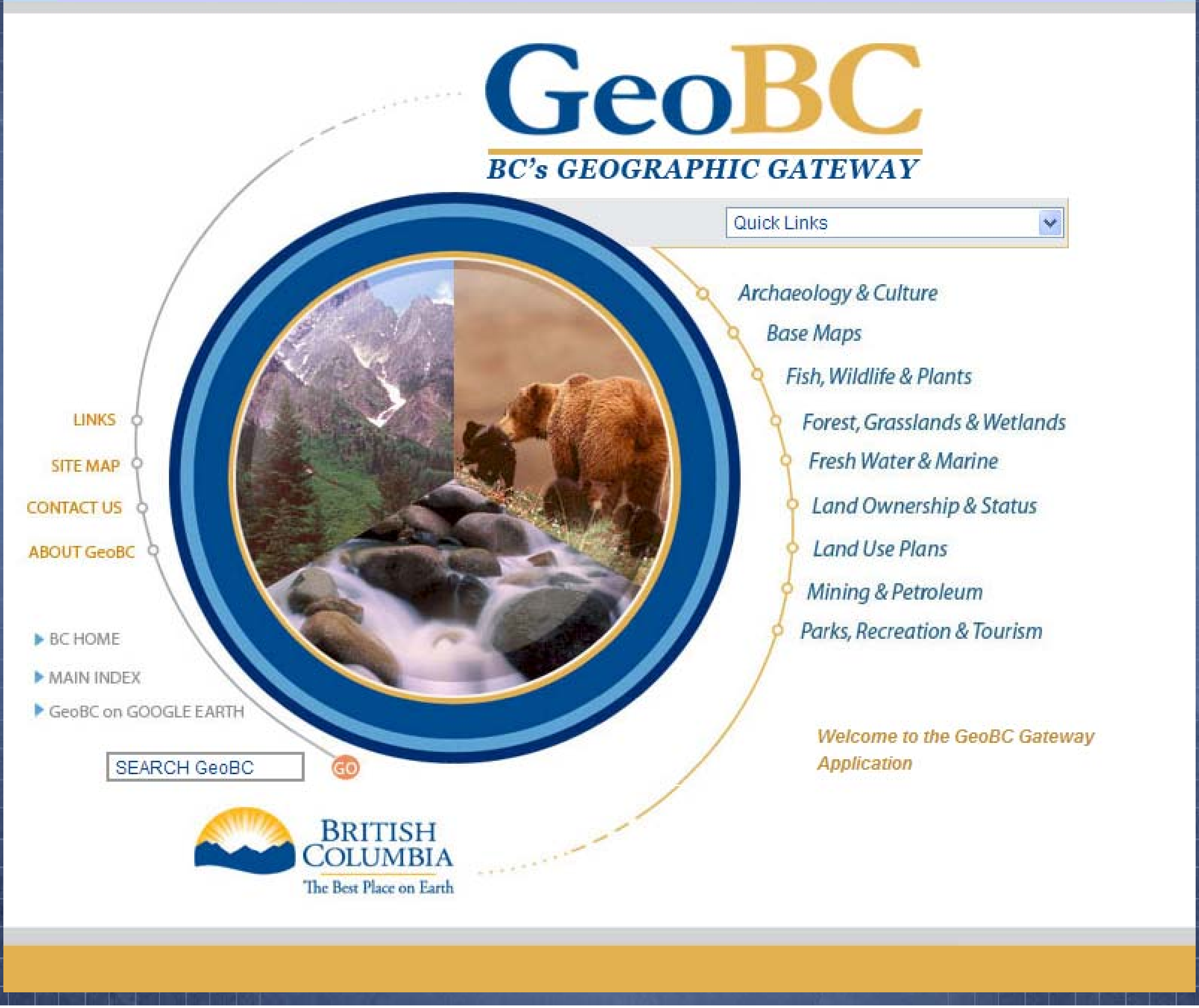
"BC really has its act together when it comes to putting information in the public domain.

Many jurisdictions go only part way, but BC does a lot more than asked to."

Fraser Institute Survey 2008



Collaboration with www.GeoBC.gov.bc.ca



Digital Access Efficiencies

Reduce environmental footprint

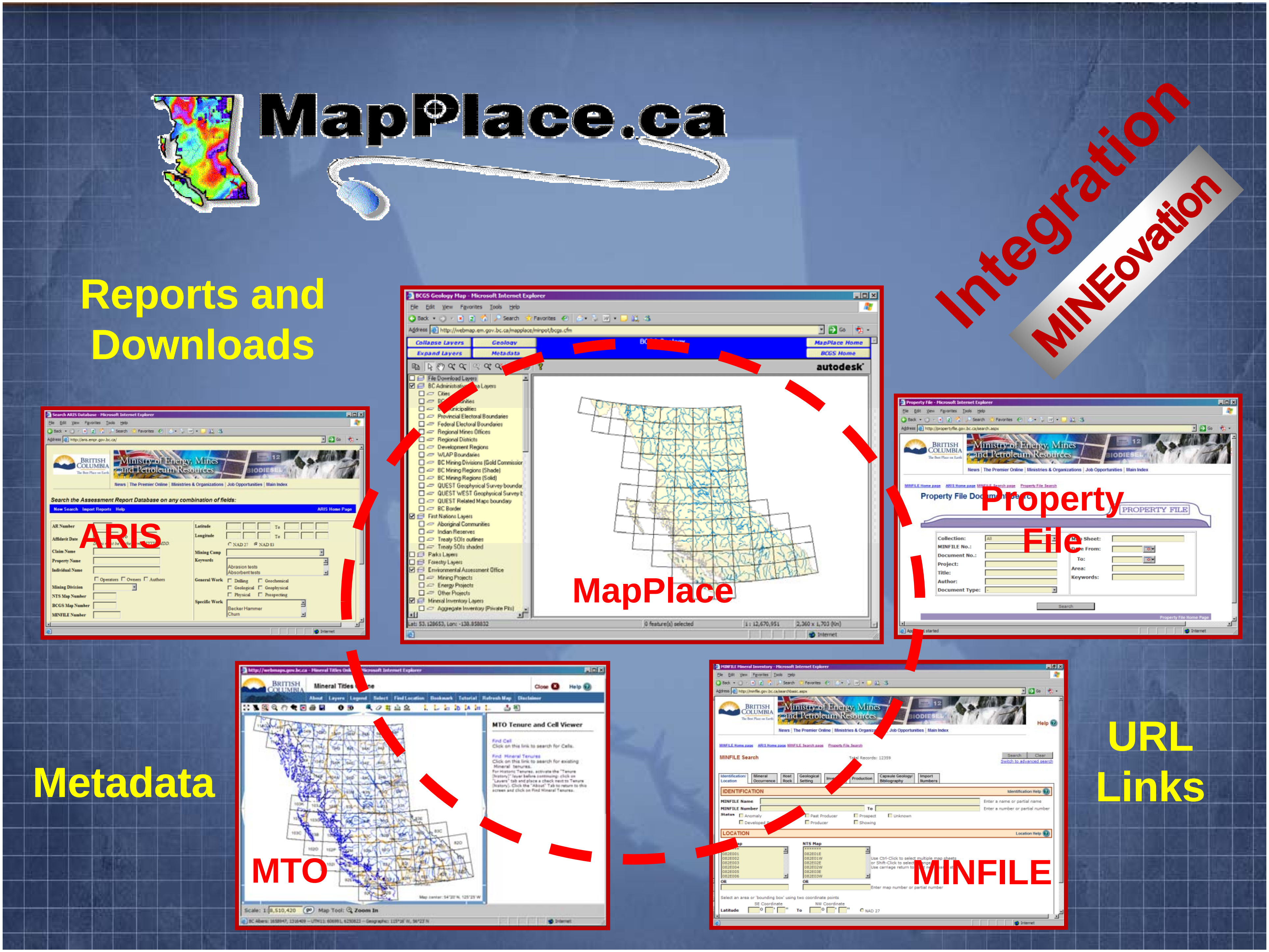
Save exploration dollars

Less travel and use of resources
e.g. Victoria-Vancouver:
CO_2 Equivalent Emissions: 90 kg

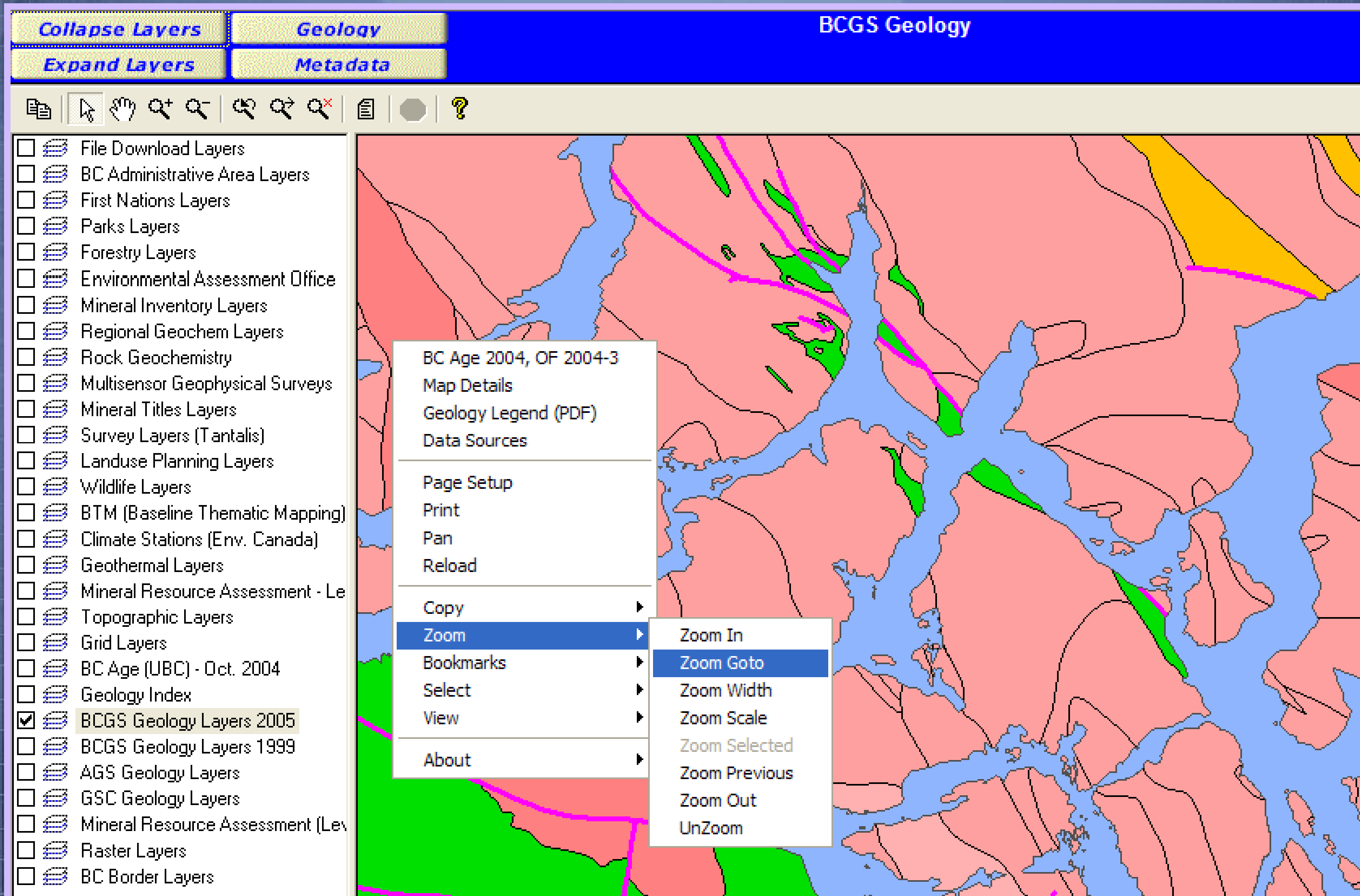
Historical exploration reports
e.g. $90K drill hole

Mineral Titles Online staking since 2005

Interactive linkages with other databases

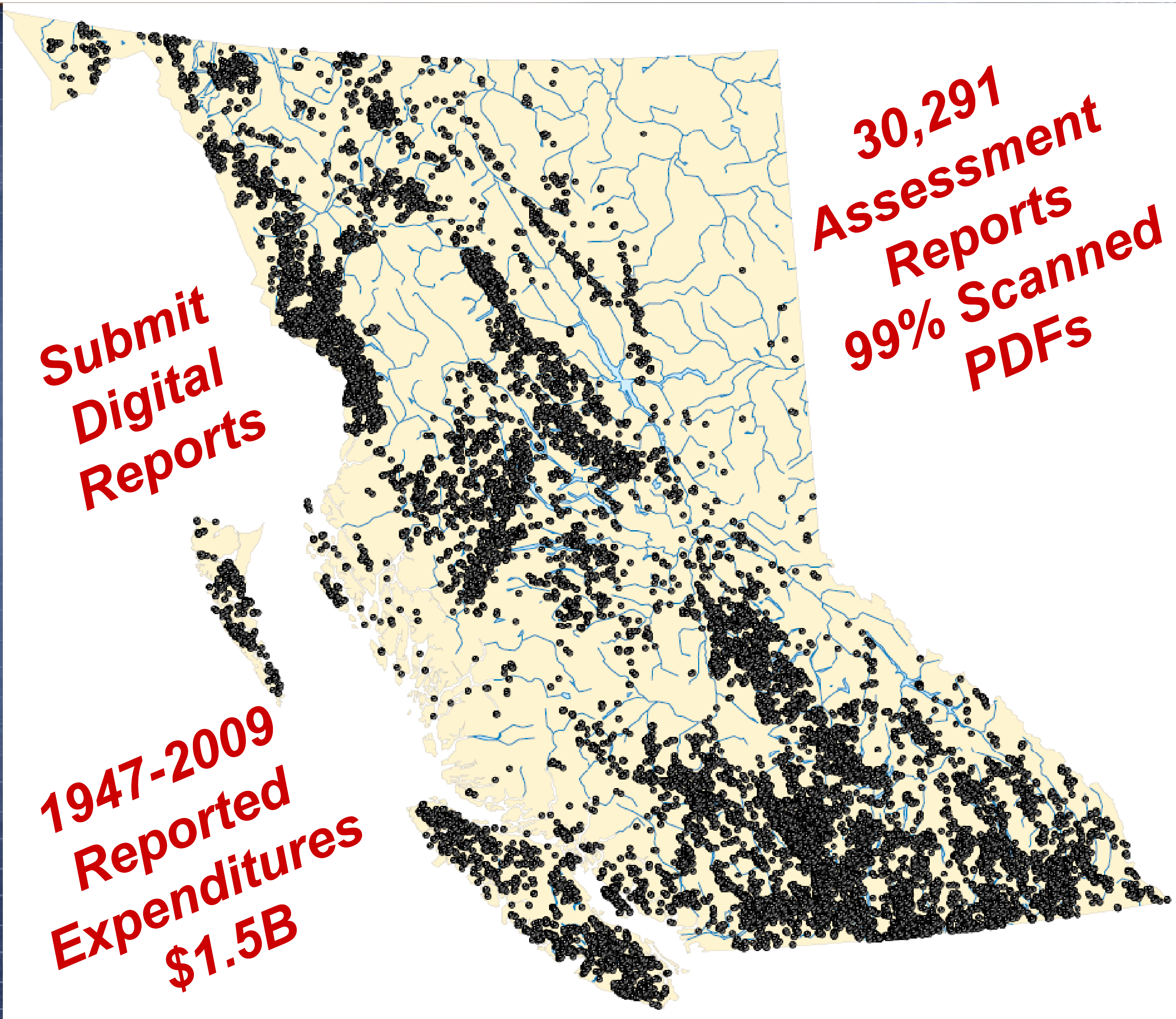

MapPlace.ca
Integration
MINEovation
Reports and Downloads
ARIS
MapPlace
Property File
Metadata
MTO
MINFILE
URL Links

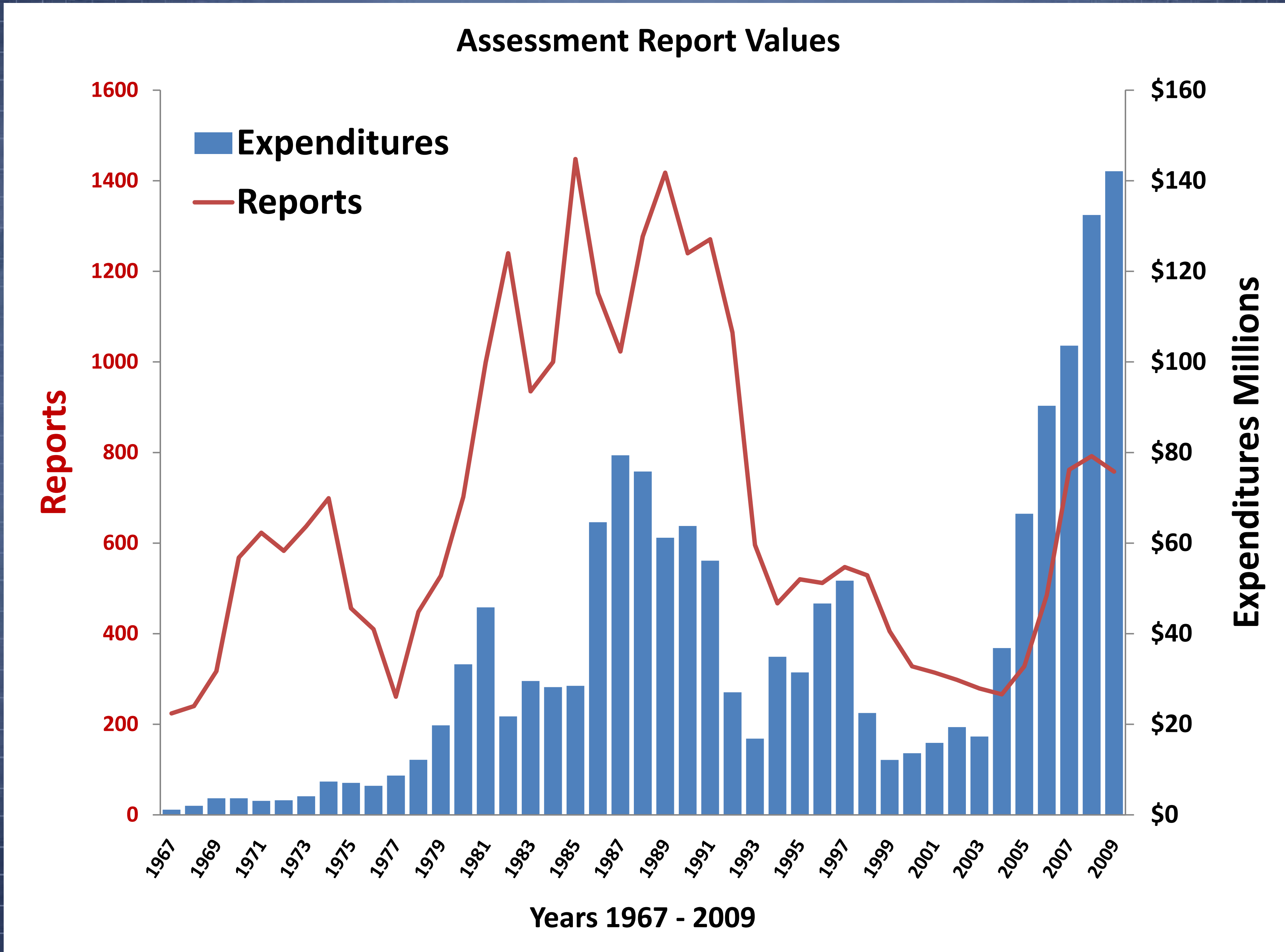
MapPlace Toolbar & PopUp Menu



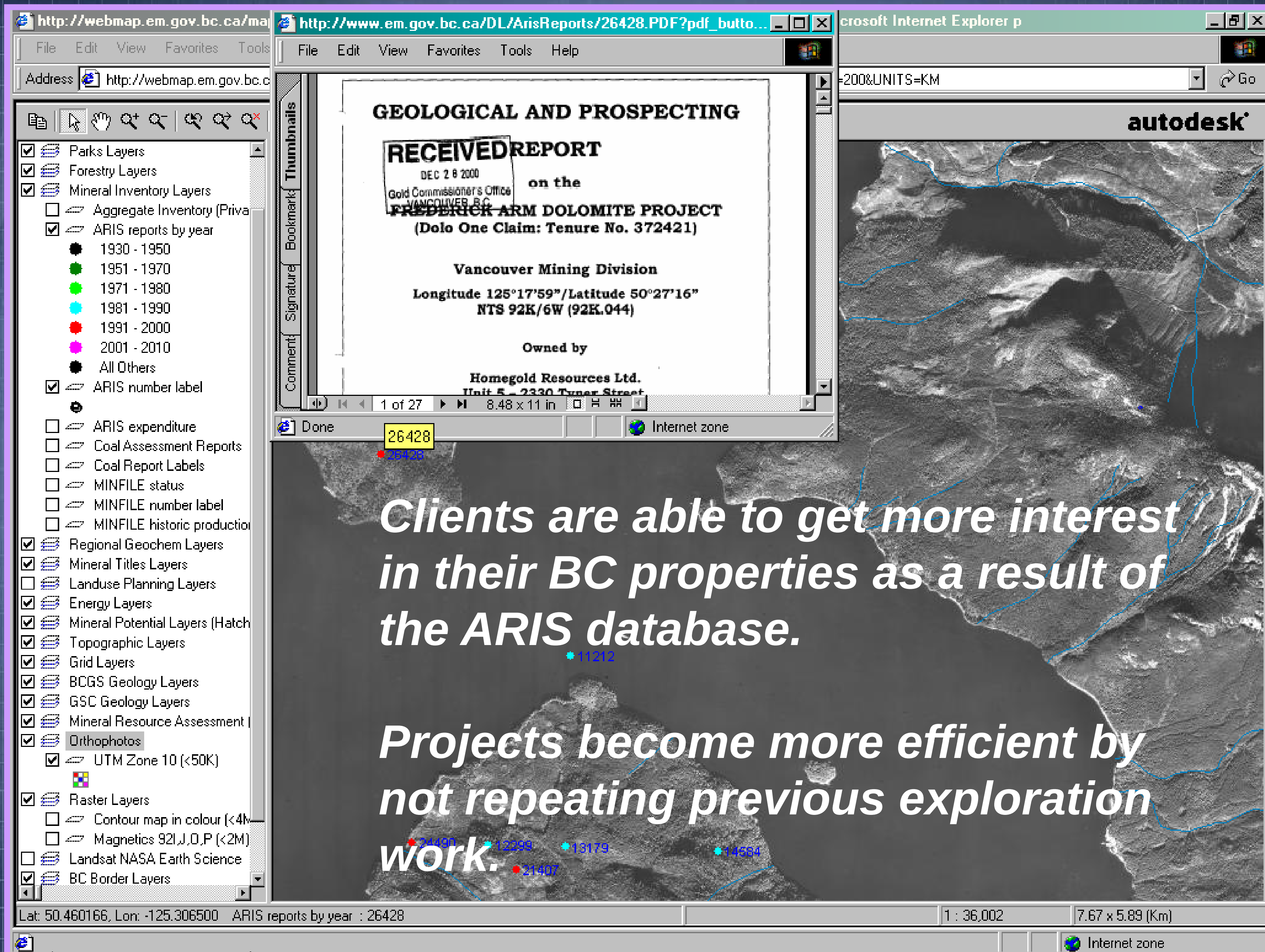
BC Geoscience Databases

MINFILE	➢ 12,441 mineral occurrences
Digital Geology Map	➢ 28,438 polygons
MINEovation Mineral Potential	➢ 930 tracts
Geochemical Data	➢ 55K+ RGS; 10K rock; till
Geophysical Data	➢ 35 published surveys
Exploration Reports	➢ 30,000+ ARIS 99% scanned
COALFILE Library	➢ 860 reports; 10K boreholes
Property Files	➢ 43,000+ maps and reports
MINEovation Deposit Profiles	➢ 105 deposit descriptions
BC Age database	➢ 7760+ records
Publications from 1887	➢ 3700 geoscience maps & reports
...on top of Base Data	➢ Topo, Admin, Landuse, Imagery, geophysics


30,291
Assessment
Reports
99% Scanned
PDFs
Submit
Digital
Reports
1947-2009
Reported
Expenditures
$1.5B



Assessment Report Values
Expenditures
Reports
1600
1400
1200
1000
800
600
400
200
0
$160
$140
$120
$100
$80
$60
$40
$20
$0
Reports
Expenditures Millions
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Years 1967 - 2009



Clients are able to get more interest in their BC properties as a result of the ARIS database.

Projects become more efficient by not repeating previous exploration work.

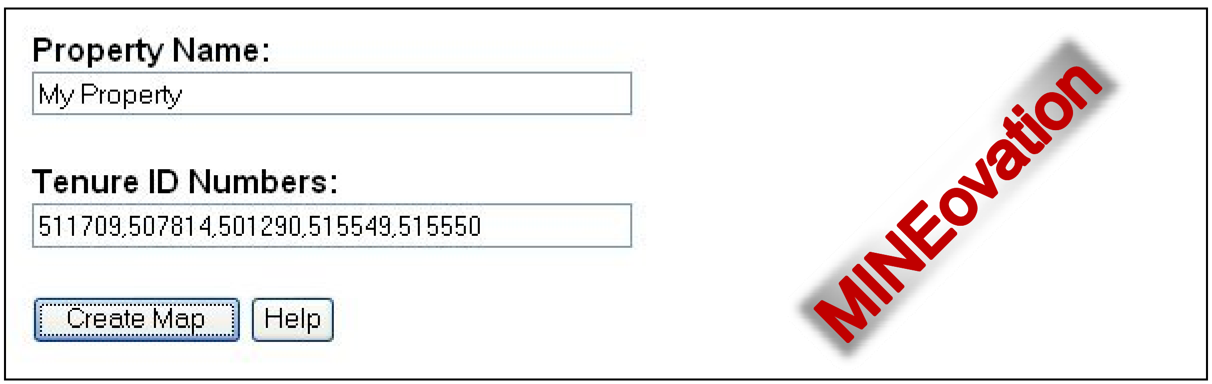
ARIS with Orthophoto & Link to PDF Report

ARIS MapBuilder

ARIS Map Builder Help

Step 1: The Data Entry Form

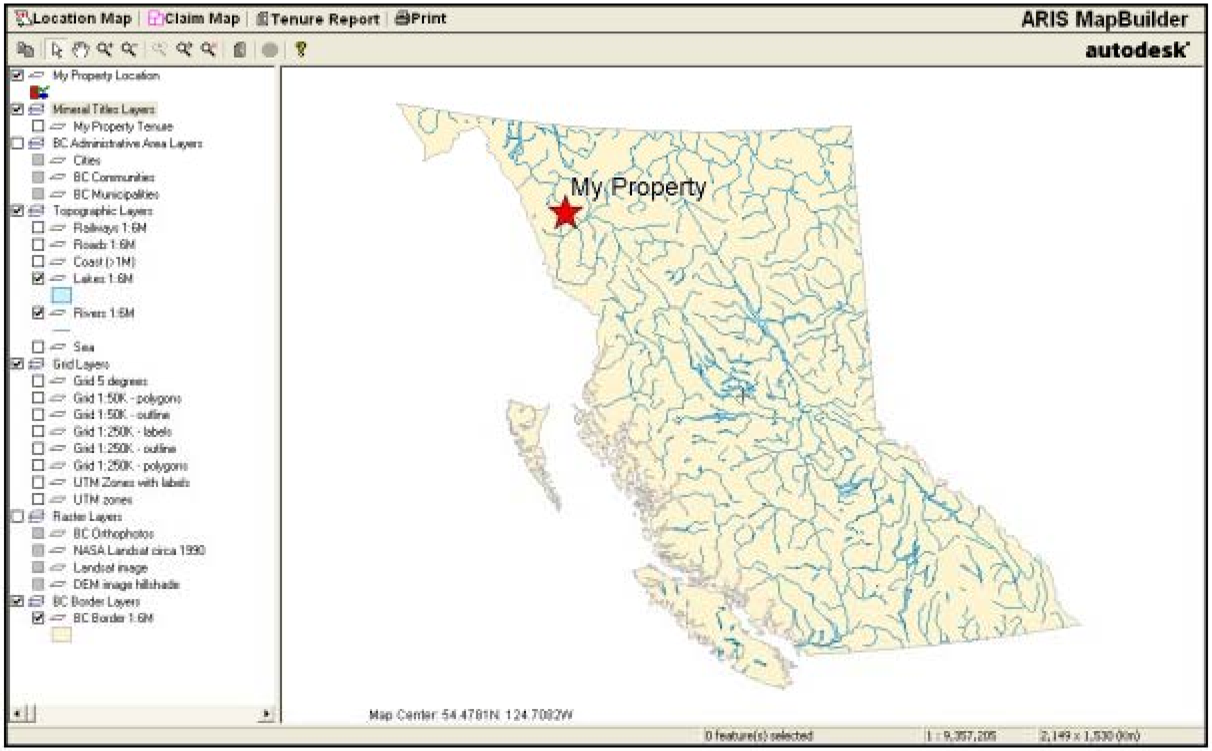
- Enter the name of your property.
- Enter all Tenure ID Numbers for your property. Separate the ID numbers by commas.
- Press the Create Map button.



ARIS MapBuilder

Step 2: The Location Map

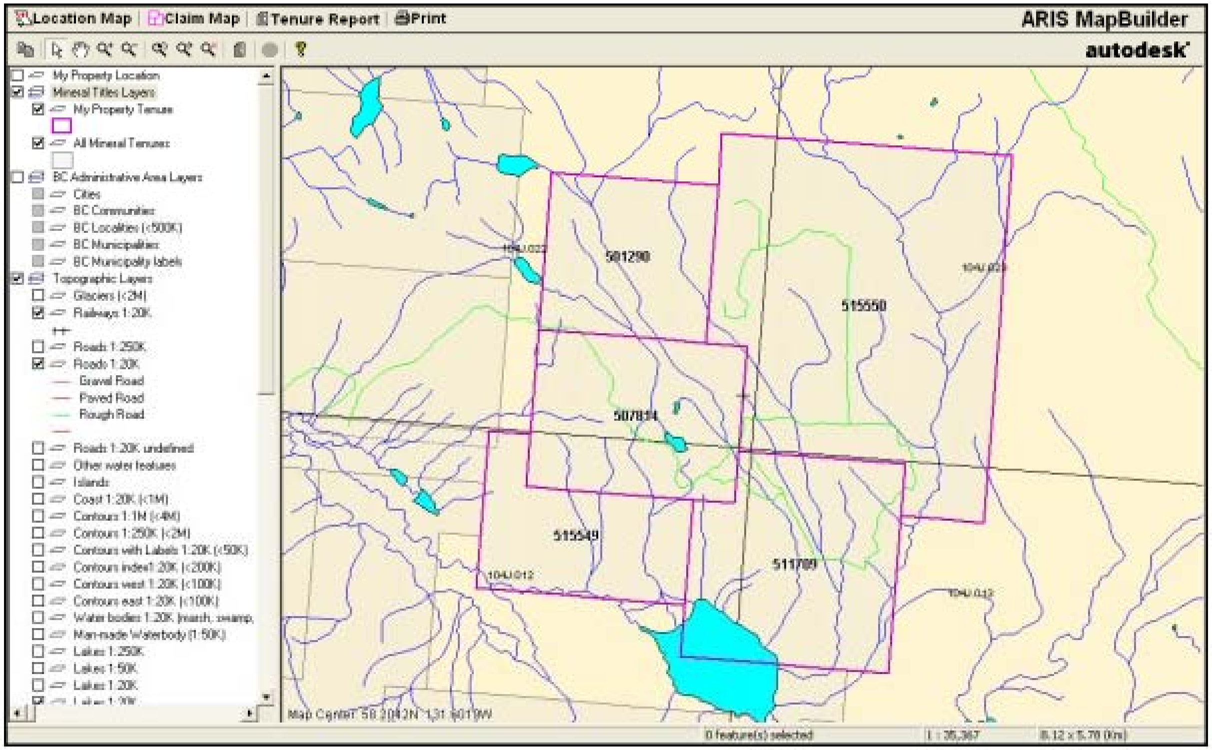
- The map opens and displays your property's location.
- Clicking **Claim Map** will zoom in to your property.
- Clicking **Print** will print your Location Map. PDF Sample



ARIS MapBuilder

Step 3: The Claim Map

- The map zooms in to show your property.
- Clicking **Location Map** will zoom out to the Location Map.
- Clicking **Print** will print your Claim Map. [PDF Sample]



ARIS MapBuilder

Step 4: The Tenure Report

- Clicking **Tenure Report** will open a new window with a report of all tenures in your property.
- The Tenure Report provides links to MTO.

Mineral Titles Online Report

Click on Tenure Number for more information

Download to Excel

Tenure Number	Type	Claim Name	Good Until	Area (ha)
501290	Mineral	HAT	20070112	204.528
507814	Mineral		20060930	255.738
511709	Mineral		20060930	324.014
515549	Mineral		20060930	187.587
515550	Mineral		20060930	715.865

LIBC Metadata

Mineral Title Online
BC Geological Survey
British Columbia Ministry of Energy, Mines and Petroleum Resources

My Property Claim Map

Mineral Titles Layers

- My Property Tenure
- All Mineral Tenures

Topographic Layers

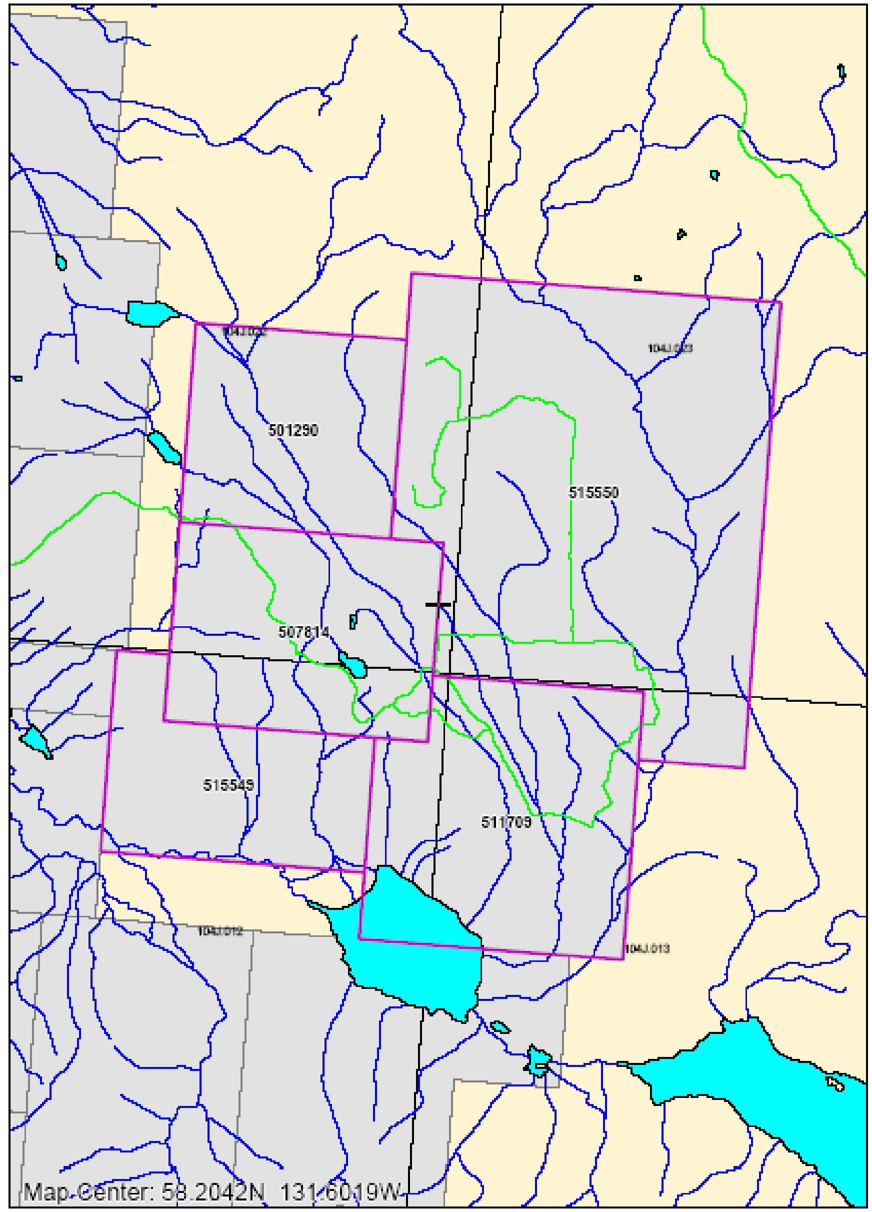
- Railways 1:20K
- Roads 1:20K
  - Gravel Road
  - Paved Road
  - Rough Road
- Lakes 1:20K
- Rivers 1:20K

Grid Layers

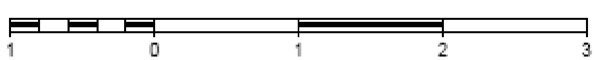
- Grid 1:20K - labels
- Grid 1:20K - outline

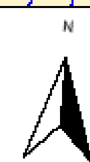
BC Border Layers

- BC Border 1:50K

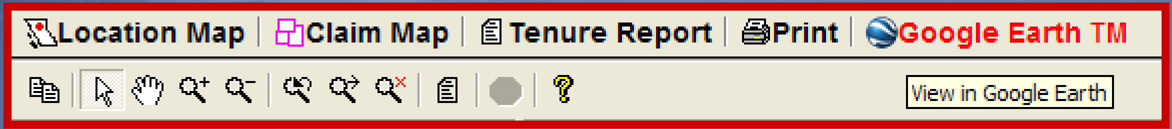


SCALE 1 : 46,541



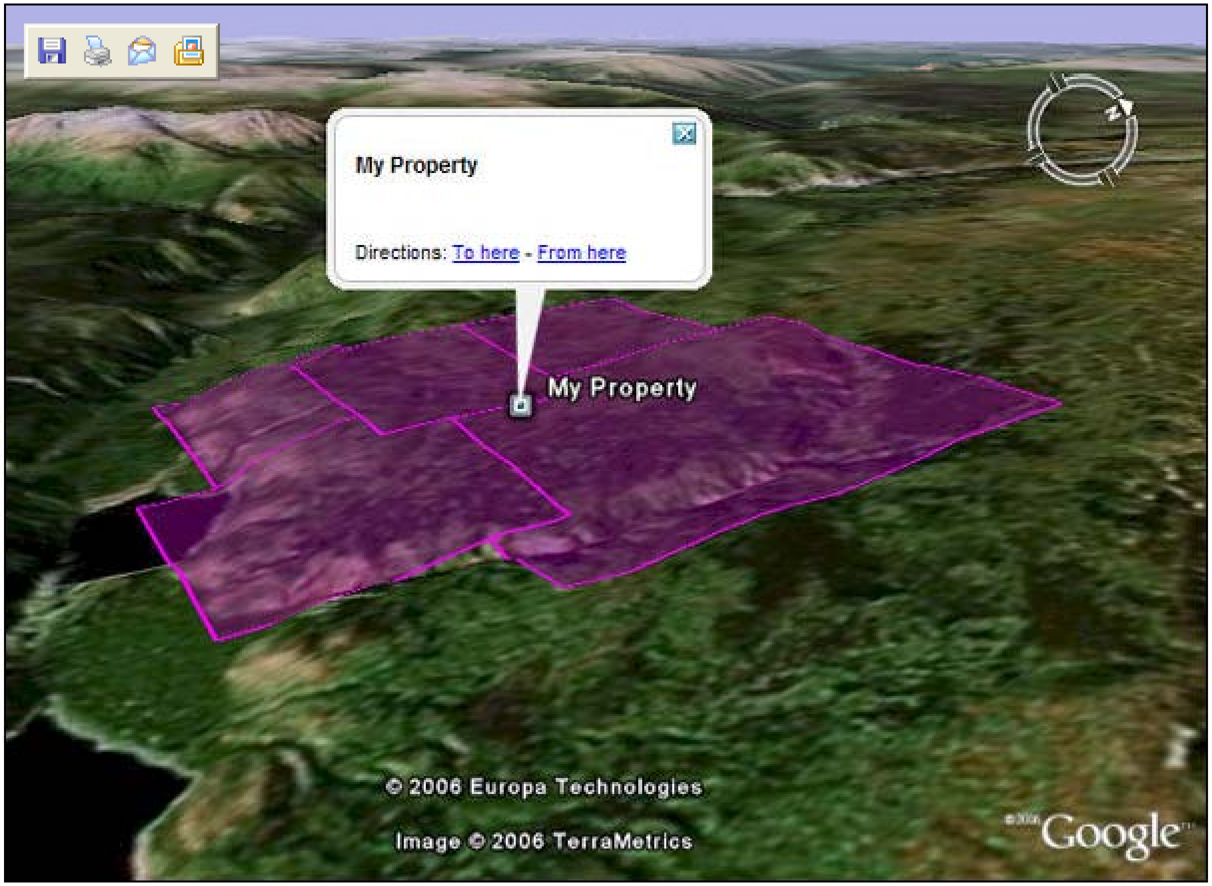


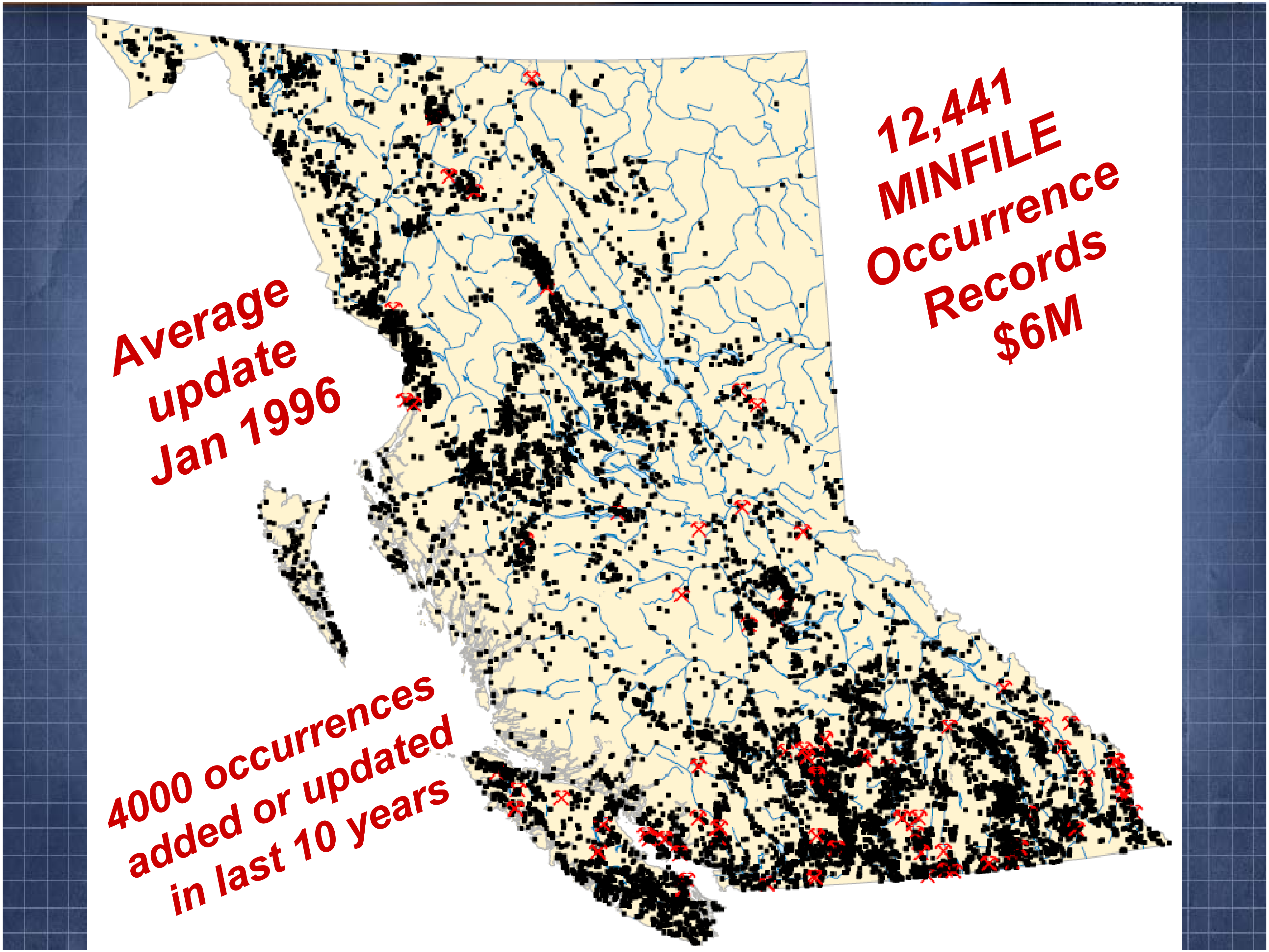
ARIS MapBuilder

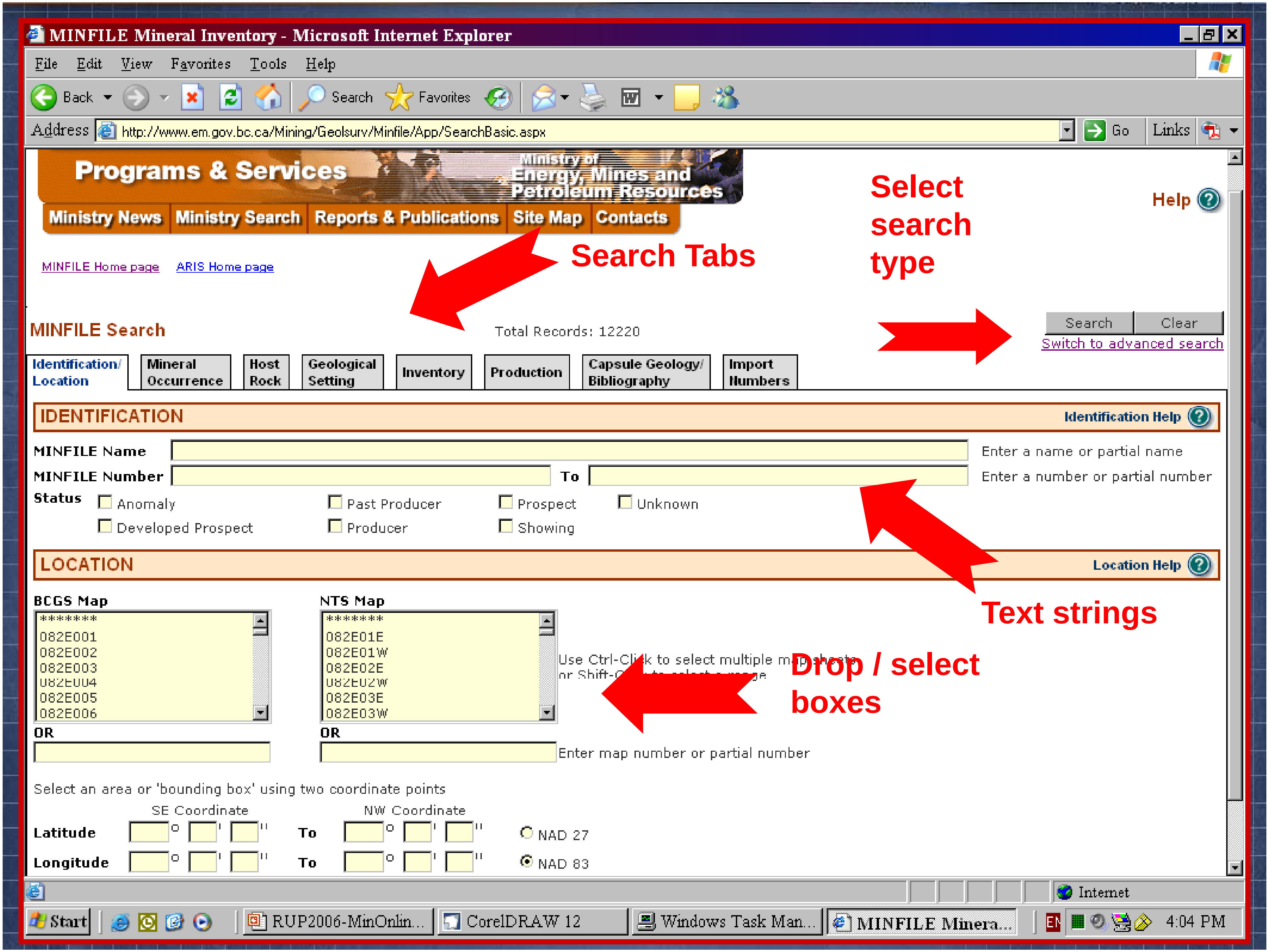


Step 5: View your claims in Google Earth

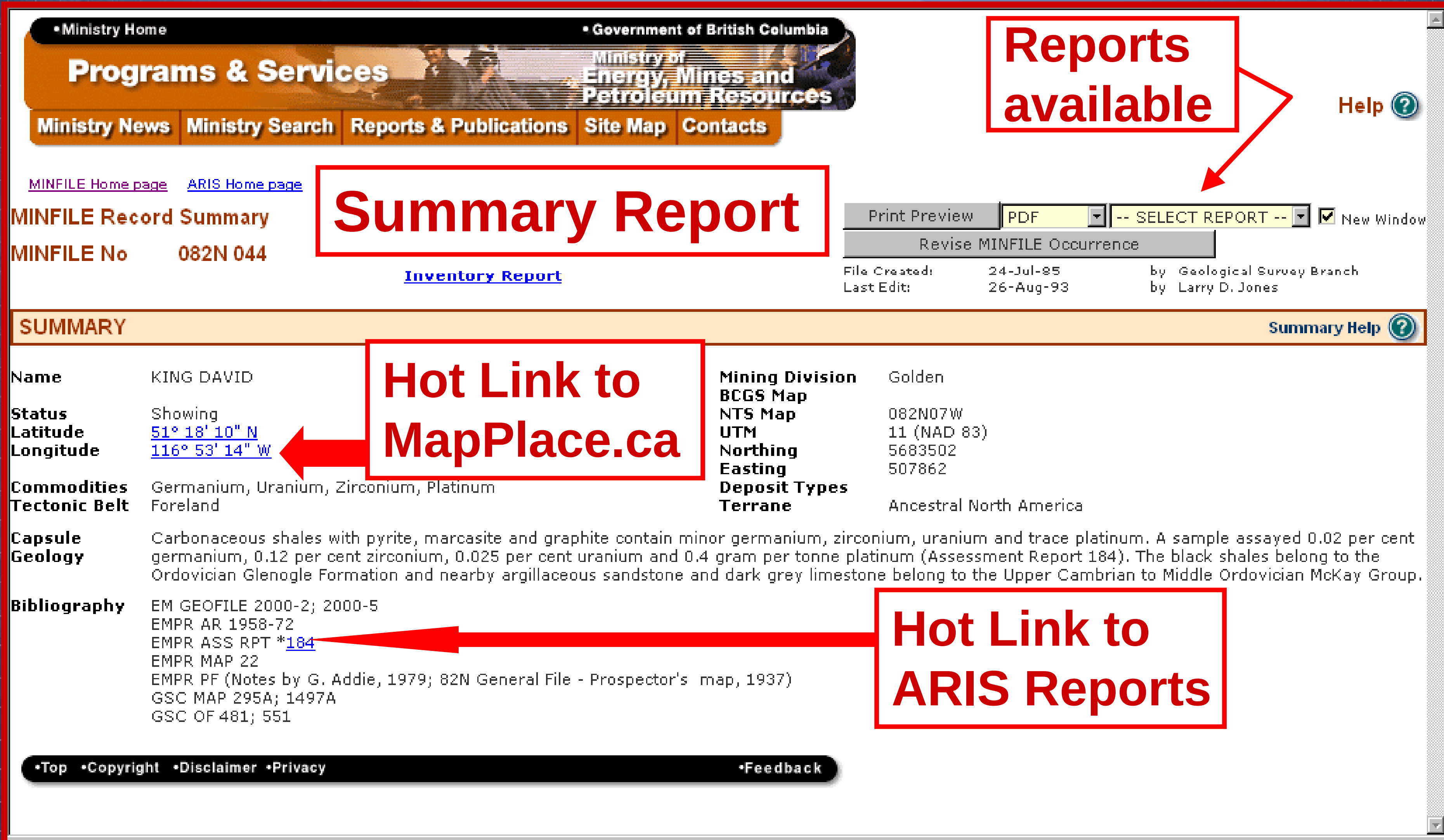
- Clicking **Google Earth** will download a Google Earth **KML** file.
- You must have Google Earth installed on your computer to view KML files.



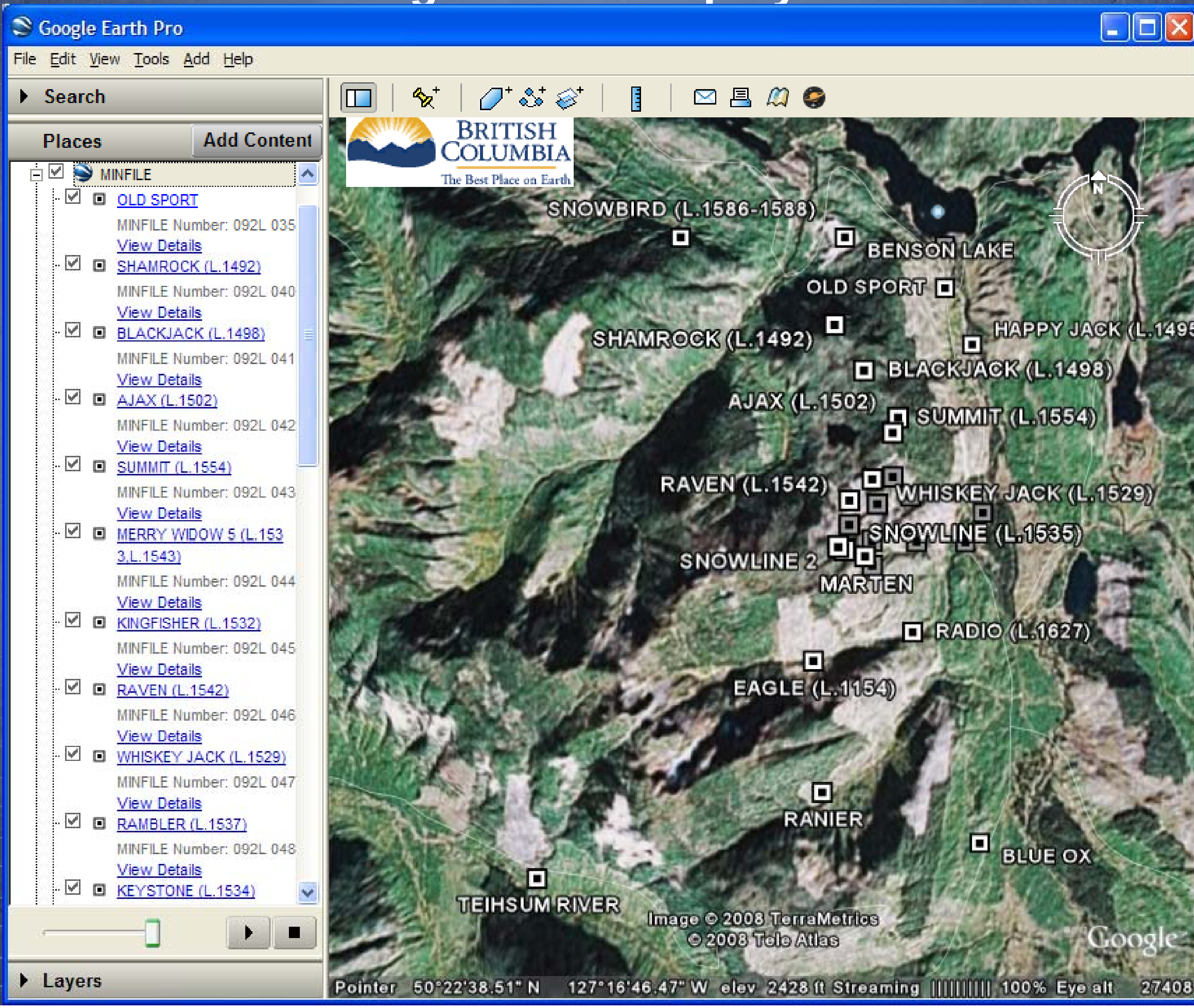

12,441
MINFILE
Occurrence
Records
$6M
Average
update
Jan 1996
4000 occurrences
added or updated
in last 10 years

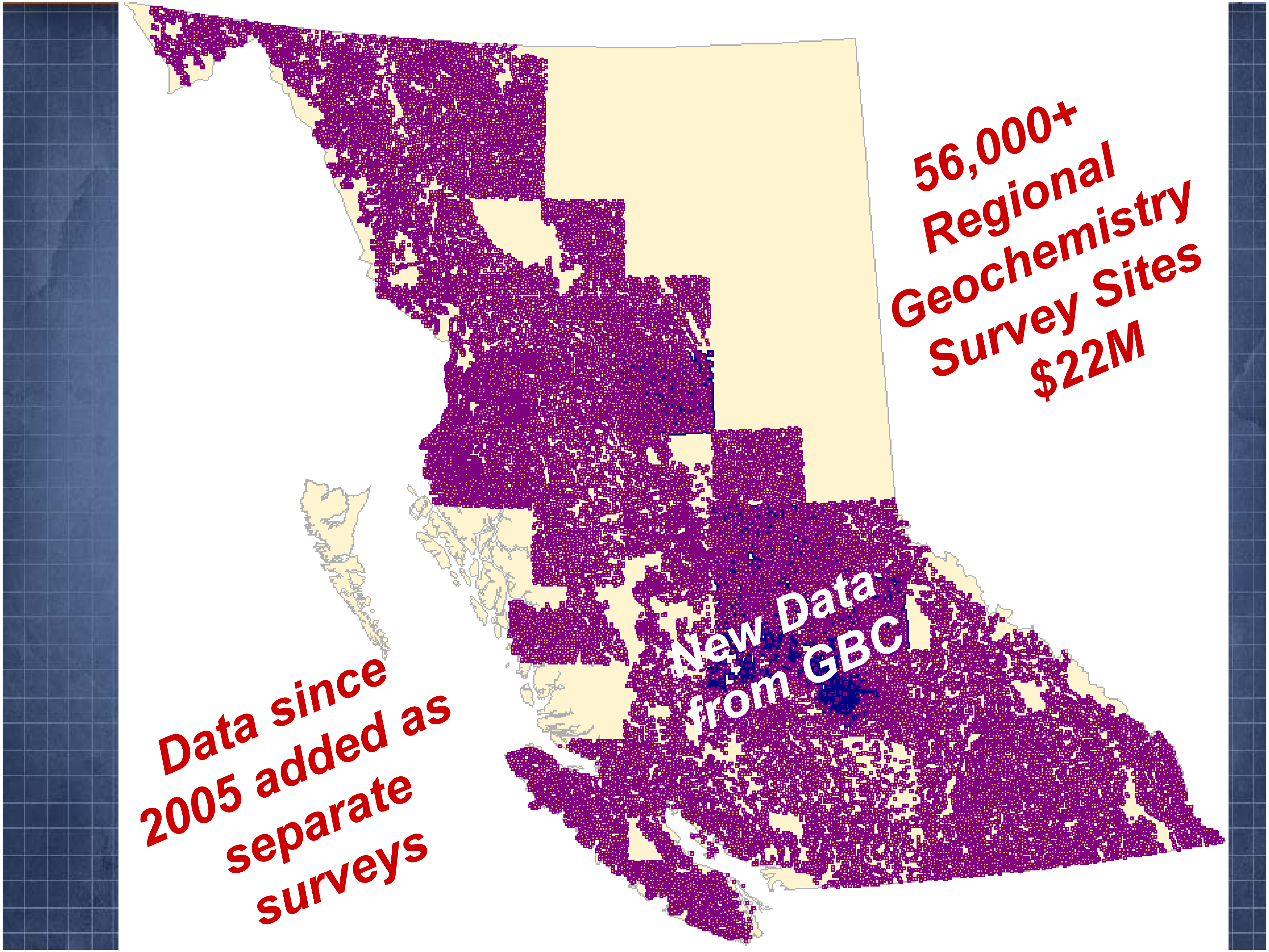

MINFILE Mineral Inventory - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://www.em.gov.bc.ca/Mining/Geolsurv/Minfile/App/SearchBasic.aspx
Go Links
Programs & Services
Ministry of Energy, Mines and Petroleum Resources
Ministry News Ministry Search Reports & Publications Site Map Contacts
MINFILE Home page ARIS Home page
Help
Search Tabs
Select search type
MINFILE Search
Total Records: 12220
Search Clear
Switch to advanced search
Identification/ Location
Mineral Occurrence
Host Rock
Geological Setting
Inventory
Production
Capsule Geology/ Bibliography
Import Numbers
IDENTIFICATION
Identification Help
MINFILE Name
Enter a name or partial name
MINFILE Number To
Enter a number or partial number
Status
Anomaly
Past Producer
Prospect
Unknown
Developed Prospect
Producer
Showing
LOCATION
Location Help
Text strings
BCGS Map
****
082E001
082E002
082E003
082E004
082E005
082E006
NTS Map
****
082E01E
082E01W
082E02E
082E02W
082E03E
082E03W
Use Ctrl-Click to select multiple map sheets
Drop / select boxes
OR
OR
Enter map number or partial number
Select an area or 'bounding box' using two coordinate points
SE Coordinate
NW Coordinate
Latitude To
Longitude To
NAD 27
NAD 83
Internet
Start
RUP2006-MinOnlin...
CorelDRAW 12
Windows Task Man...
MINFILE Minera...
4:04 PM

MINFILE Summary Report



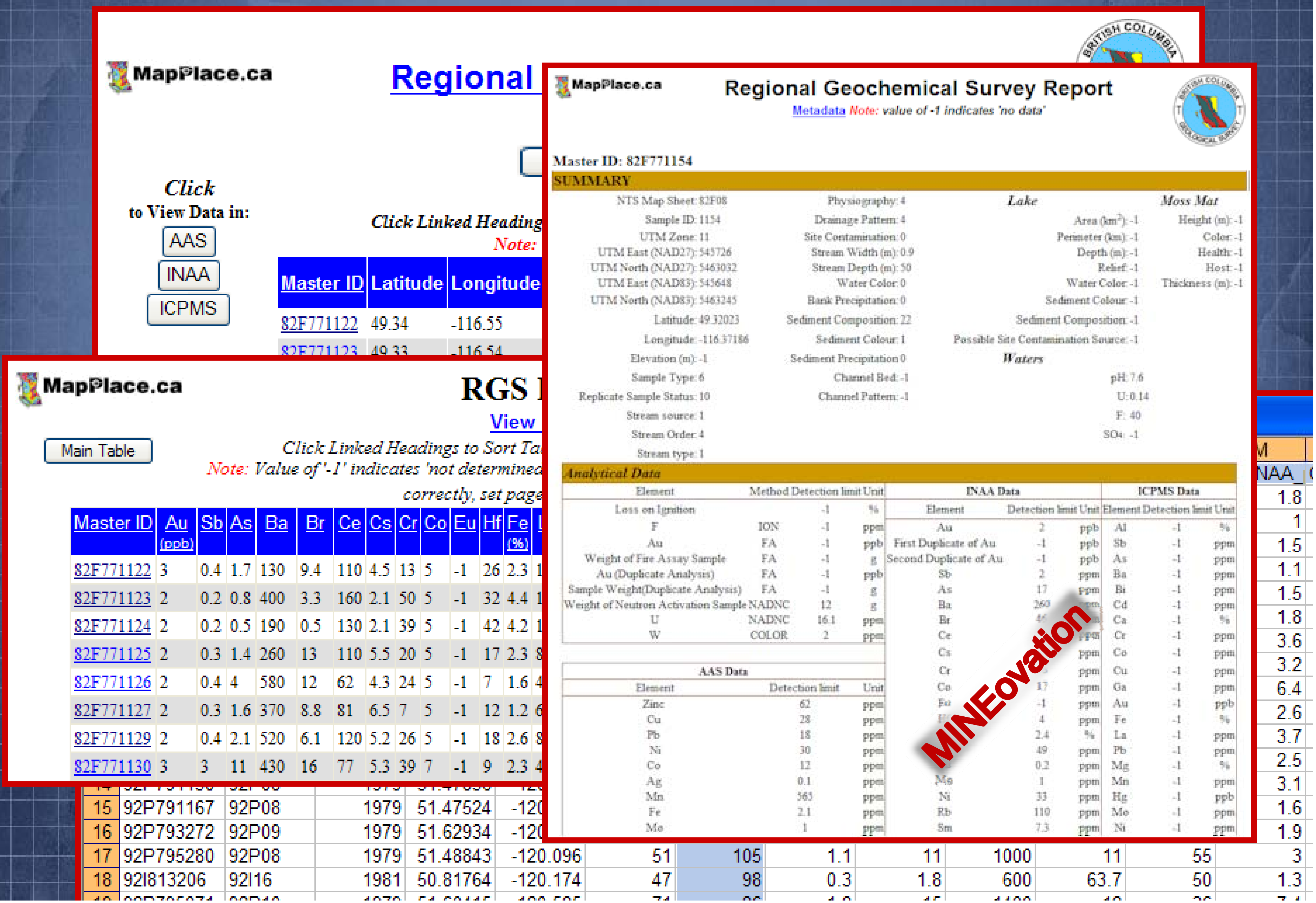
Google Earth Display





56,000+
Regional
Geochemistry
Survey Sites
$22M
New Data
from GBC
Data since
2005 added as
separate
surveys

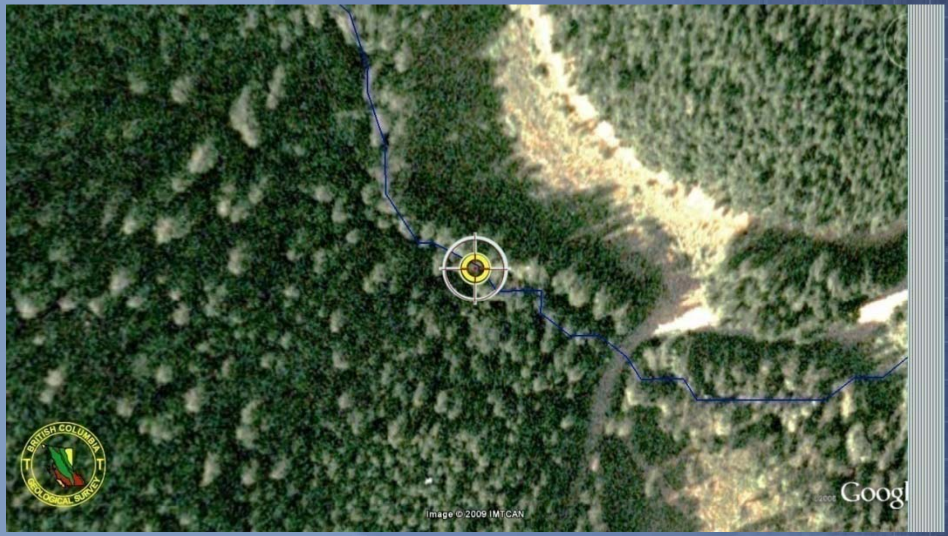
New Report Design

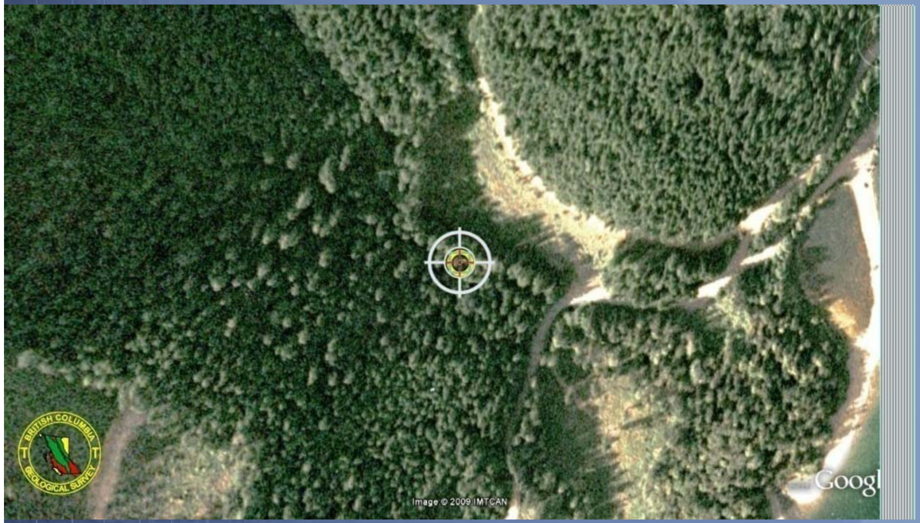


Upstream Query Demo on Google Earth

(Yao Cui)

Upstream Watersheds

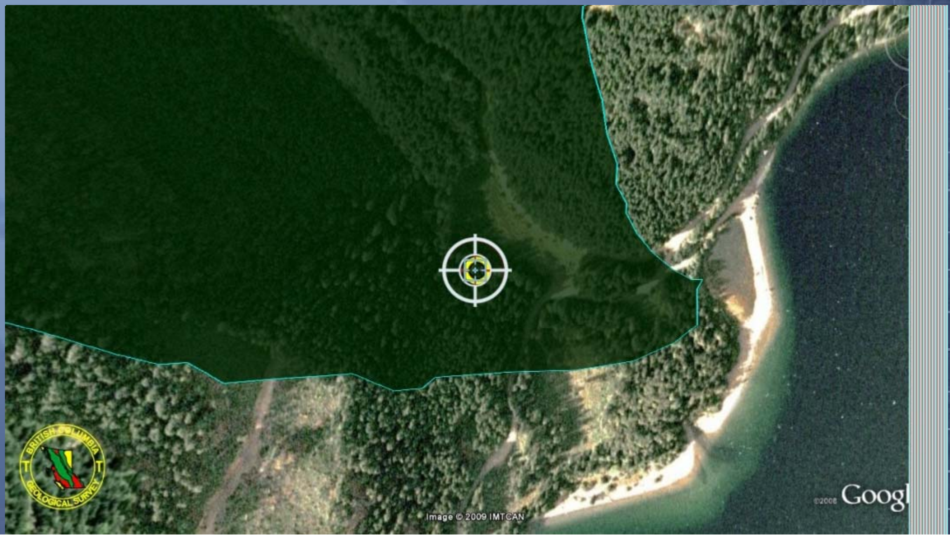


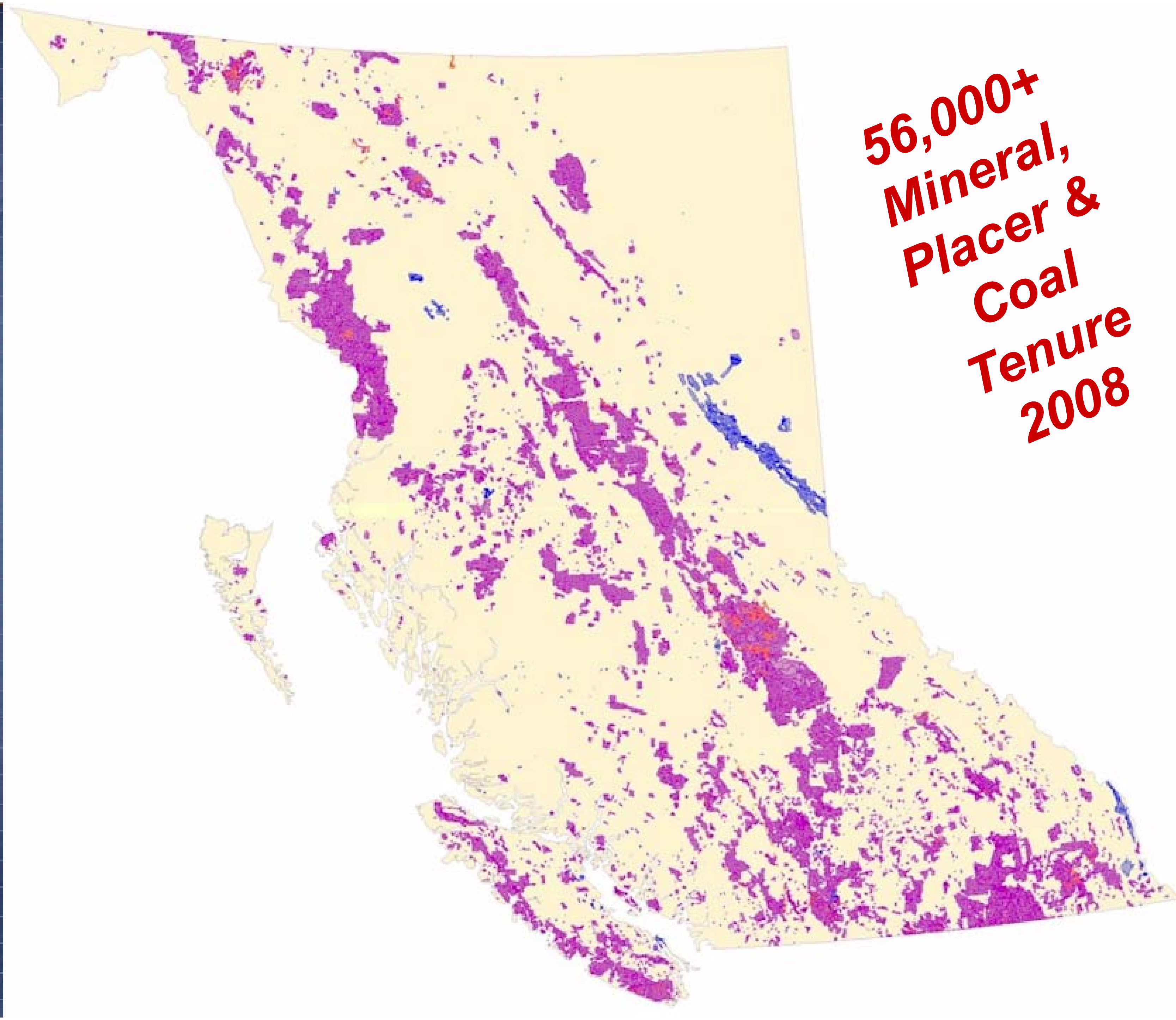


Catchment Basin

MINEovation

Upstream Edges




56,000+
Mineral,
Placer &
Coal
Tenure
2008

Mineral Titles OnLine Report

Links to multiple claims.

Access to all aspects of the MTO website information

Mineral Titles Online Report

Click on Tenure Numbers for more information.
Click column headings to sort results.

Download to Excel

Tenure Number	Type	Claim Name	Good Until	Area (ha)
232763	Mineral	GOLD MTN NO. 9 FR.	20140228	25
[illegible]	Mineral	MAC #1	20140228	500
233261	Mineral	LINDE #2	20140228	25
233262	Mineral	LINDE #1	20140228	25
233294	Mineral	KENA FR.	20140228	25
235349	Mineral	KENA #18	20140228	[illegible]
235350	Mineral	KENA #19	20140228	[illegible]
235351	Mineral	KENA #20	20140228	[illegible]
235352	Mineral	KENA #21	[illegible]	[illegible]
235353	Mineral	KENA #22	[illegible]	[illegible]
235354	Mineral	KENA #23	[illegible]	[illegible]
235356	Mineral	KENA #25	[illegible]	[illegible]
374208	Mineral	CAT 34	[illegible]	[illegible]
512465	Mineral	BLUEBIRD	[illegible]	[illegible]
512466	Mineral	BLUEBIRD II	[illegible]	[illegible]
512589	Mineral	CAT	20090514	[illegible]
517762	Mineral	SILVER QUEEN	20071220	[illegible]
537232	Mineral	CAT 1	20100714	[illegible]
550200	Mineral	CATHERINE	20080125	63.02
550203	Mineral	CAT 1	20080125	21.009
550210	Mineral	FRANK&DON	20080125	252.194
550275	Mineral	F&D FR.	20080125	21.016
567053	Mineral	COPPER CAT 26	20080929	524.898
567054	Mineral	COPPER CAT 27	20080929	525.491
567056	Mineral	COPPER CAT 28	20080929	520.067
567827	Mineral	KENEL	20081011	184.825

Total Area: 3917.812 ha

Summary Report for the selected claims

Mineral Titles Detail Report

Tenure Number ID	512465 View Tenure
Tenure Type	Mineral (M)
Tenure Sub Type	Claim (C)
Title Type	Mineral Cell Title Submission (MCX)
Mining Division	
Good To Date	2007/may/12
Issue Date	2005/may/12
Termination Type	
Termination Comments	
Termination Date	
Tag Number	
Claim Name	BLUEBIRD
Old Tenure Code	
Area In Hectares	501.043

Map Numbers:

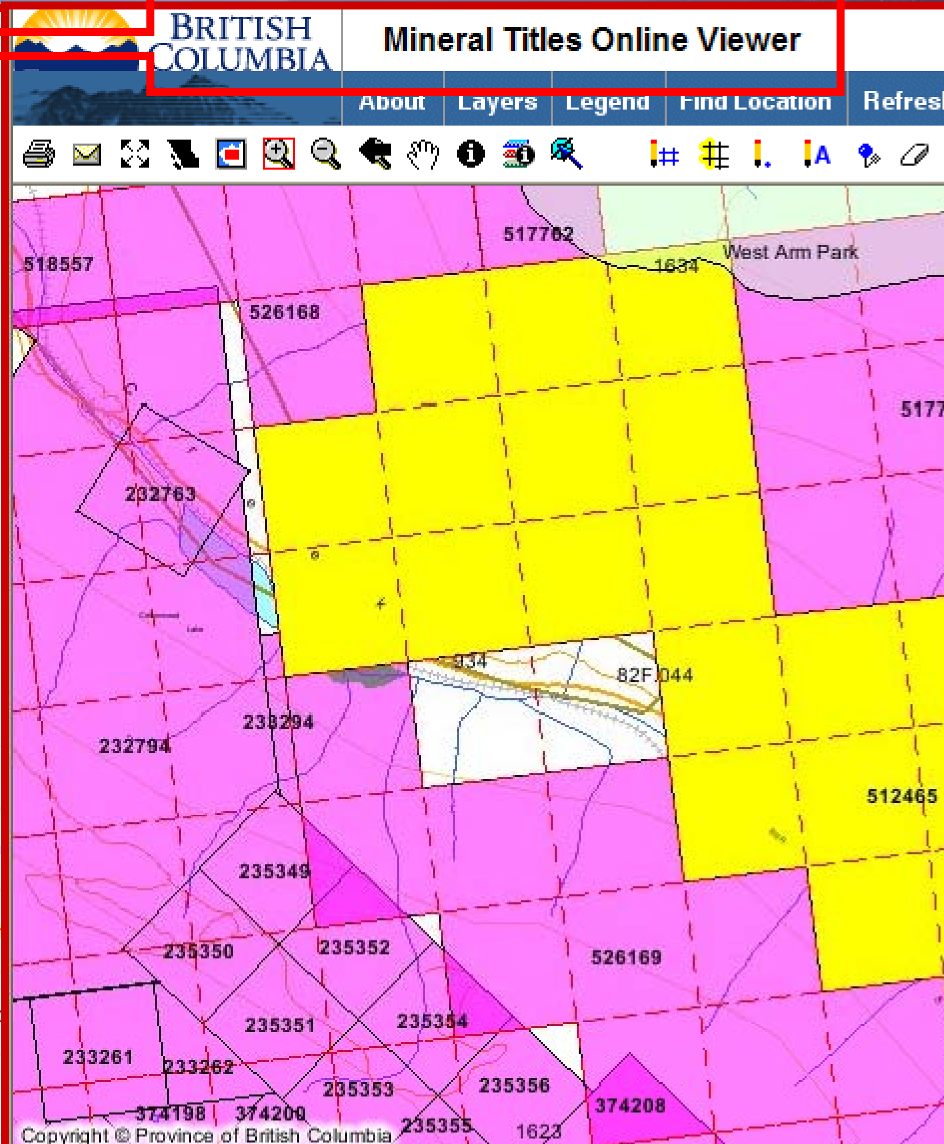
082F

Owners:

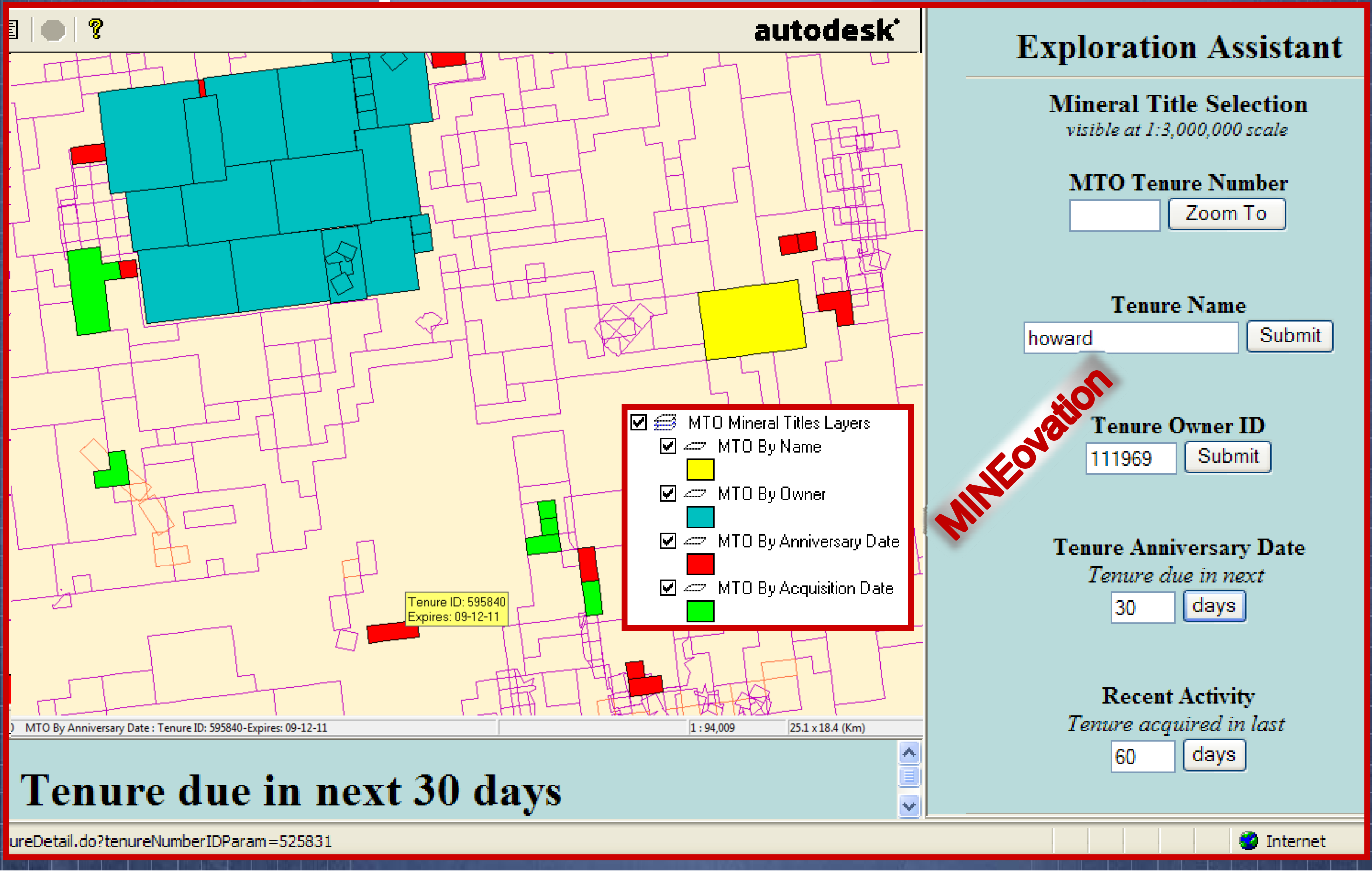
201067 Peter Lawrence Wells 100.0%

Tenure Events:

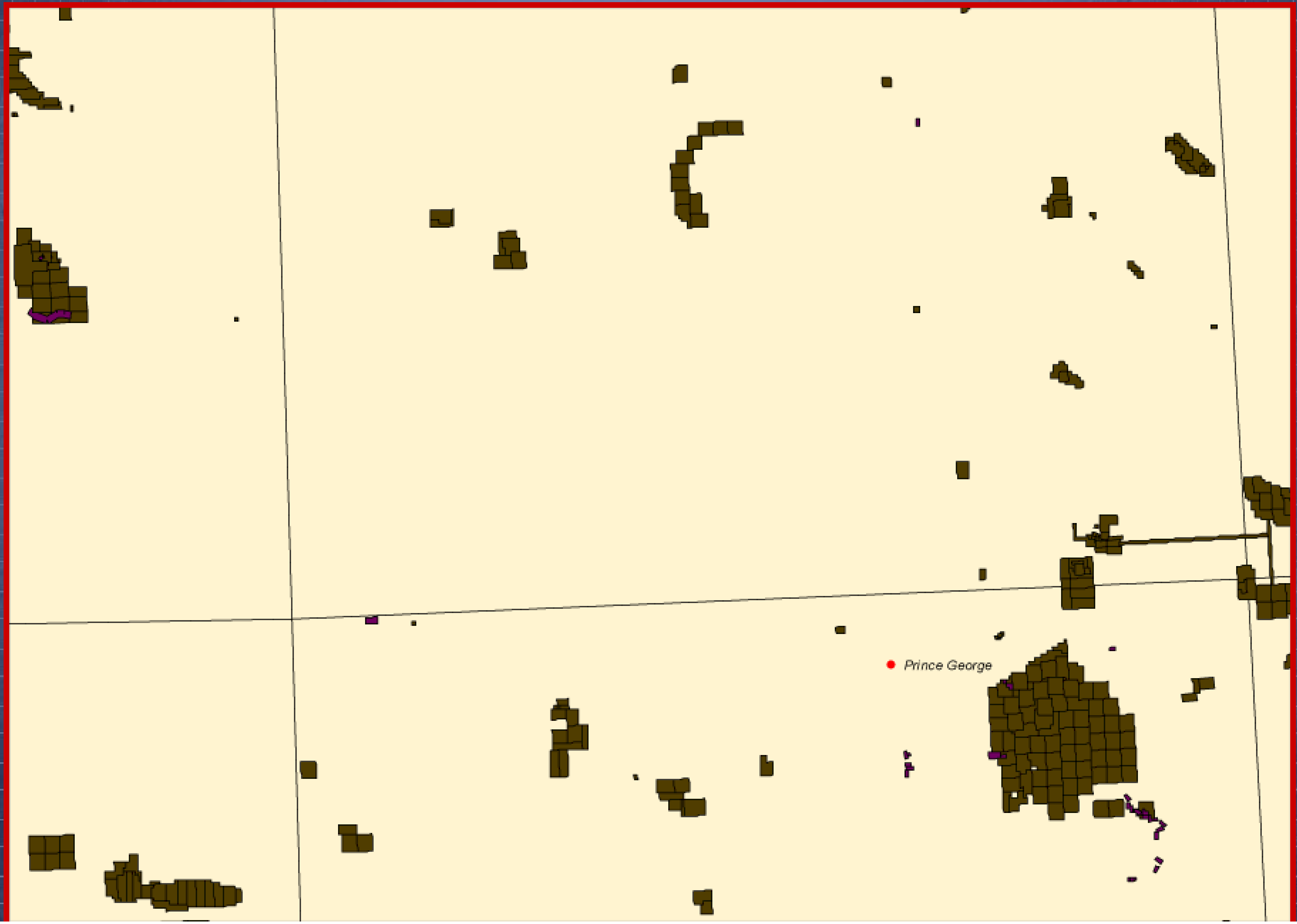
Submitter		Event
106726	ELLSWORTH EDWARD DICKSON	CEXT Claim Registration (Acquisition)(4030
106726	ELLSWORTH EDWARD DICKSON	BSLI Transfer of Ownership (Bill of Sale Ini
201067	Peter Lawrence Wells	BSLC Transfer of Ownership (Bill of Sale Co
116400	ROBERT DOUGLAS MACHRAY	SOW Exploration and Development Work /



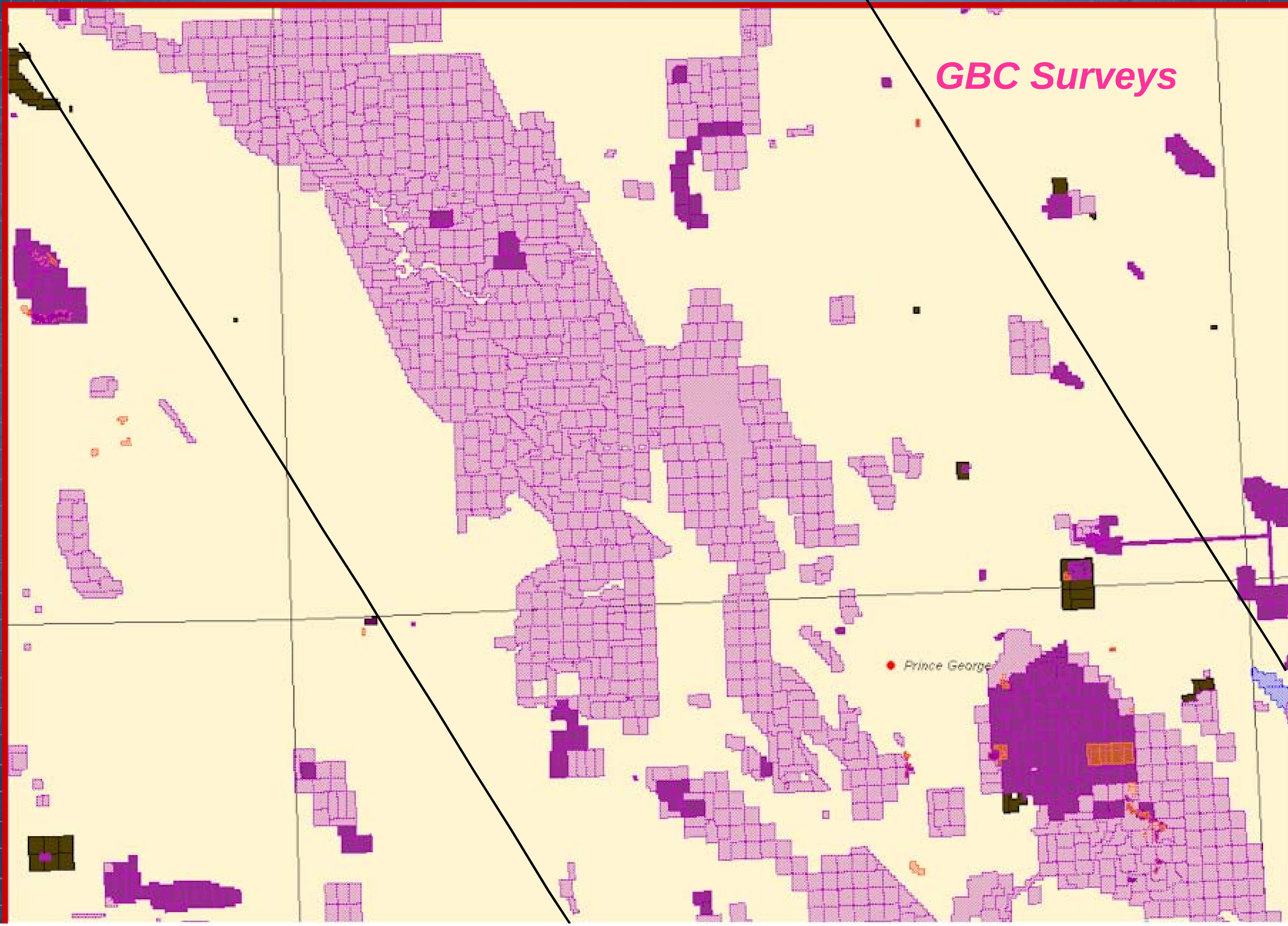
Investigate Mineral Tenures with the Exploration Assistant

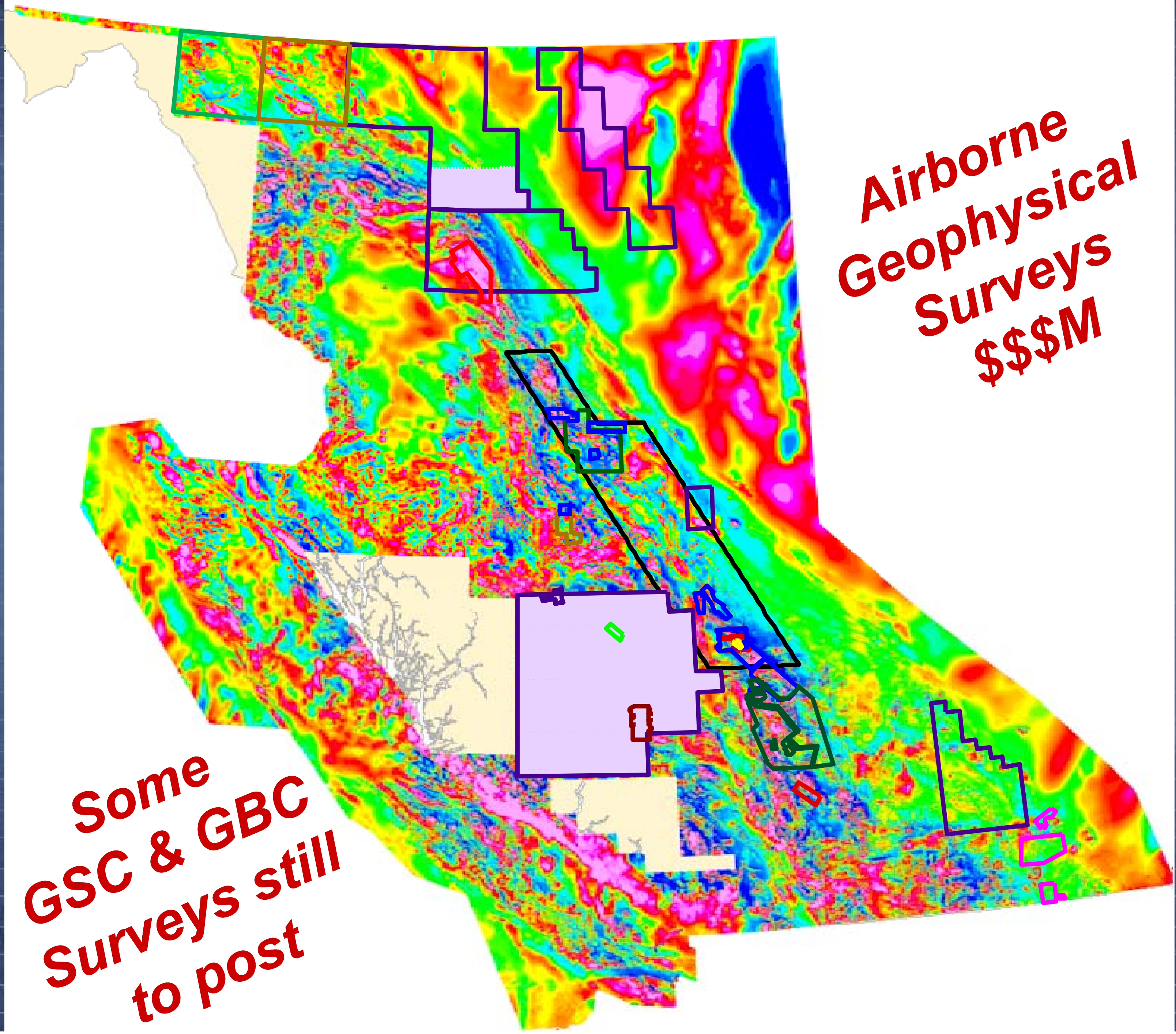


Mineral Titles Archive - January 2007

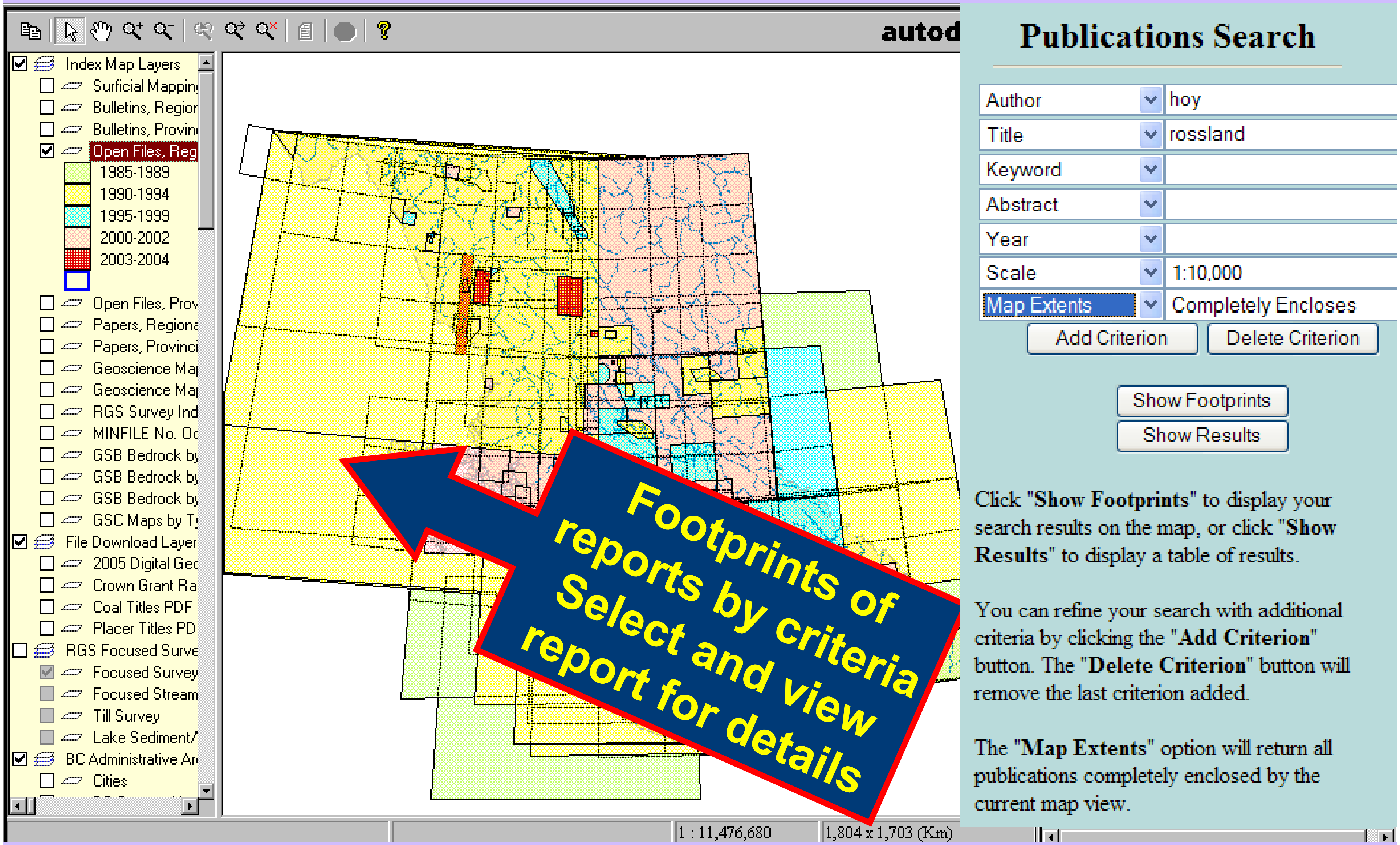


Compare Titles today with January 2007

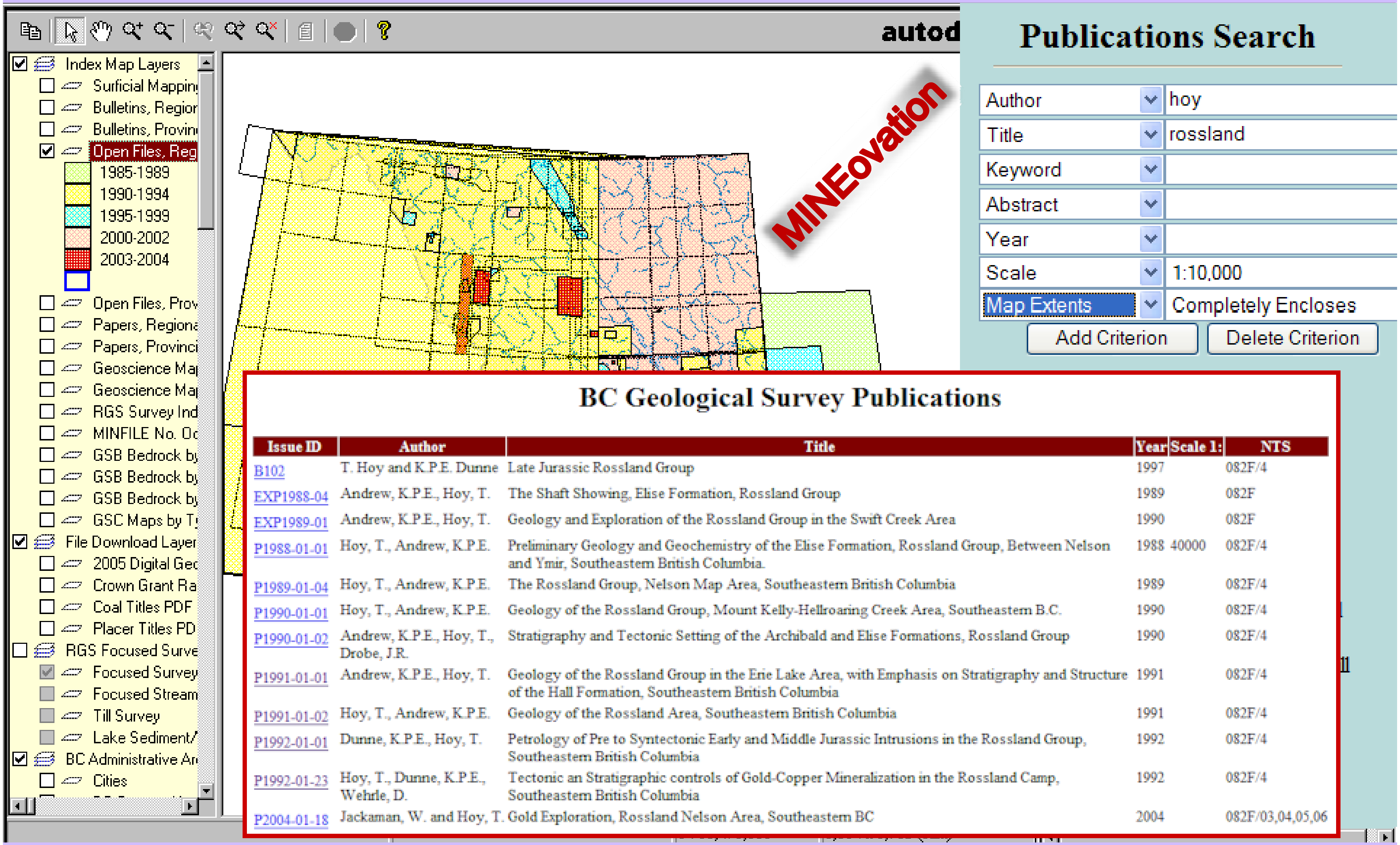



Airborne Geophysical Surveys $$$M
Some GSC & GBC Surveys still to post

Publications Search Tool



Publications Search Tool



Issue ID	Author	Title	Year	Scale 1:	NTS
B102	T. Hoy and K.P.E. Dunne	Late Jurassic Rossland Group	1997		082F/4
EXP1988-04	Andrew, K.P.E., Hoy, T.	The Shaft Showing, Elise Formation, Rossland Group	1989		082F
EXP1989-01	Andrew, K.P.E., Hoy, T.	Geology and Exploration of the Rossland Group in the Swift Creek Area	1990		082F
P1988-01-01	Hoy, T., Andrew, K.P.E.	Preliminary Geology and Geochemistry of the Elise Formation, Rossland Group, Between Nelson and Ymir, Southeastern British Columbia.	1988	40000	082F/4
P1989-01-04	Hoy, T., Andrew, K.P.E.	The Rossland Group, Nelson Map Area, Southeastern British Columbia	1989		082F/4
P1990-01-01	Hoy, T., Andrew, K.P.E.	Geology of the Rossland Group, Mount Kelly-Hellroaring Creek Area, Southeastern B.C.	1990		082F/4
P1990-01-02	Andrew, K.P.E., Hoy, T., Drobe, J.R.	Stratigraphy and Tectonic Setting of the Archibald and Elise Formations, Rossland Group	1990		082F/4
P1991-01-01	Andrew, K.P.E., Hoy, T.	Geology of the Rossland Group in the Erie Lake Area, with Emphasis on Stratigraphy and Structure of the Hall Formation, Southeastern British Columbia	1991		082F/4
P1991-01-02	Hoy, T., Andrew, K.P.E.	Geology of the Rossland Area, Southeastern British Columbia	1991		082F/4
P1992-01-01	Dunne, K.P.E., Hoy, T.	Petrology of Pre to Syntectonic Early and Middle Jurassic Intrusions in the Rossland Group, Southeastern British Columbia	1992		082F/4
P1992-01-23	Hoy, T., Dunne, K.P.E., Wehrle, D.	Tectonic an Stratigraphic controls of Gold-Copper Mineralization in the Rossland Camp, Southeastern British Columbia	1992		082F/4
P2004-01-18	Jackaman, W. and Hoy, T.	Gold Exploration, Rossland Nelson Area, Southeastern BC	2004		082F/03,04,05,06

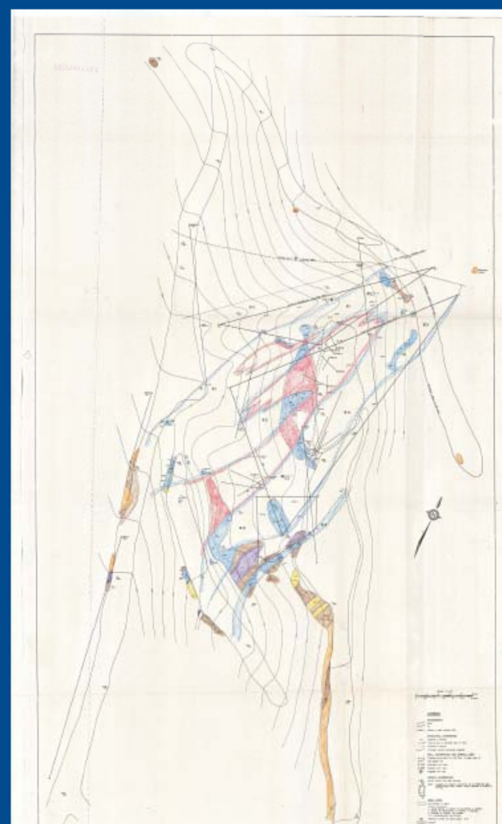
Property File

The Reference Library Supporting MINFILE

- Documents to be scanned and posted as PDF files
- Indexed and Catalogued
- Search Utility
- Internet Access
- Linked to MINFILE Bibliography and MapPlace

comprises:

- Published and unpublished documents
- Maps and photos
- Press clippings and investor newsletters
- Corporate library donations
- Other ...



Map original: 1948

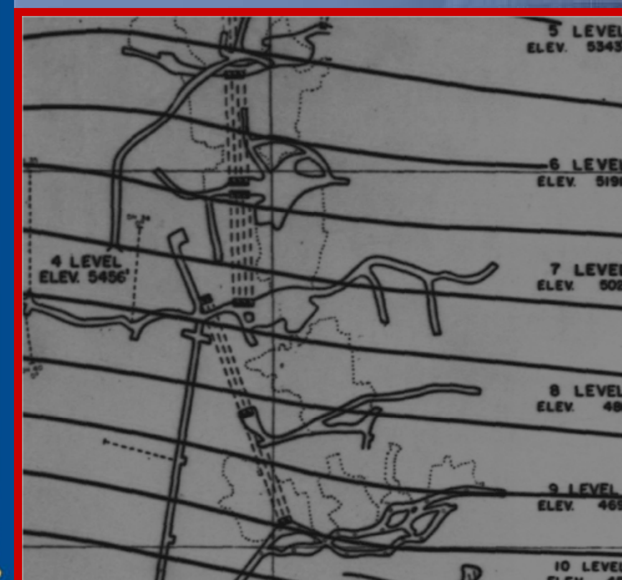
Reference Scale
to assist with reproduction / printing

43K Documents
9585 online

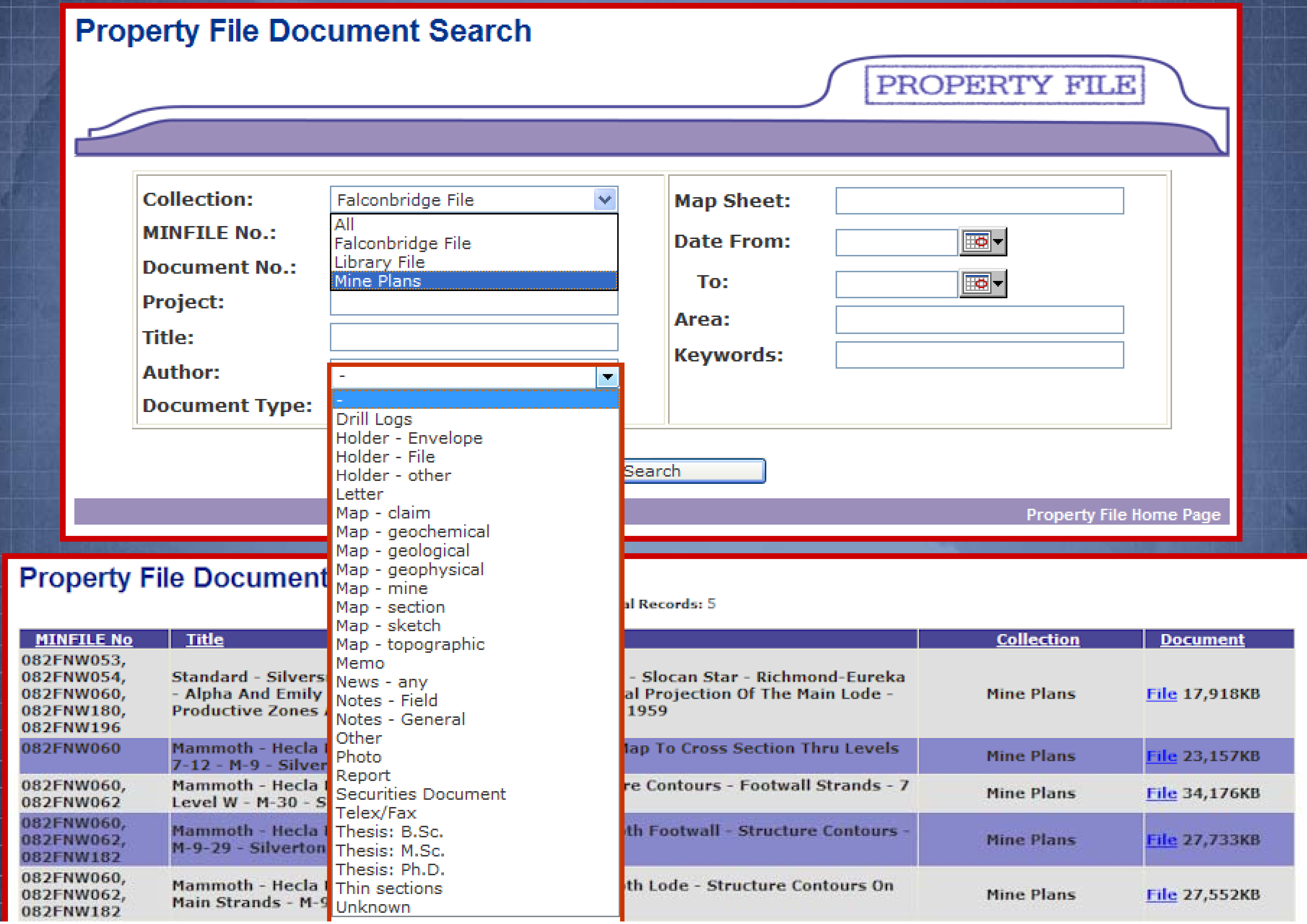
$300K to
index & scan

Donations:
Chevron, Placer Dome, Rimfire...

Mine Plans

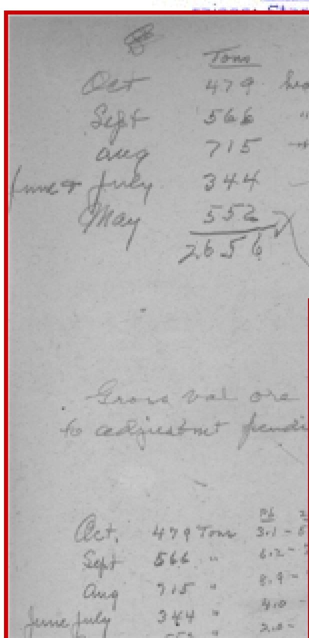


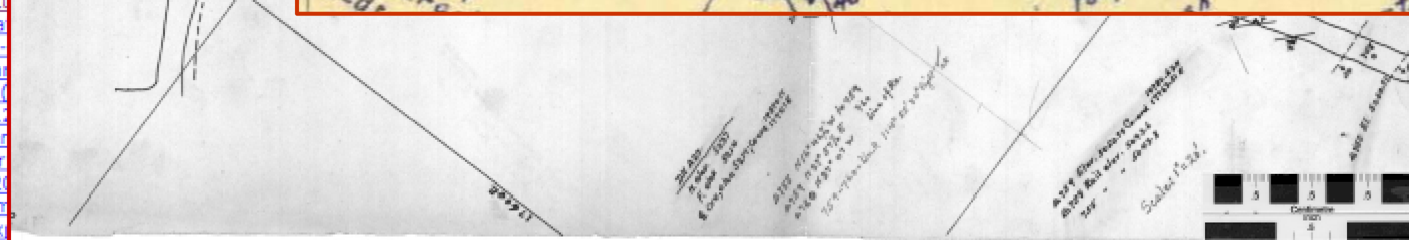
Property File Project

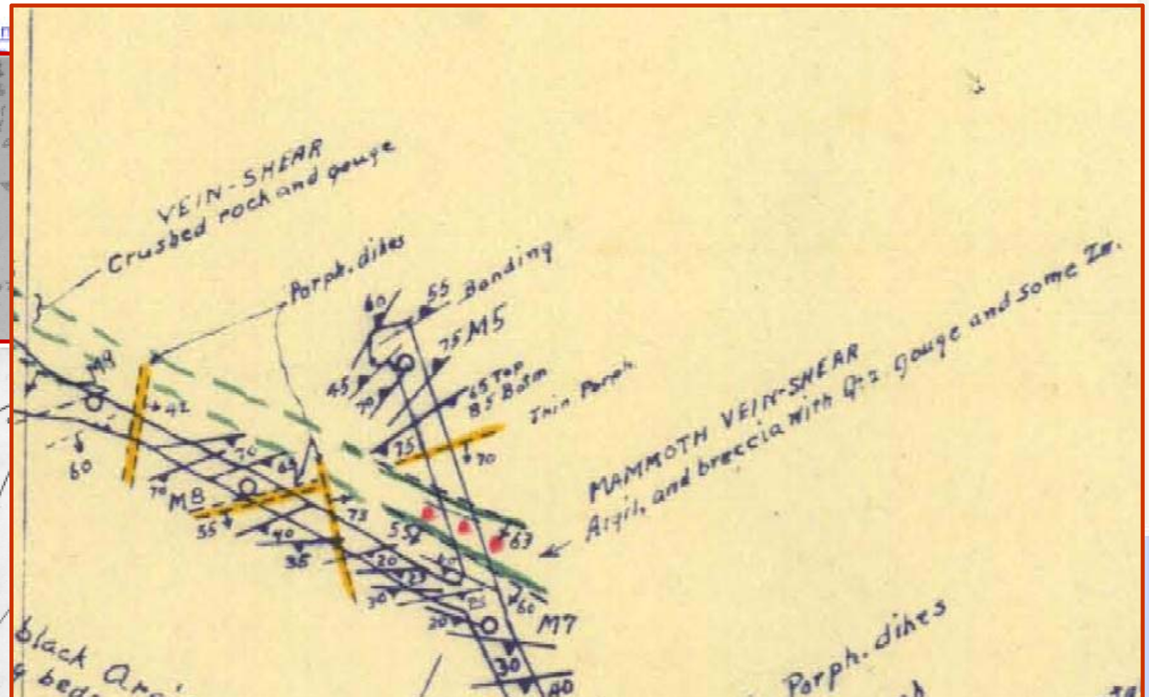


MINFILE links to Property File

Bibliography EMPR AR 1922-202; 1923-227; 1925-246,446; 1926-256; 1927-275; *1928-291; 1929-285,314; 1930-251; 1932-178; 1933-200,206; 1934-A26,E34; 1935-A26,E34,G48,51; 1936-E51; 1937-A37,41,E55; 1942-27,73; 1943-72; 1944-41,72; 1945-43,106; 1946-35,166; 1947-172; 1948-146; 1949-191; 1950-148; 1951-43,174; 1952-44,178; 1953-46,141; 1954-51,141; 1955-A49,63; 1956-A51,96; 1957-A47,54; 1958-A46,47; 1959-A49,69; 1961-A50,77; 1962-A50,82; 1963-78; 1964-A55,126; 1965-193; 1966-220; 1967-251
EMPR BULL *29, pp. 86-90, Fig. 10
EMPR BC METAL *MM01290
EMPR EXPL 1976-E42; 1980-88
EMPR INDEX 3-204; 4-123
EMPR LMP Fiche No. 60971-60977
EMPR P 1989-5
EMPR PF (Tonnage/assay calculations - han







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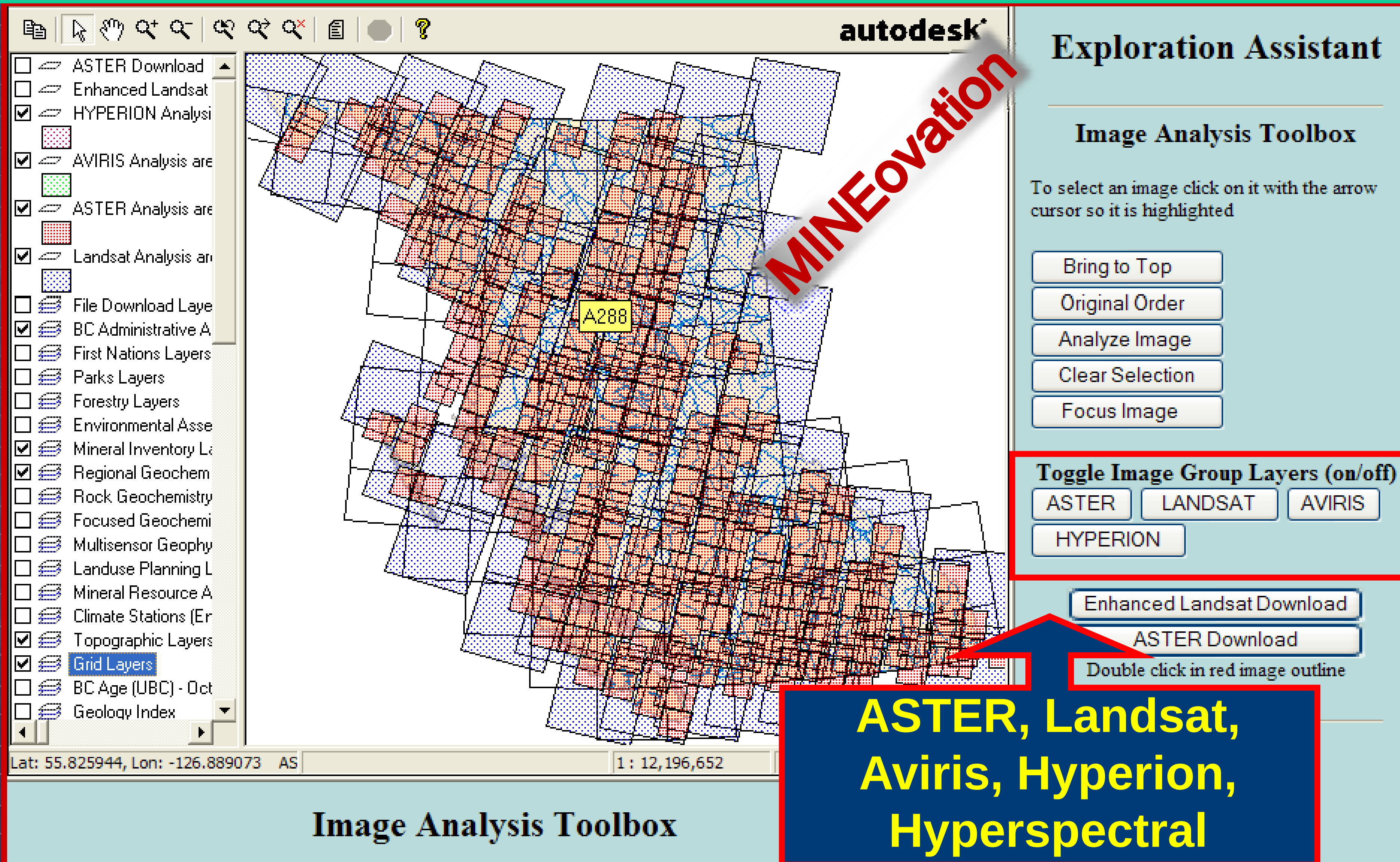
Western Ex
(1956-12-18): Letter regarding mine development work and core samples with reply; Starr, C.C. (1956-12-31): Letter regarding Ripple Rock court case; Starr, C.C. (1956-12-31): Letter regarding mine report; Ham, A.M. (1957-01-09): Letter regarding mine zinc grades; Starr, C.C. (1957-01-30): Letter regarding CPR strike; Starr, C.C. (1957-06-25): Report to shareholders: with financial statements and supporting documents; Ham, A.M. (1958-05-15): Letter regarding mine development and reply; Starr, C.C. (1958-05-25): Letter regarding mine development and reply; Klinestiver, H.P.

Image Analysis Tool



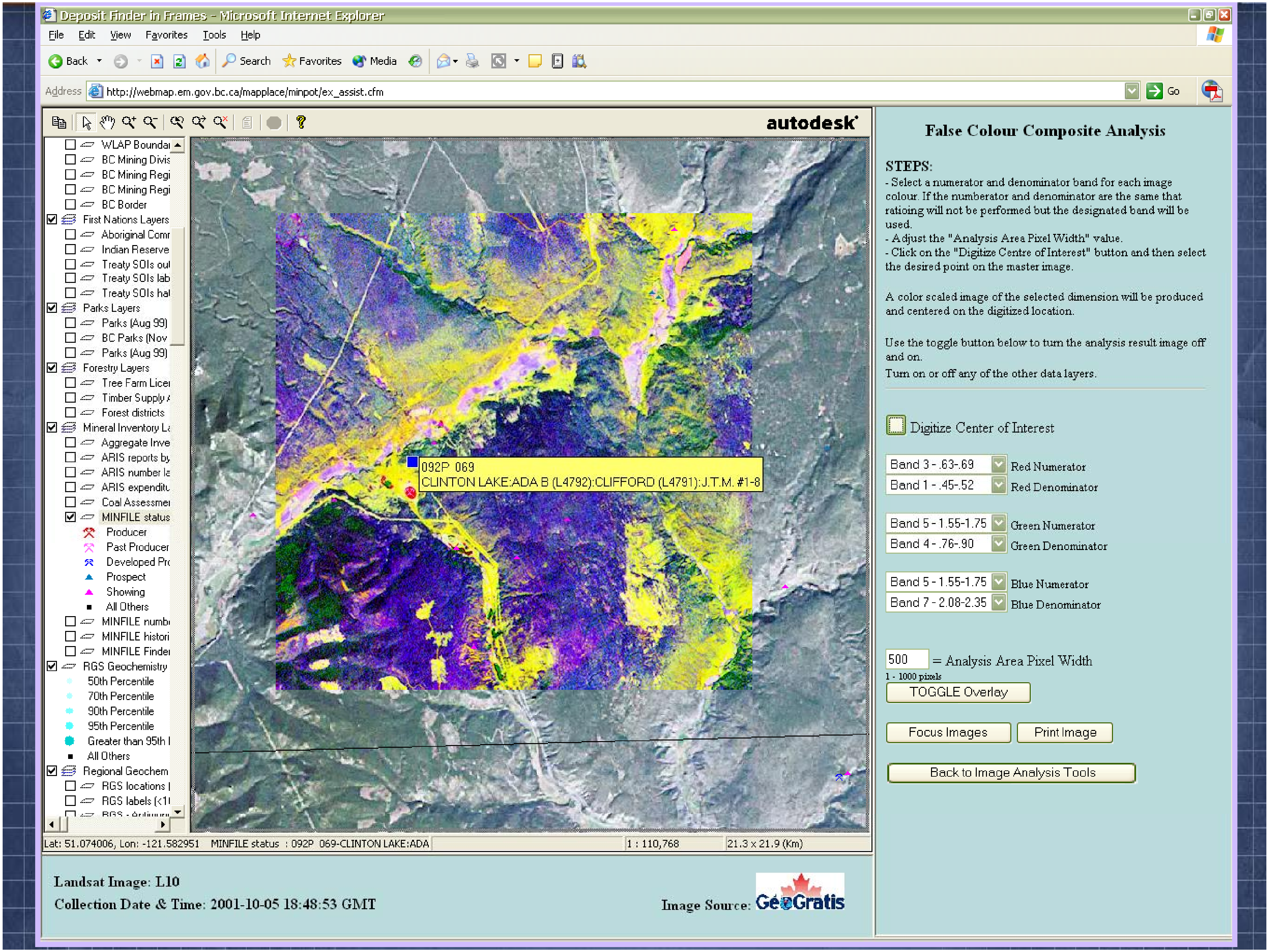

Deposit Finder in Frames - Microsoft Internet Explorer
File Edit View Favorites Tools Help
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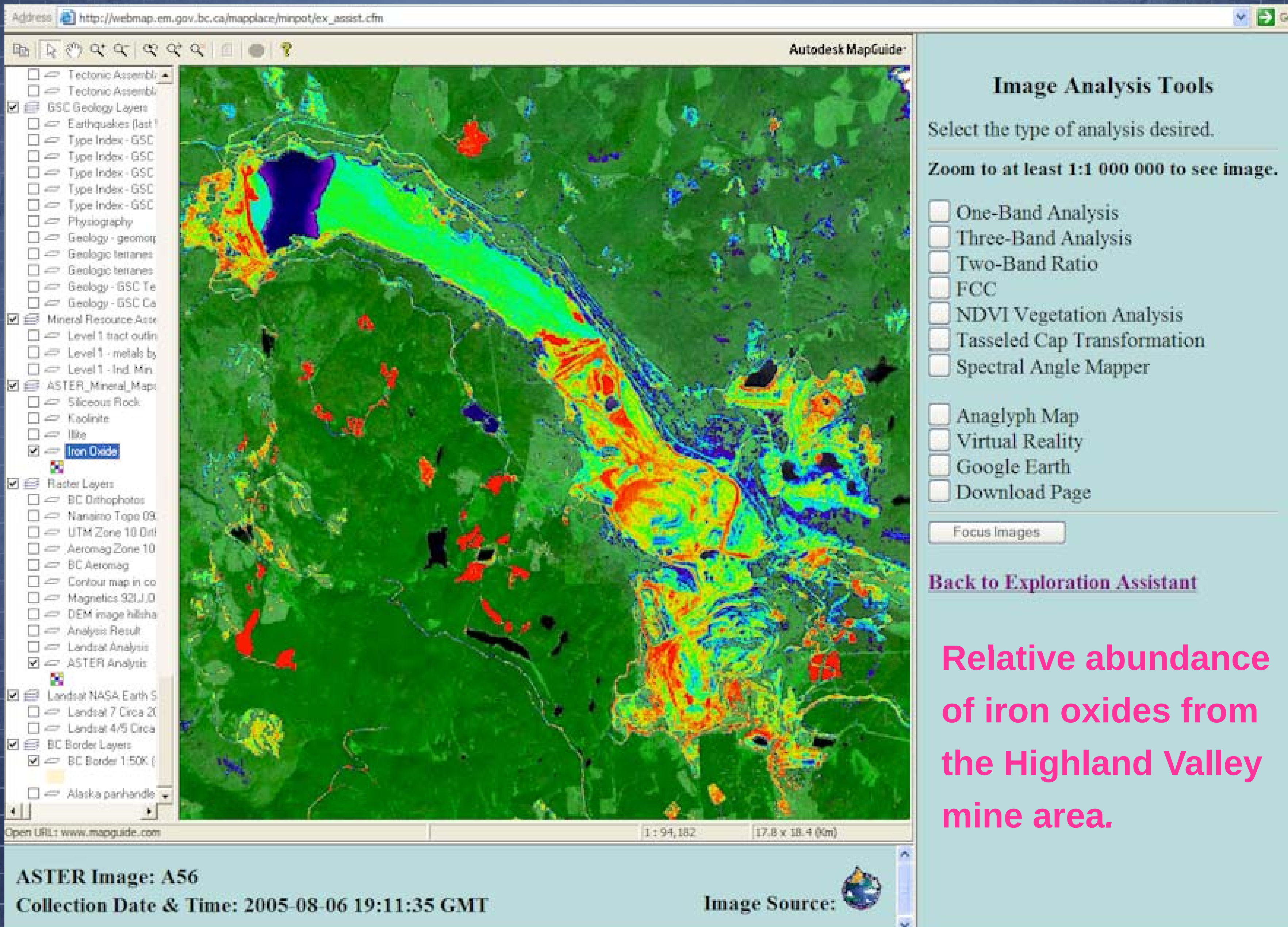
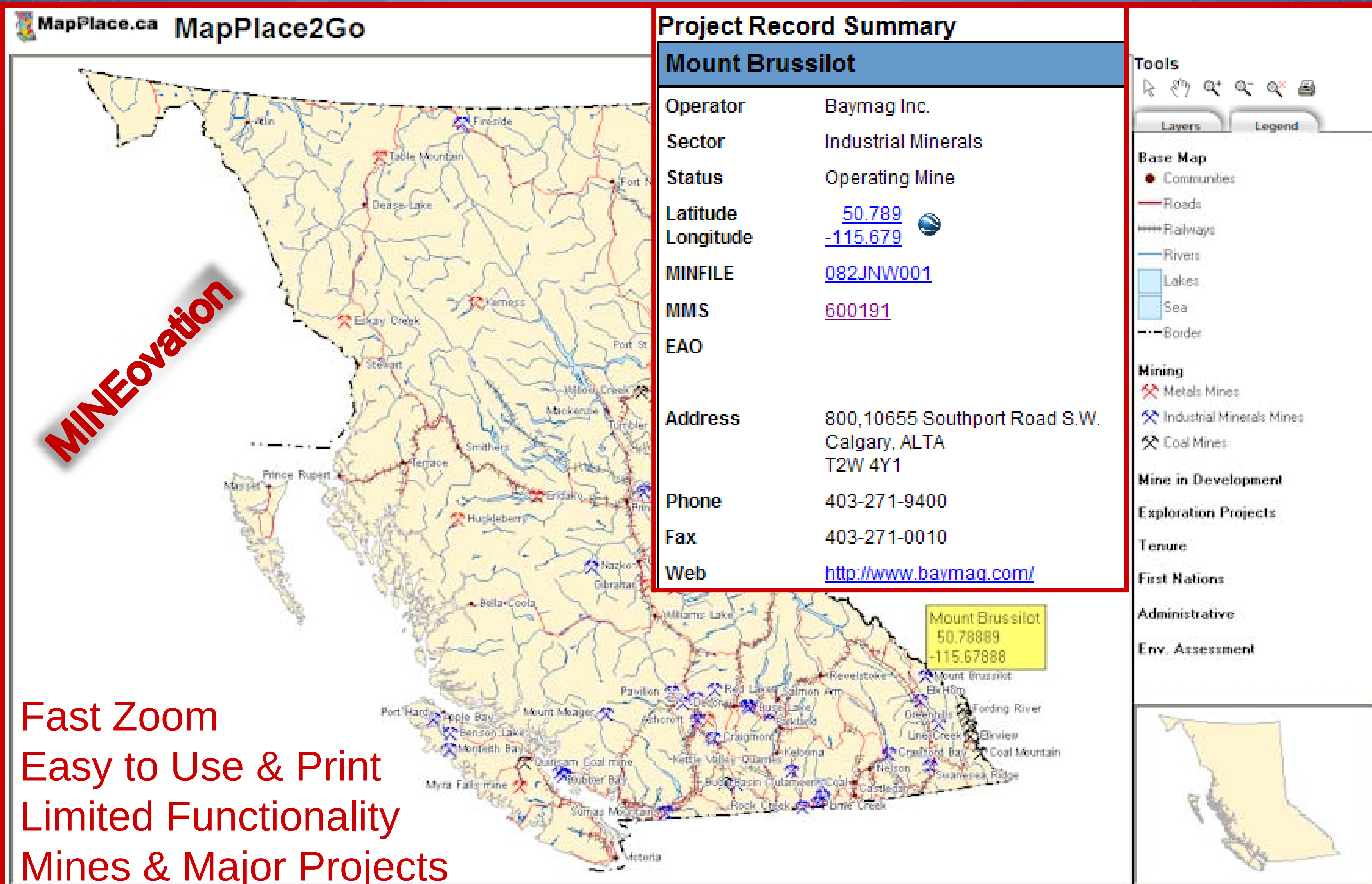
Image Source: GeoGratis
False Colour Composite Analysis
STEPS:
- Select a numerator and denominator band for each image colour. If the numberator and denominator are the same that ratioing will not be performed but the designated band will be used.
- Adjust the "Analysis Area Pixel Width" value.
- Click on the "Digitize Centre of Interest" button and then select the desired point on the master image.
A color scaled image of the selected dimension will be produced and centered on the digitized location.
Use the toggle button below to turn the analysis result image off and on.
Turn on or off any of the other data layers.
Digitize Center of Interest
Band 3 - .63-.69 Red Numerator
Band 1 - .45-.52 Red Denominator
Band 5 - 1.55-1.75 Green Numerator
Band 4 - .76-.90 Green Denominator
Band 5 - 1.55-1.75 Blue Numerator
Band 7 - 2.08-2.35 Blue Denominator
500 = Analysis Area Pixel Width
1 - 1000 pixels
TOGGLE Overlay
Focus Images
Print Image
Back to Image Analysis Tools

Alteration-Mineral Map Image



Relative abundance of iron oxides from the Highland Valley mine area.

MapPlace2Go designed for simple use



Fast Zoom
Easy to Use & Print
Limited Functionality
Mines & Major Projects

MapPlace2Go Database Linkages

Project Record Summary

MapPlace.ca

Wolverine - Perry Creek

Operator	Western Canadian Coal Corp
Sector	Coal
Status	Operating Mine
Commodity	Coking Coal
Latitude Longitude	55.129 -121.382
MINFILE	093P 015 093P 025
MMS	1640013
EAO	162
Address	900-580 Hornby St. Vancouver V6C 3B6
Phone	604-608-2692
Fax	604-629-0075
Web	http://www.westerncoal.com/

MapPlace & Google Earth
MINFILE Reports
Notices of Work
Environmental Assessments

Company Website

MMS Notice of Work List - Mine #1640013

Click Notice of Work to See a Detailed Report

Identifier	Mine Name	Mine Alias	Status	Type	Date	Latitude	Longitude
1640013200801	Perry Creek	Western Coal Corp., Wolverine MINE Spieker	Active	M	04-Mar-08	55.0875100	-121.2497700
						375100	-121.2497700

Project Information Centre (e-PIC)

Wolverine Coal Mine

Type:	Typical EA Process (Active and Complete)	**Status:**	Completed / Certified
Category:	Mining	**Pre-application Start Date:**	2001/12/31

Comments: Proponent receives provincial approval to construct a new coal mine near Tumbler Ridge. Amendment to Environmental Assessment Certificate M04-01, and Mine Permit No. C-223 received June 3 2005

Location: N.W. of Tumbler Ridge

List of Contacts
Document Index

Documents

Under Review

- Application and Supporting Studies
- Aboriginal Comments/Submissions
- EAO Generated Documents
- Federal Comments/Submissions
- Notices - News Releases

Completed / Certified

- Notices - News Releases
- EA Certificate Documentation
- Amendment Certificate
- Amendment to Certificate Documentation
- Post Certificate Documentation

WESTERN CANADIAN COAL

Western Canadian Coal Corp. is a publicly traded Company listed on the Toronto Stock Exchange (Symbol "WTN") and the Alternative Investment Market of the London Stock Exchange ("AIM") (Symbol "WTN"). Western's corporate and administrative offices are located in Vancouver, British Columbia.

The Company was founded in October 1997 for the purpose of acquiring, exploring and developing coal mining properties for the international metallurgical markets. The current focus of the Company is on bringing into production a high quality, low cost portfolio of assets in Northeast BC, Canada which will take advantage of the infrastructure already established for the Northeast BC coalfields, including rail, port, town and other facilities.

NEWS RELEASES & UPDATES

May 2, 2008 Western Canadian Coal Closes Short-term Financing and Reduces Debt

Apr 25, 2008 Western Canadian Coal Obtains Short-Term Financing to Accelerate the Development of the Willow Creek Mine

Apr 2, 2008 Western Canadian Coal to Present to Institutional Investors on April 2 to 7, 2008

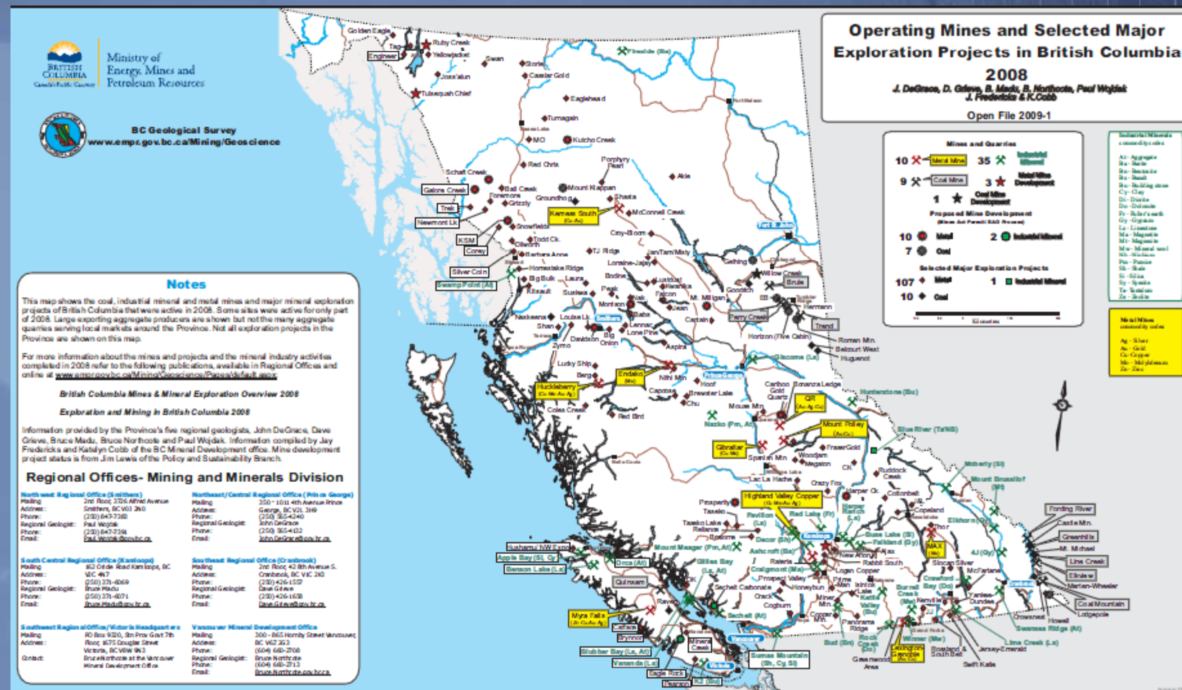
Apr 1, 2008 Western Canadian Coal Announces Fiscal 2009 Operations Update

(More News Releases)

2007 ANNUAL REPORT

Mines & Exploration:

1. Exploration & Mines page: Operating Mines and Exploration Projects.



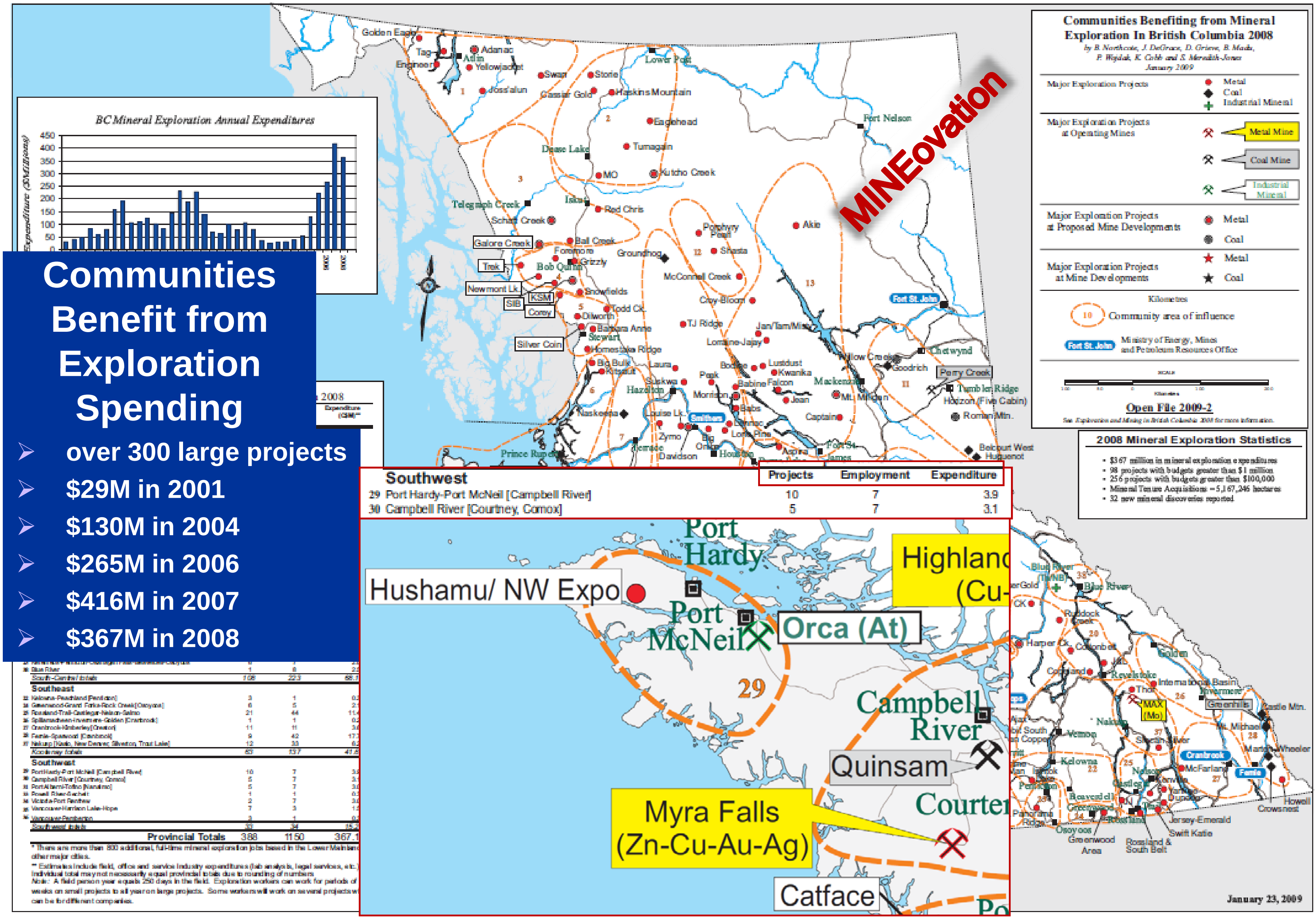
2. Thematic Maps: Mining Economy interactive maps; select projects and report button.

Advanced Stage Exploration Projects and Recent Mine Developments - Jan 2008 MapPlace.ca

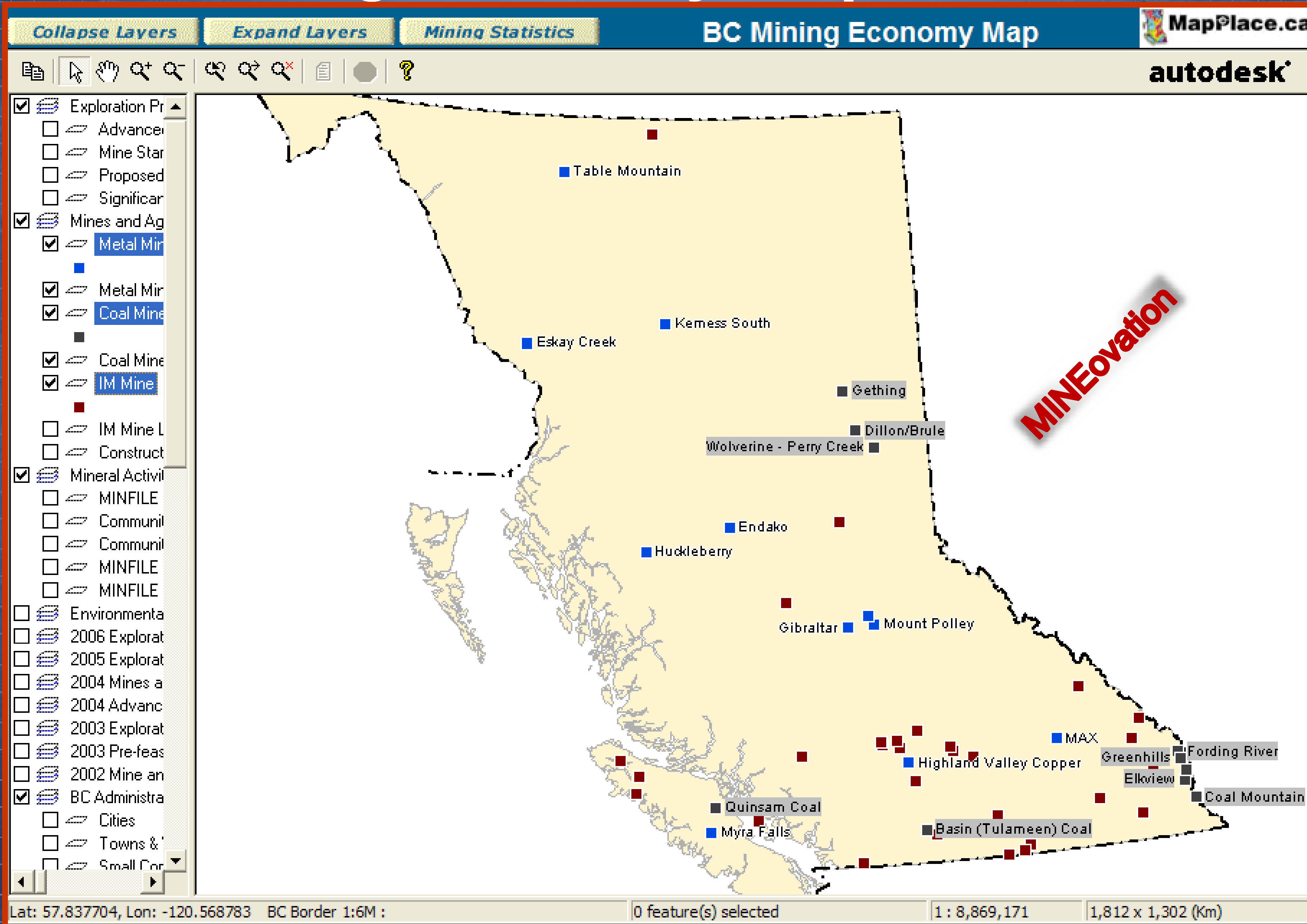
Exploration Project/ Operation	Company / Operator	Sector	Commodity	MINFILE	Lat	Long
Mine Starts & Re-starts - Within Last 3 Years						
Brule Mine	Western Canadian Coal Corp.	Coal	Coal-PCI	093P 007	55.387	-121.820
Decor	Pacific Bentonite Ltd.	IM	Burnt Shale	092INW084	50.771	-121.617
Max Molybdenum	Roca Mines Inc.	Metal	Mo	082KNW087	50.636	-117.603
Mount Polley Mine	Imperial Metals Corporation	Metal	Au, Cu	093A 008	52.554	-121.642
Orca Sand and Gravel	Polaris Minerals Corporation	Aggregate	Sand & Gravel		50.599	-127.159
QR	Cross Lake Minerals Ltd.	Metal	Au	093A 121	52.669	-121.786
Swamp Point	Ascot Resources Ltd.	Aggregate	Sand & Gravel	103O 020	55.465	-130.028
Trend	Peace River Coal LP	Coal	Coal-met	093I 030	54.880	-120.961
Wolverine Coal Mine	Western Canadian Coal Corp.	Coal	Coal	093P 015	55.129	-121.382

Communities Benefit from Exploration Spending

- over 300 large projects
- $29M in 2001
- $130M in 2004
- $265M in 2006
- $416M in 2007
- $367M in 2008



BC Mining Economy Map with Mines



BC Mining Economy Mine Report

MapPlace.ca

Mining Company Information

download in Excel format

Click Headings to Sort Table. Click on Report Number link for complete report.

Mine/Location	Company Website/Operator	Deposit Type	Commodity	Latitude	Longitude	Region	MINFILE
Basin (Tulameen) Coal	Compliance Energy Corp	Sedimentary	Thermal Coal	49.489	-120.754	South Central	
Eskay Creek	Barrick Gold Corporation	Epithermal VMS	Au, Ag	56.654	-130.429	Northwest	104B 008
Gibraltar	Taseko Mines Ltd	Calc-alkalic Porphyry	Cu-Mo	52.518	-122.287	Cariboo	093B 006
Huckleberry	Huckleberry Mines Ltd	Porphyry	Cu, Mo	53.681	-127.178	Northwest	093E 037
Kemess South	Northgate Minerals Corporation	Calc-alkalic P	Au-Cu	57.006	-126.751	Cariboo	094E 094
MAX	Roca Mines Inc/Forty Metals Inc					Southeast	082KNW003
Mount Polley	Imperial Metals Corp					Cariboo	093A 008
Myra Falls	NVI Mining Ltd (Brea Resources Ltd)					Southwest	092F 330
QR	Cross Lake Minerals					Cariboo	093A 121
Quinsam Coal	Quinsam Coal Corp (Hillsborough Resou					Southwest	092F 319
Wolverine - Perry Creek	Western Canadian C					Northeast	093P 015
Endako	Thompson Creek Mi Sojitz Moly Resource					Northwest	093K 006
Dillon/Brule	Western Canadian C					Northeast	093P 007
Nazko	PRICEWATERHOUS INC					Cariboo	093B 060
Coal Mountain	Elk Valley Coal Partne		coal			Southeast	
Elkview	Elk Valley Coal Partnership	Sedimentary	Metallurgical coal	49.786	-114.828	Southeast	082GNE017

Project Record Summary MapPlace.ca

Kemess South

Operator	Northgate Minerals Corporation
Sector	Metal
Status	Operating Mine
Commodity	Au-Cu
Latitude	57.006
Longitude	-126.751
MINFILE	094E 094 094E 021
MMS	1300244
EAO	22
Address	PO Box 3519 Smithers V0J 2N0
Phone	250-881-8400
Fax	250-881-8418
Web	http://www.northgateexploration.ca/frame_kemess_mine.html

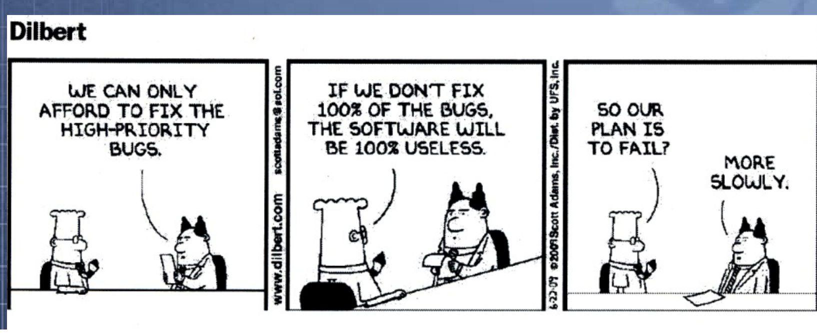
Database Management

Challenges

- Format incompatibility
- Application/visualization tools
- Interpreting geoscience data
- Ageing & New data
- Storage costs
- Upgrades - servers, website, OS

Solutions

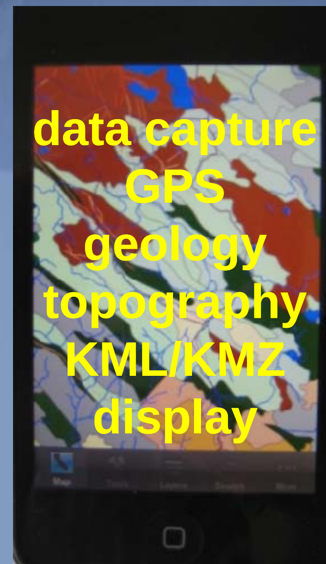
- ✓ Improvements/maintenance
- ✓ Innovative development
- ✓ Training (Live Meeting)
- ✓ Focused updates
- ✓ Reclamation
  (disk space discipline)
- ✓ Deal with it

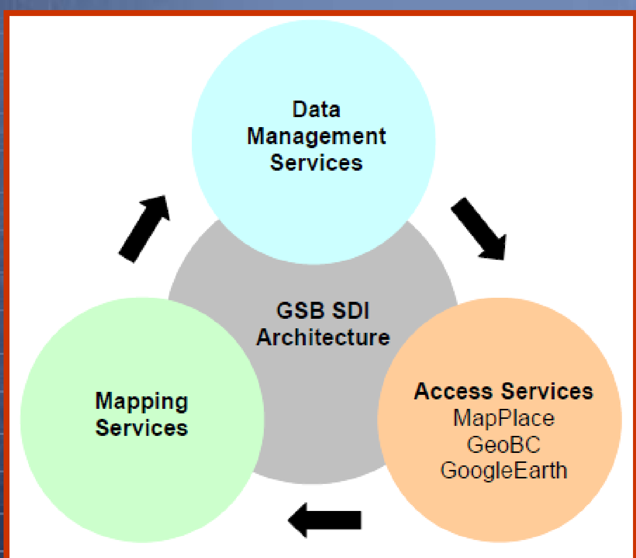


Students
Messaging
Collaboration

What's Next...

Geomatic Magic





BC Geology on MapPlace.ca

Strategy for timely updates

MINEovation

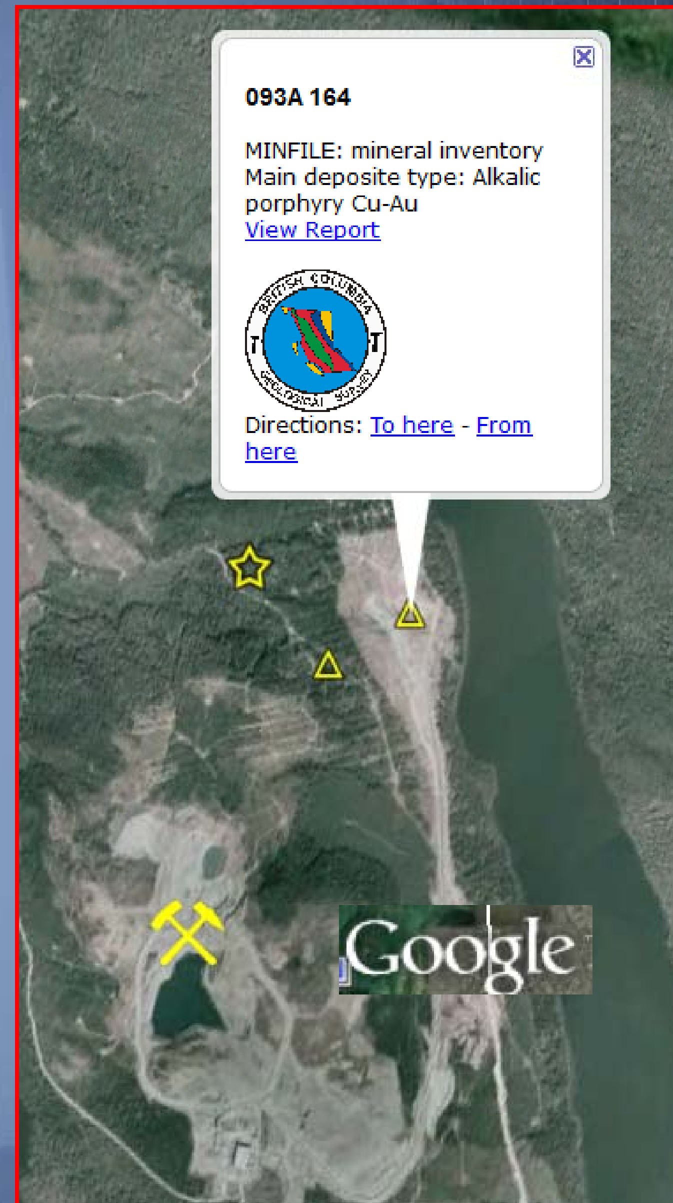
Open Source
WMS

Collaboration

Integration

Partnerships

TECHNovation



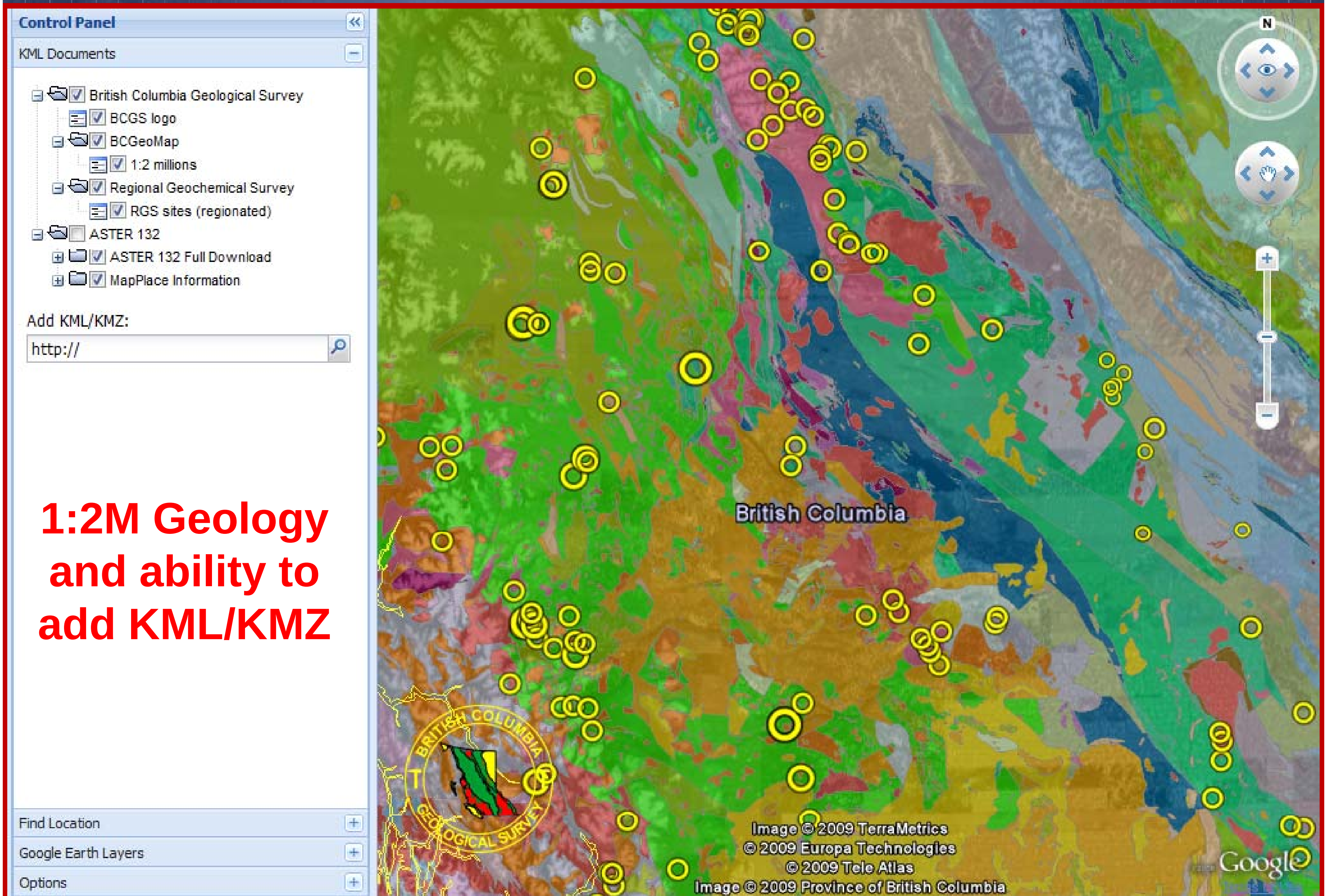
Web-enabled Google Earth API Application

(Yao Cui)

An enhanced scale-based density display of RGS KML files with link to detailed reports.

Regionated KML files for MINFILE.

1:2M Geology is also displayed.



1:2M Geology and ability to add KML/KMZ

RGS Follow-up in Yukon led to ‘White Gold Rush’

- Over 4800 claims staked after 2008 discovery by Shawn Ryan. Original discovery 1887.
- “First significant hard rock gold discovery in the Klondike in over 100 years” Mike Burke.
- YMIP $20K covering 50% to 100% of exploration work; 2008 $700K budget increased to $1.8M in 2009; 106 applications.
- 1.84 GT over 102.5 m, with 8.81 GT over 24m.
- $10M spending in 2010. Company moved from New Zealand.
- Exploration stimulated by reinterpretation of the Casino copper-gold porphyry project.
- NATMAP geological compilation 2005.

Databases & Applications

- ARIS Assessment Reports
- MINFILE Mineral Occurrences
- MapPlace Maps / MapBuilders / MapPlace2Go / Google Earth
- BCGeoMap - Bedrock Geology
- Publications / Catalogue / Index / Website
- Property File
- COALFILE / Coal Assessment Reports
- Historic Mine Sites / Historic Mines Atlas
- Mineral Potential (Provincial/Regional)
- Mineral Deposit Profiles
- RGS Regional Geochemisty Survey / Till Data / Focused Surveys
- Surficial Geology
- Tectonic Assemblage (Tectonic Belts & Terranes)
- Rock Geochemical Database
- Aggregate Pits & Potential
- Terrain & Soils / Hazards Map
- Geophysical Data (Provincial/Regional)
- ExplorTrak Mineral Exploration
- Image Analysis Toolbox and images
- BC Age Data
- Rock Properties Database
- Catchment Basins
- SUPPORT FOR: MMS Notices of Work / Oil & Gas / First Nations data
- FUTURE: Digital Data from Assessment Reports / Diamond Drill Hole Database / eMining

Data Mining with

MapPlace.ca

Thank You

BRITISH COLUMBIA

Mining and Mineral Exploration Update - 2009

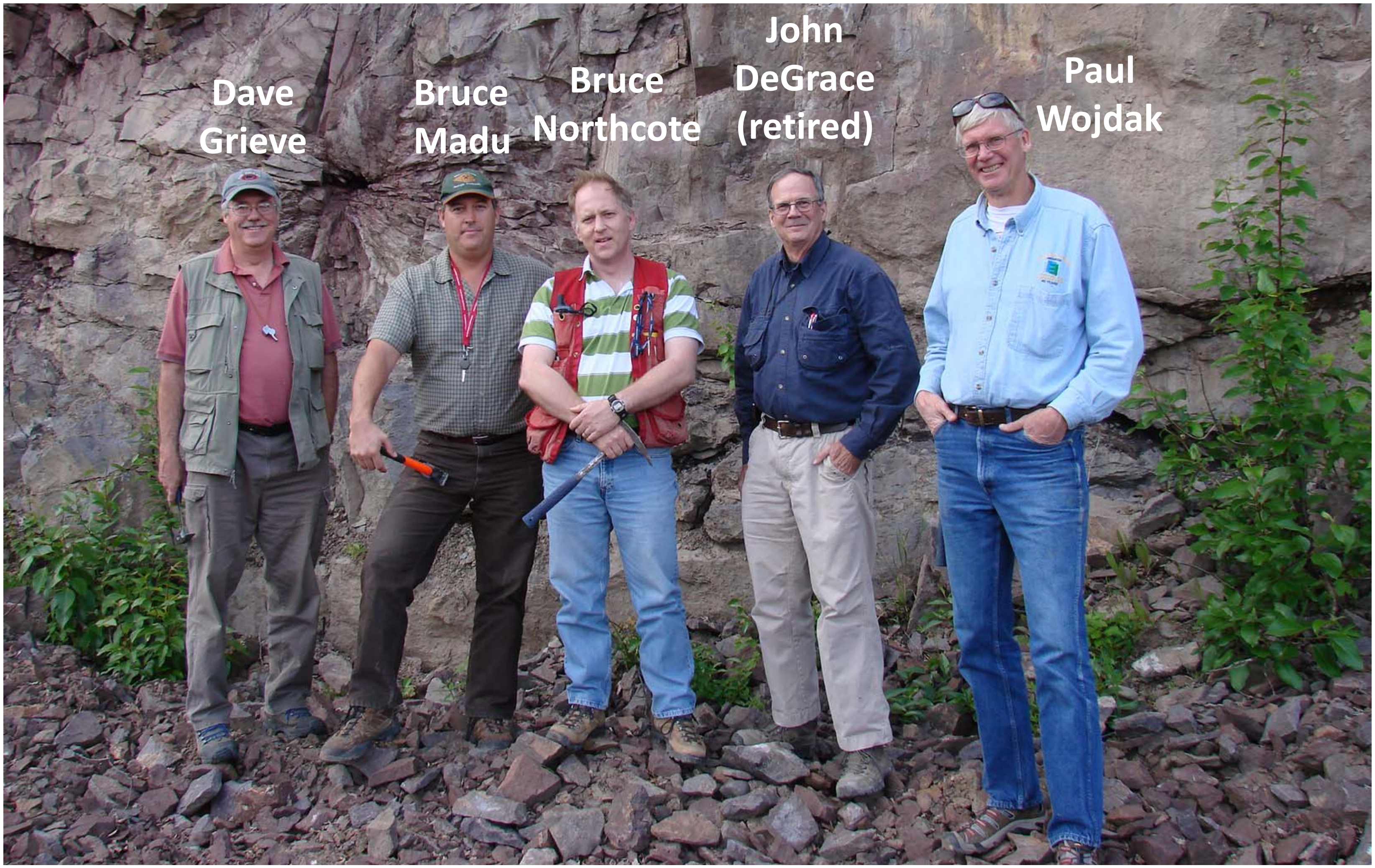
David Lefebure and Jay Fredericks
BC Ministry of Energy Mines & Petroleum Resources

BRITISH COLUMBIA
The Best Place on Earth

BCGS Open House

Nov. 13, 2009

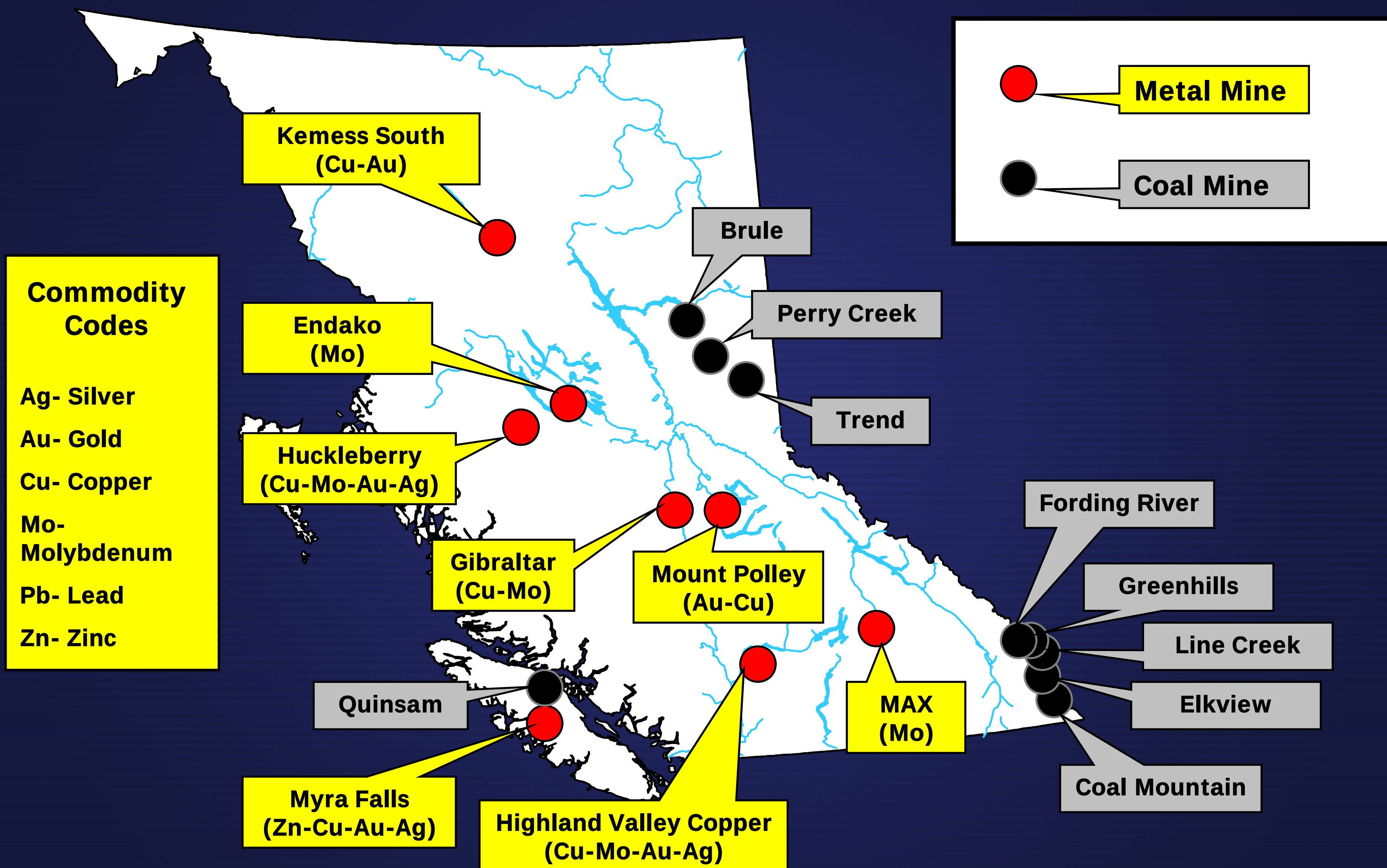
Your Regional Geologists



Highlights

- Mines rebounding and starting again to invest in their future
- Numerous mine development projects; some stalled
- Reduced exploration activity; generally smaller and fewer
- Asian investments

Operating Metal and Coal Mines 2009



Coal

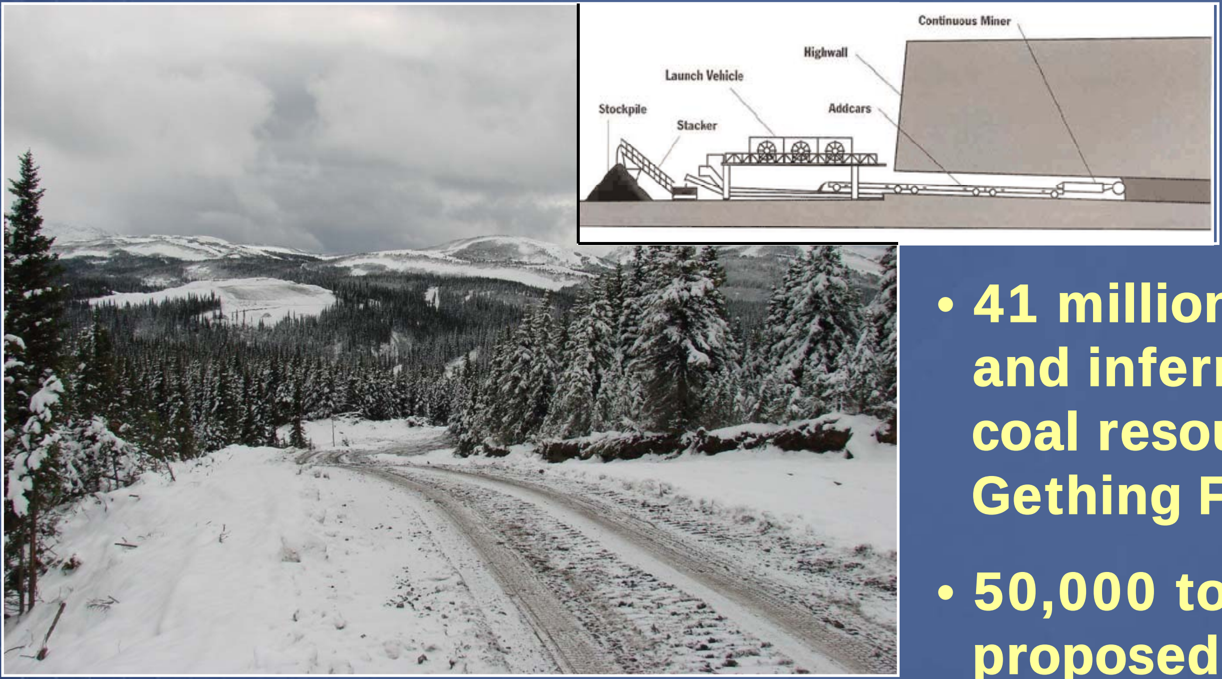
<u>Established Mines</u>
Fording River
Elkview
Greenhills
Line Creek
Coal Mountain
Quinsam

<u>New Mines</u>
Brule
Trend Wolverine
Wolverine

<u>Proposed</u>
Gething
Horizon
Lodgepole
Hermann
Roman Mtn
Goodrich

Goodrich Central South

First Coal Corp



- Project would apply AddCar remote u/g mining method
- 41 million tonnes measured and inferred metallurgical coal resource, Bickford & Gething Fms.
- 50,000 tonne bulk sample proposed for 2010

"Spine Road" access to project, site "C3" in the distance

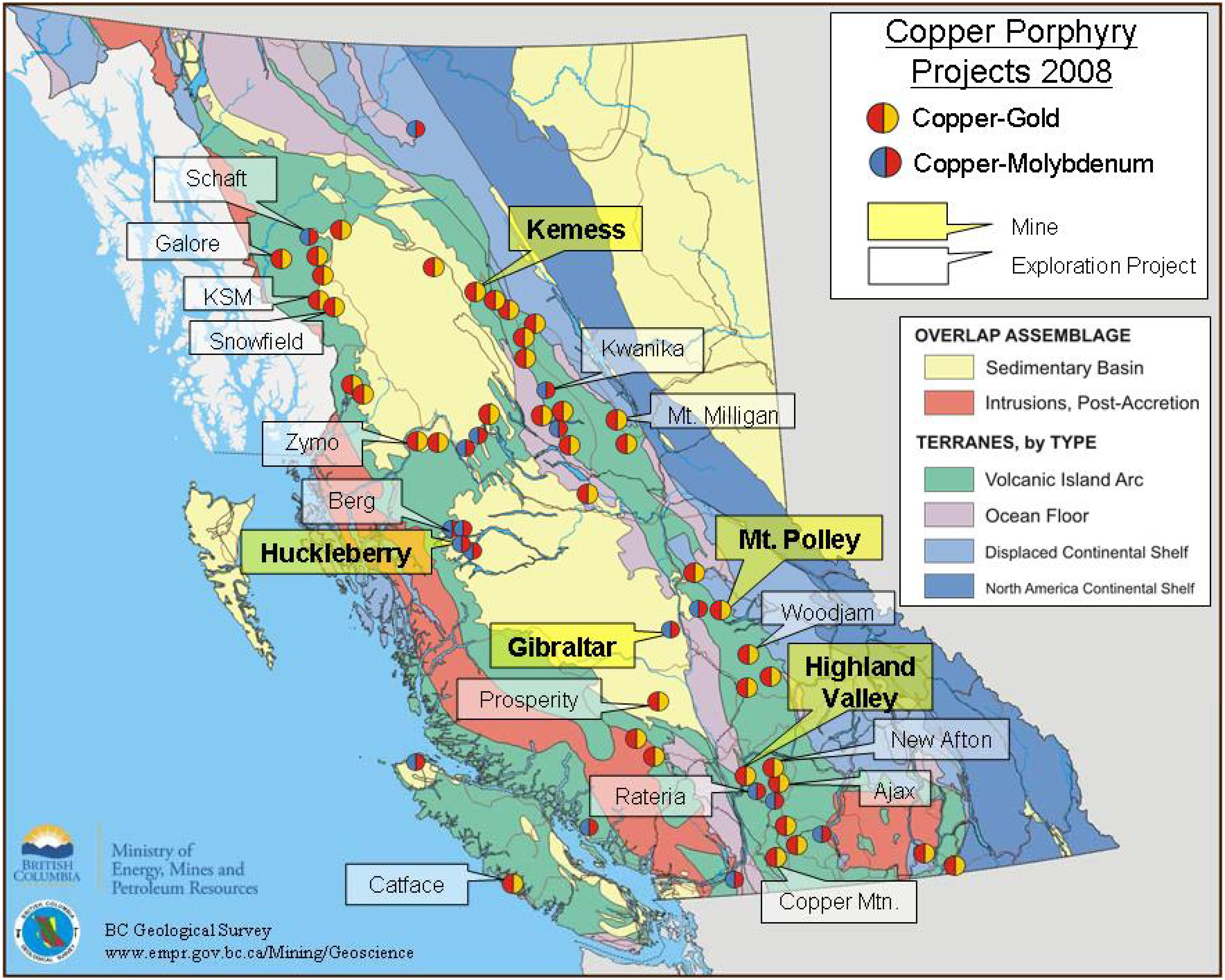
Raven Project

Compliance Energy, Itochu & LG

metallurgical or thermal coal markets

42 drill holes (9,899 m) in 2009

Project description filed with Environmental Assessment Office



Copper Porphyry Projects 2008
Copper-Gold
Copper-Molybdenum
Mine
Exploration Project
OVERLAP ASSEMBLAGE
Sedimentary Basin
Intrusions, Post-Accretion
TERRANES, by TYPE
Volcanic Island Arc
Ocean Floor
Displaced Continental Shelf
North America Continental Shelf
Schaft
Galore
KSM
Snowfield
Kemess
Kwanika
Mt. Milligan
Zymo
Berg
Huckleberry
Mt. Polley
Woodjam
Gibraltar
Highland Valley
Prosperity
New Afton
Ajax
Rateria
Catface
Copper Mtn.
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
BC Geological Survey
www.empr.gov.bc.ca/Mining/Geoscience

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Porphyry Copper

New Afton

New Gold

New Afton

- $590 million Underground mine, 11 000 t/day
- Working to develop underground, including new 4525 m conveyor access decline
- Production planned for late 2012
- 44.4 Mt @0.98% Cu, 0.72 g/t Au, 2.27 g/t Ag

Porphyry Copper

Copper Mountain

Copper Mountain Mining Corp

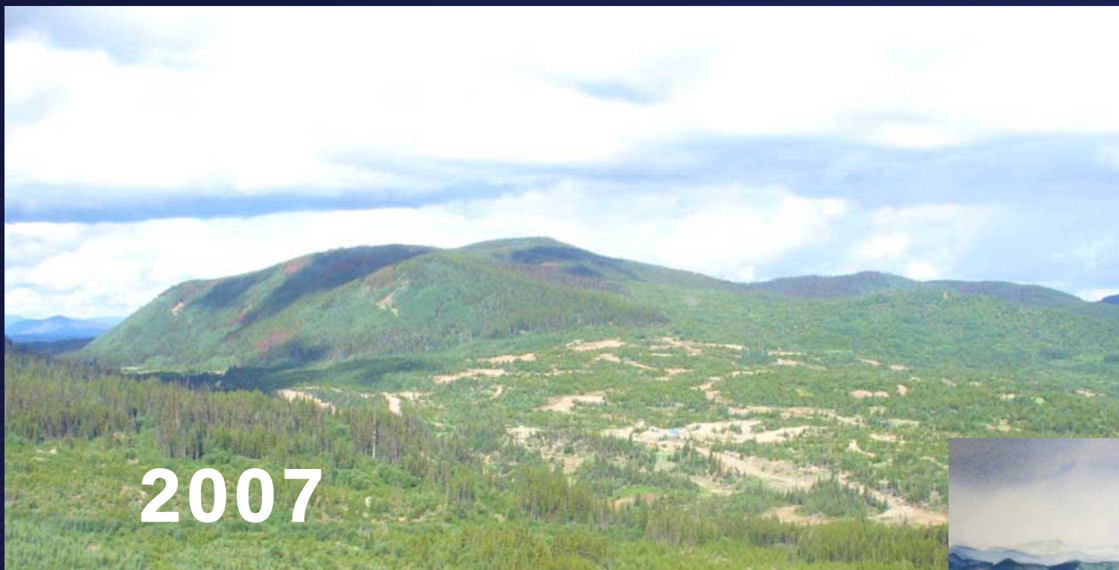
- New resource 186 mT @ 0.411% Cu
- Plan mining revival - $402 million, 35,000 T/day
- Financing partnership with Mitsubishi
- Mill construction started
- Planned start of production by mid 2011

Designing Mines for Reclamation

Mt. Milligan
Terrane Metals Corp.

- Smaller footprint
- Pit design to reduce highwall
- Tailings impoundment planned for wetlands

Designing Mines for Reclamation



Mt. Milligan
Terrane Metals Corp.

- Returned to wilderness site with logging potential
- Pits become lakes
- Tailings impoundment becomes wetlands

Copper-Gold Projects in Environmental Assessment

Schaft Ck Reserves – 812 mT @ 0.30% Cu, 0.21 g/t Au, 0.020% Mo

Prosperity Reserves – 487 mT @ 0.22% Cu, 0.43 g/t Au

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Copper-Gold Porphyry

KSM (Kerr-Sulphurets-Mitchell)
Seabridge Gold

- 1.4 Billion tonnes, 0.66 g/t gold 0.17% copper
- Shifted to geotechnical, engineering, environmental
- Entered Environmental Assessment Process

Copper-Gold Porphyry Exploration

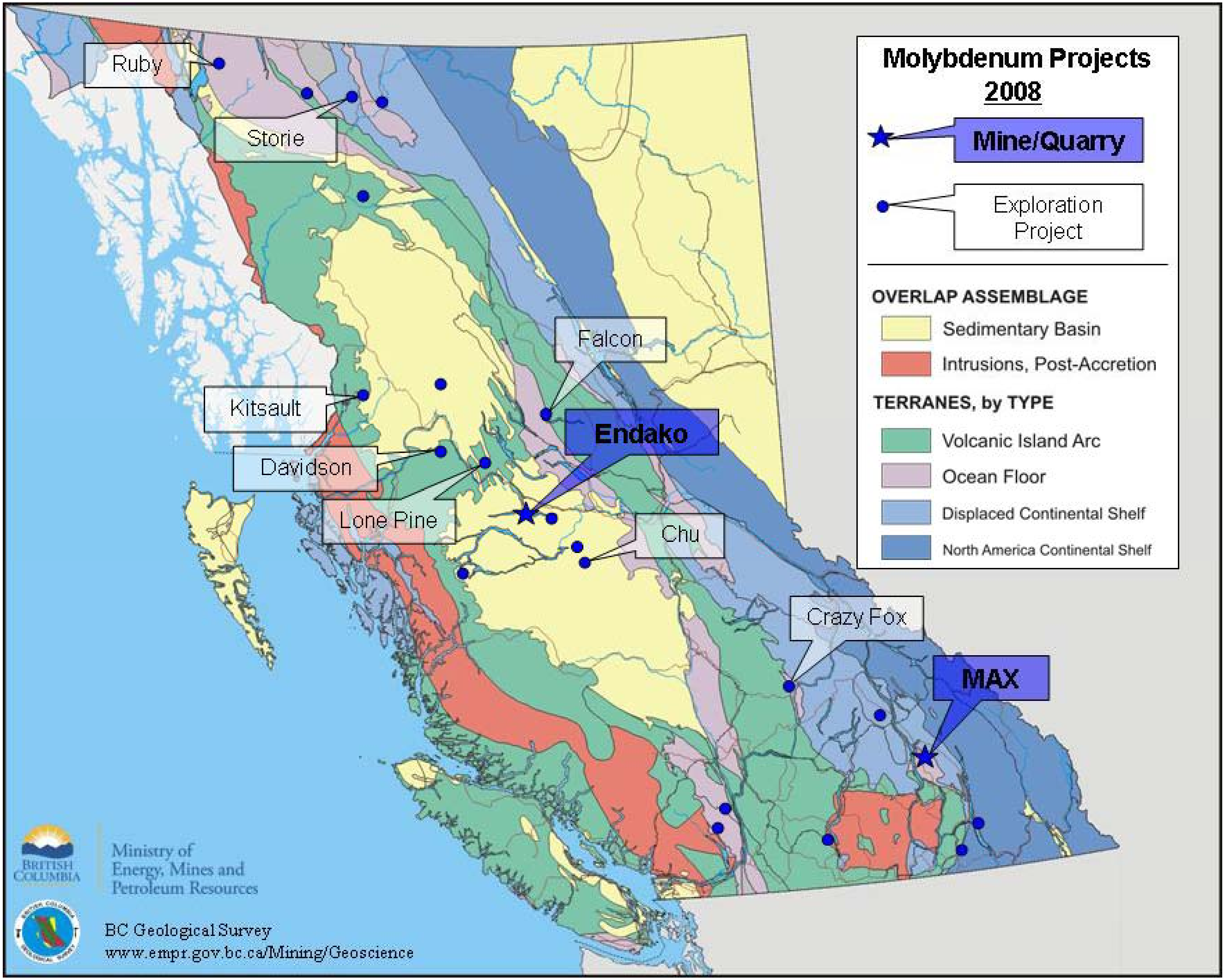
Ajax-Afton
• Preliminary economic assessment

Woodjam
• Goldfields signed agreement to explore Woodjam North

Kwanika
• Drilling on South Zone increases potential

Zymo
• Drilling expanded mineralized zone

Big Bulk
• Optioned by Anglo-Ashanti with drilling



Molybdenum Projects 2008
Mine/Quarry
Exploration Project
OVERLAP ASSEMBLAGE
Sedimentary Basin
Intrusions, Post-Accretion
TERRANES, by TYPE
Volcanic Island Arc
Ocean Floor
Displaced Continental Shelf
North America Continental Shelf
Ruby
Storie
Falcon
Kitsault
Endako
Davidson
Lone Pine
Chu
Crazy Fox
MAX
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
BC Geological Survey
www.empr.gov.bc.ca/Mining/Geoscience

Porphyry Molybdenum

Chu
TTM Resources Inc.

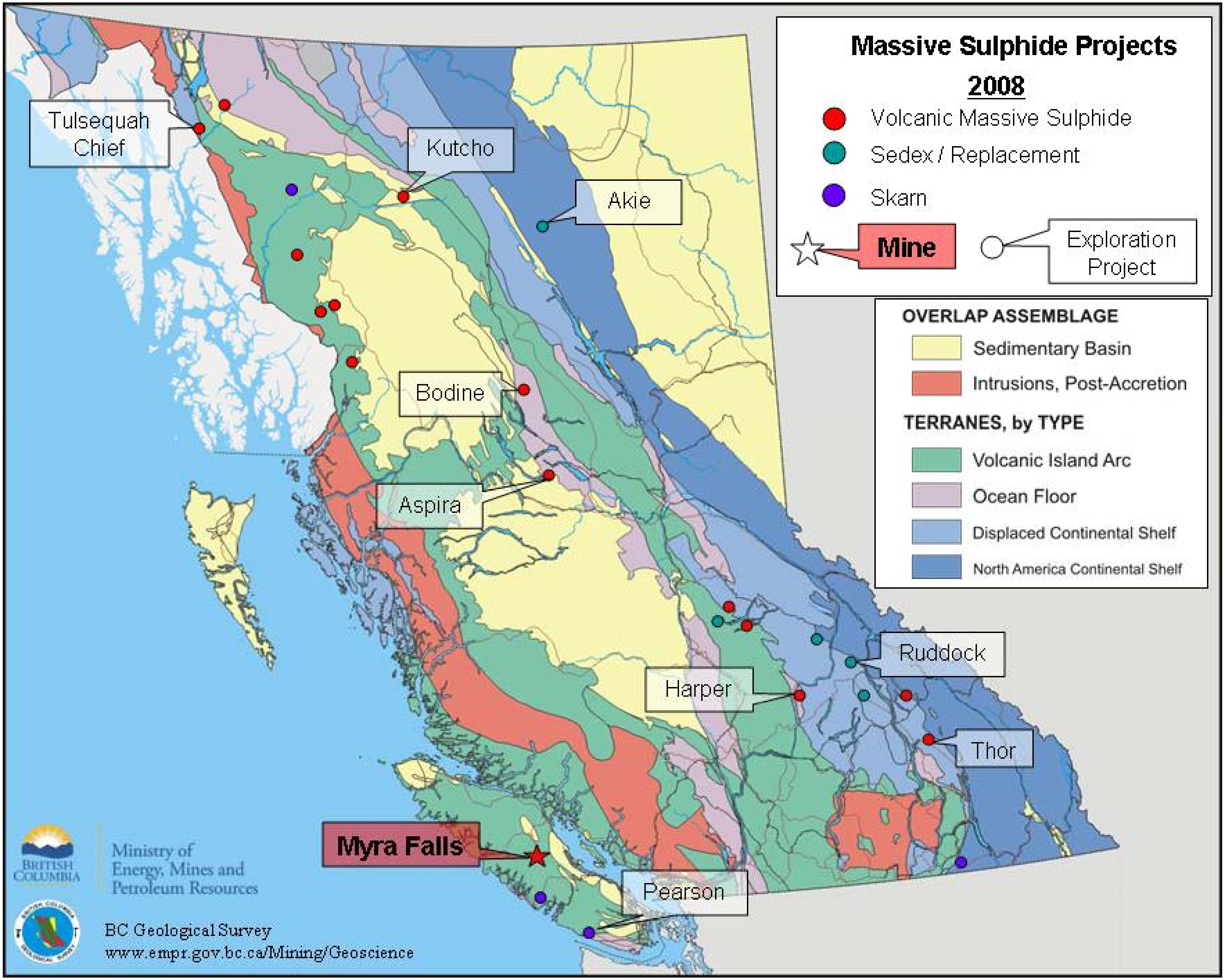
- **Resource – 63,000,000 T @ 0.104% Mo** (Meas + Ind.)
- **80 km south of Vanderhoof; entered environmental assessment process**

Porphyry Molybdenum

Kitsault

Avanti Mining Inc

- Resource 158 m tonnes @ 0.10% Mo (Ind.) + 133 m T inf.
- Past mining – 13 m tonnes at 0.11% Mo (1967-1972, 1981-82)
- Work focused on assessment of a new tailings impoundment



Massive Sulphide Projects
2008
Volcanic Massive Sulphide
Sedex / Replacement
Skarn
Mine
Exploration Project
OVERLAP ASSEMBLAGE
Sedimentary Basin
Intrusions, Post-Accretion
TERRANES, by TYPE
Volcanic Island Arc
Ocean Floor
Displaced Continental Shelf
North America Continental Shelf
Tulsequah Chief
Kutcho
Akie
Bodine
Aspira
Ruddock
Harper
Thor
Myra Falls
Pearson
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
BC Geological Survey
www.empr.gov.bc.ca/Mining/Geoscience

Volcanogenic Massive Sulphide

Kutcho Creek
Capstone Mining

Capstone Mining (formerly Sherwood Copper)

- Limited fieldwork; engineering studies

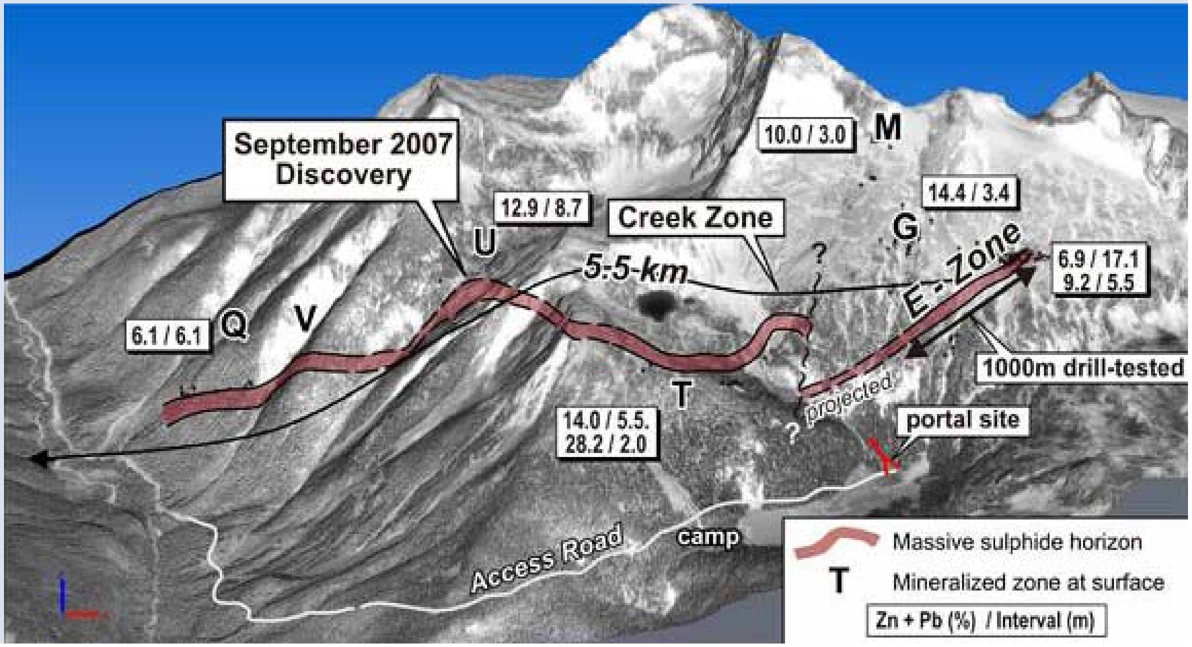
Volcanic "Massive" Sulphide

Harper Creek
Yellowhead Mining Inc.

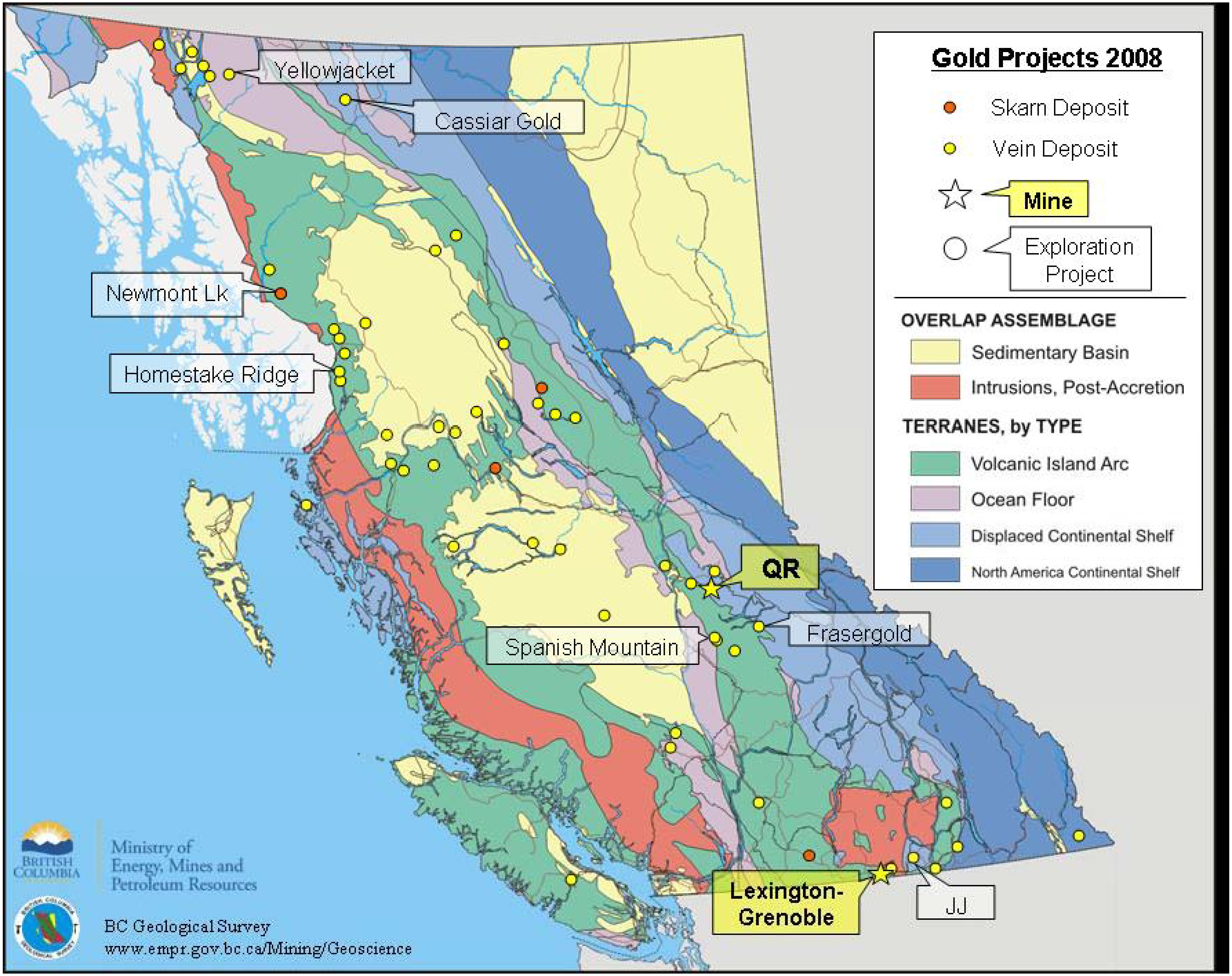
- Entered Environmental Assessment Process
- Modelling the deposit and collating data
- 538.4 Mt of 0.32% Cu at a 0.2% cut-off

Sedex Zinc-Lead Exploration

Ruddock Creek
Selkirk Metals Corp. merged with Imperial Metals Corp.



- Submitted project to Environmental Assessment Process


Gold Projects 2008
Skarn Deposit
Vein Deposit
Mine
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OVERLAP ASSEMBLAGE
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North America Continental Shelf
Yellowjacket
Cassiar Gold
Newmont Lk
Homestake Ridge
QR
Frasergold
Spanish Mountain
Lexington-Grenoble
JJ
Ministry of Energy, Mines and Petroleum Resources
BC Geological Survey
www.empr.gov.bc.ca/Mining/Geoscience

Orogenic Gold Vein

Yellow Jacket
Prize Mining Corporation and Eagle Plain Resources

- Atlin placer camp
- Volcanic and ultramafic-hosted gold-quartz stockworks
- Plan to mine 32,000 t in 2009

Snowfield
Silver Standard Resources

- New Snowfield North = East extension of Mitchell zone
- Seven drills and 80 member team
- New intersection of 0.70 g/t gold over 483m

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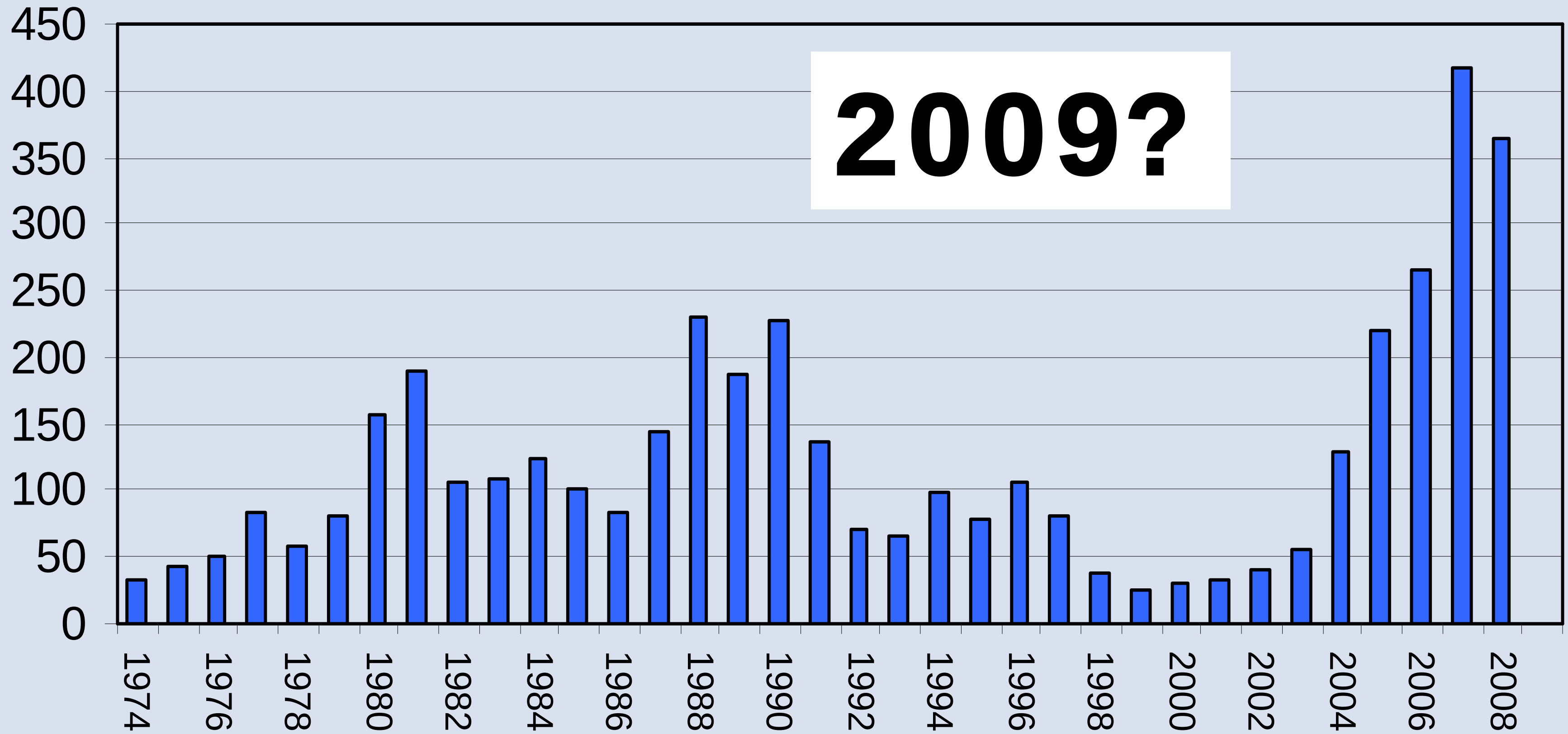
Carbonatite: Tantalum-Niobium Exploration

Blue River
Commerce Resources Corp.

- Preliminary economic evaluation

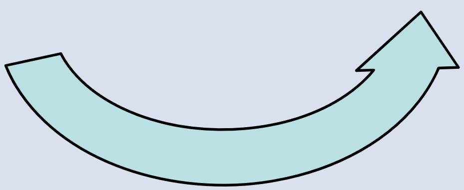
BC Mineral Exploration Expenditure $367 million in 2008



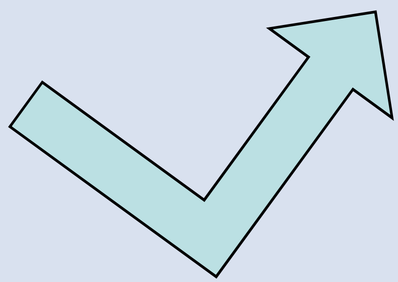
British Columbia
The Best Place on Earth

Recent Commodity Prices
(in US $)

Met Coal:	$125-$150/t
Copper:	$2.60-3.00/lb
Gold:	$900-1120/oz
Molybdenum:	$10-15/lb



vs



?

BRITISH COLUMBIA

Elk Valley Coal Corporation

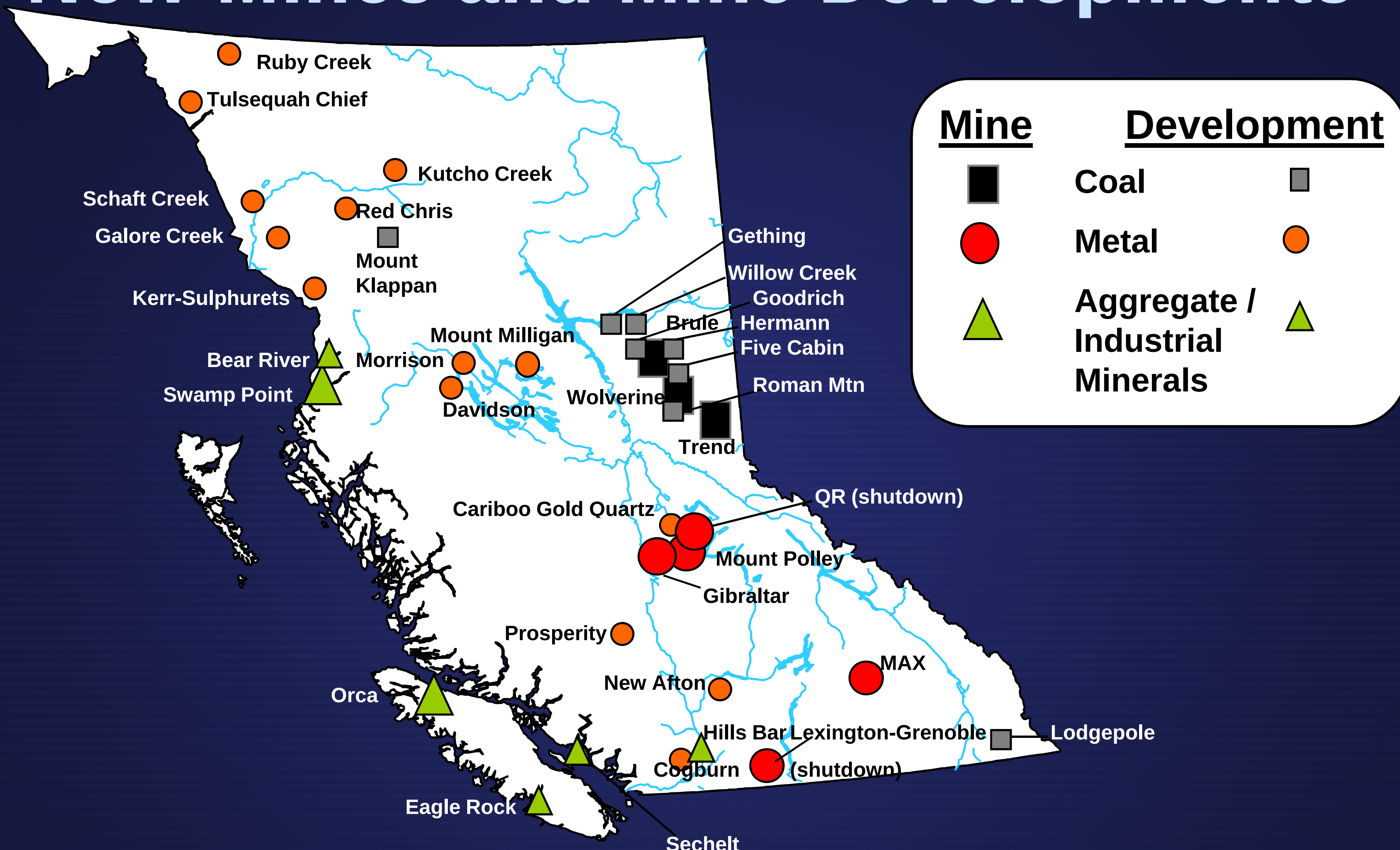
Fording River, Elkview, Greenhills, Line Creek, Coal Mountain


Perry Creek (Wolverine)
Western Canadian Coal
204

Brule Mine
Western Canadian Coal Corp.

Trend
Peace River Coal Limited Partnership

New Mines and Mine Developments



Since 2005

January 2009

Copper Mines

Copper-Moly Mines

Highland Valley - Teck & Highmont
Gibraltar – Taseko Mines
Huckleberry – Imperial Metals (50%)

Copper-Gold Mines

Kemess – Northgate
Mount Polley - Imperial Metals

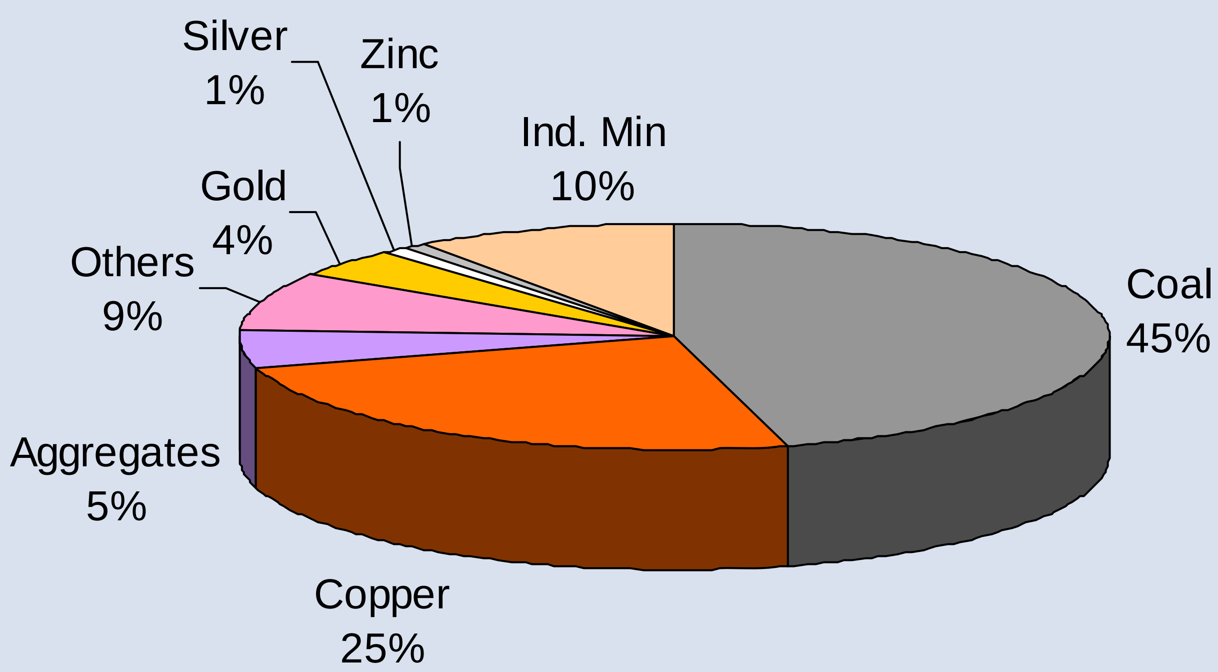
Volcanogenic Massive Sulphide

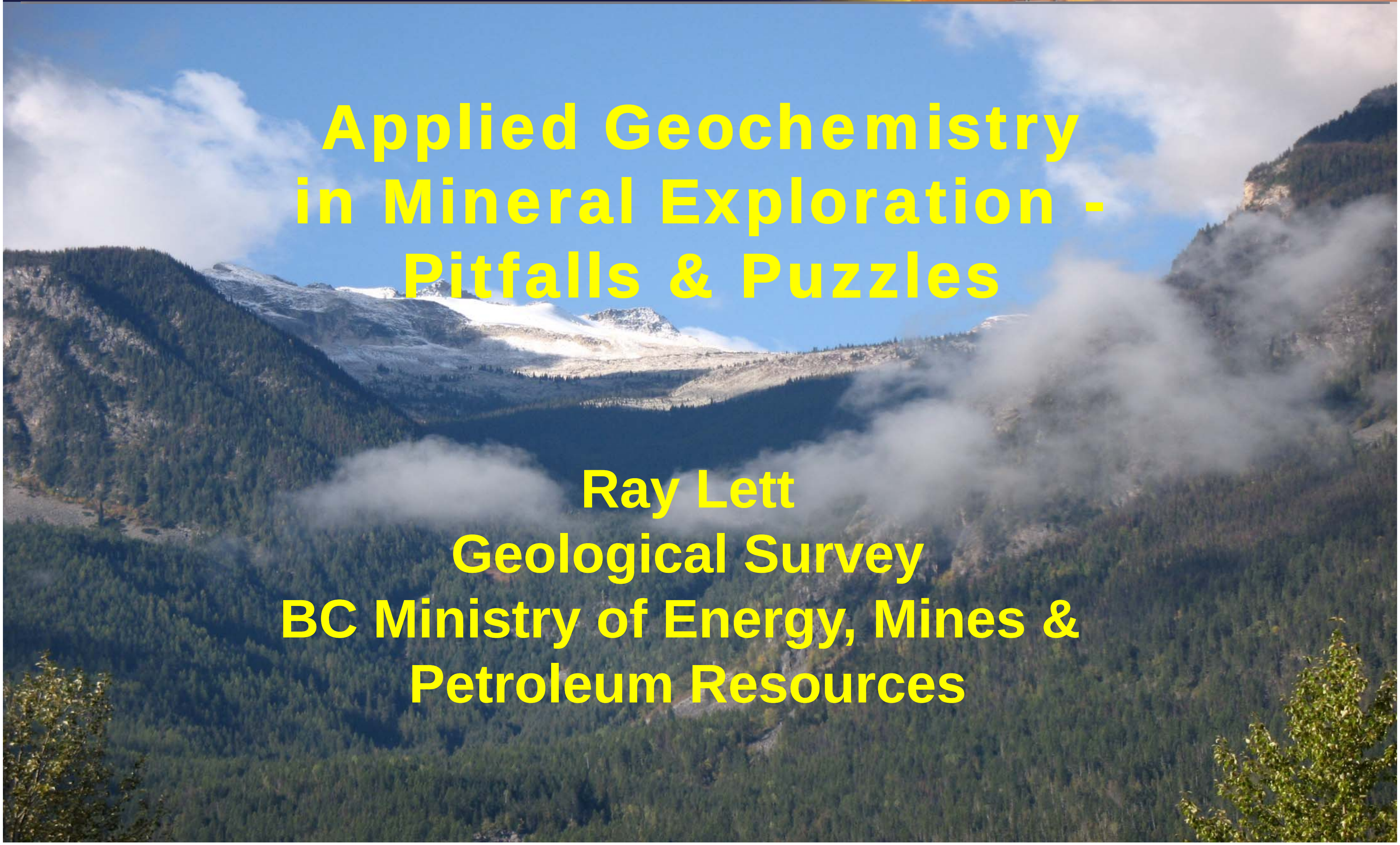
Myra Falls Mine

Breakwater Resources Ltd

- **Discovered new high grade South Flank zone (averted shutdown)**
- **5,835,000 T @ 5.4% Zinc, 1.0% Copper, 1.3 g/t Gold, 45 g/t Silver**

2008 Value of Mineral Production: $6.7 Billion





Applied Geochemistry in Mineral Exploration - Pitfalls & Puzzles

Ray Lett
Geological Survey
BC Ministry of Energy, Mines & Petroleum Resources

Geochemical Survey Pitfalls

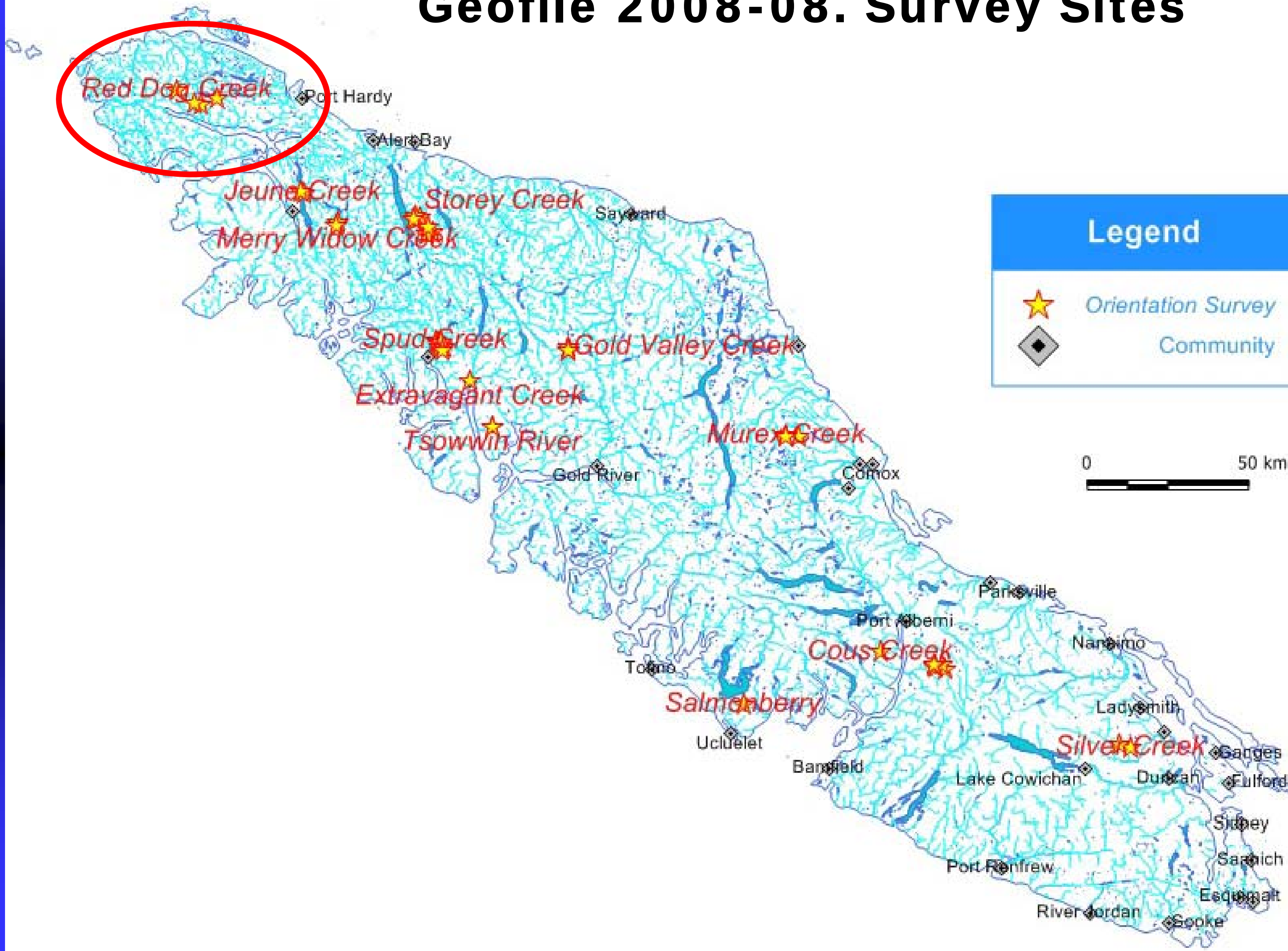
- Sampling
- Sample preparation
- Sample analysis

A pitfall of moss mat sampling

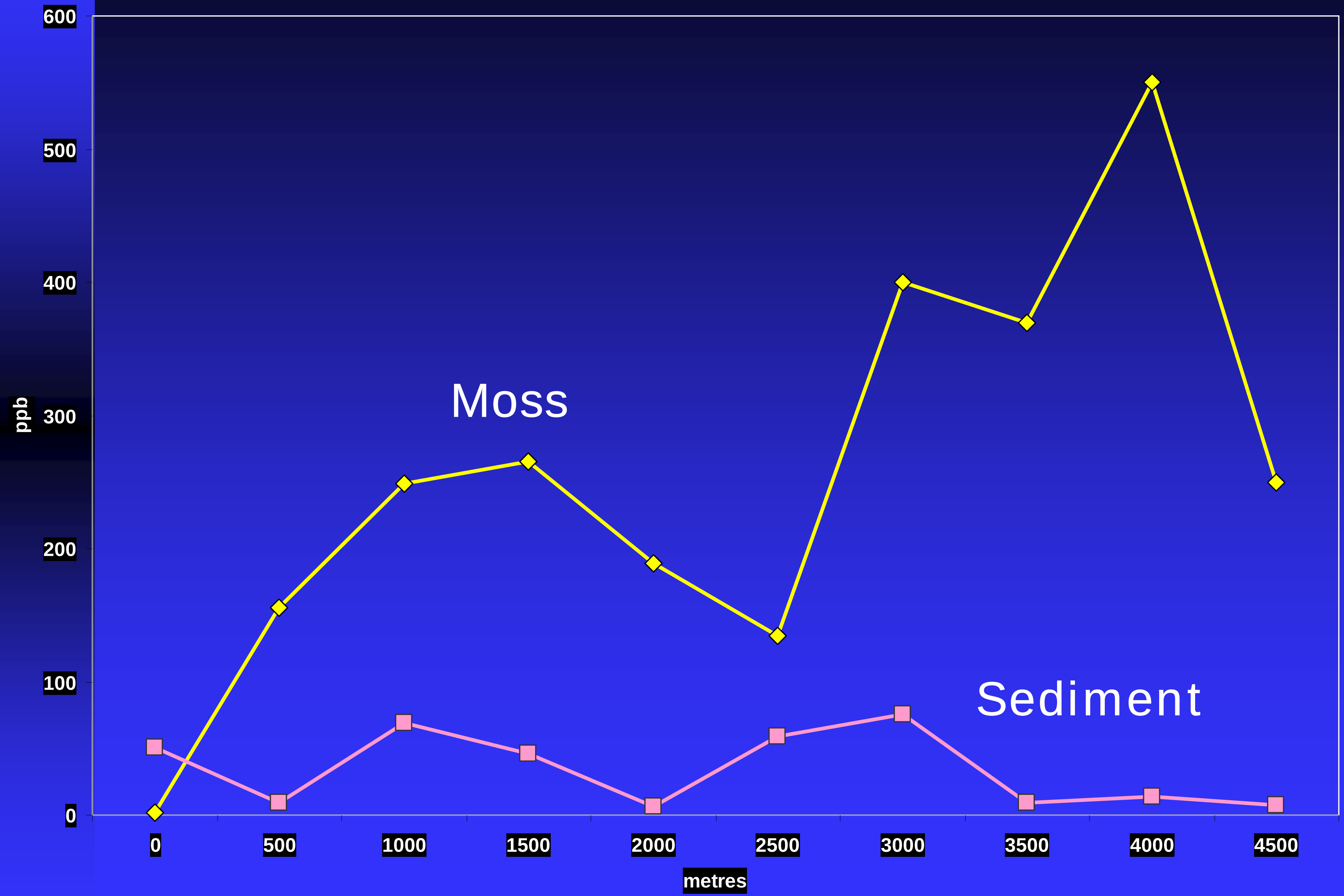
- Moss mat sediment can improve gold anomaly contrast.
- Moss mats are an alternative where fine-grained sediment is limited in fast flowing streams.
- Moss should be collected from above & close to the water level.

Using Moss Mat Samples – An Alternative sediment in fast-flowing mountain streams

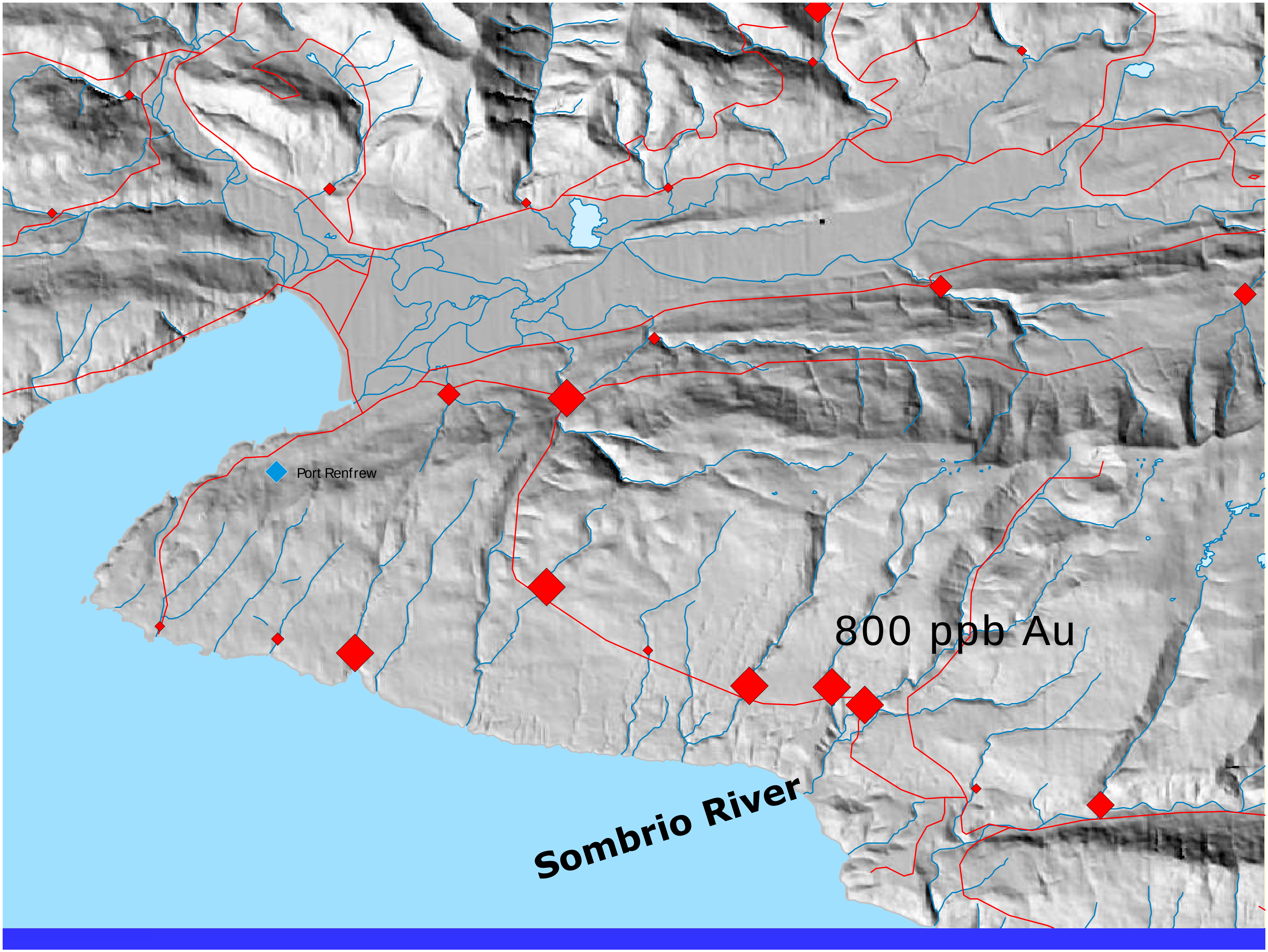
Geofile 2008-08. Survey Sites



Au (ppb) in conventional and moss sediment – Red Dog



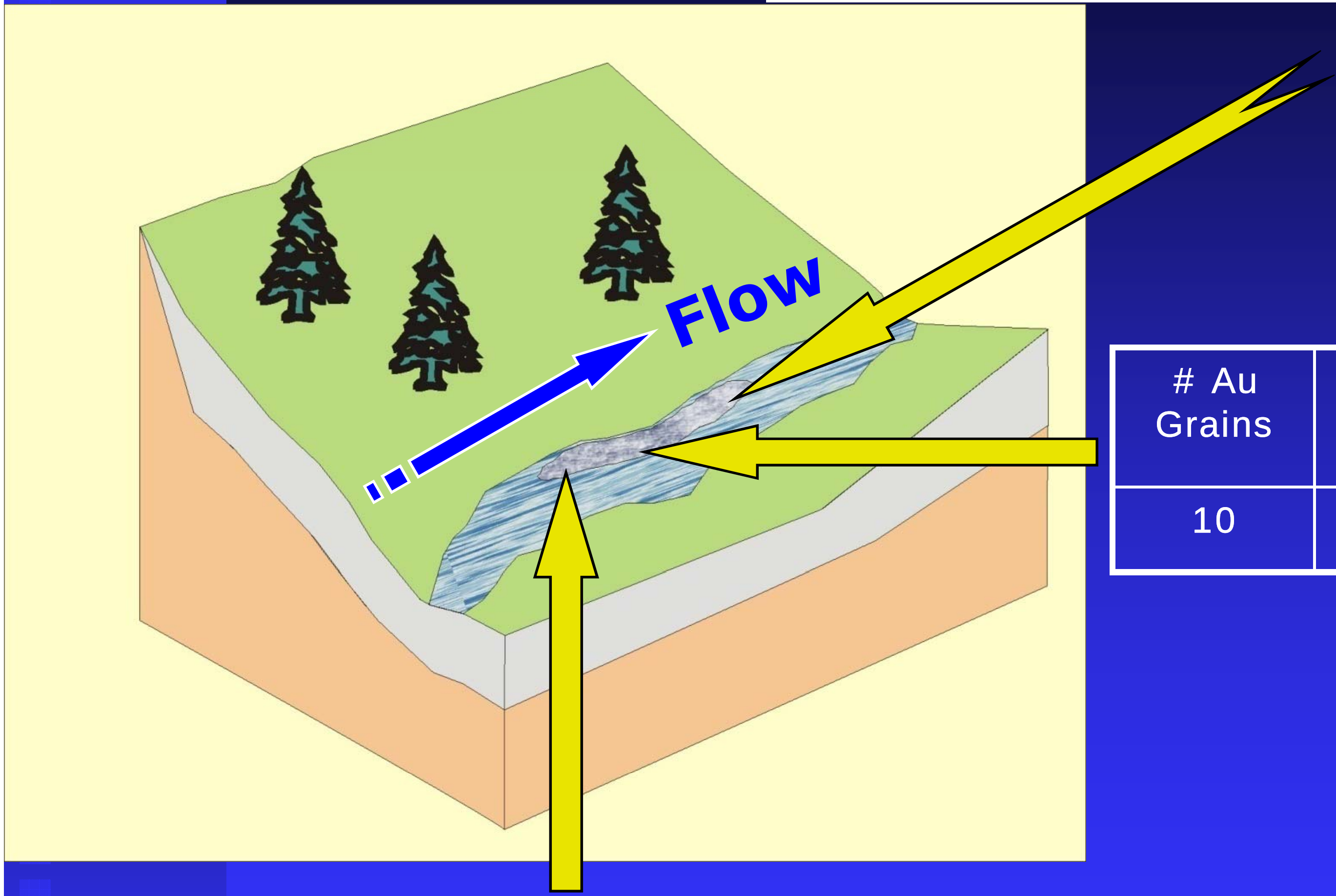
Distance from Source (m)


Port Renfrew
800 ppb Au
Sombrio River

Sombrio Cr.

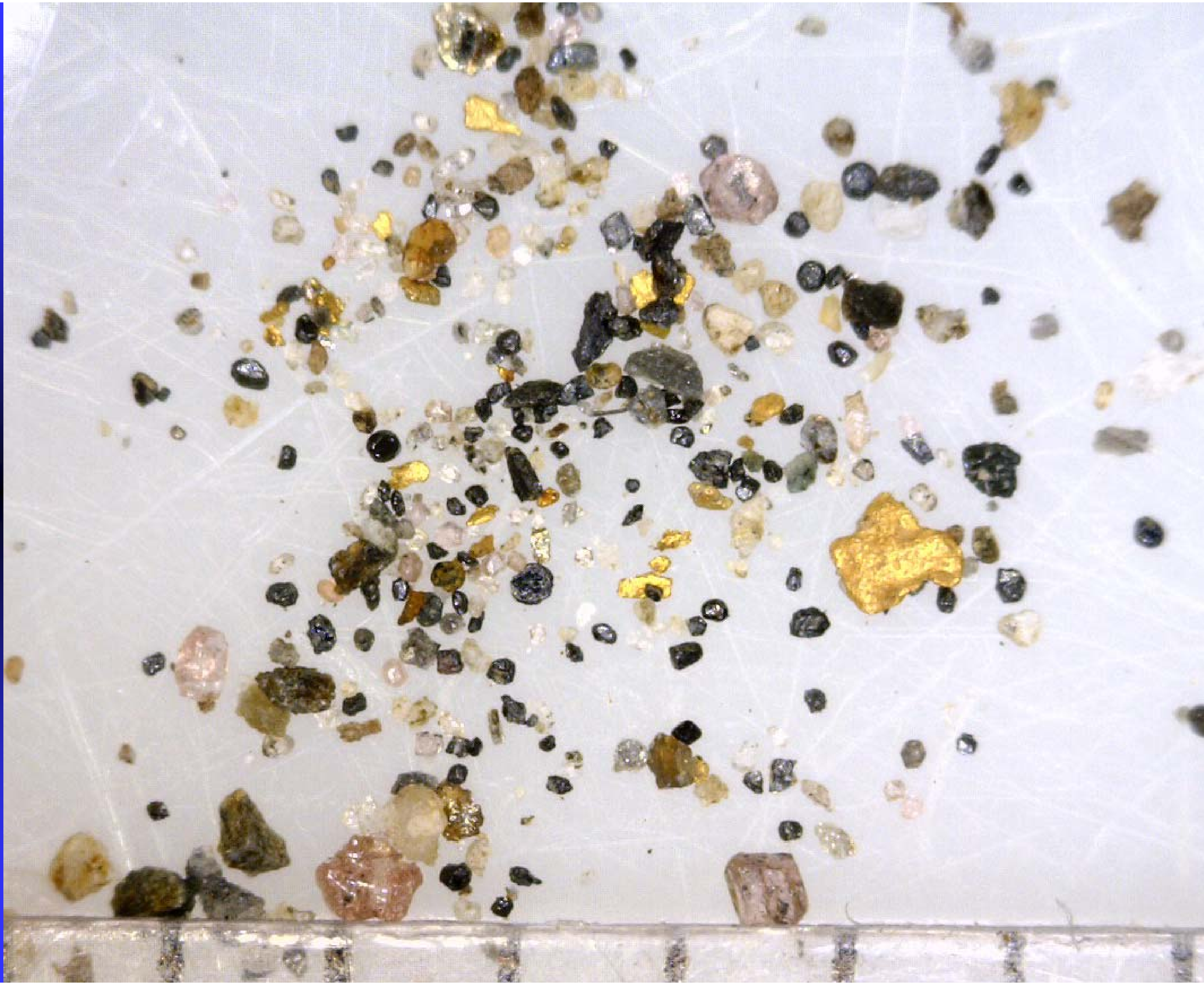
Sombrio Cr.

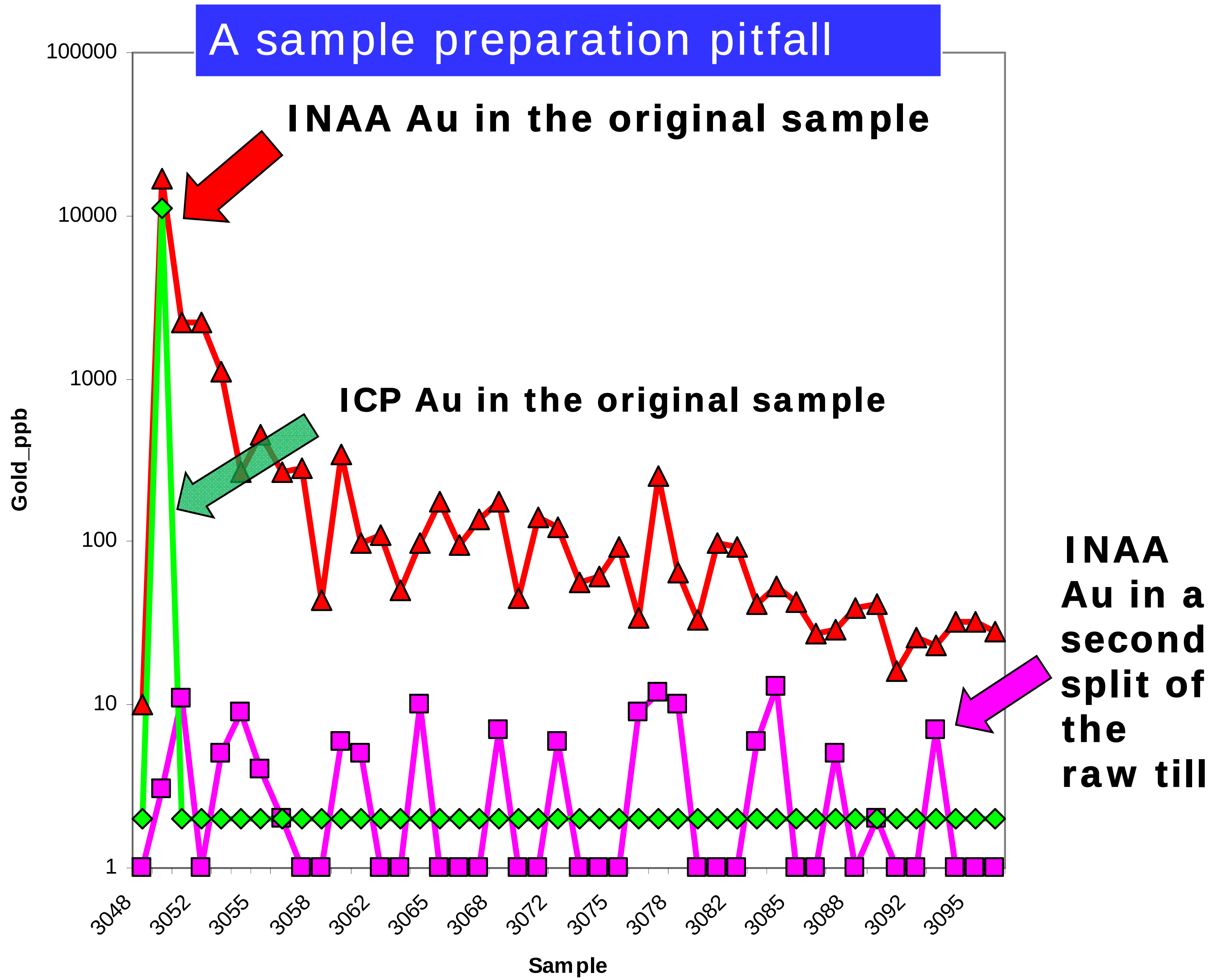
# Au Grains	- 80 Sed. (ppb)	-80 Moss (ppb)	- 80 Moss REP (ppb)
15	1.9	1.9	58



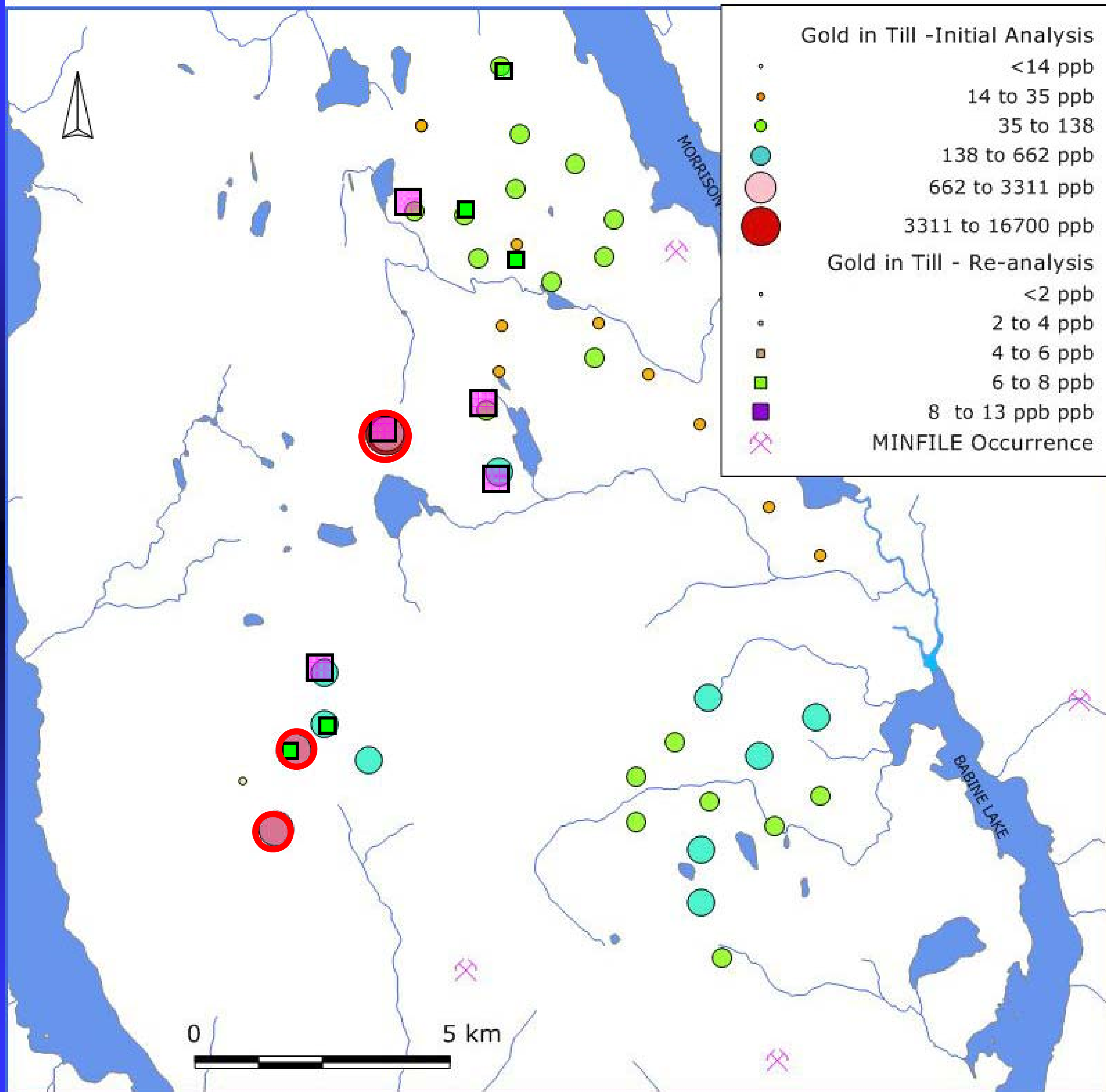
# Au Grains	- 80 Sed. (ppb)	- 80 Moss (ppb)
10	8.6	7.1

# Au Grains	- 80 Sed. (ppb)	- 80 Moss (ppb)
6	454.4	2.7





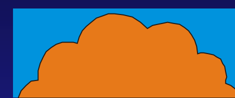
A sample preparation pitfall
INAA Au in the original sample
ICP Au in the original sample
INAA Au in a second split of the raw till
Gold_ppb
100000
10000
1000
100
10
1
3048
3052
3055
3058
3062
3065
3068
3072
3075
3078
3082
3085
3088
3092
3095
Sample


Gold in Till -Initial Analysis
<14 ppb
14 to 35 ppb
35 to 138
138 to 662 ppb
662 to 3311 ppb
3311 to 16700 ppb
Gold in Till - Re-analysis
<2 ppb
2 to 4 ppb
4 to 6 ppb
6 to 8 ppb
8 to 13 ppb ppb
MINFILE Occurrence
MORRISON
BABINE LAKE
0
5 km

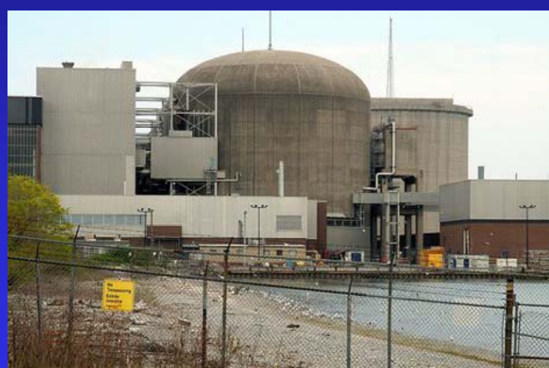
A pitfall of sample analysis

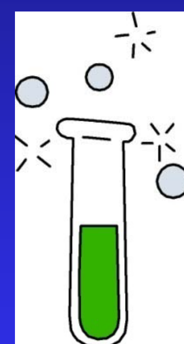
Neutron activation

Sample



ICP Mass Spectrometry





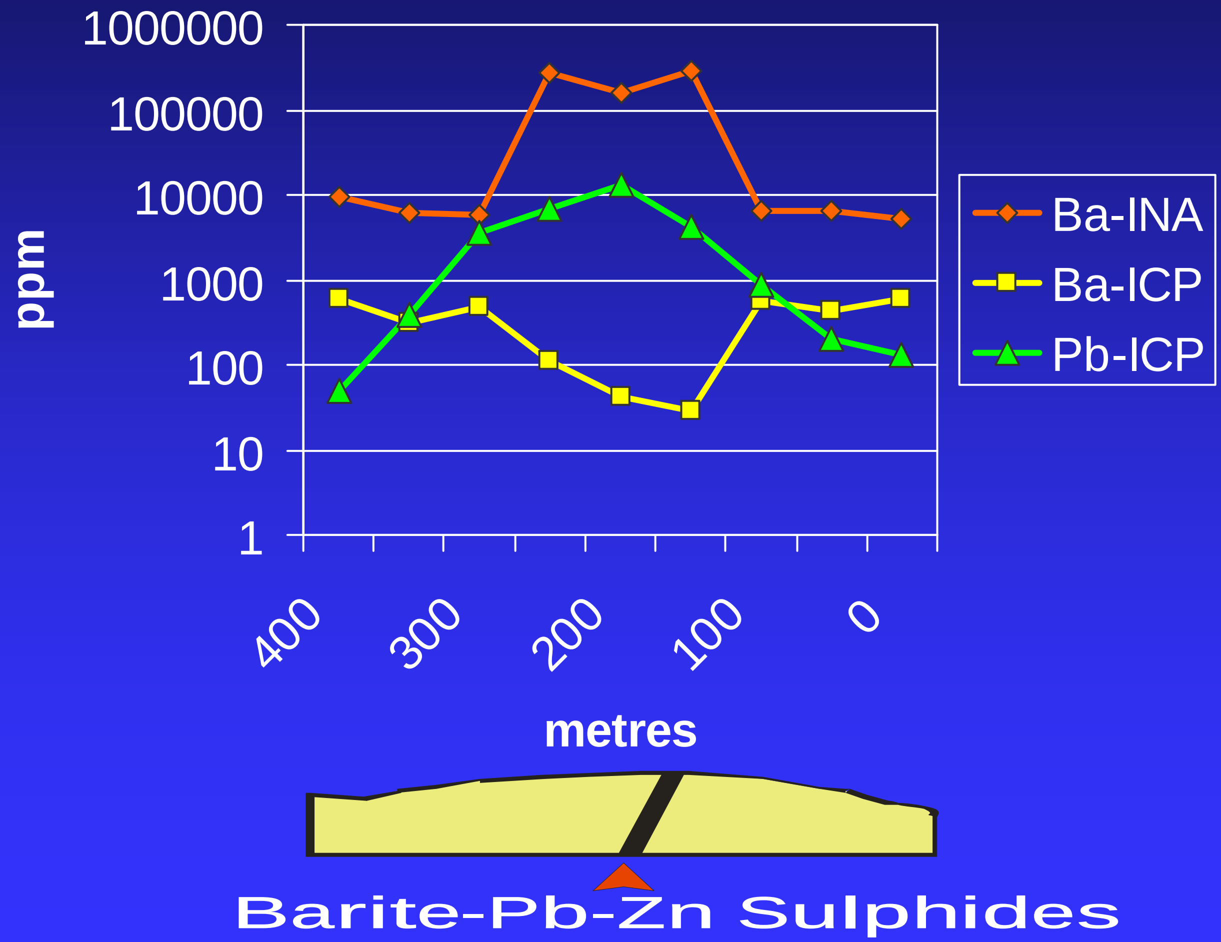
Irradiate in nuclear reactor & count isotopes

Leach in aqua regia & analyze by spectrometer

33 elements – near total

50+ elements - partial

Barium and lead in soil over sedex mineralization

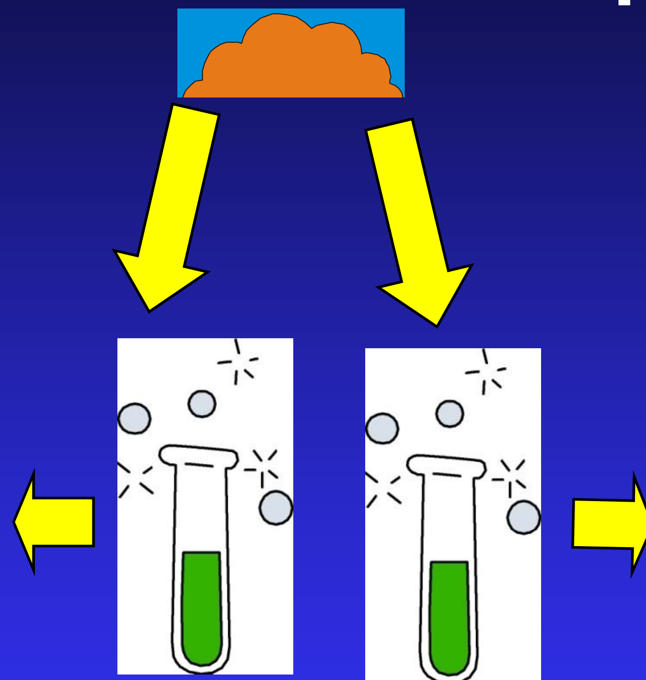


A pitfall of RGS sample analysis

Atomic absorption

Sample

ICP Mass Spectroscopy

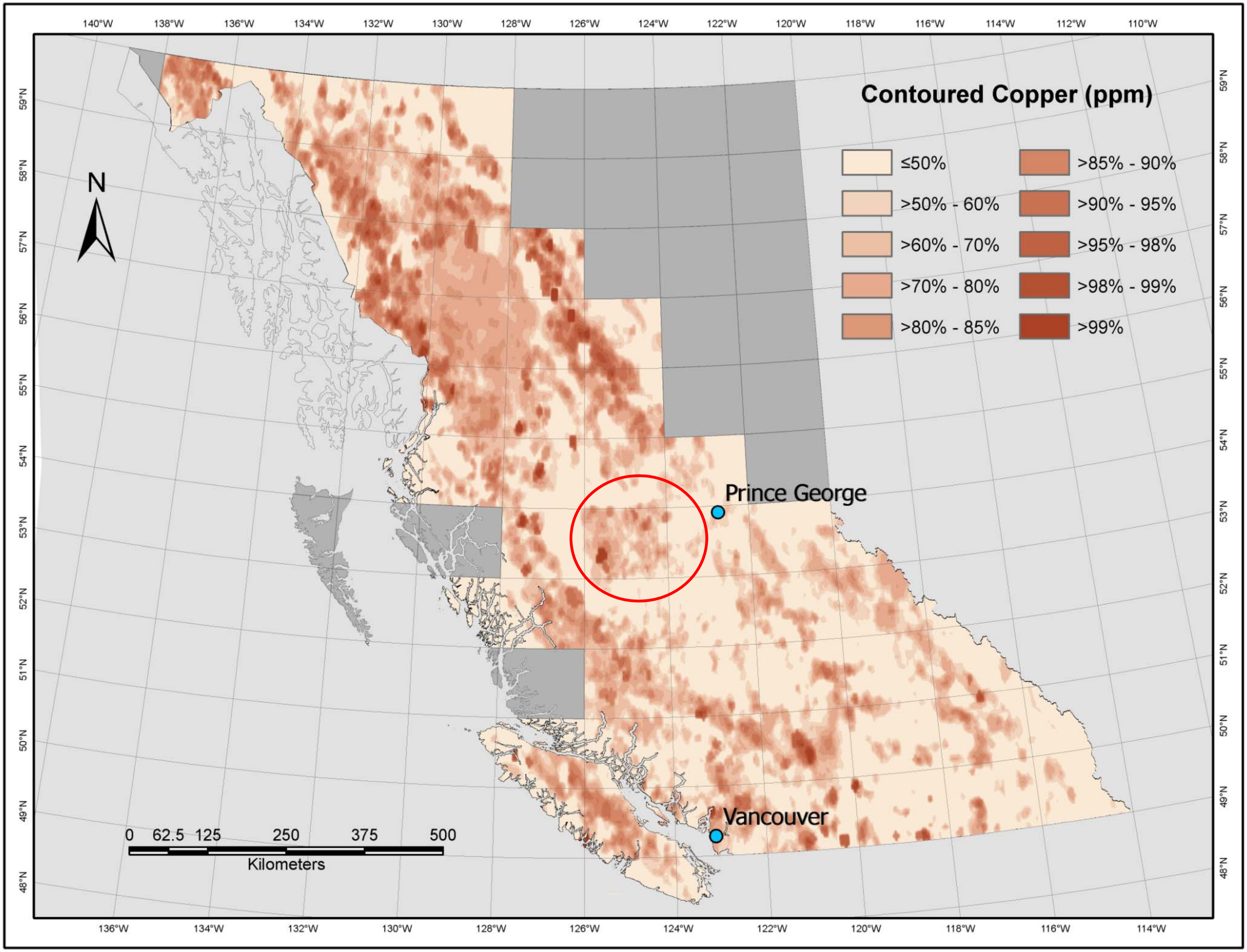


Aqua regia digestion - Spectrometer -analysis

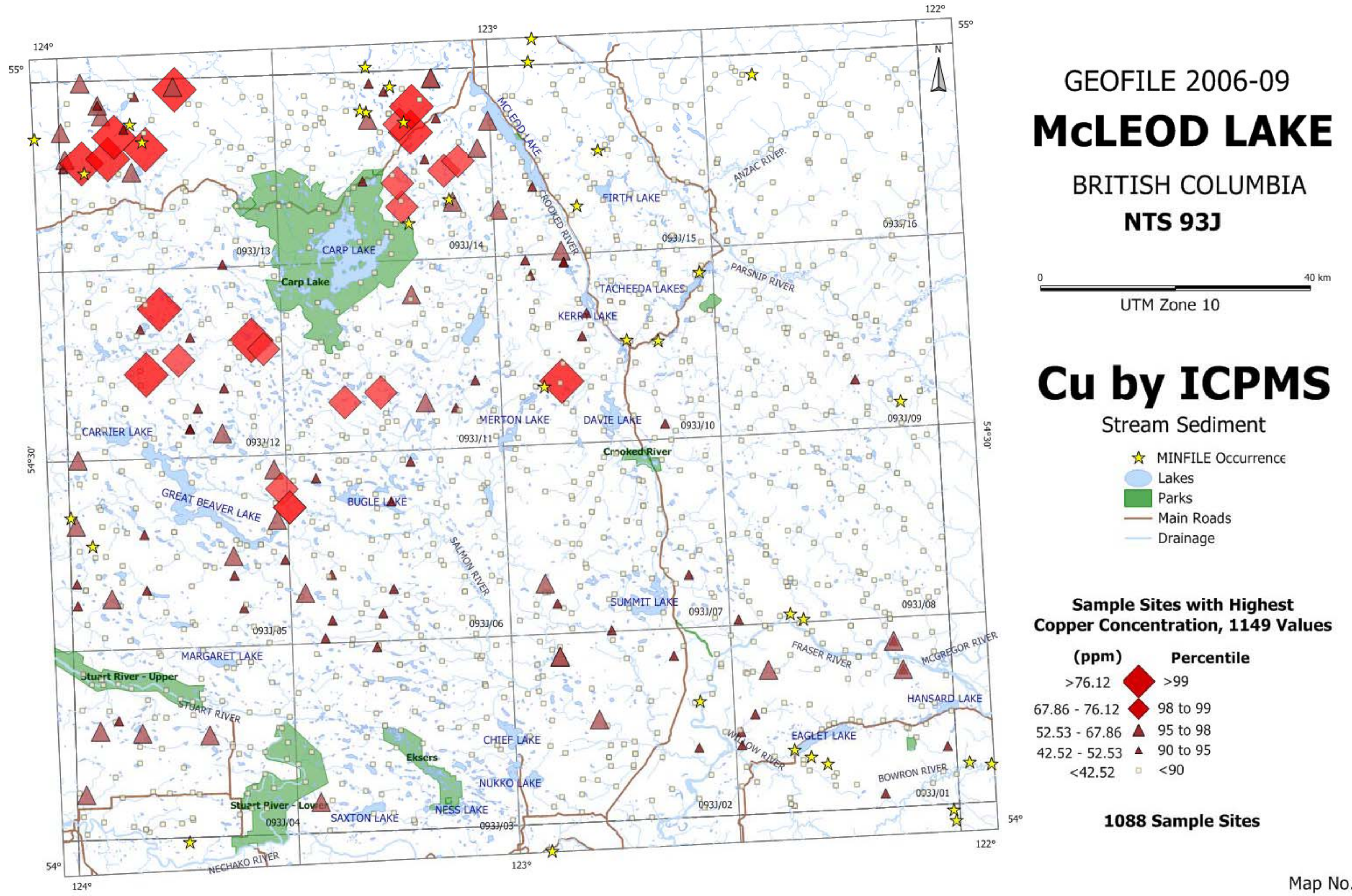
single element -robust

Aqua regia digestion - Spectrometer -analysis

Multi – element - versatile


Contoured Copper (ppm)
≤50%
>50% - 60%
>60% - 70%
>70% - 80%
>80% - 85%
>85% - 90%
>90% - 95%
>95% - 98%
>98% - 99%
>99%
N
Prince George
Vancouver
0 62.5 125 250 375 500
Kilometers

Copper in stream sediment samples



Map No. 14

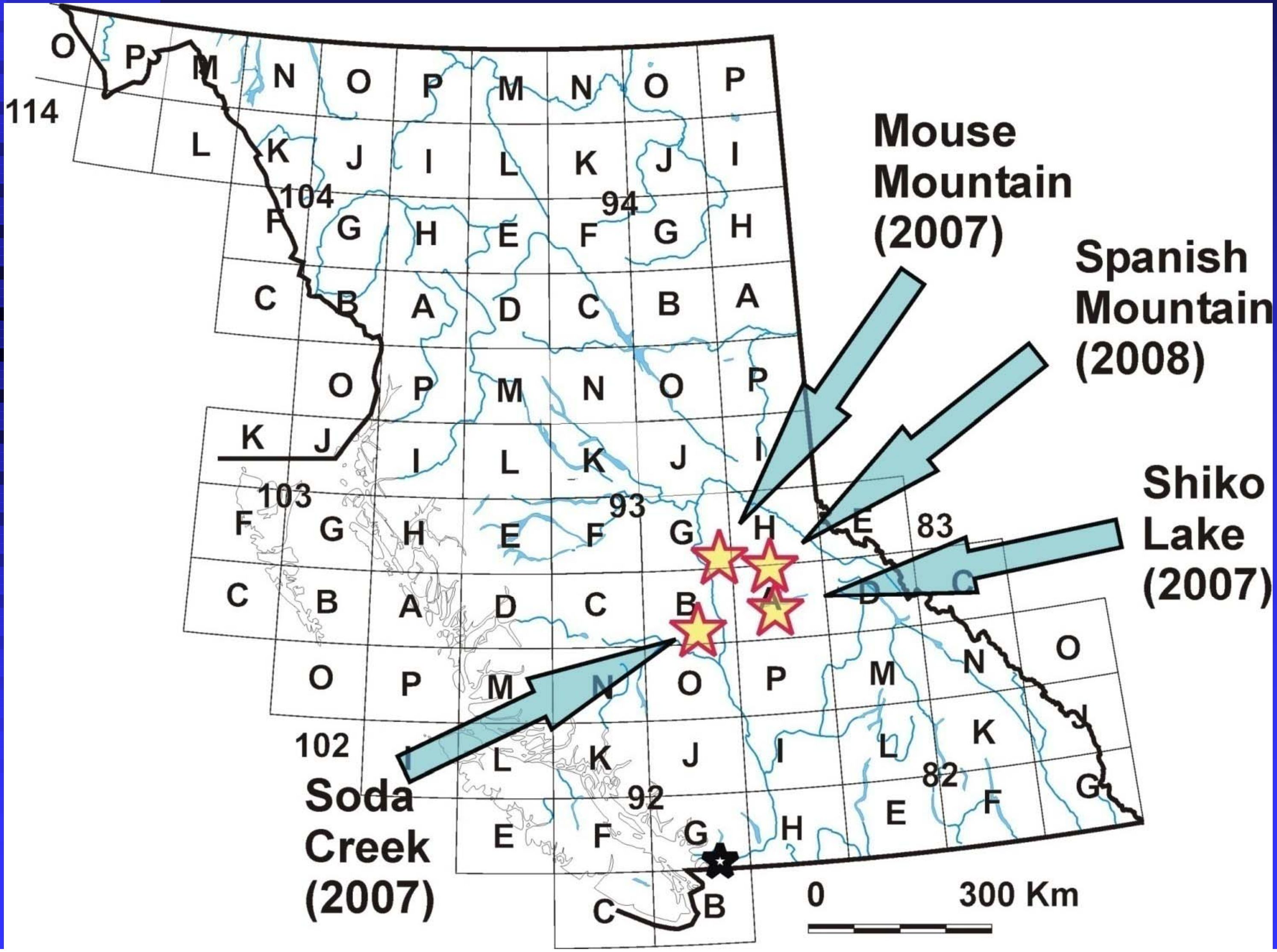
AAS mean vs ICPMS mean T test (1149 RGS values - NTS 93J)

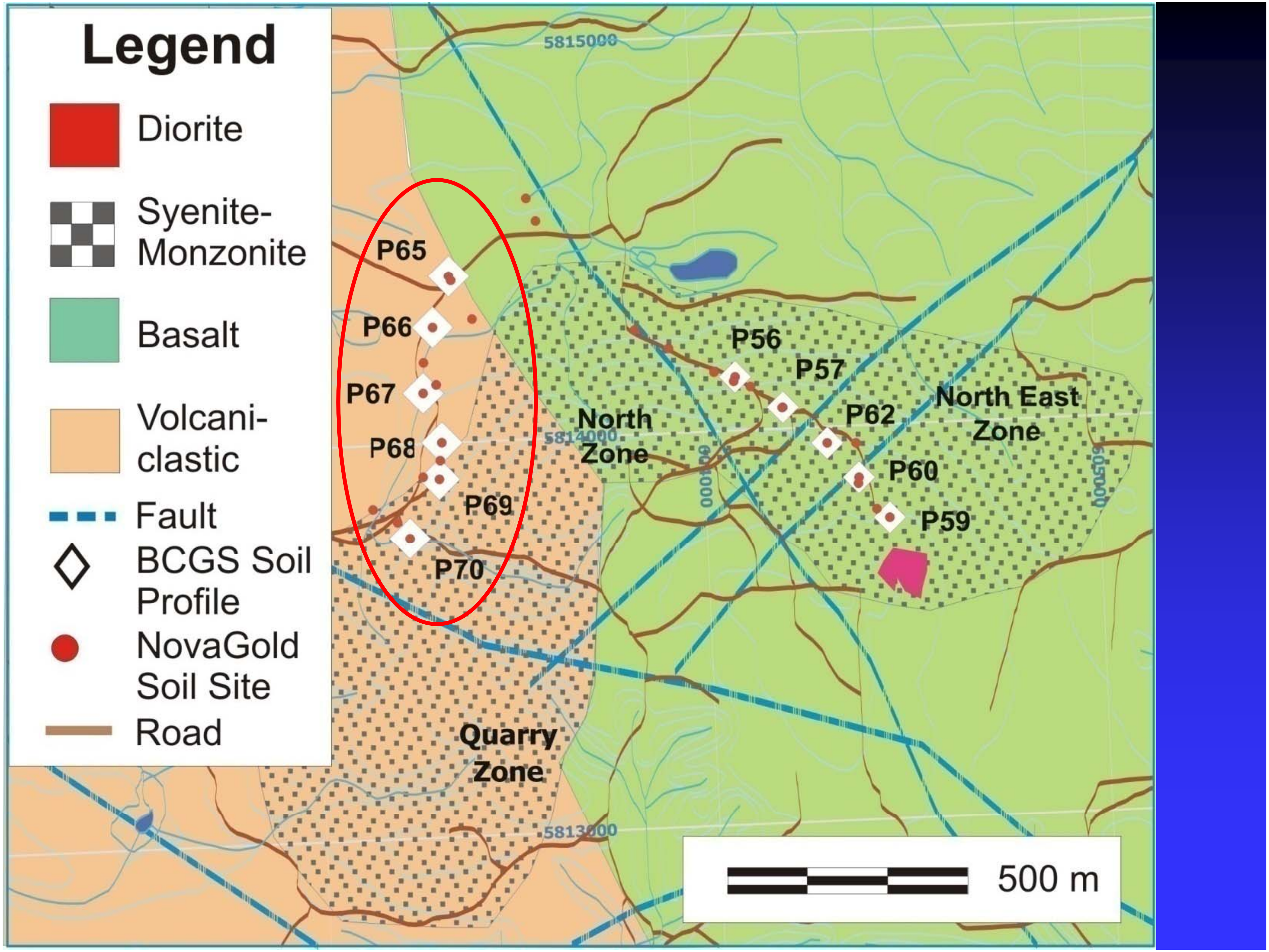
	Aqua Regia-AAS	Aqua Regia-ICPMS	AR_AA-Mean	AR_ICPMS-Mean
As			4.5	4.7
Cd			0.4	0.46
Co			10	11
Cu			24	24.61
Fe			2.14	2.22
Hg			141	132
Mn			741	747
Mo			2	1.06
Ni			36	39.3
Pb			5	7.5
Sb			0.4	0.33
V			37	40
Zn			72	74.5

Different

Same

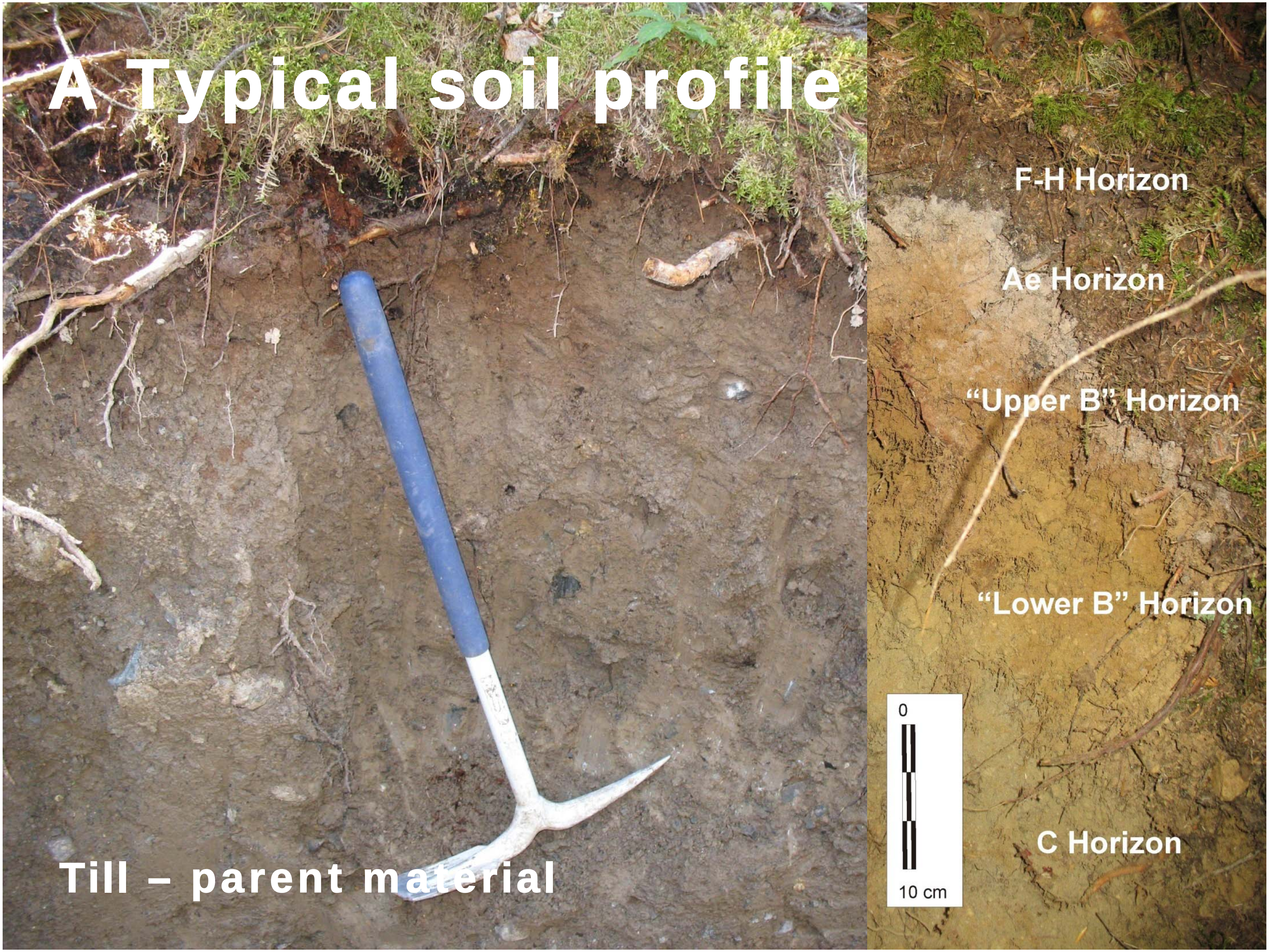
Some Puzzles e.g. Shiko Lake Soil Geochemistry





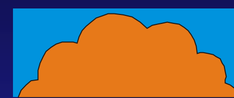
Legend
Diorite
Syenite-Monzonite
Basalt
Volcani-clastic
Fault
BCGS Soil Profile
NovaGold Soil Site
Road
5815000
5814000
5813000
P65
P66
P67
P68
P69
P70
P56
P57
P62
P60
P59
North Zone
North East Zone
Quarry Zone
500 m


Shiko Lake – view N across the Quarry Zone

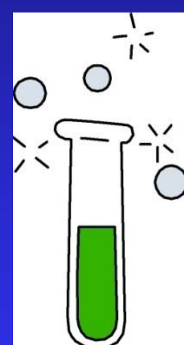

A Typical soil profile
F-H Horizon
Ae Horizon
"Upper B" Horizon
"Lower B" Horizon
0
10 cm
C Horizon
Till – parent material

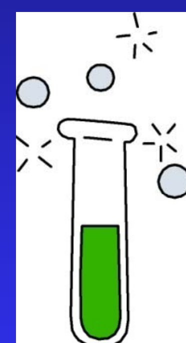
ICP Mass Spectroscopy

Sample



ICP Mass Spectroscopy



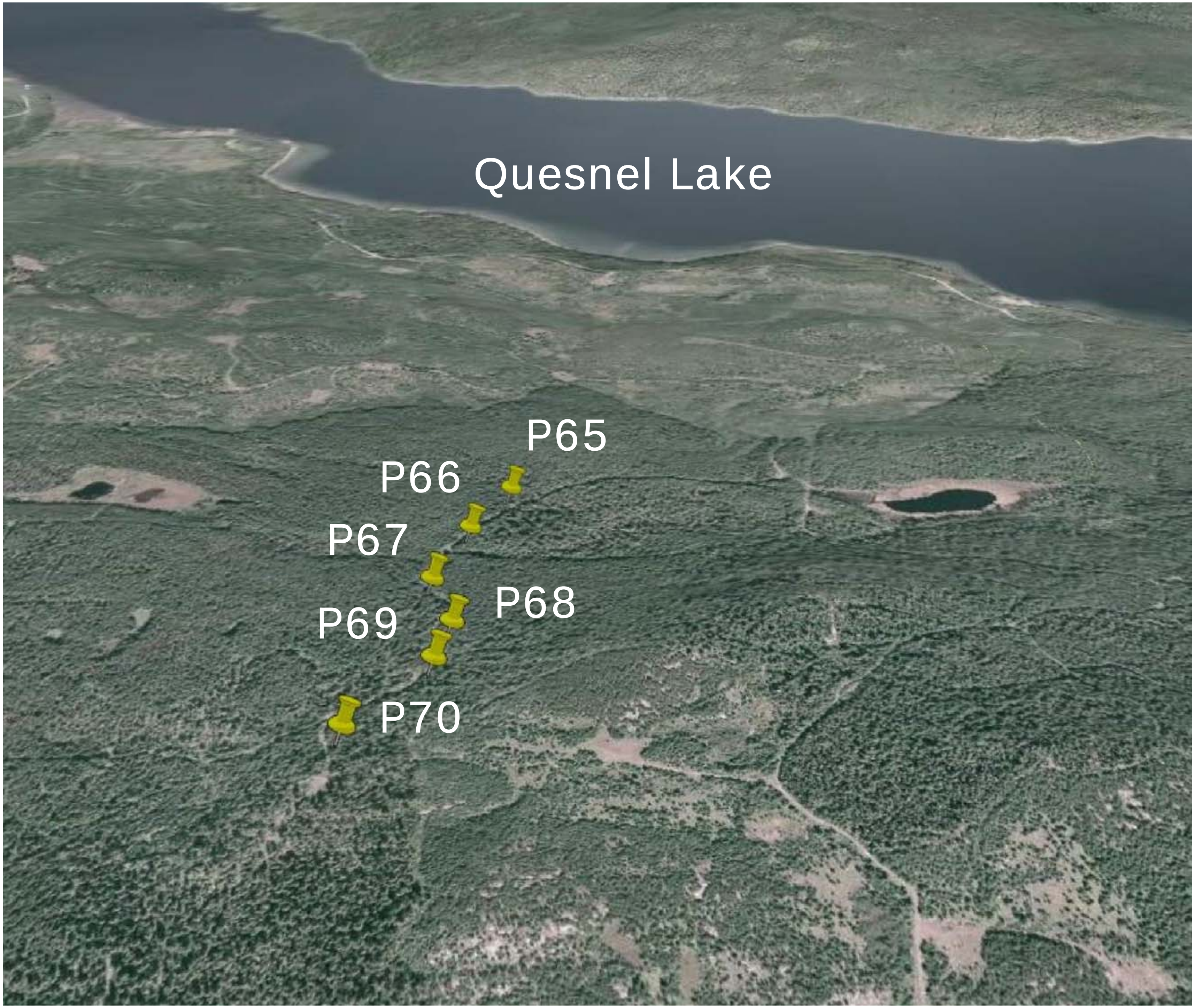


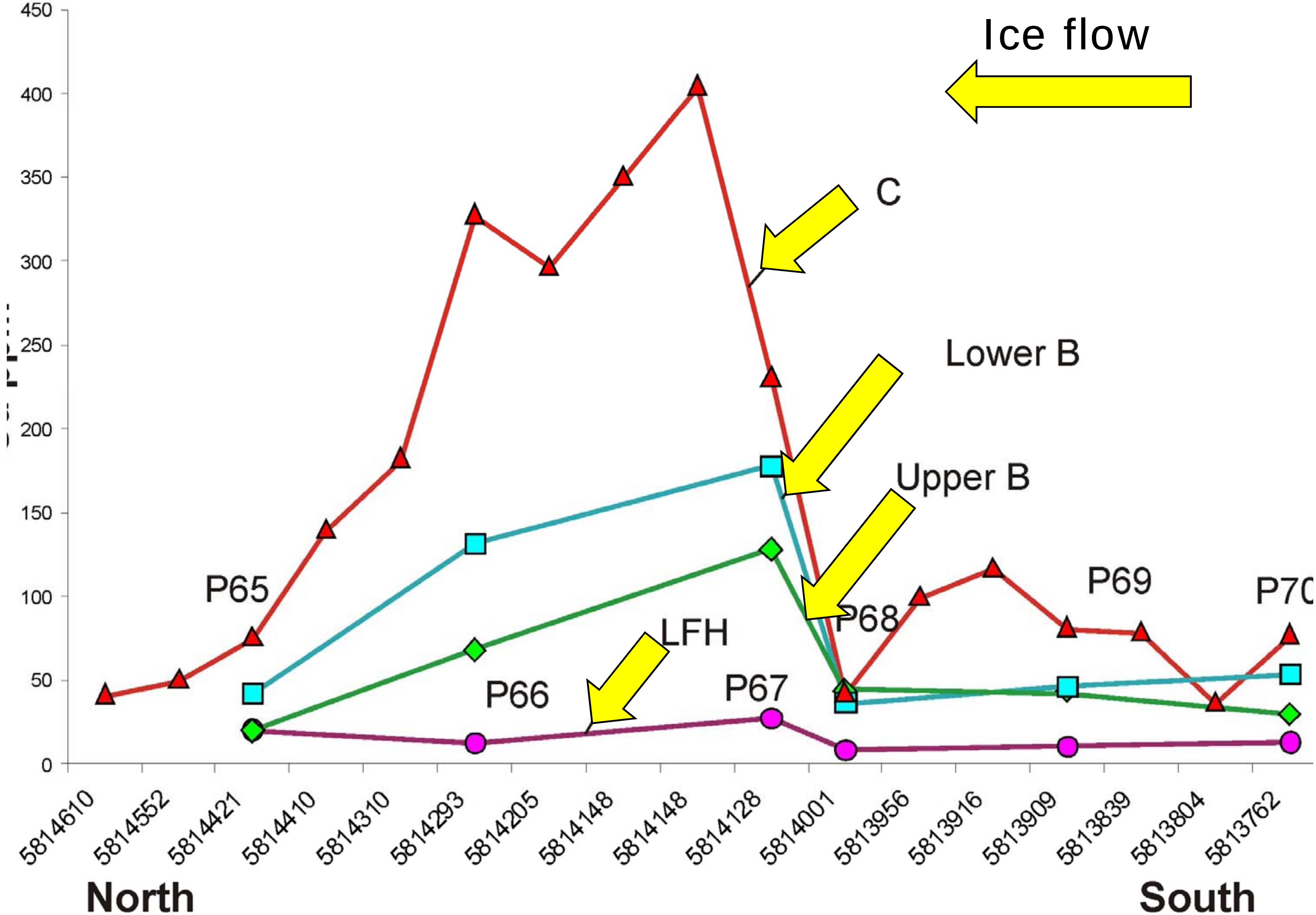
Mobile metal ion (MMI)
Bioleach, Enzyme
Leach-ICPMS analysis

Improves contrast

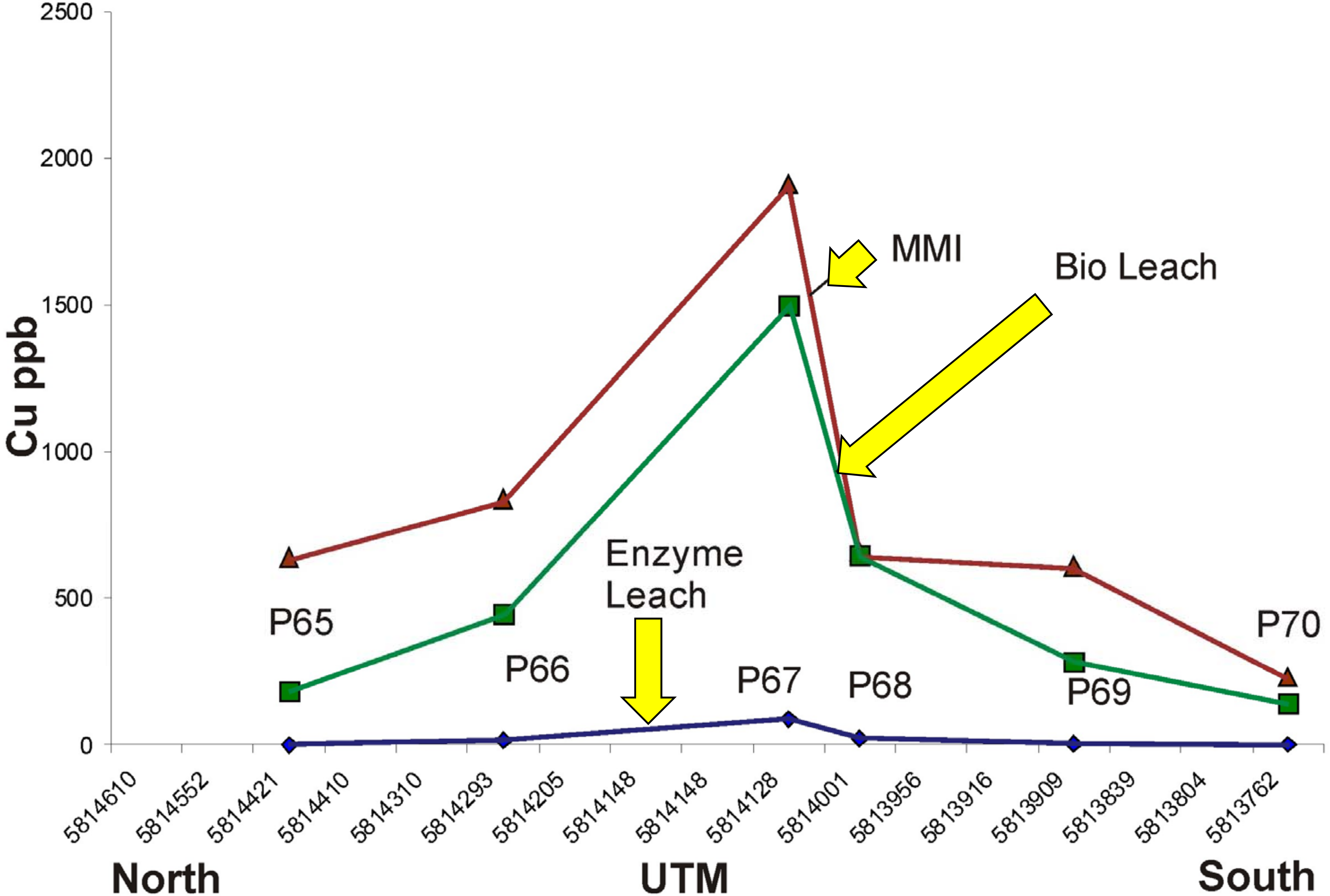
Aqua regia digestion -
Spectrometer -analysis

Multi – element - versatile

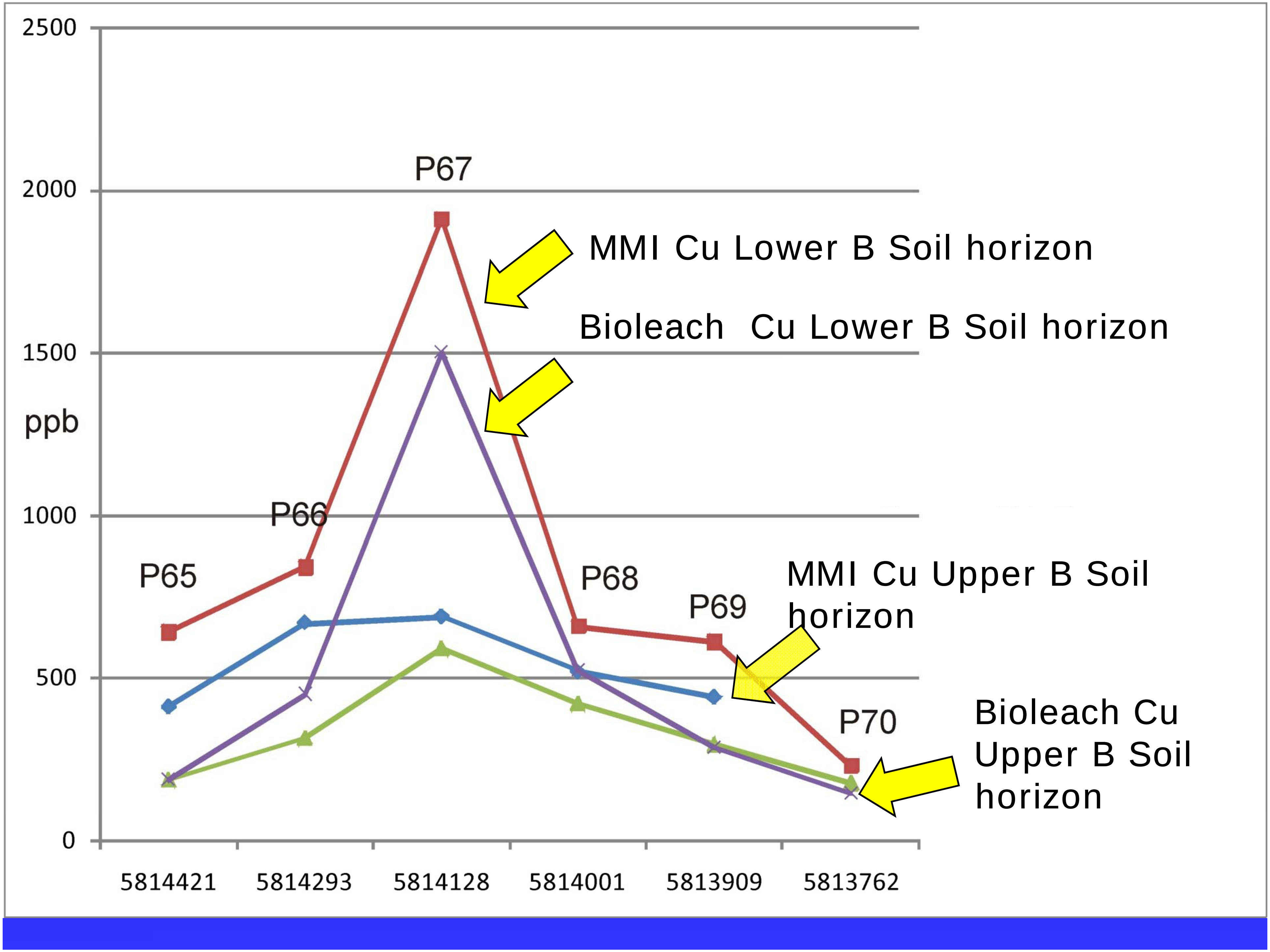

Quesnel Lake
P65
P66
P67
P68
P69
P70



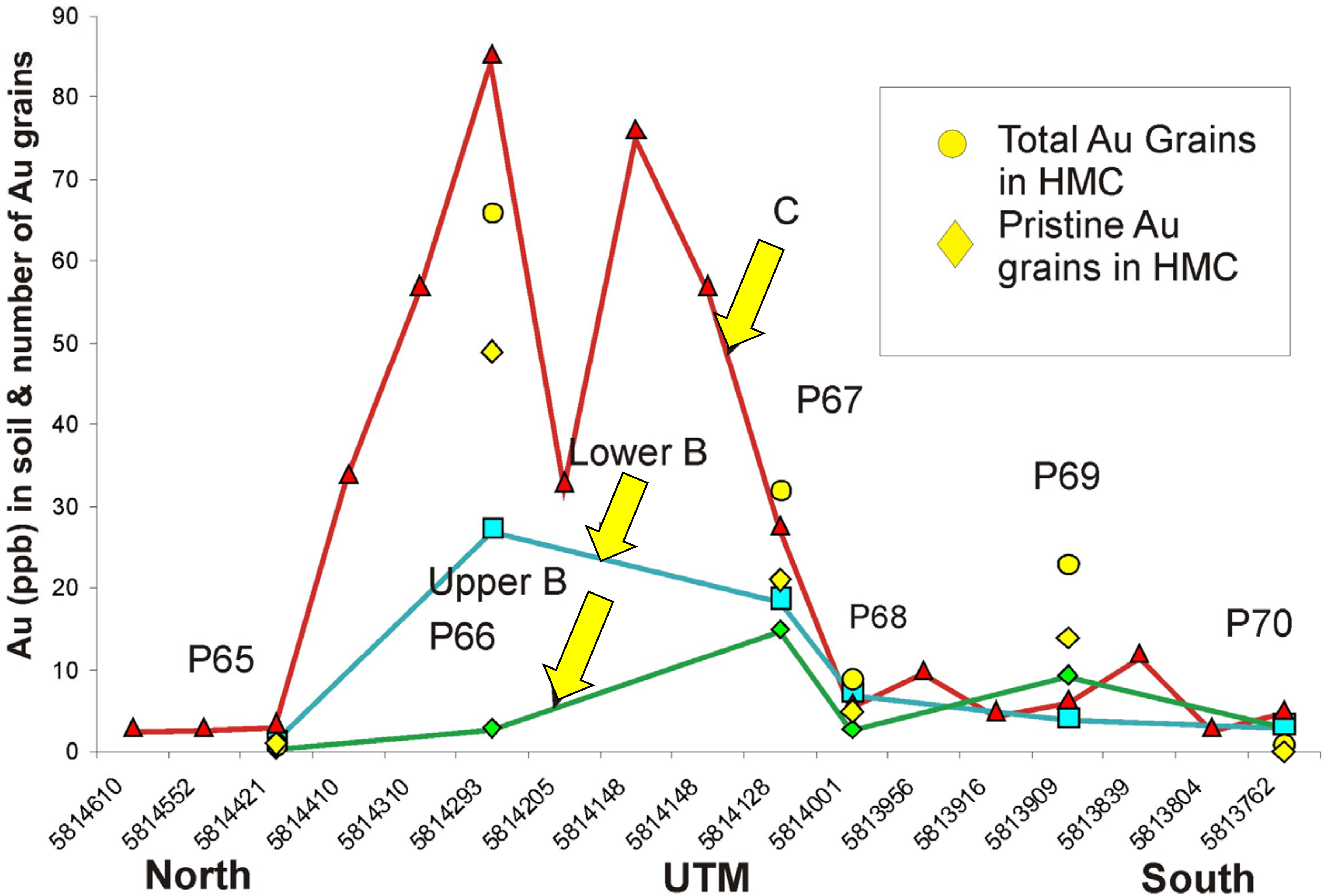
Ice flow
C
Lower B
Upper B
P65
P66
P67
P68
P69
P70
LFH
450
400
350
300
250
200
150
100
50
0
5814610
5814552
5814421
5814410
5814310
5814293
5814205
5814148
5814148
5814128
5814001
5813956
5813916
5813909
5813839
5813804
5813762
North
South



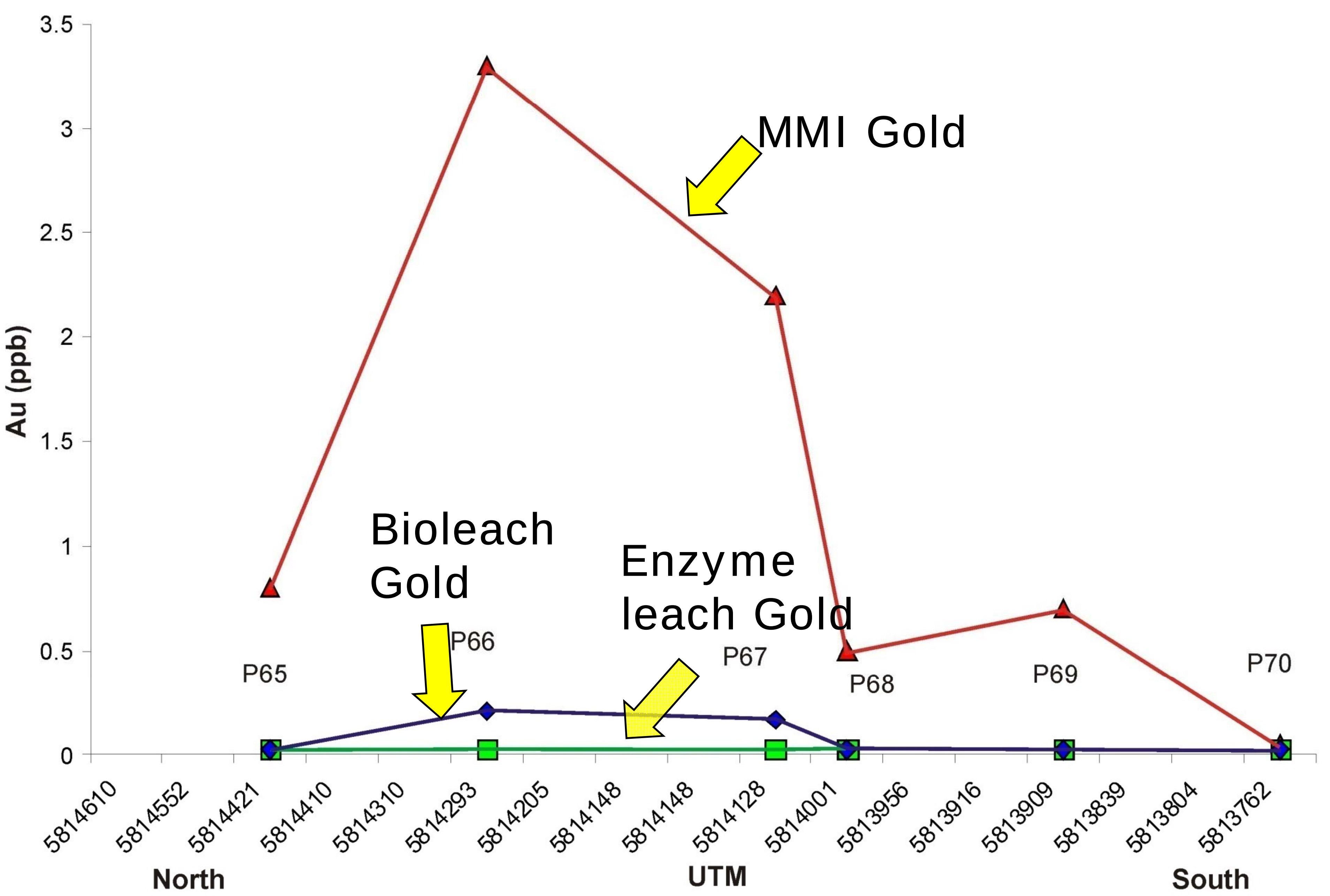
Cu ppb
2500
2000
1500
1000
500
0
MMI
Bio Leach
Enzyme Leach
P65
P66
P67
P68
P69
P70
5814610
5814552
5814421
5814410
5814310
5814293
5814205
5814148
5814148
5814128
5814001
5813956
5813916
5813909
5813839
5813804
5813762
North
UTM
South



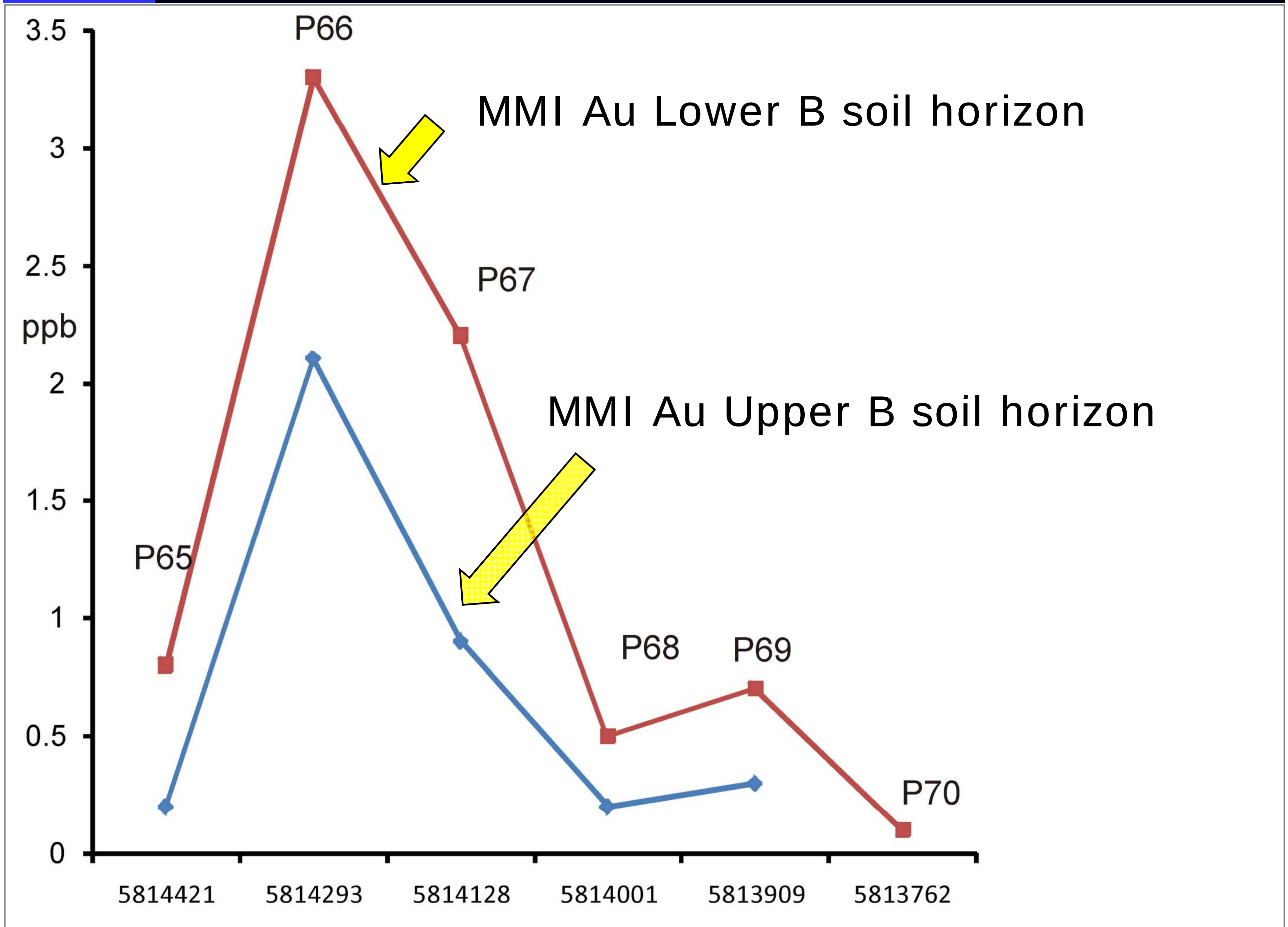
2500
2000
1500
1000
500
0
ppb
P65
P66
P67
P68
P69
P70
MMI Cu Lower B Soil horizon
Bioleach Cu Lower B Soil horizon
MMI Cu Upper B Soil horizon
Bioleach Cu Upper B Soil horizon
5814421
5814293
5814128
5814001
5813909
5813762

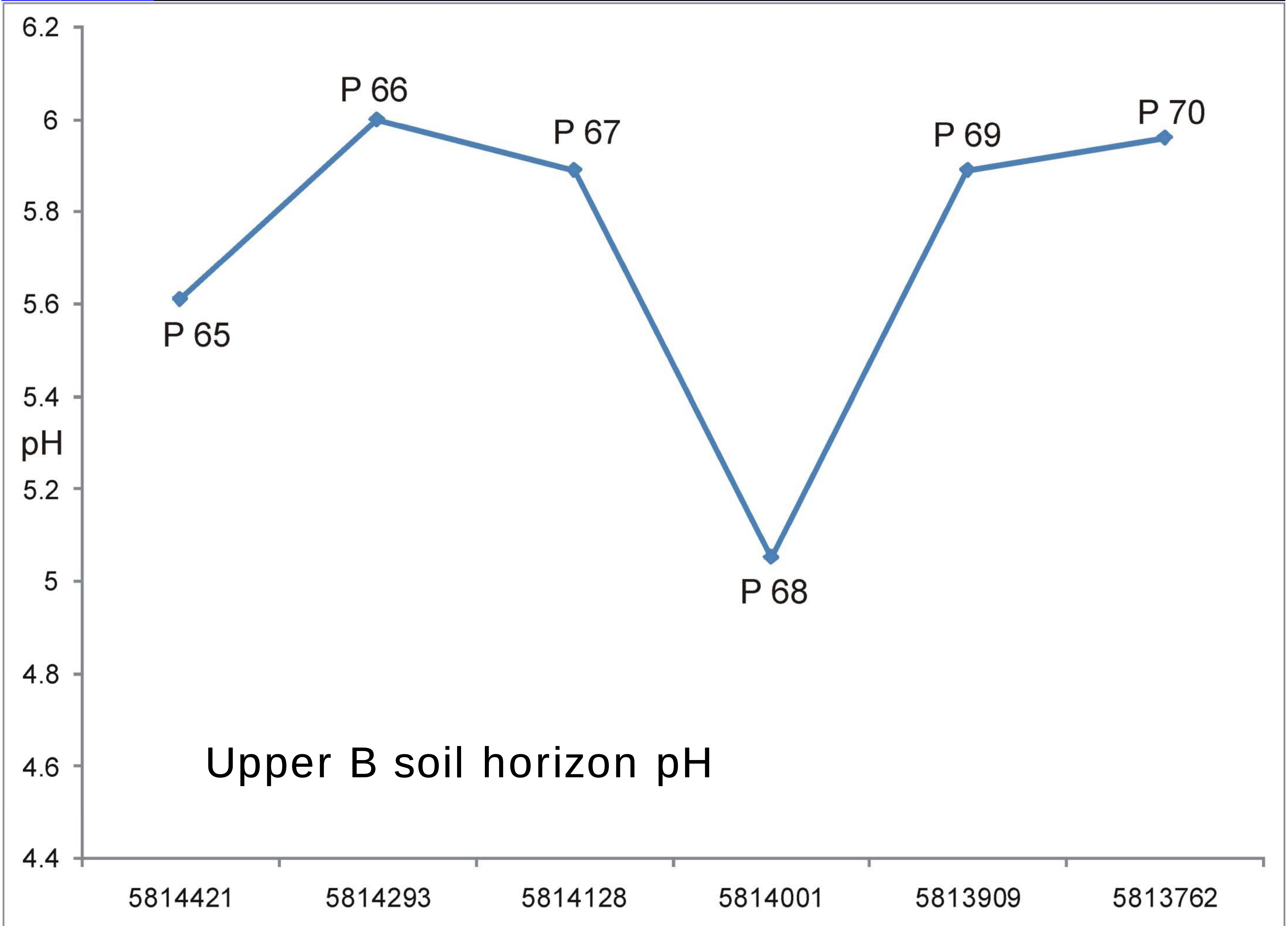


Au (ppb) in soil & number of Au grains
90
80
70
60
50
40
30
20
10
0
5814610
5814552
5814421
5814410
5814310
5814293
5814205
5814148
5814148
5814128
5814001
5813956
5813916
5813909
5813839
5813804
5813762
North
UTM
South
Total Au Grains in HMC
Pristine Au grains in HMC
C
Lower B
Upper B
P65
P66
P67
P68
P69
P70

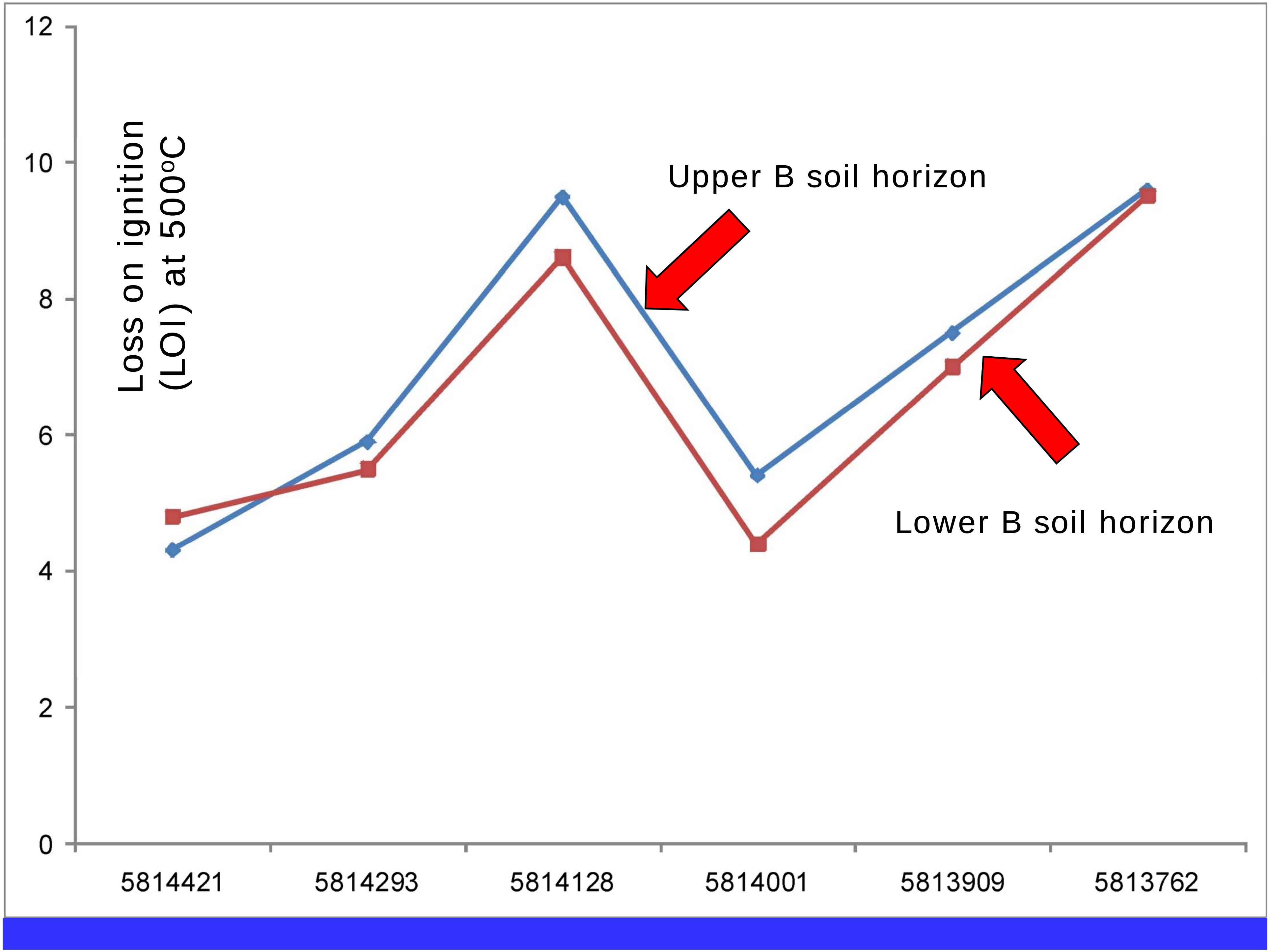


MMI Gold
Bioleach Gold
Enzyme leach Gold
P65
P66
P67
P68
P69
P70
Au (ppb)
3.5
3
2.5
2
1.5
1
0.5
0
5814610
5814552
5814421
5814410
5814310
5814293
5814205
5814148
5814148
5814128
5814001
5813956
5813916
5813909
5813839
5813804
5813762
North
UTM
South


3.5
3
2.5
ppb
2
1.5
1
0.5
0
P66
P67
P65
P68
P69
P70
MMI Au Lower B soil horizon
MMI Au Upper B soil horizon
5814421
5814293
5814128
5814001
5813909
5813762

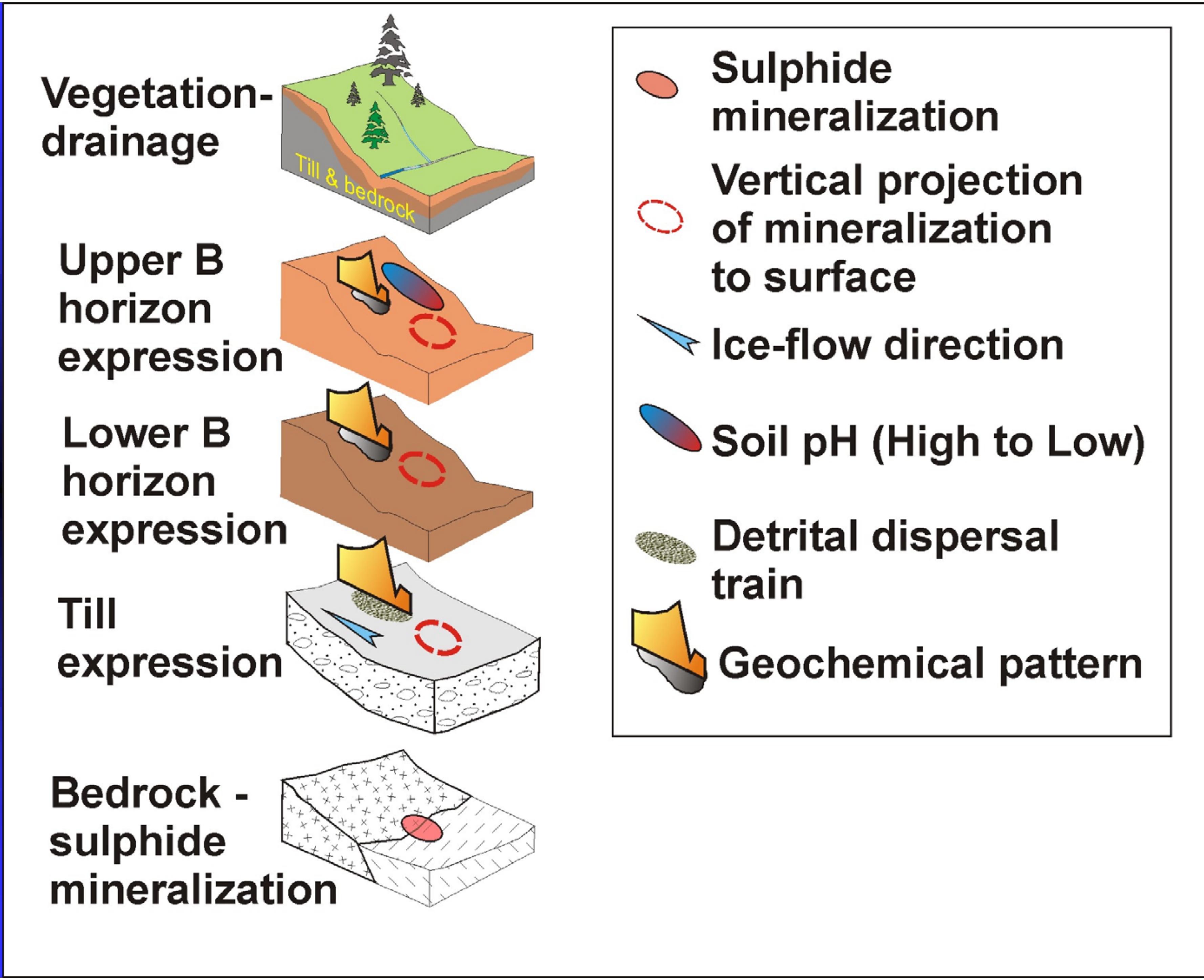


Upper B soil horizon pH
pH
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
P 65
P 66
P 67
P 68
P 69
P 70
5814421
5814293
5814128
5814001
5813909
5813762



Loss on ignition (LOI) at 500ºC
Upper B soil horizon
Lower B soil horizon
12
10
8
6
4
2
0
5814421
5814293
5814128
5814001
5813909
5813762


HANNA
6.71
CAL
/MODE
SET/HOLD
Combo
pH & EC
waterproof
EXTECH
INSTRUMENTS
7.44
ExStik II
MODE
HOLD
CAL
RECALL
ON
OFF
PH110
Refillable pH
perpHect™
Buffer 7
ORION



Vegetation-drainage
Till & bedrock
Upper B horizon expression
Lower B horizon expression
Till expression
Bedrock - sulphide mineralization
Sulphide mineralization
Vertical projection of mineralization to surface
Ice-flow direction
Soil pH (High to Low)
Detrital dispersal train
Geochemical pattern

GSB Geochemistry

- Field – Improve geochemical methods.
- Training – Support student research.
- Laboratory – GSB Analytical Services.
- Assayers Program – Certification.
- Partnerships – GSC, GSBC, Industry.
- Database upgrades (e.g. RGS)
- Client services

New Geochemical Information

- BCGS Geofile 2008-8 Vancouver Island Geochemical Orientation Survey Results – Sept. 2008.
- BCGS Geofile 2009- 11 Geochemical pathfinders for Cu-Au porphyry deposits – Dec. 2009.

Key Geological Concepts on the Distribution of Jurassic Porphyry Au-Cu (Mo) and Epithermal (Au-Ag) Deposits in the Toodoggone District, North-Central B.C.

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Dept. of Earth & Ocean Sciences, University of British Columbia

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Sponsors :

The Toodoggone Team - Acknowledgements

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Jenni Dickinson – M.Sc. Student
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U Alberta
Dr. Robert A. Creaser
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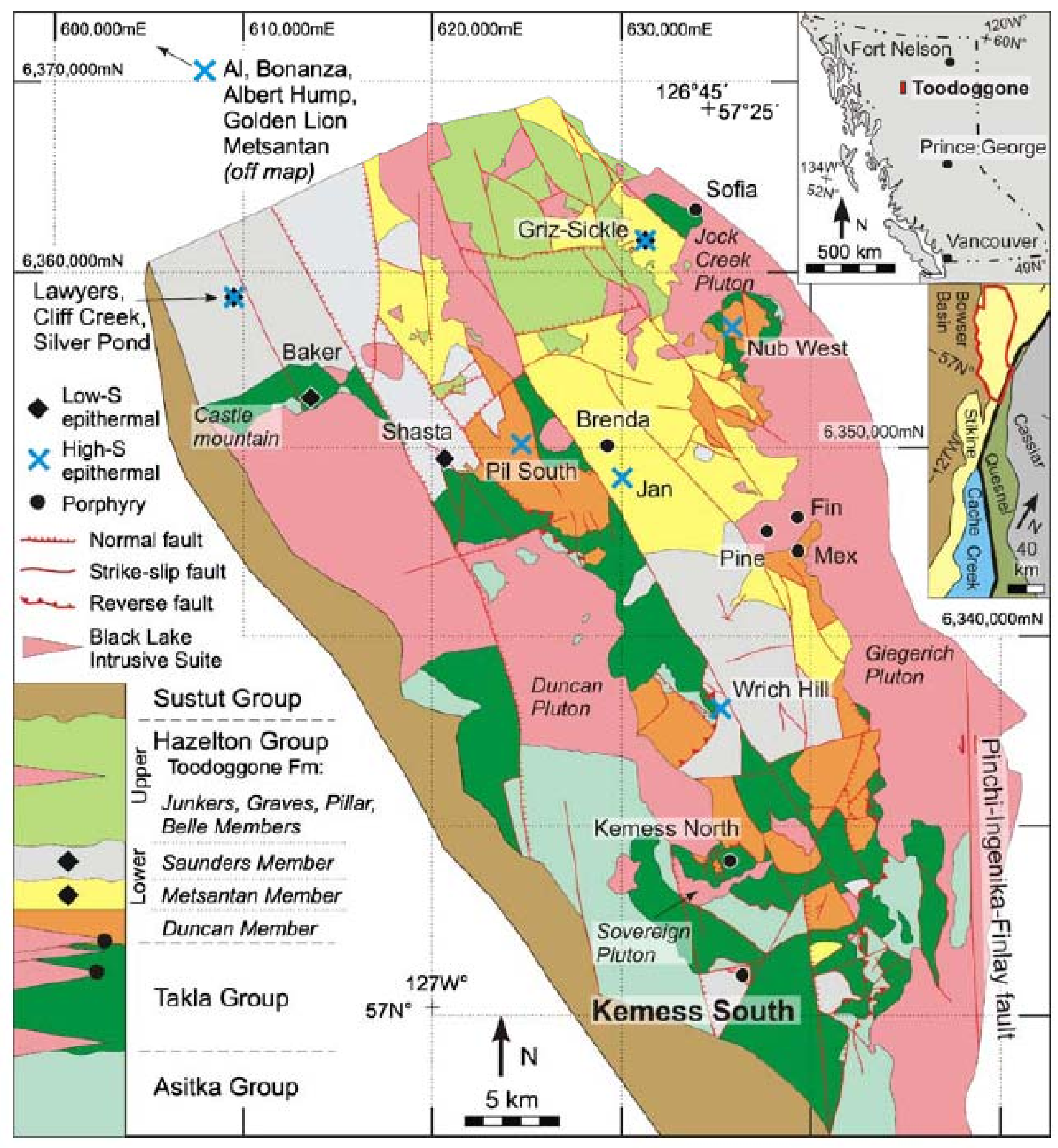
Stealth Minerals
Bill McWilliam, Dave Kuran, Dave Blann
Sable Resources
Mel Rahal
GSC
Rob Shives

Toodoggone NSERC-CRD Project 2004-2007

Two papers just out this summer

- Duuring et al. (2009) Magmatic and structural controls on porphyry-style Cu-Au-Mo mineralization at Kemess South, Toodoggone district of British Columbia, Canada. *Mineralium Deposita,* v. 44, p. 435-462.
- Duuring et al. (2009) Examining potential genetic links between Jurassic porphyry Cu-Au±Mo and epithermal Au±Ag mineralization in the Toodoggone district of North-Central British Columbia, Canada. *Mineralium Deposita,* v. 44, p. 463-496.
- Dickinson et al. on the Pine Porphyry Au-Cu and McKinley et al. on Kemess North submitted shortly.



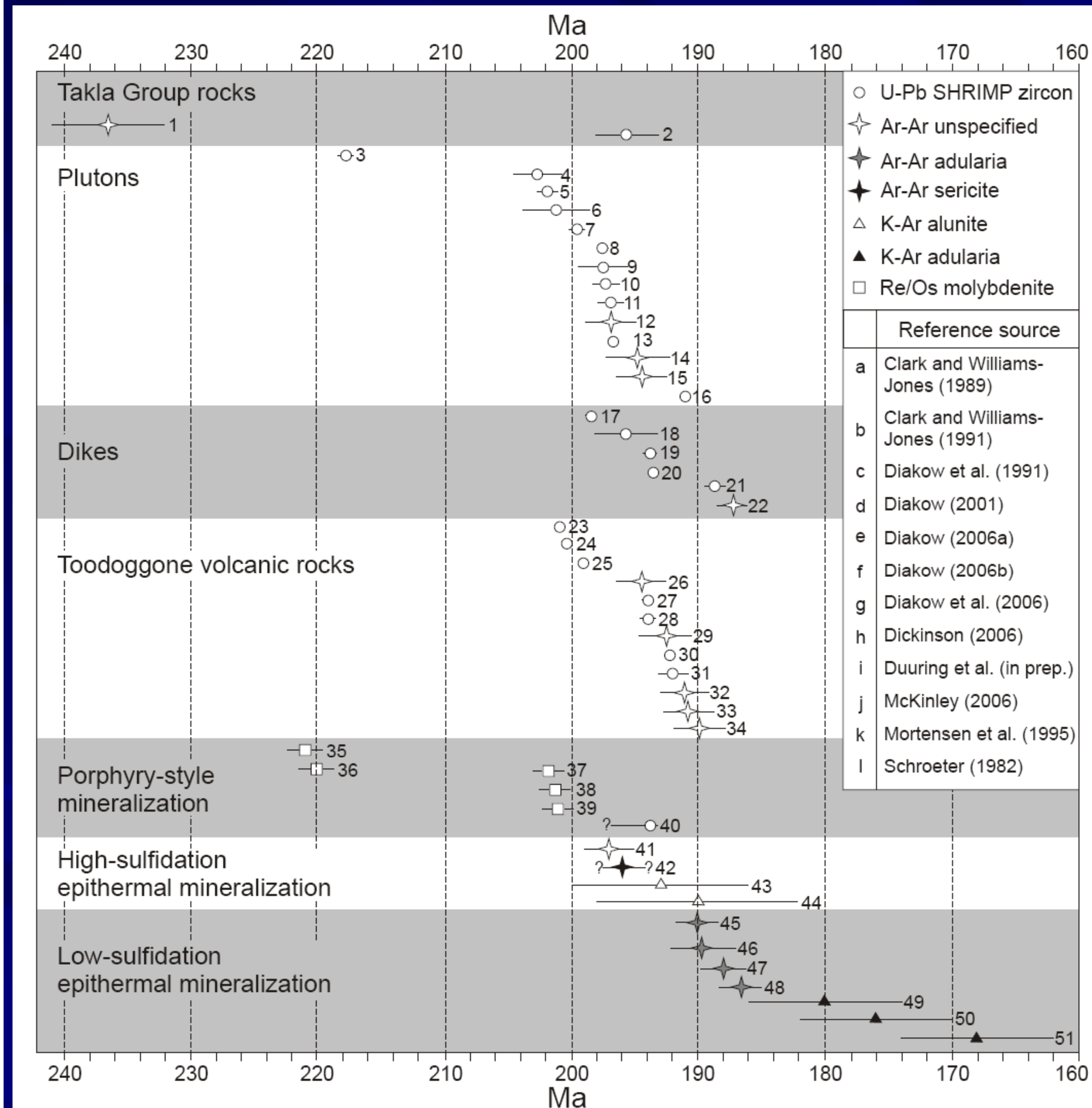
Toodoggone geology

100 km long by 30 km wide, NNW-trending belt of volcano-sedimentary rocks that hosts porphyry and epithermal deposits

Project aims :

- Construct detailed deposit models for porphyry and epithermal systems and investigate possible linkages
- Use the factual deposit models to develop a predictive Au-Cu exploration model for the entire district

Summary of Geochronological Data (*Duuring et al. 2009*)

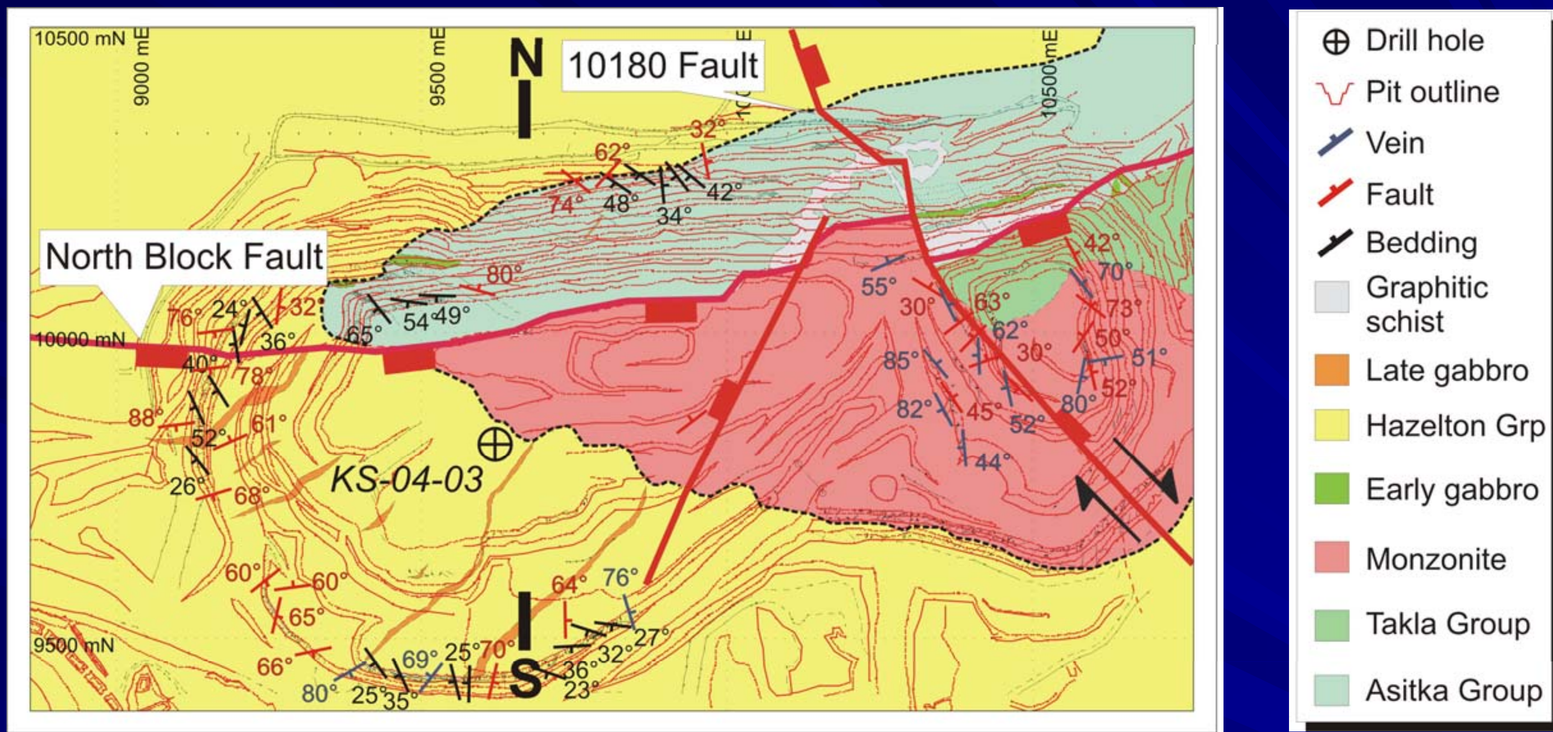


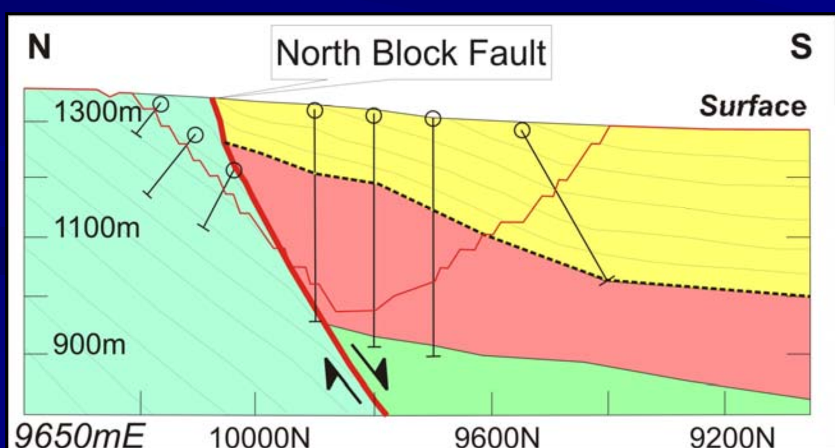
Close temporal overlap between porphyry intrusion ages (ca. 205-191 Ma) and porphyry-style mineralization (ca. 203-194 Ma).

HS ages (ca. 201-182 Ma) overlap proximal porphyry intrusions and the youngest porphyry-style mineralization in the district at Pine (194 Ma).

LS ages (ca. 192-162 Ma) only overlap poorest quality HS ages and none of the porphyry intrusion ages. (several dykes at Griz-Sickle & Brenda do overlap).

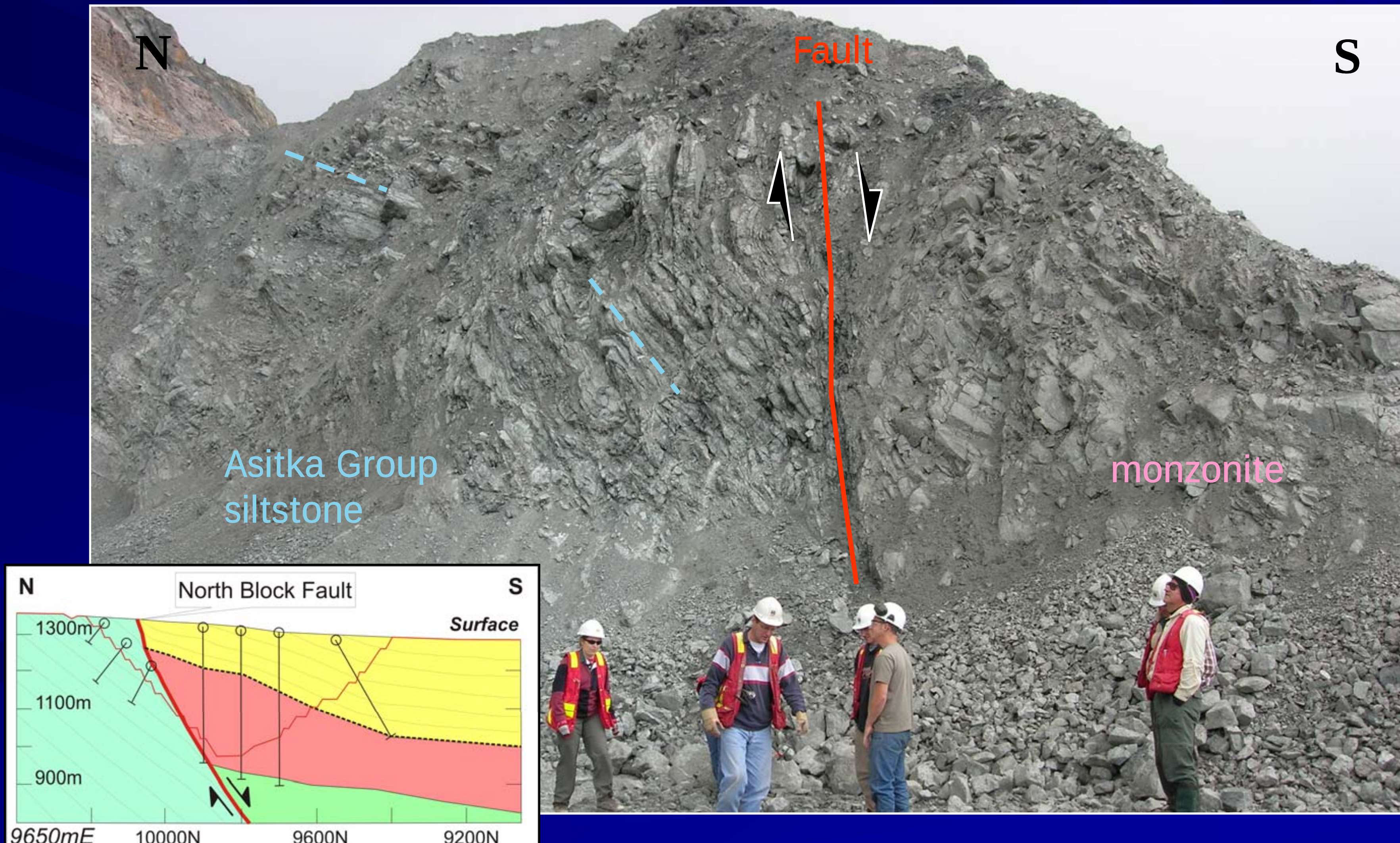
The Kemess South Mine - structure



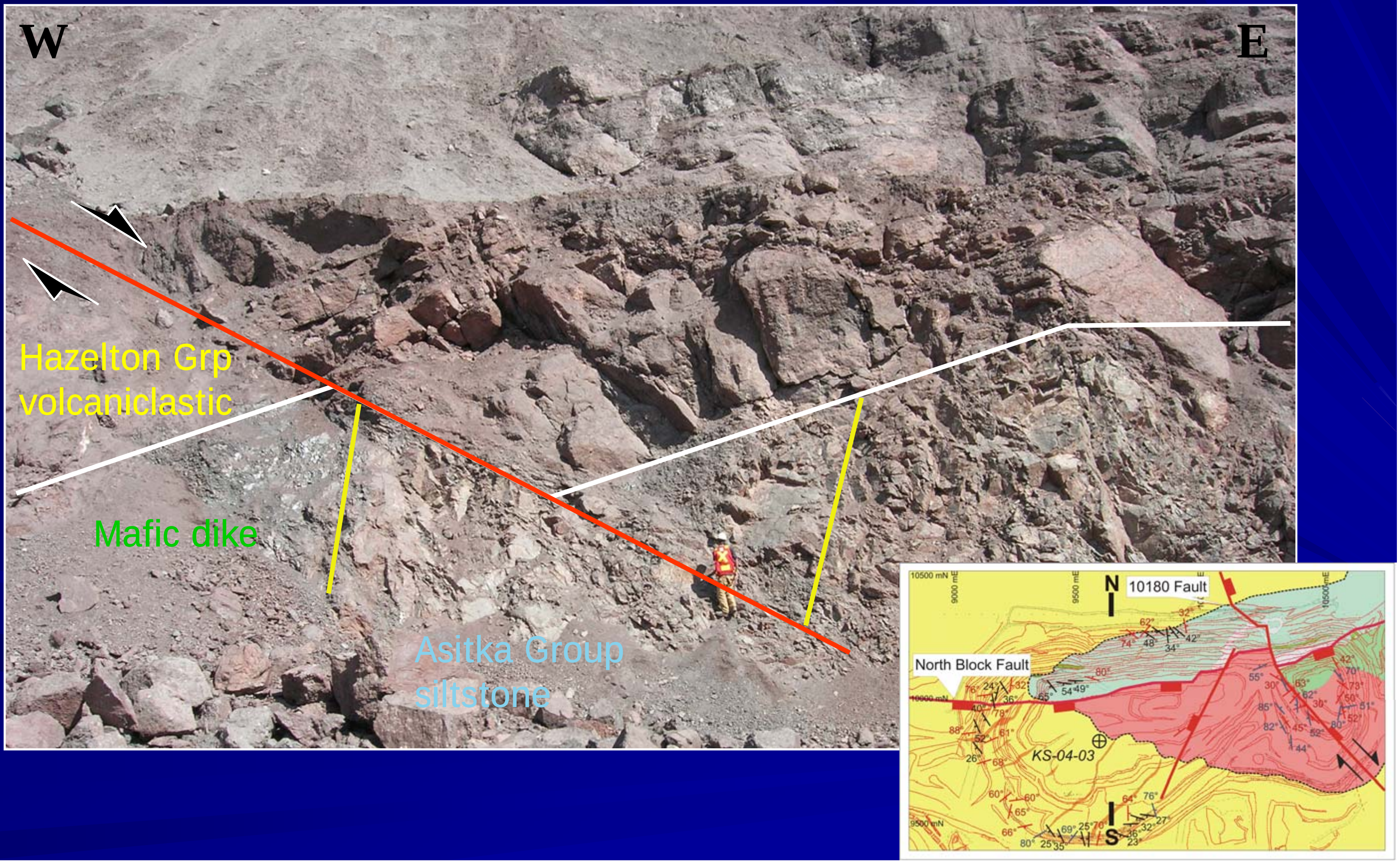


- E-striking fault
- Cut by later NW- and NE-striking faults
- Contact between MLG & Takla is intrusive
- Contact between MLG & Asitka is tectonic (fault)
- Contact between MLG & Hazelton Gr. is nonconformable

E-striking fault

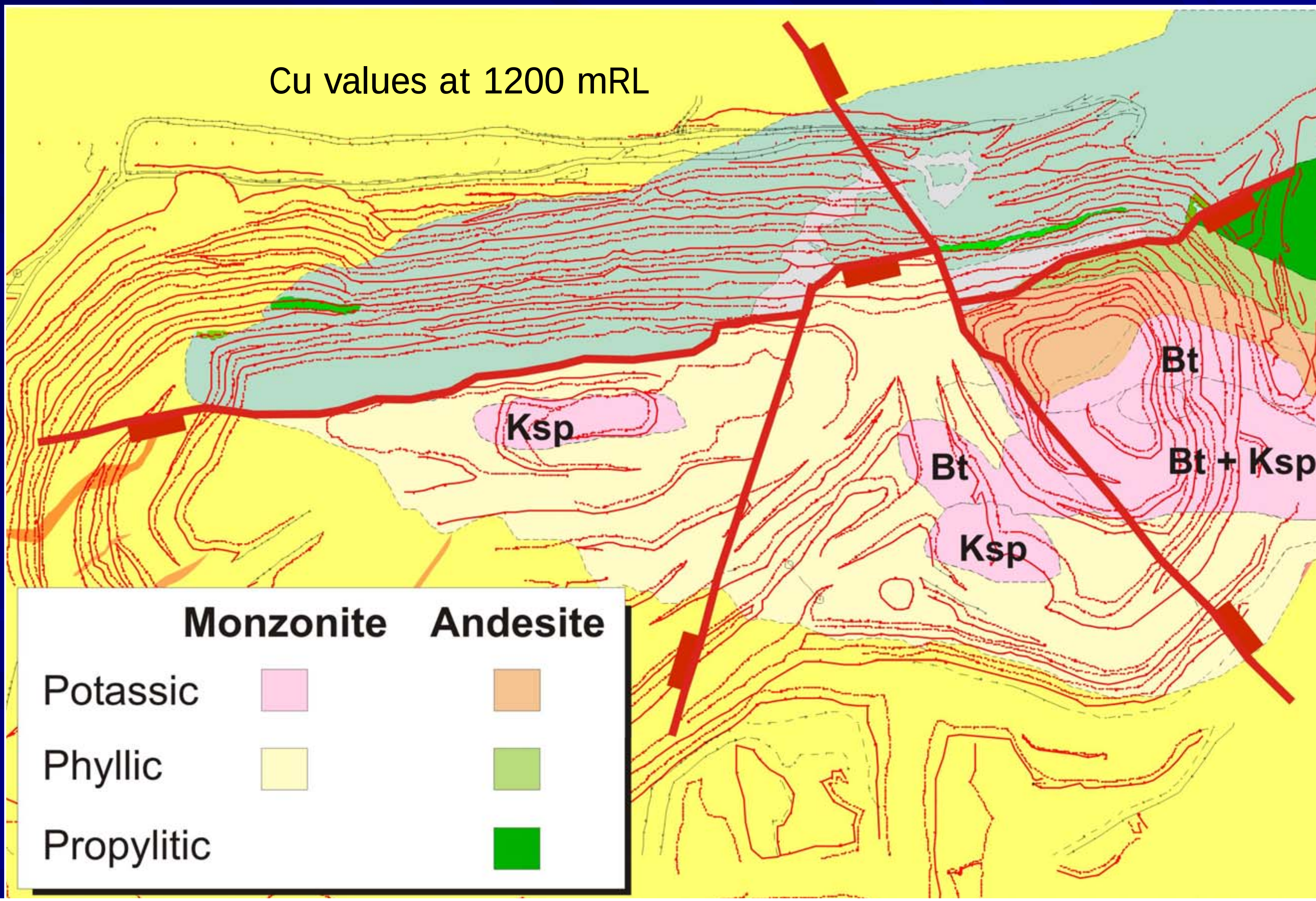


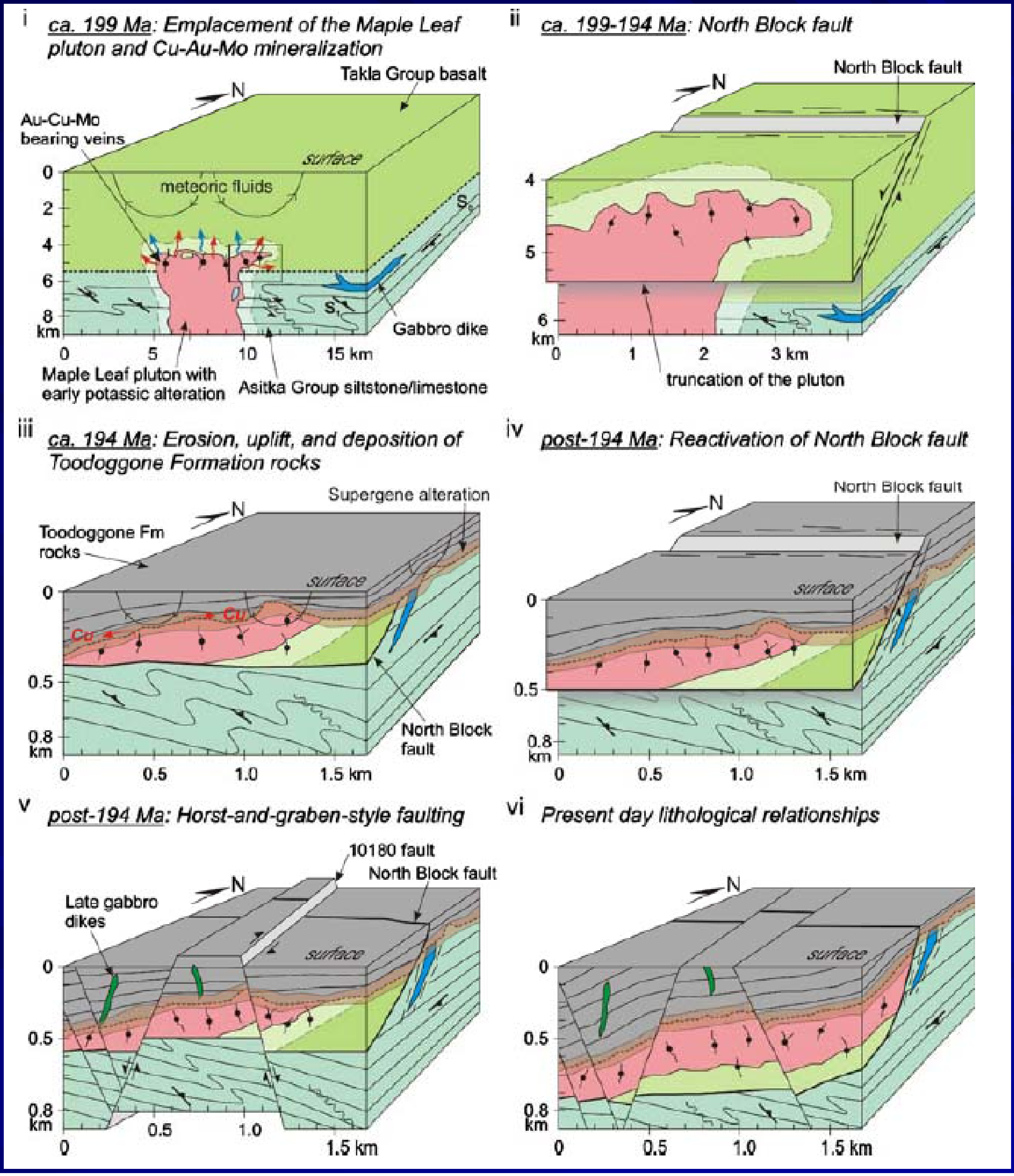
NW- and NE-striking faults



Au-Cu-Mo distribution

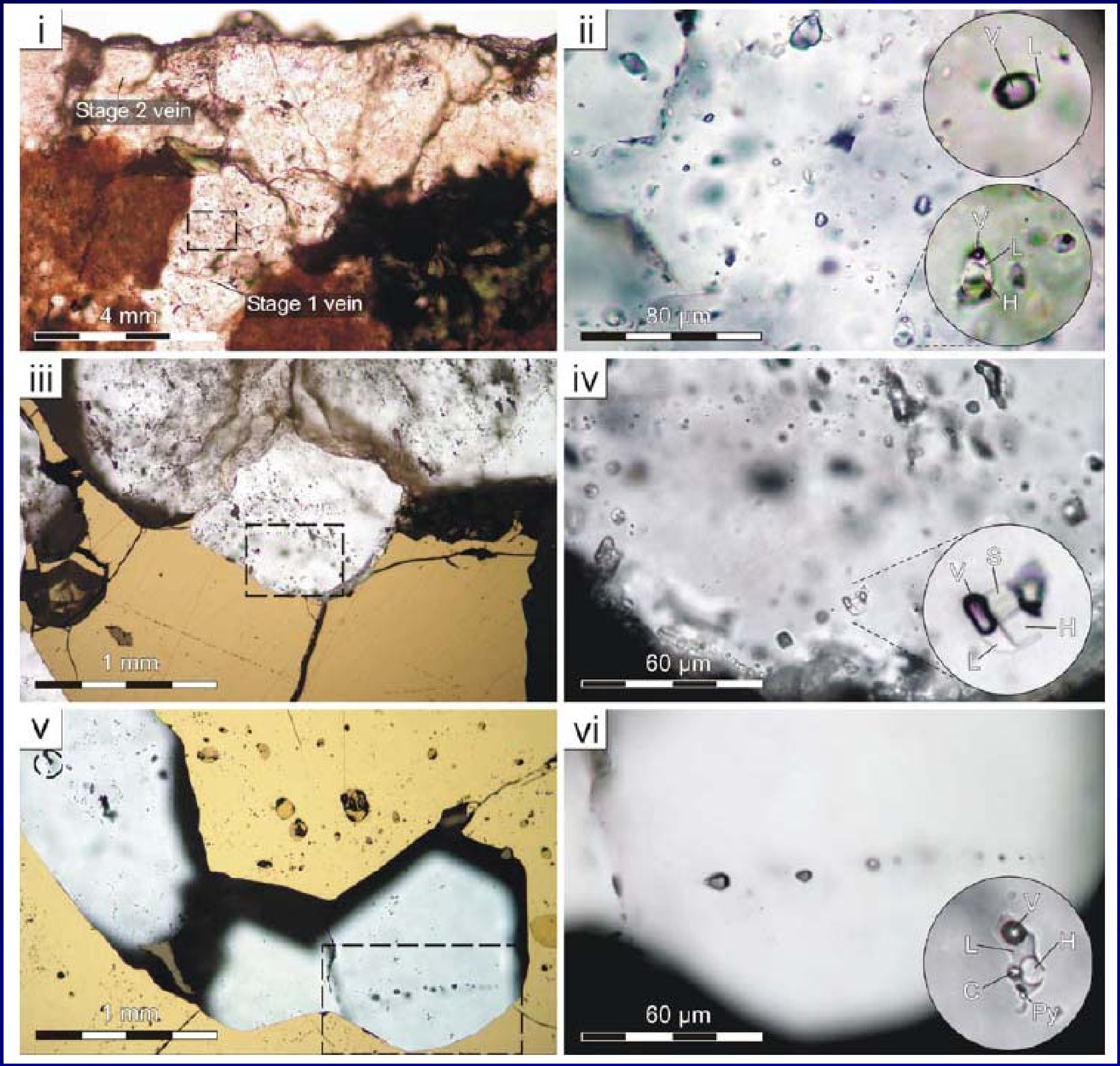
Alteration





Tectono-magmatic Evolution of Kemess South

- i: Emplacement of MLG
- ii: NBF
- iii: Erosion, uplift, deposition of TD Fm. Rocks
- iv: Reactivation of NBF
- v: Horst-and-graben faults
- vi: Present-day



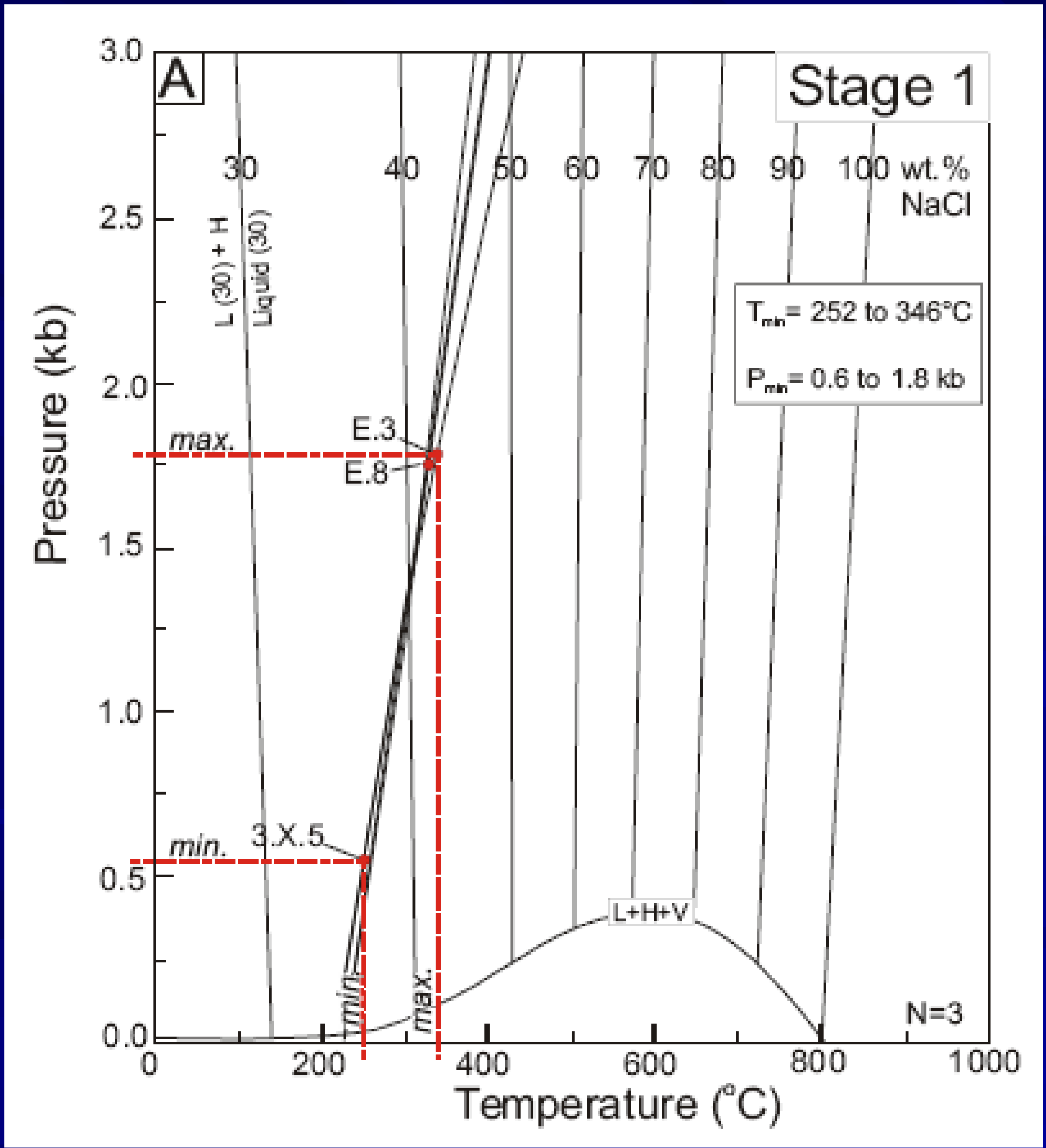
Kemess South Fluid Inclusion Petrography

i & ii: Early Stage (Stage 1) Qtz-Py-Bt vein

iii & iv: Early Stage (Stage 2) Qtz-Py-Cpy-Mo-Mag-Bis vein

v & vi: Main-stage (Stage 3) Py-Qtz-Cpy-Ser-Cal-Mo vein

Kemess South Microthermometry: Early-stage veins (Stage 1)

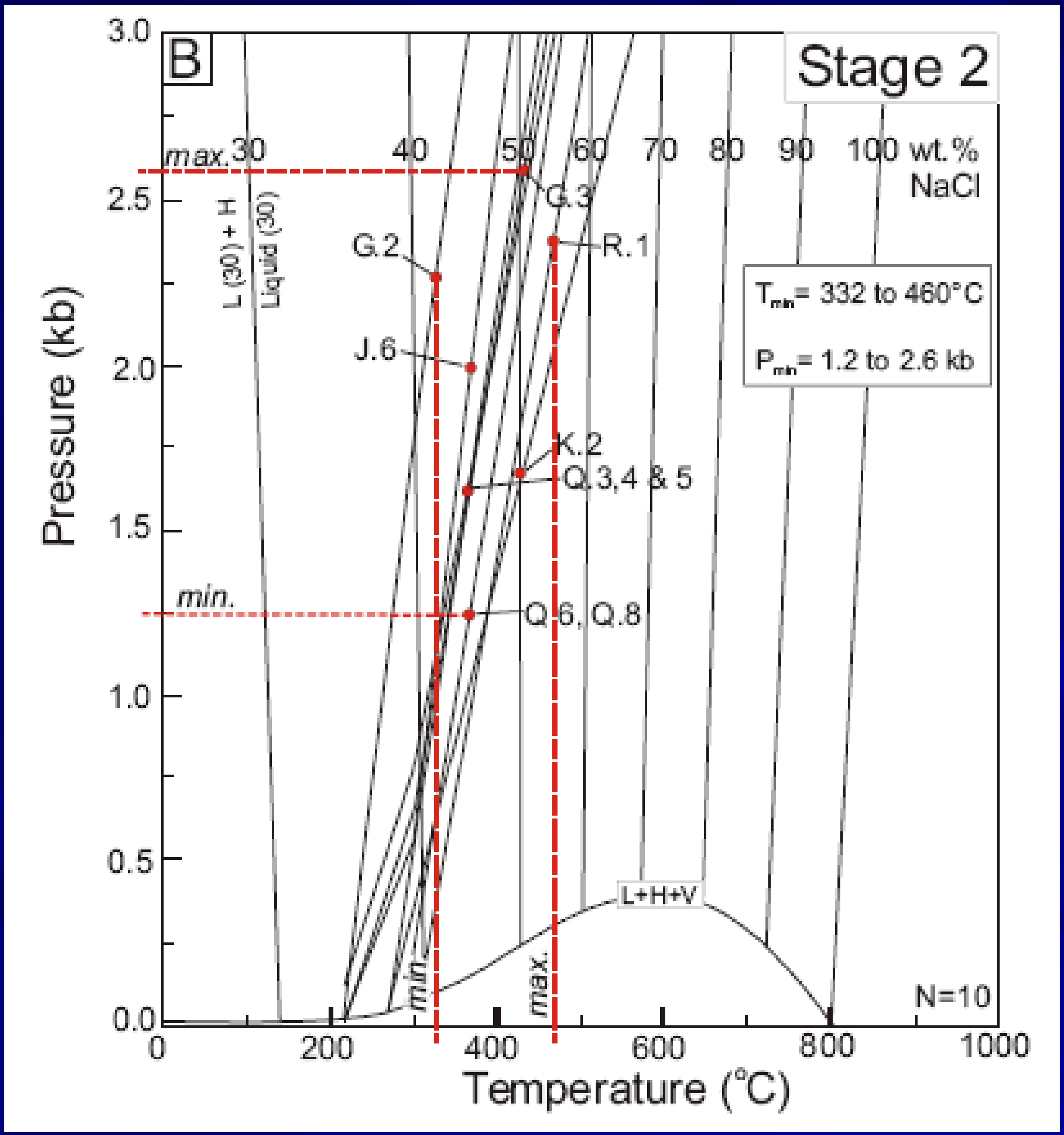


P-T diagram of the H2O-NaCl system with halite liquidii and isochores for fluid inclusions from Kemess South.

Pressures of 0.6 to 1.8 kb correspond to depths of vein formation from 2.0 km to 5.9 km assuming lithostatic conditions and 1 kb = 3.3 km.

(Bodnar and Vityk, 1994)

Kemess South: Early-stage veins (Stage 2)



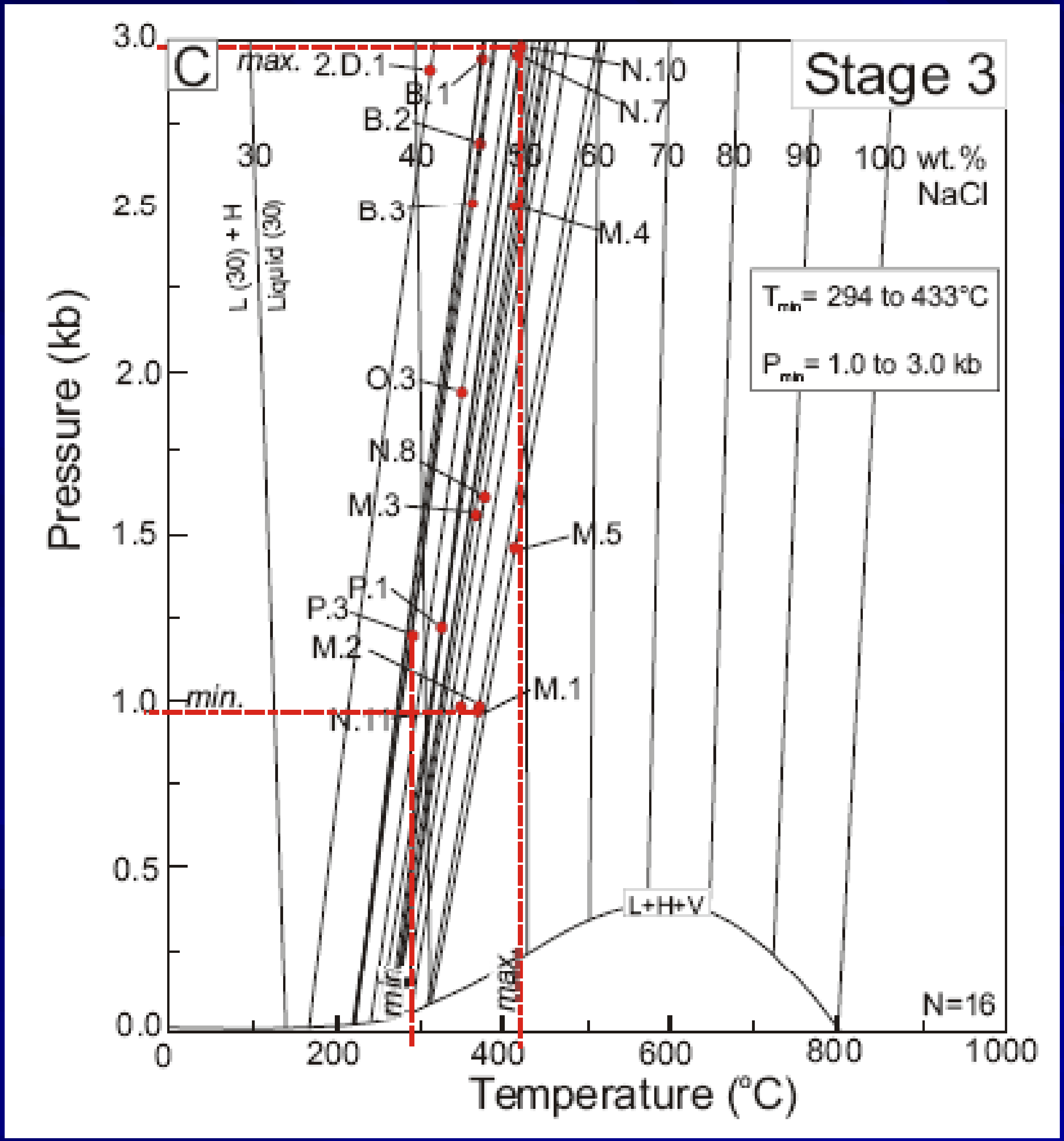
P-T diagram of the H2O-NaCl system with halite liquidii and isochores for fluid inclusions from Kemess South.

Pressures of 1.2 to 2.6 kb correspond to depths of vein formation from 4.0 km to 8.6 km assuming lithostatic conditions and 1 kb = 3.3 km.

The deeper estimates may be unreliable, although Butte has roots to 9 km.

(Bodnar and Vityk, 1994)

Kemess South: Main-stage veins (Stage 3)



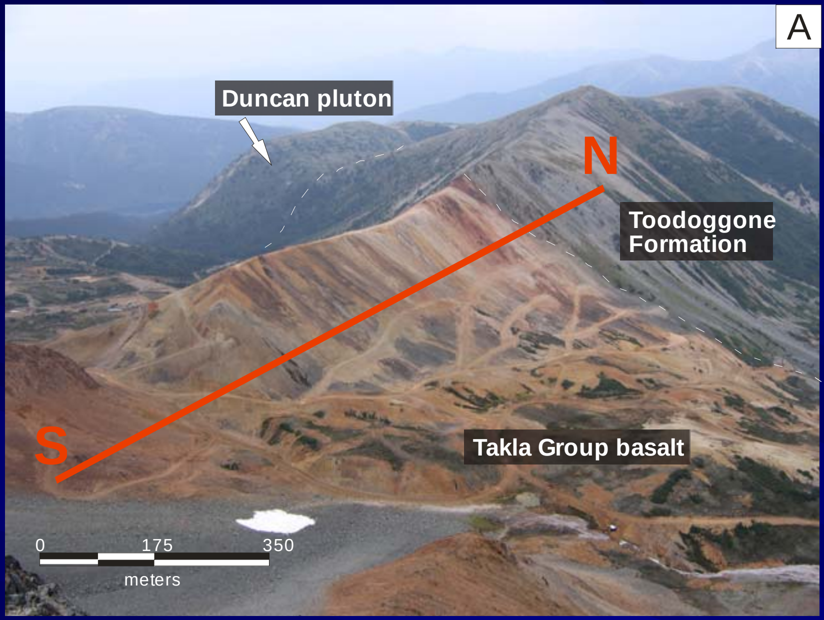
P-T diagram of the H2O-NaCl system with halite liquidii and isochores for fluid inclusions from Kemess South.

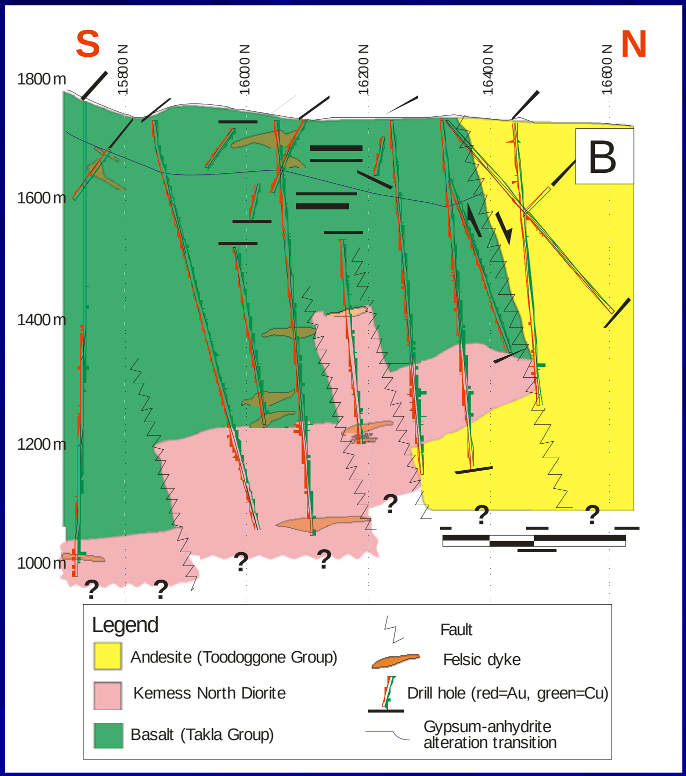
Pressures of 1.0 to 3.0 kb correspond to depths of vein formation from 3.3 km to 9.9 km assuming lithostatic conditions and 1 kb = 3.3 km.

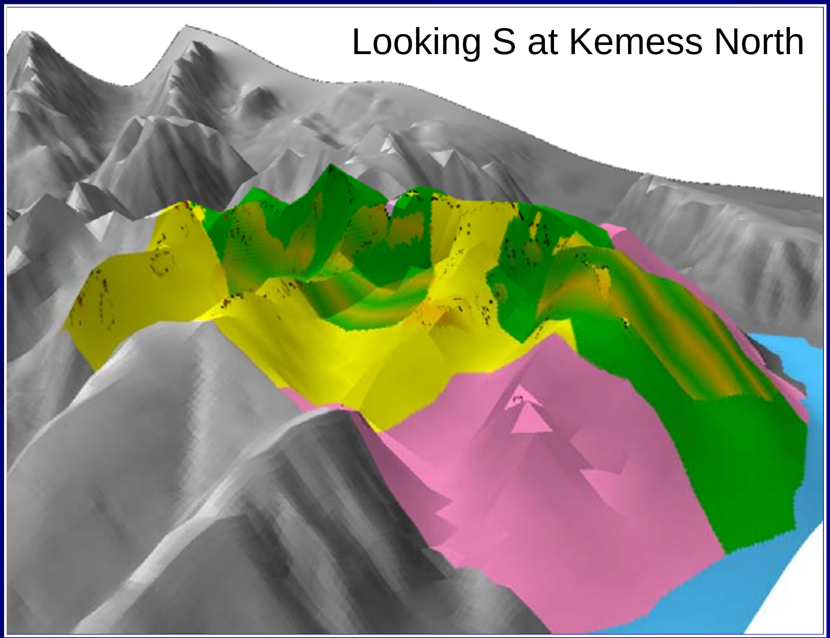
The deeper estimates are unreliable.

Greater pressure variation may be expected in Main-stage veins (longer event and more widely distributed).

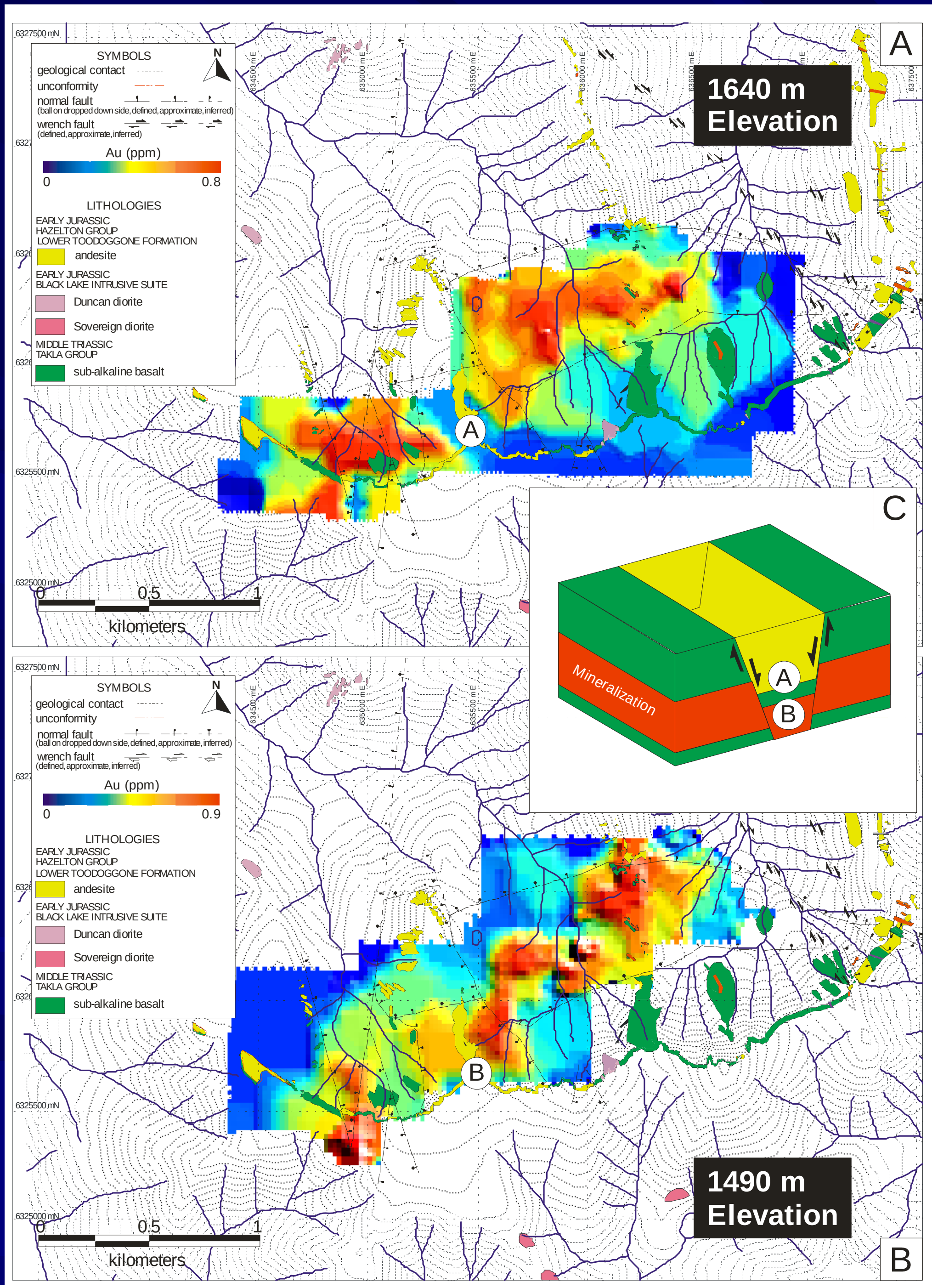
The Kemess North Deposit







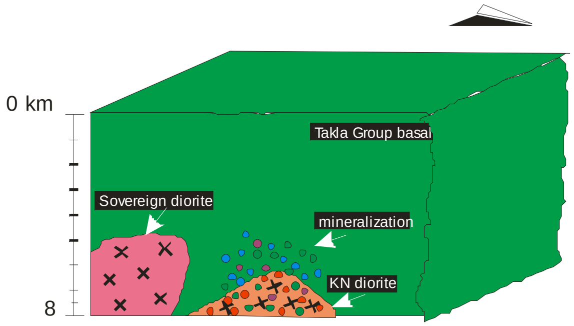
- Proven & probable reserve of 424 Mt containing 0.30 g/t Au and 0.16% Cu (Gray, 2005).
- Hosted in ca. 202 Ma diorite and overlying Takla Gr. basalt.
- Toodoggone Fm. Volcaniclastic rocks are ca. 199 Ma and crop out as prominent N-trending ridges



Kemess North: Gridded Au concentrations from 216 ddh's.

A. Two discrete near-surface ore bodies in Takla Gr. basalt separated by unmineralized TD Fm.
B. 150 m below the 1640 m RL, Au values are continuous across Takla Gr.
C. Block model demonstrating the disruption of a laterally continuous orebody by horst-and-graben normal faulting. Unmineralized TD Fm rocks down-dropped in the graben thereby lying adjacent to mineralized Takla Gr.

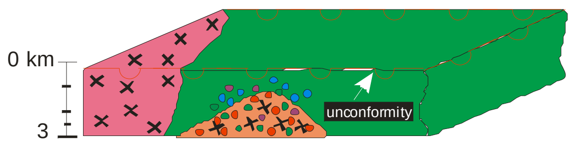
Reverse Fault Model



A. Sovereign diorite intrudes the Takla Group basalt at 202.7 ± 1.9 Ma (Diakow 2001)

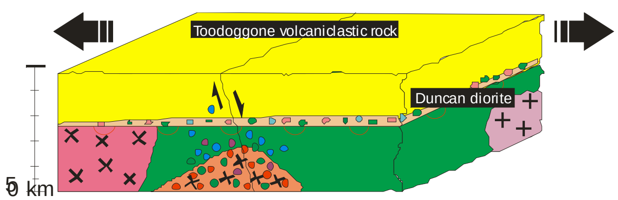
Kemess North diorite intrudes at ca. 202 Ma (Diakow 2006b).

Au-Cu-Mo mineralization associated with the Kemess North diorite occurs at 201.8 ± 1.2 Ma (Re-Os on molybdenite)



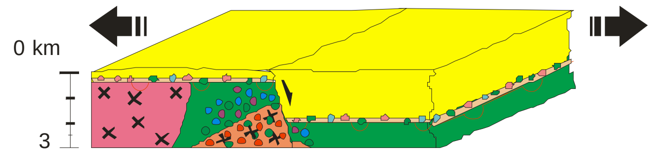
B. Erosion and uplift occurs at an estimate rate of 1.7 km/My

This results in the exposure of the Sovereign diorite

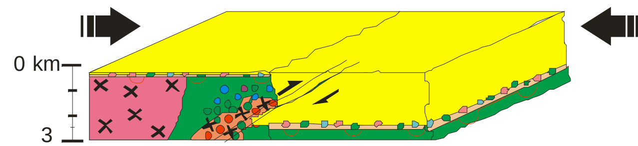


C. Toodoggone Formation rocks (Duncan Member) are deposited at 199.1±0.3 Ma (Diakow 2001)

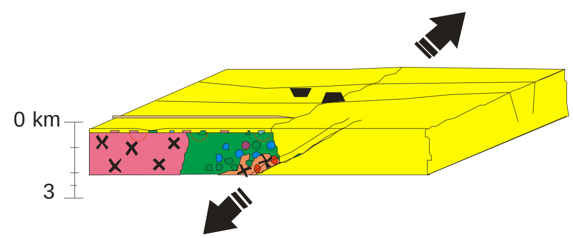
The Duncan diorite pluton intrudes the Toodoggone Formation volcaniclastic rocks and Takla Group basalt at 197.3 ± 1.1/0.9 Ma (Diakow 2001)



D. North-south directed extension results in a steeply dipping, E-W striking normal fault that truncates the diorite and Takla Group basalt, and Toodoggone Formation rocks.

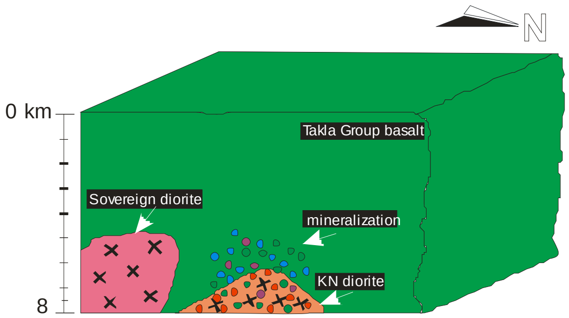


E. North-south directed shortening results in the formation of shallow, S-dipping reverse faults that truncate the Kemess North diorite. Younger Toodoggone Formation rocks are displaced beneath the Kemess North diorite



F. NW directed extension results in horst-and-graben style block shuffling of the stratigraphy

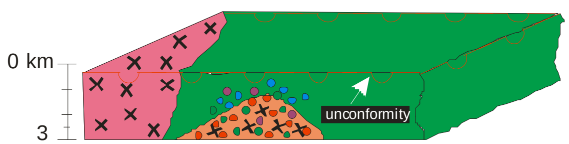
G. Finally, uplift and erosion results in the present-day exposure at Kemess North.



A. Sovereign diorite intrudes the Takla Group basalt at 202.7 ± 1.9 Ma (Diakow 2001)

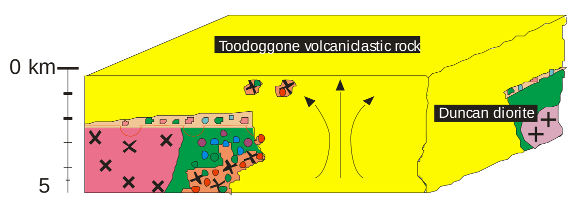
Kemess North diorite intrudes at ca. 202 Ma (Diakow 2006b).

Au-Cu-Mo mineralization associated with the Kemess North diorite occurs at 201.8 ± 1.2 Ma (Re-Os on molybdenite)



B. Erosion and uplift occurs at an estimate rate of 1.7 km/Ma

This results in the exposure of the Sovereign diorite

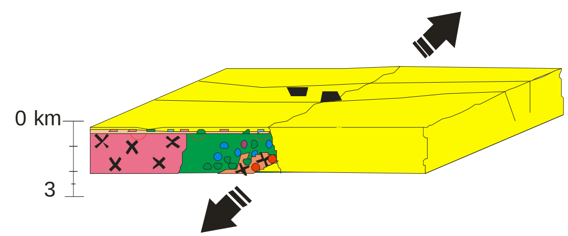


C. Toodoggone Formation (Duncan Member) rocks are deposited at 199.1± 0.3 Ma (Diakow 2001) via a fissure-style eruption, with the volcanic vent truncating the Kemess North pluton

Toodoggone Formation rocks contain clasts of Takla Group basalt and Sovereign diorite

E. Period of extension producing a large deep seated normal fault

North side of the EW-trending normal fault is down

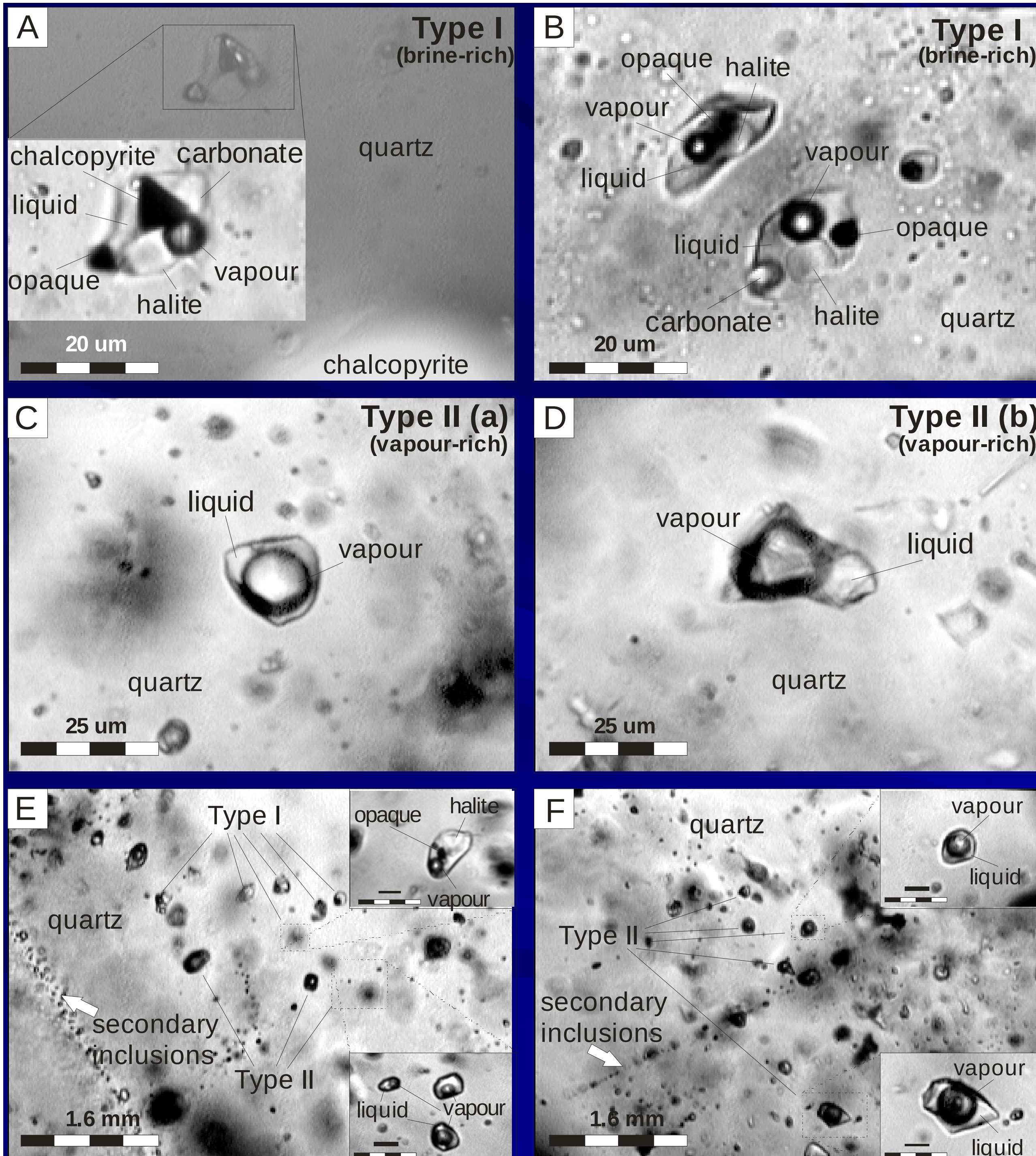


F. NW directed extension results in horst-and-graben style block shuffling of the stratigraphy

G. Finally, uplift and erosion results in the present-day exposure at Kemess North.

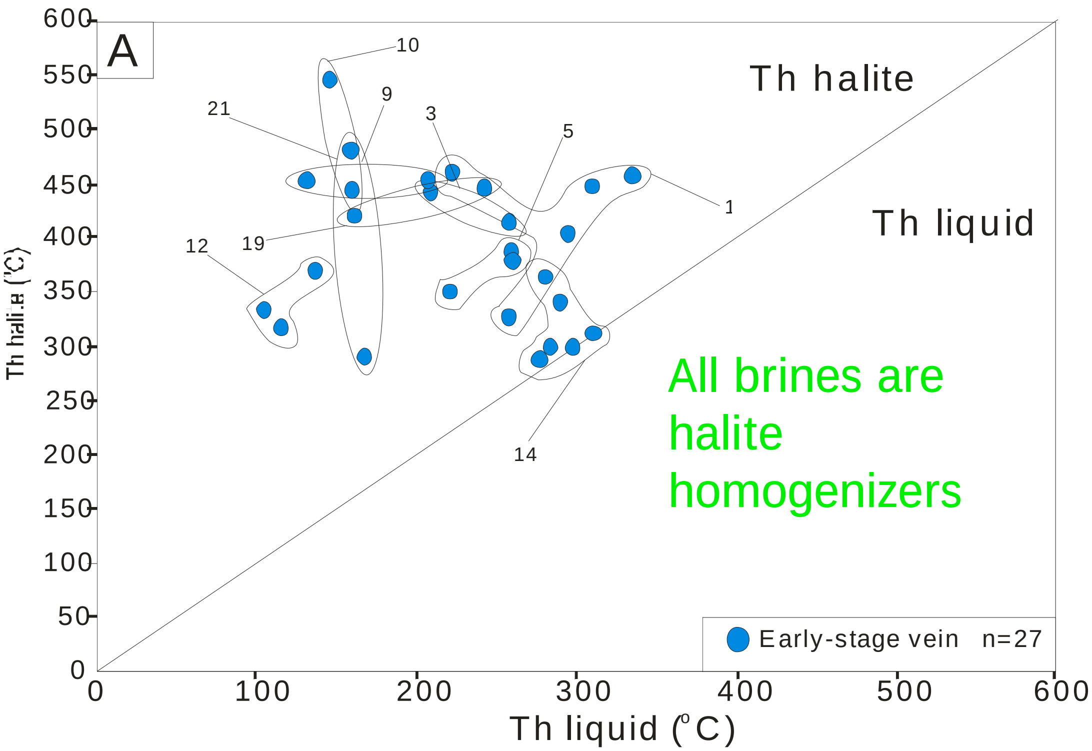
"Fissure-style Eruption"

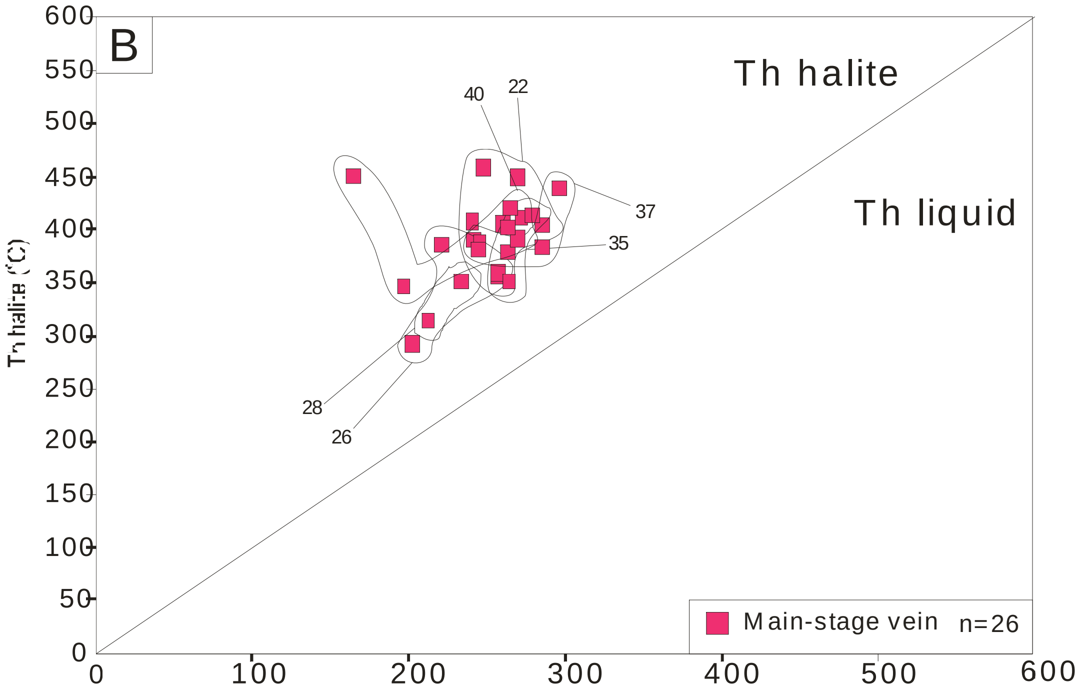
D. Duncan diorite intrudes the Toodoggone Formation volcaniclastic rocks and Takla Group basalt at 197.3 ± 1.1/0.9 Ma (Diakow 2001)



Kemess North: Fluid Inclusion Petrography

A: Early-stage vein
B: Main-stage vein
C: Early-stage vein
D: Main-stage vein
E: Early-stage vein
F: Main-stage vein



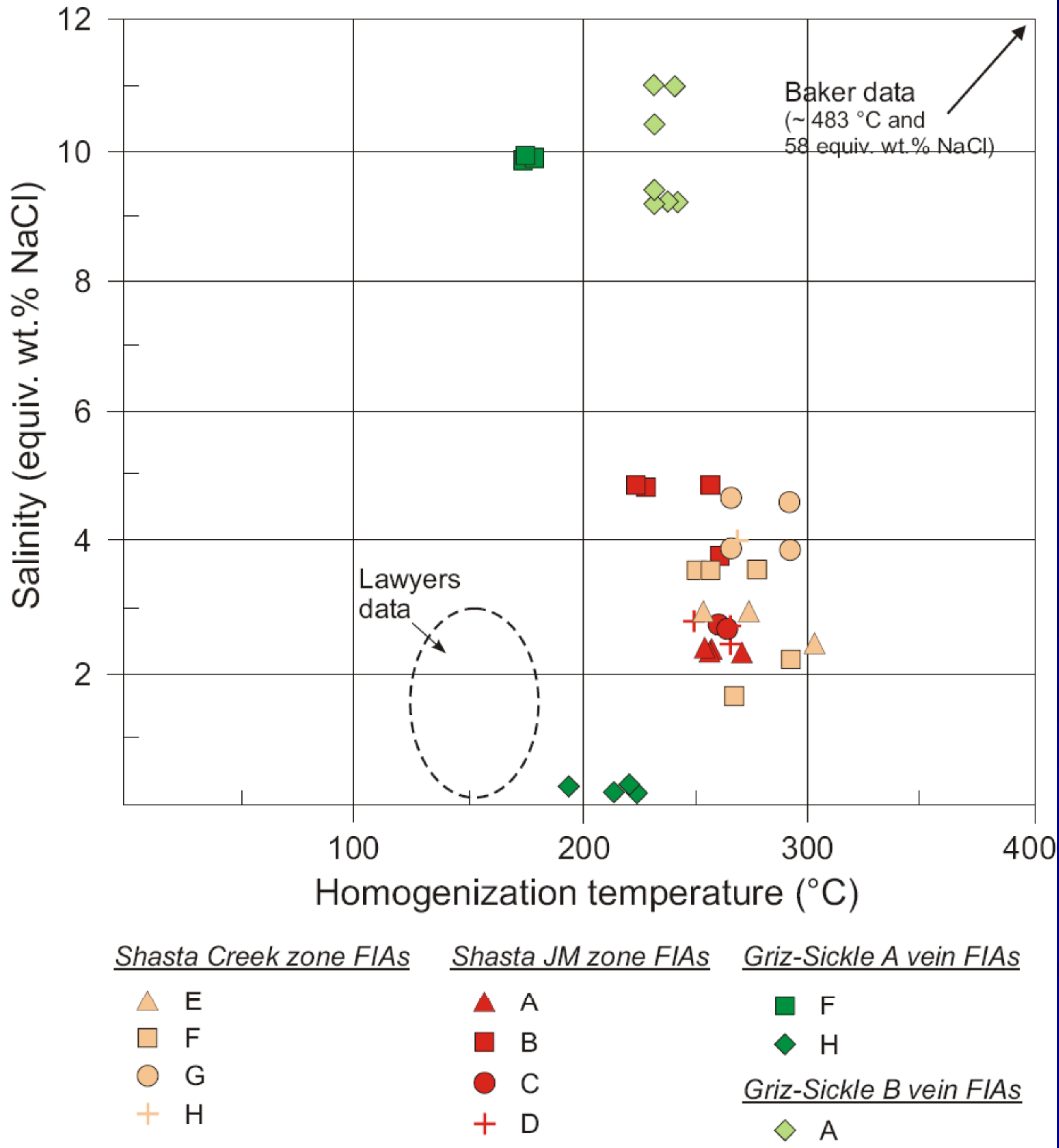


Kemess North Microthermometry

Early-stage veins (biotite)
1.5 – 2.0 kb corresponding to depths of vein formation at 5.0 to 6.6 km (using 1 kb = 3.3 km at lithostatic conditions). Corresponding temperatures range from 250° to 400 °C.

Main-stage veins (sericite)
1.2 – 2.5 kb corresponding to depths of vein formation at 4.0 to 8.2 km (using 1 kb = 3.3 km at lithostatic conditions). Corresponding temperatures range from 225° to 400 °C.

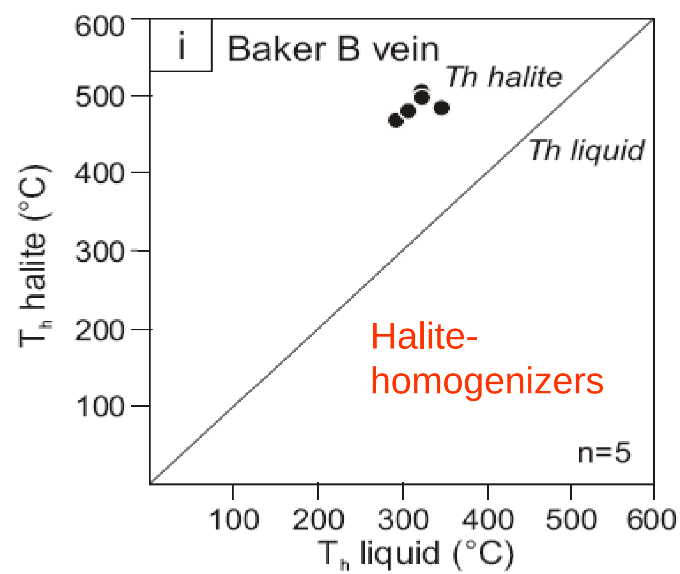
KN depths of 4 to 5 km just slightly deeper than KS depths of 2 to 4 km

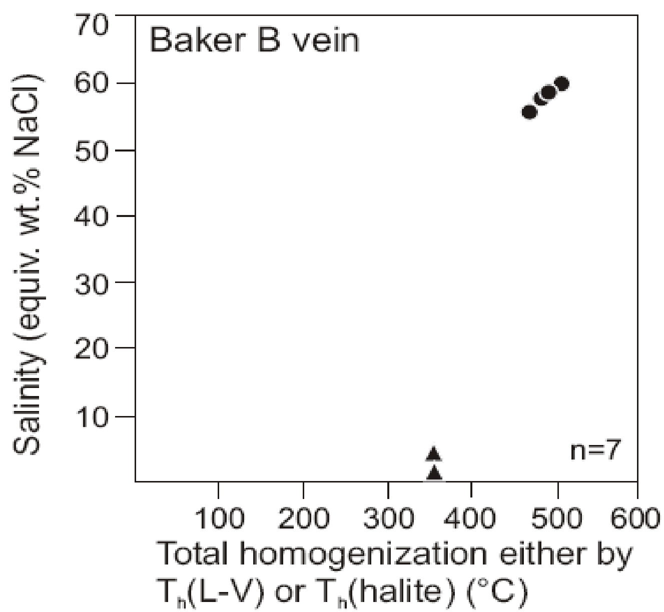


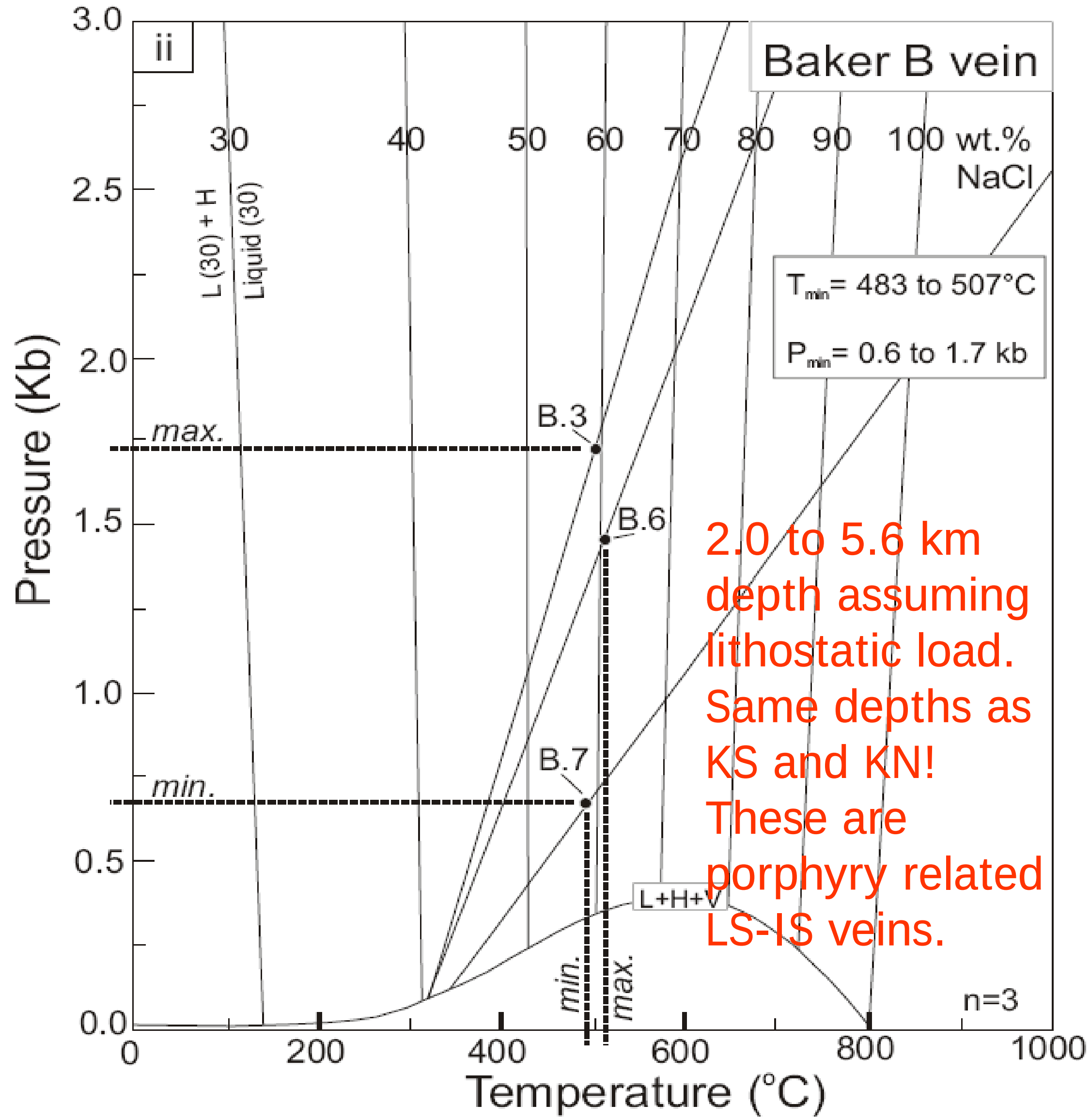
Salinity-Th (total) diagram for primary fluid inclusions from LS epithermal veins

Excluding Baker, all inclusions are primary 2-phase, liquid-rich, aqueous inclusions. Baker is anomalous with primary inclusions including high-temperature, brine-rich and vapour-rich varieties.

The Baker “B” vein - Fluid Inclusions







2.0 to 5.6 km depth assuming lithostatic load. Same depths as KS and KN! These are porphyry related LS-IS veins.

Conclusions 1: Porphyry-Epithermal Linkages

- Porphyry-style ore fluids are directly involved in the formation of LS (IS) Au (Ag) epithermal veins at the Baker mine. Baker is deep, consistent with its formation in the favourable Takla Gr. basalt, which hosts KS and KN.
- A genetic link between porphyry systems and LS Ag (Au) deposits at Shasta, Lawyers, and Griz-Sickle is not established.
- Two varieties of LS (IS) epithermal deposits in the Toodoggone. (1) “Basin & Range” types localized along the NNW-trending basin-bounding faults with no direct link to Cu-Au porphyries; and (2) Peripheral halo around porphyry systems.

Conclusions 2: Porphyry Formation Models

- Porphyry systems are "simple" (thus relatively small) and relatively deep (3-5 km). Slow-boiling "pressure cooker" release.
- Limited hypogene "upgrading" of Cu-Au ores = low grades.
- KS & KN are porphyry "cousins". Same far-field stress fields affected both deposits after formation. Similar structural controls (horst-and-graben).
- Similar vein-types and alteration styles (common magmatic systems). Local variations due to host-rock compositions.

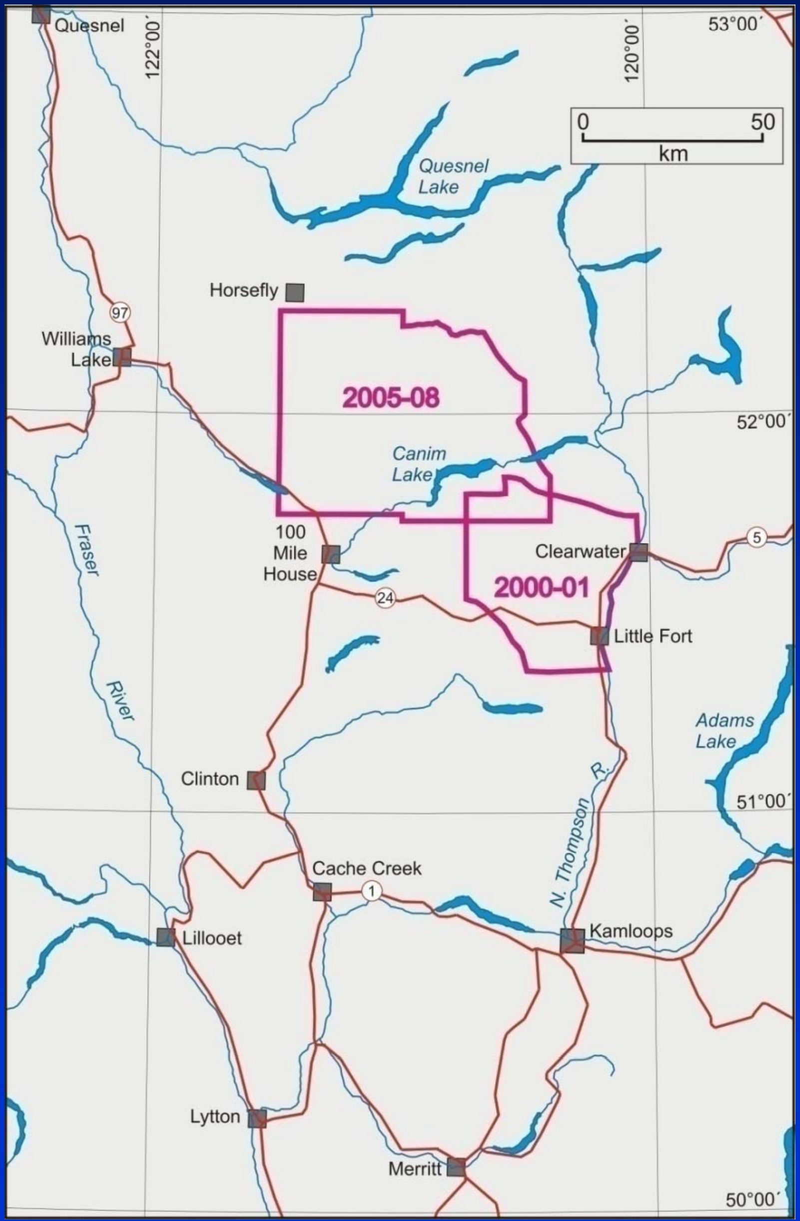
Conclusions 3: Exploration Targeting

- Normal faulting has structurally offset orebodies. They are not the result of deposits having multiple porphyry “centres”. Step across inferred faults and drill deep.
- “Point source” porphyry model with concentric zonation of alteration-mineralization is not likely very effective in the faulted & lithologically diverse Toodoggone.
- Host-rock important control over whether biotite (chl) or Kspar (ser) is dominant potassic alteration mineral. Not caused by different magma types (diorite vs. monzonite)
- No “favourable” intrusions recognized.
- Porphyries are relatively deep systems and unlikley to produce large LS epithermal systems (Baker?).
- Uplift and erosion is greatest in the south and any epithermal systems likely removed. Better epithermal preservation potential in the north, especially in “wndows” of exposed Takla Group (Baker).
- The discovery of porphyry-style mineralization in 194 Ma felsic dykes at Pine confirms temporal overlap with LS epithermal mineralization in the Toodoggone.

Stratigraphic and plutonic framework for copper, gold and molybdenum, Thuya Creek – Woodjam Creek, south-central BC

Paul Schiarizza

Location



Focus on Quesnel terrane

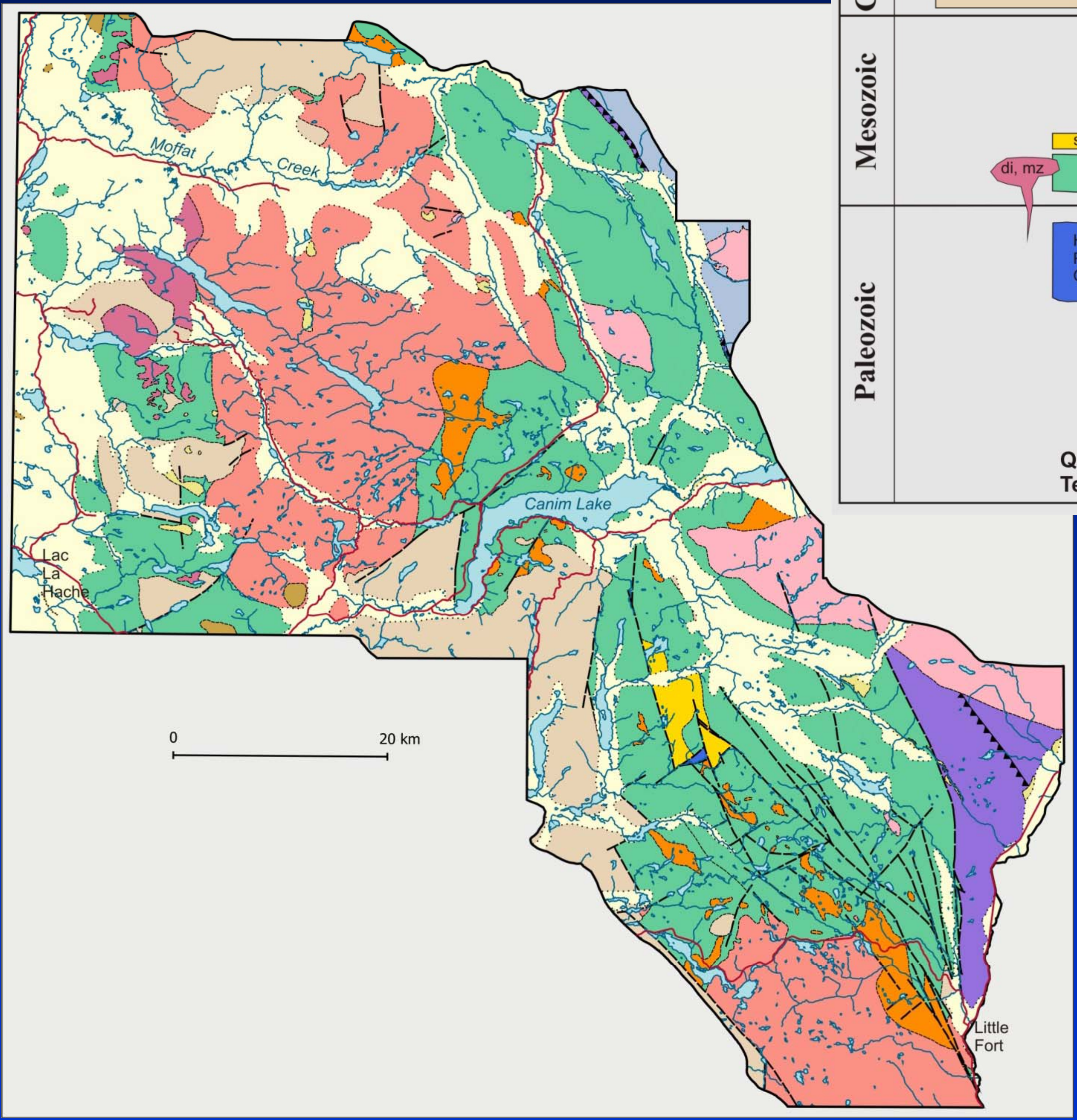
Mapping over 6 field seasons: Bonaparte Project; 2000 – 2001 Takomkane Project; 2005-2008

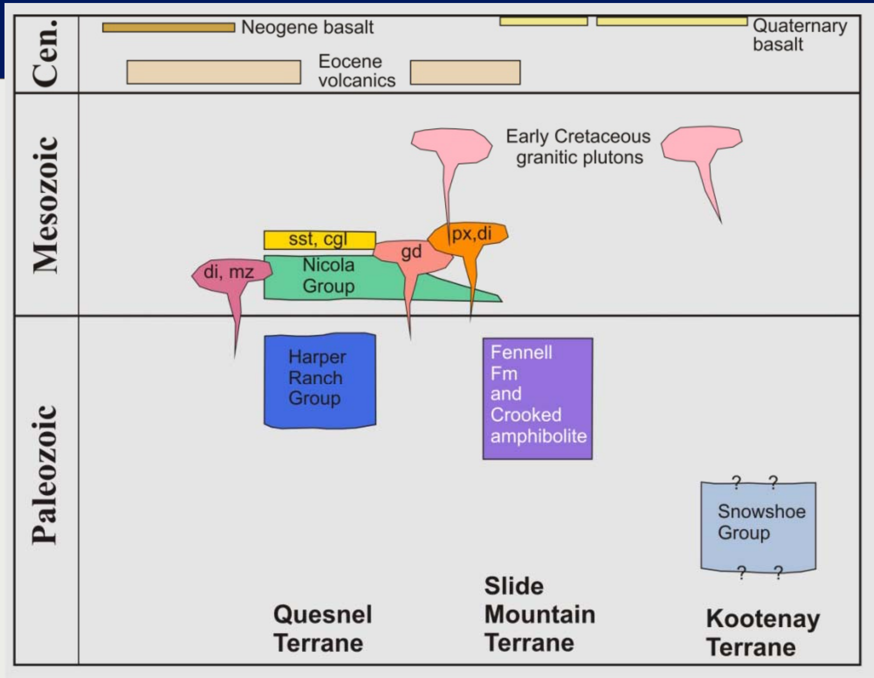
Preliminary products include 6 1:50 000-scale Open File bedrock geology maps

Final report, maps, databases in preparation

Contributions

Mapping	Steve Israel, Scott Heffernan, Amy Boulton, John Bligh, Kim Bell, Sandra Bayliss, Jenny Macauley, Britt Bluemel, Josh Zuber, Fern Wager, Arthur Paul, Devin Tait, Patrick Young, Kelly Schiarizza
Geochronology	Richard Friedman, Thomas Ullrich
Fossil Identifications	Mike Orchard, Terry Poulton, Paul Smith, Howard Tipper

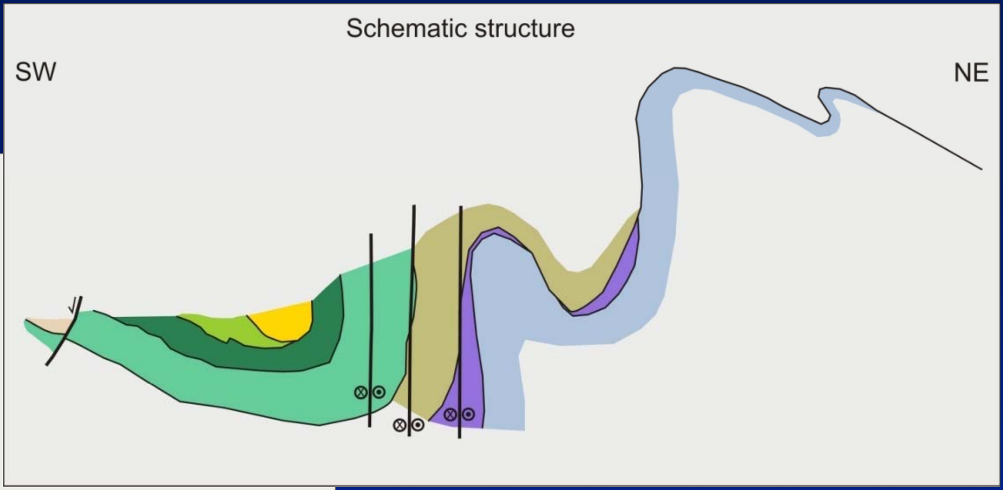


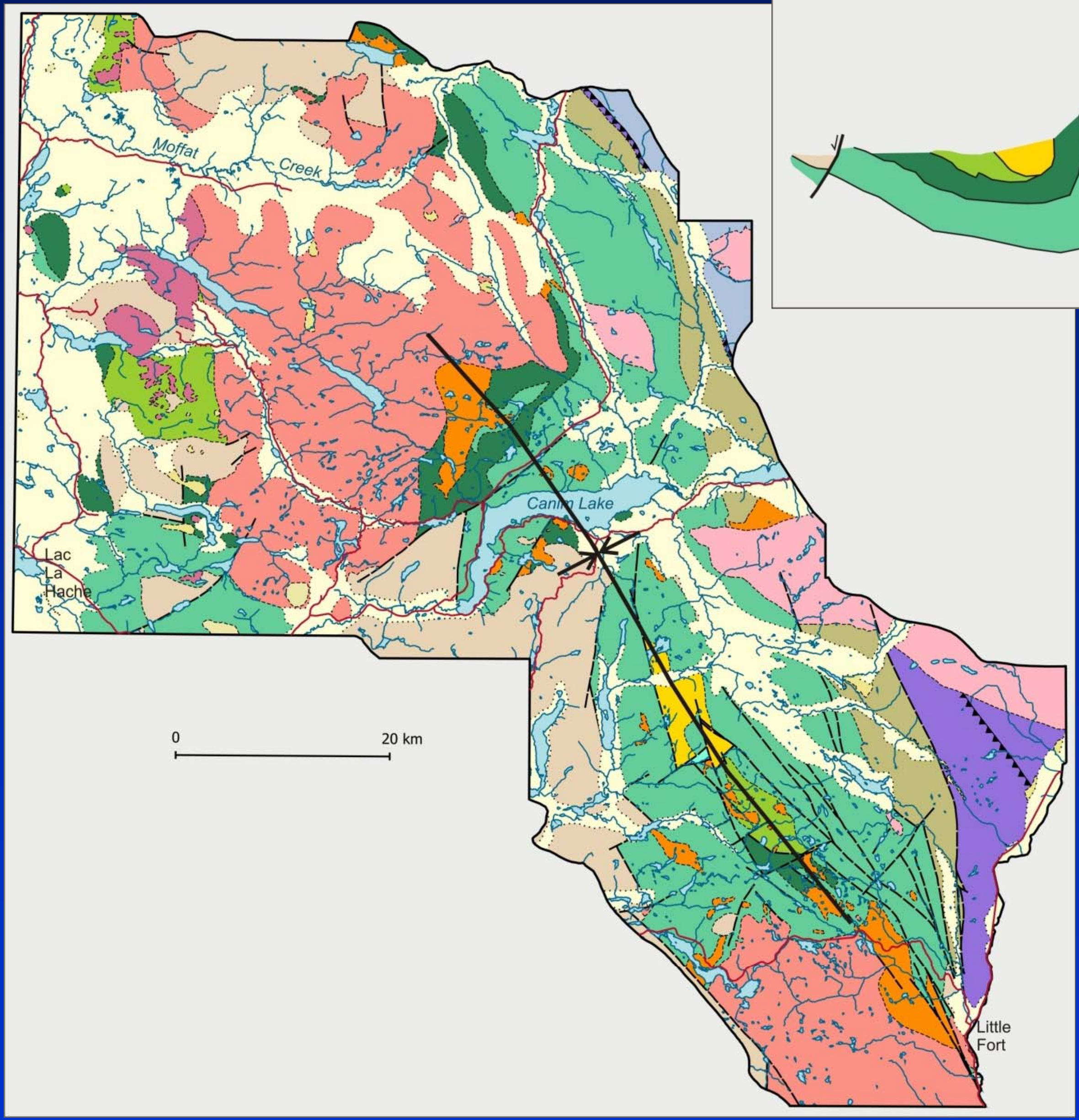


General Geology

Focus on Quesnel Terrane-Nicola Group plus several plutonic suites

Structure

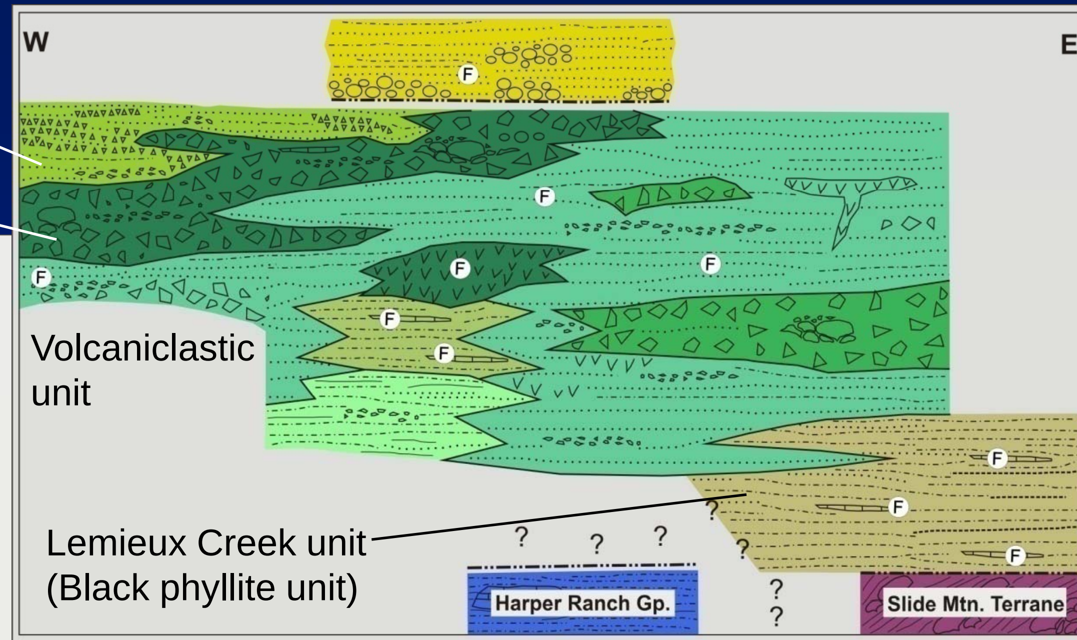


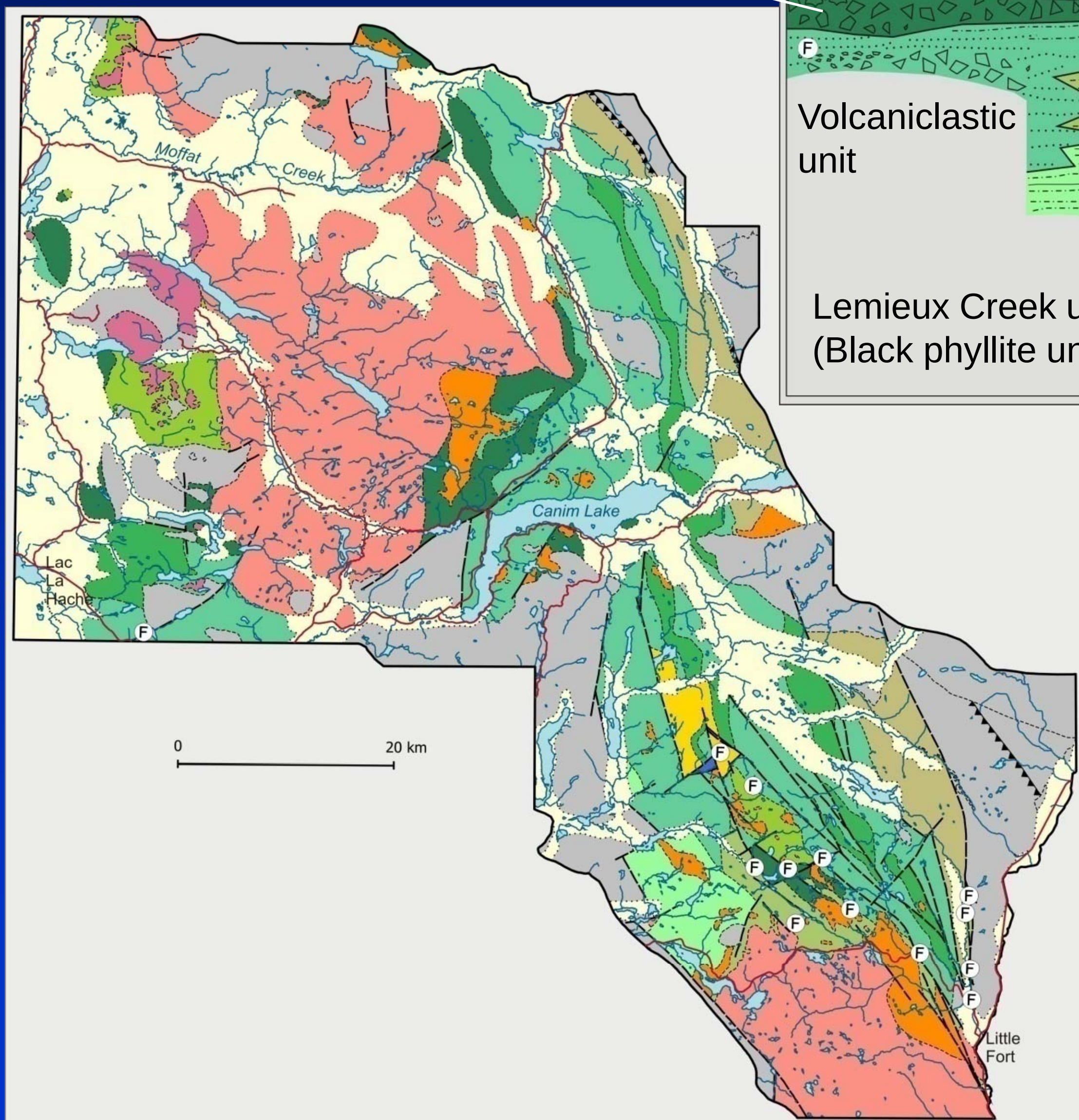


- Complex, but generally synclinal – part of west verging fold system that roots in pericratonic rocks to the east
- Steep east limb cut by Eocene dextral strike-slip faults
- Most mappable faults probably Eocene
- Low to sub-greenschist metamorphic grade; penetrative deformation only along east edge of Nicola belt (black phyllite unit)

Polylithic breccia unit

Basalt – breccia unit





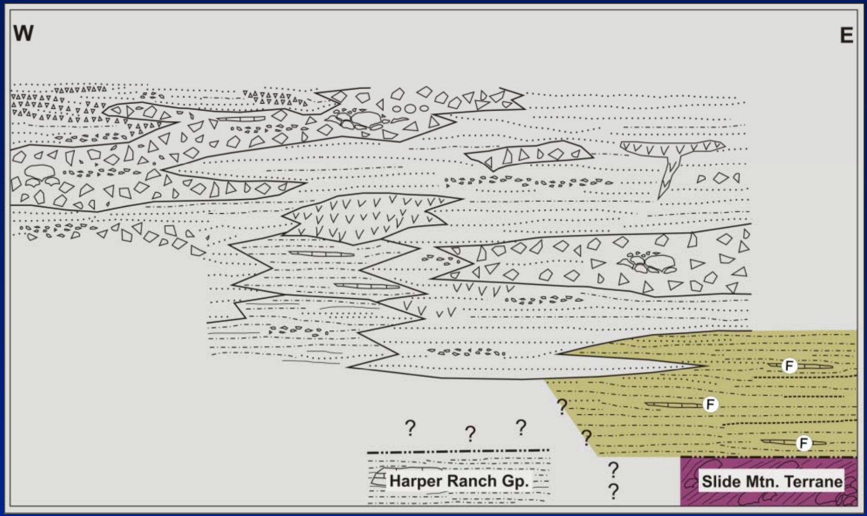
Nicola Group

Middle and Upper Triassic

Four main subdivisions

Unconformably overlain by Lower Jurassic sandstone and conglomerate

Nicola Group:
Lemieux Creek unit



Basal unit along eastern margin of group

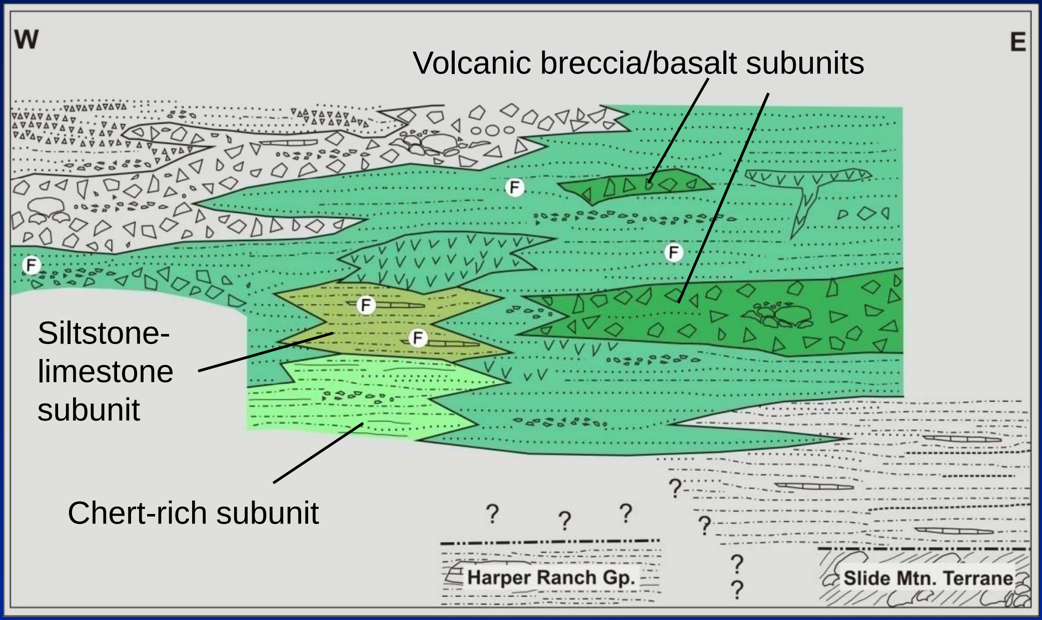
Deposited on Slide Mountain terrane

Mainly black phyllite, slate, siltstone, quartzite, limestone

Quartz-rich units probably derived from pericratonic rocks to east

Middle and Late Triassic conodonts

Nicola Group: Volcaniclastic unit



Widespread, heterogeneous unit, dominated by volcanic sandstone, conglomerate and breccia

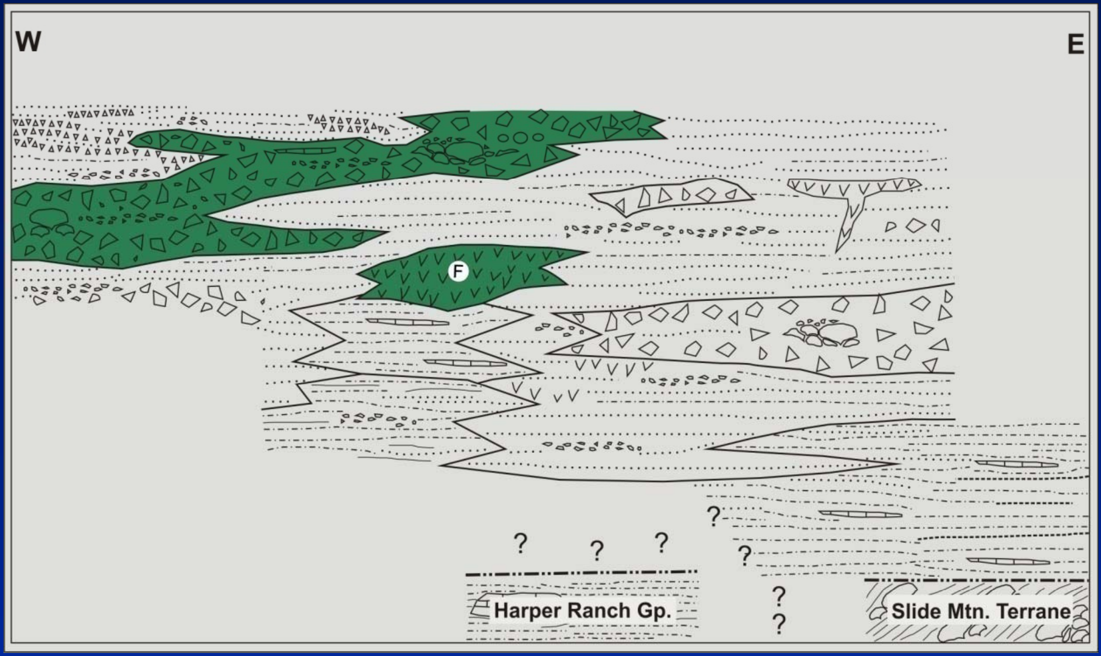
Also includes pyroxene-feldspar-phyric basalt, volcanic breccia, limestone, siltstone, chert

Scattered Late Triassic (mainly Carnian) macrofossils and conodonts

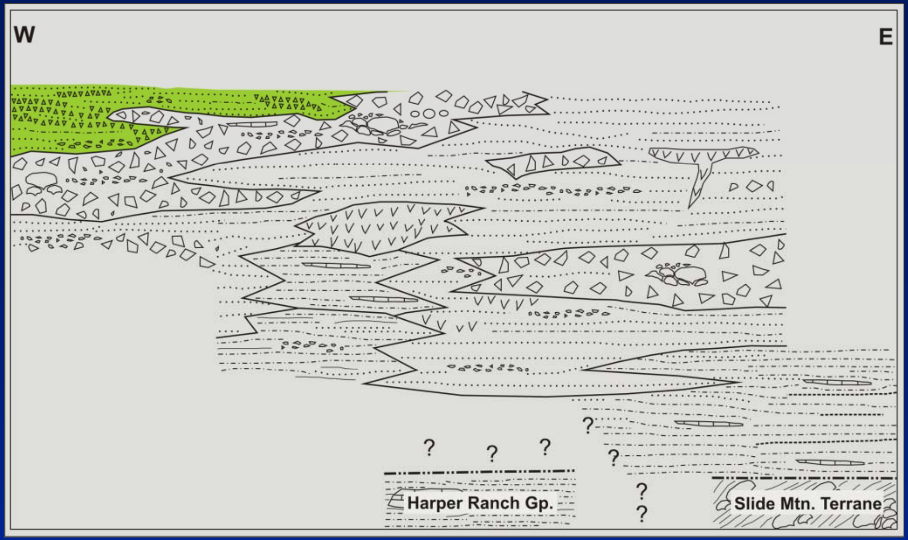
Interfingers? with upper part of Lemieux Creek unit

Nicola Group: Basalt – Breccia unit

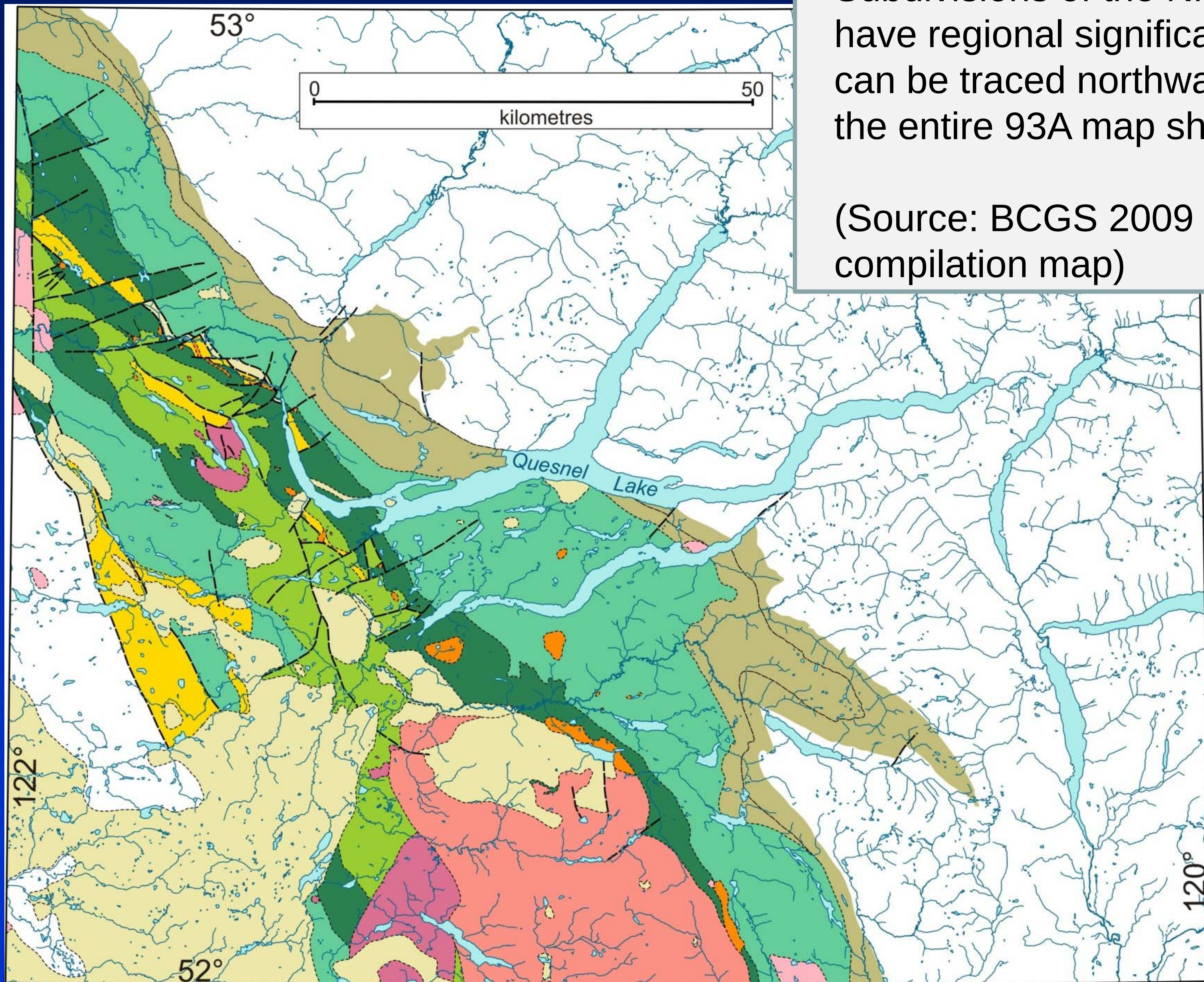
- Pyroxene-phyric basalt, pillowed basalt and basalt breccia
- Locally includes feldspar-pyroxene sandstone, and limestone



Nicola Group: Polylithic breccia unit

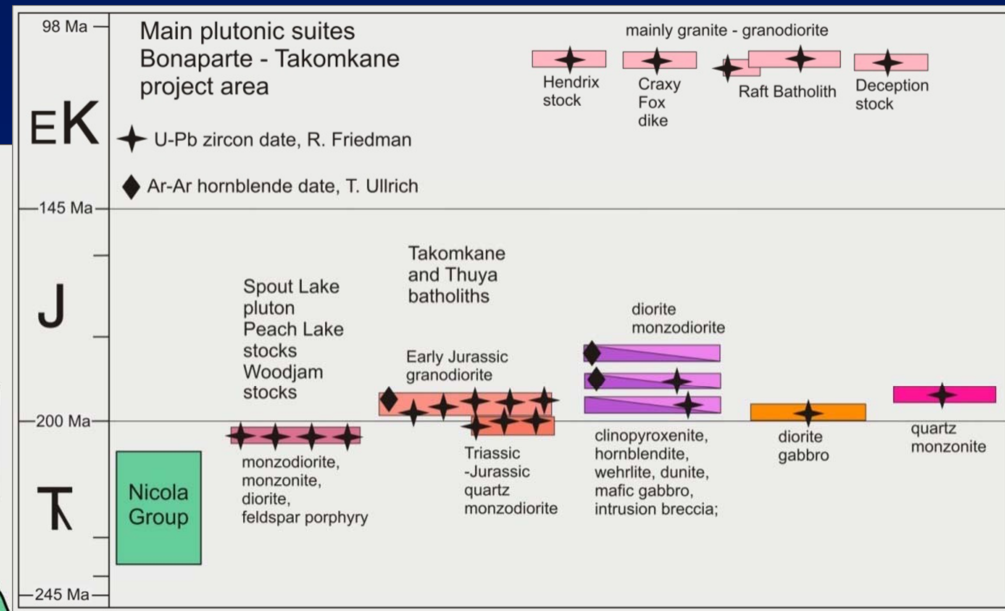


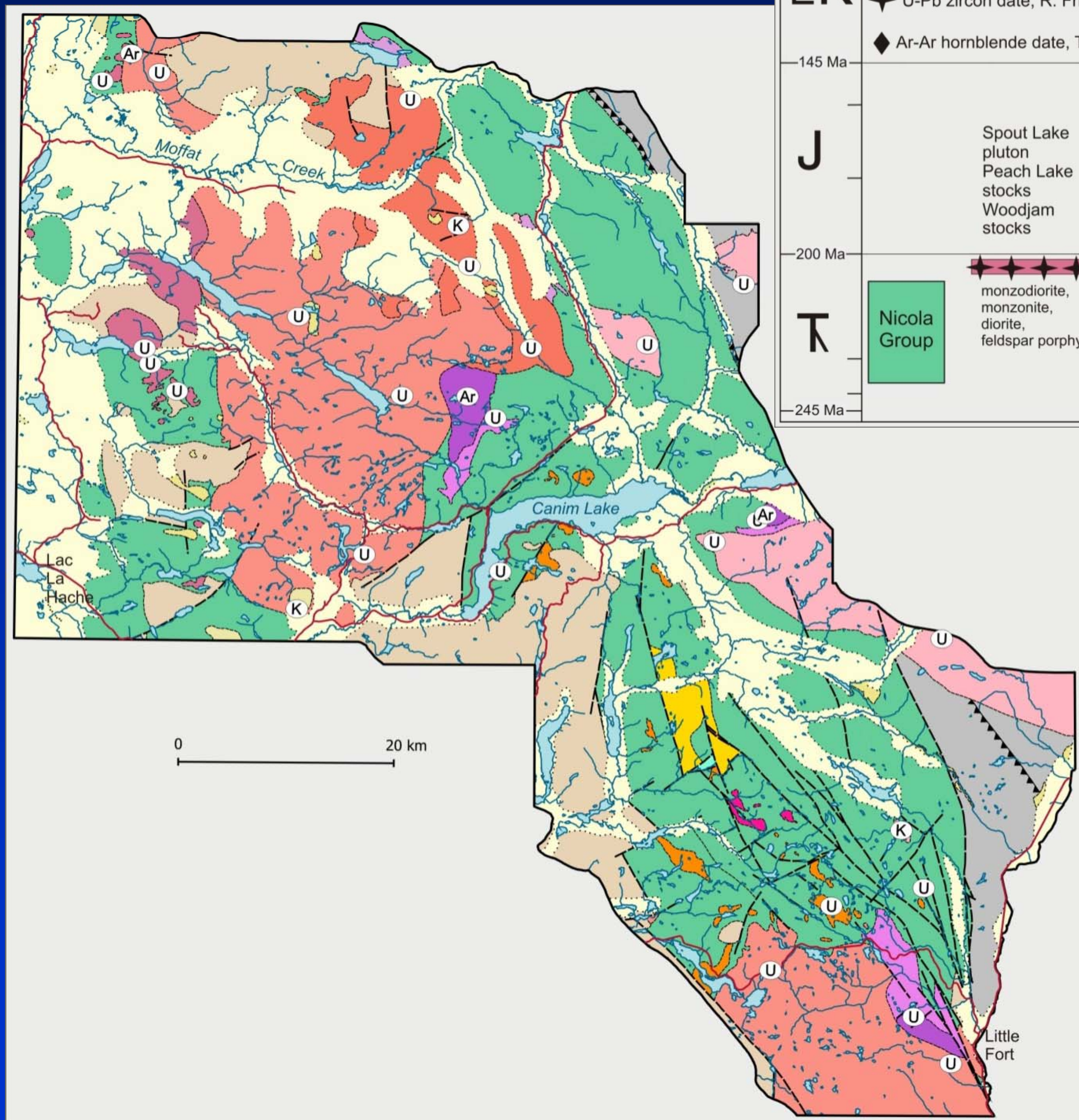
- Uppermost unit, exposed mainly on west side of Takomkane Batholith
- Mainly polylithic breccia, conglomerate and feldspathic sandstone; breccias contain feldspathic plutonic and volcanic fragments
- Locally includes pyroxene-phyric basalt
- Commonly red
- Late Triassic age constrained by underlying successions and cross-cutting Late Triassic plutons



Subdivisions of the Nicola Group have regional significance – eg. can be traced northward through the entire 93A map sheet

(Source: BCGS 2009 Quest compilation map)





Plutonic suites

Quesnel Terrane: 5 suites, Late Triassic to Early Jurassic

+Early Cretaceous granodiorite and granite

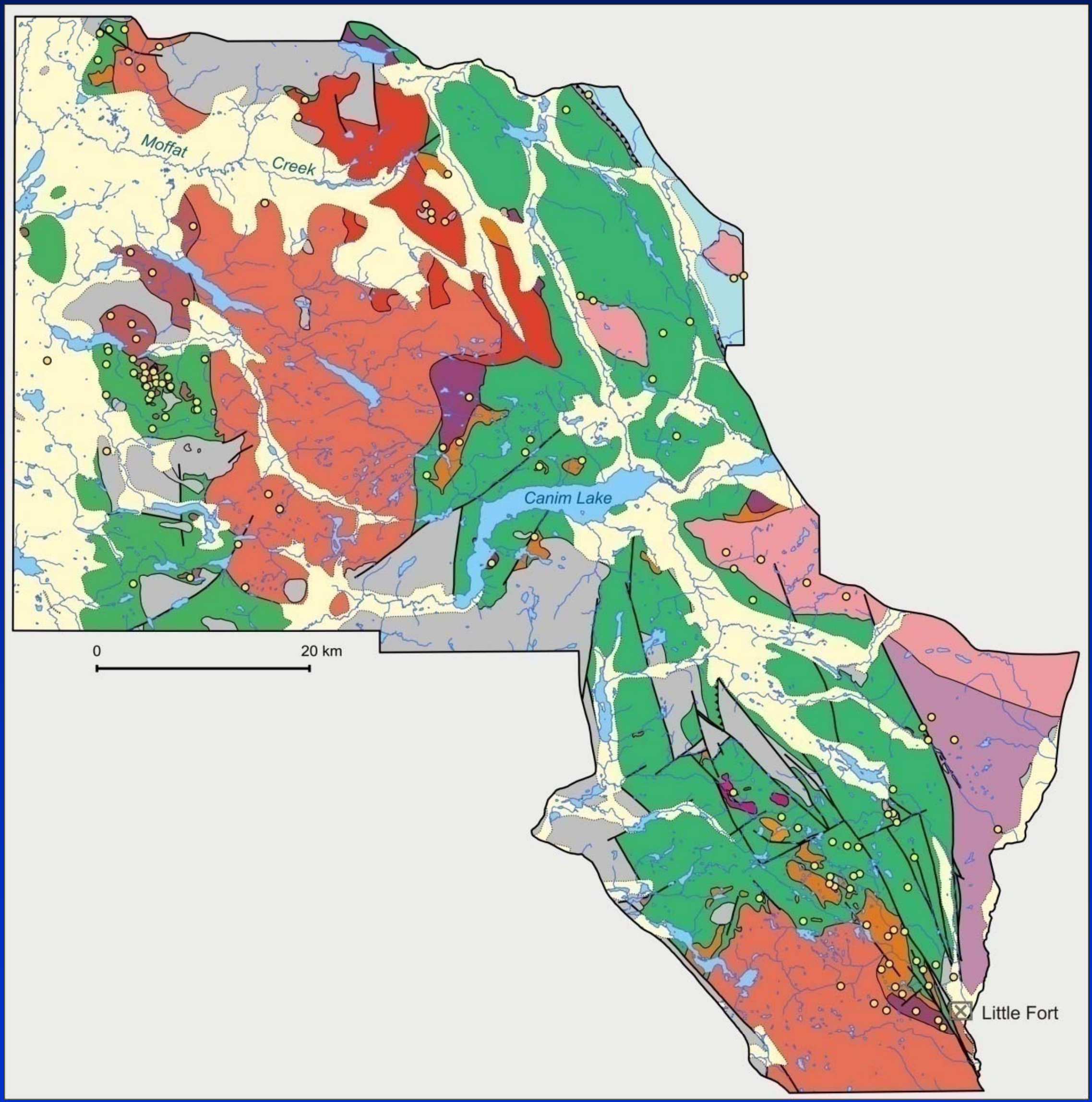
Quesnel Terrane plutonic rocks

Early Jurassic granodiorite

Late Triassic monzodiorite

Early Jurassic pyroxenite and diorite

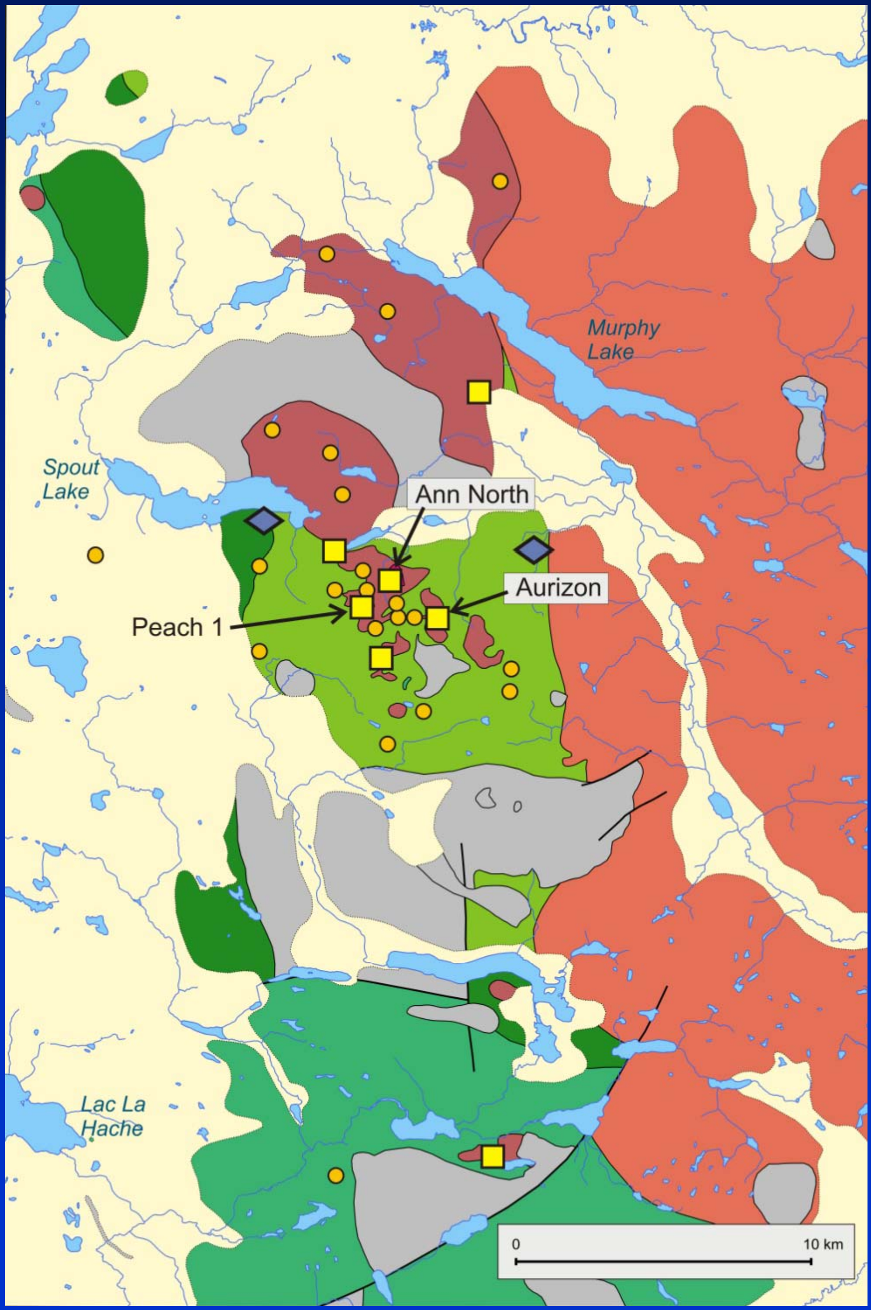
Mineral Occurrences



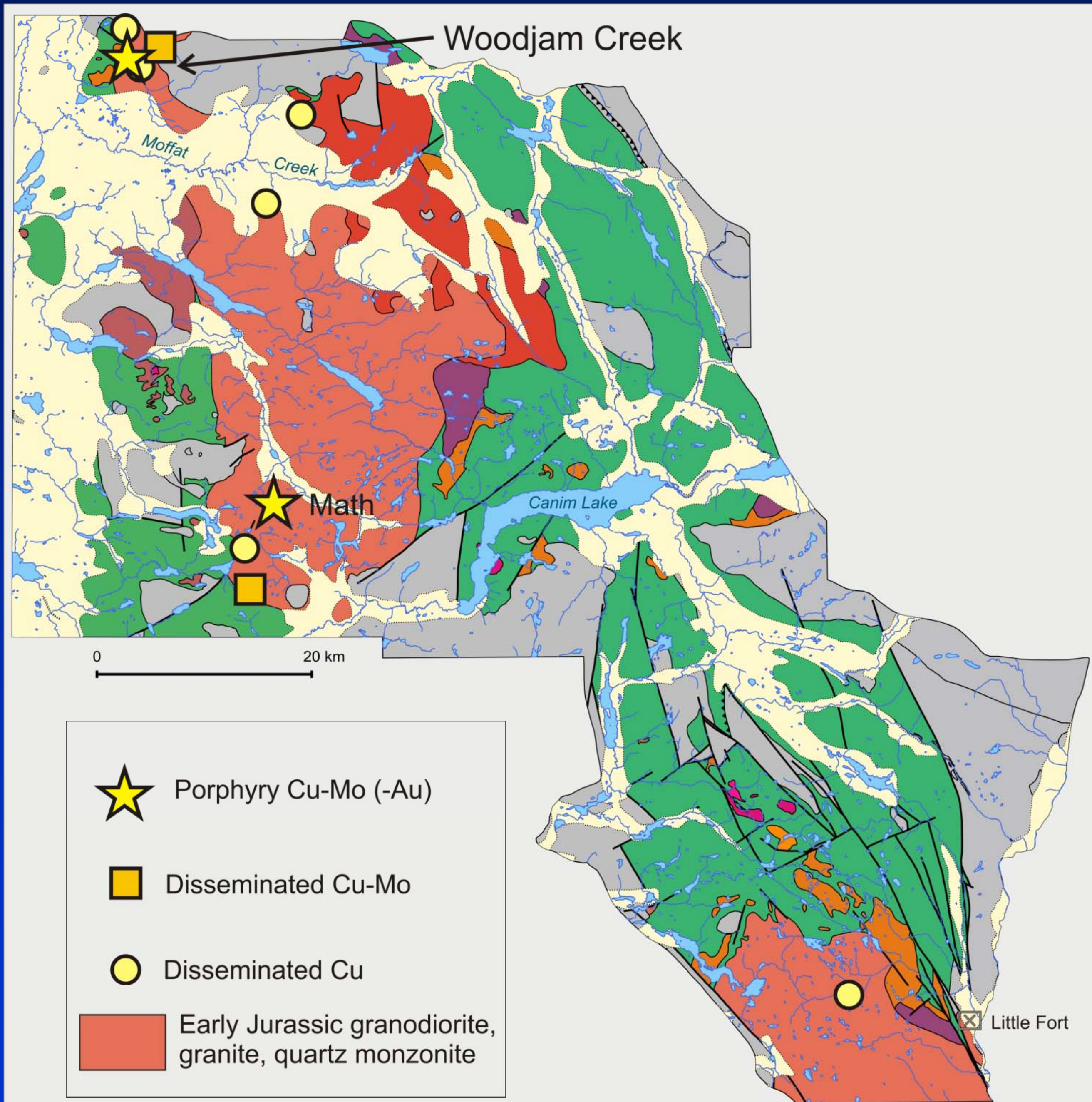
Most associated with plutonic rocks

All plutonic suites mineralized (but to varying degrees)

Mineral occurrences associated with Late Triassic monzodiorite suite

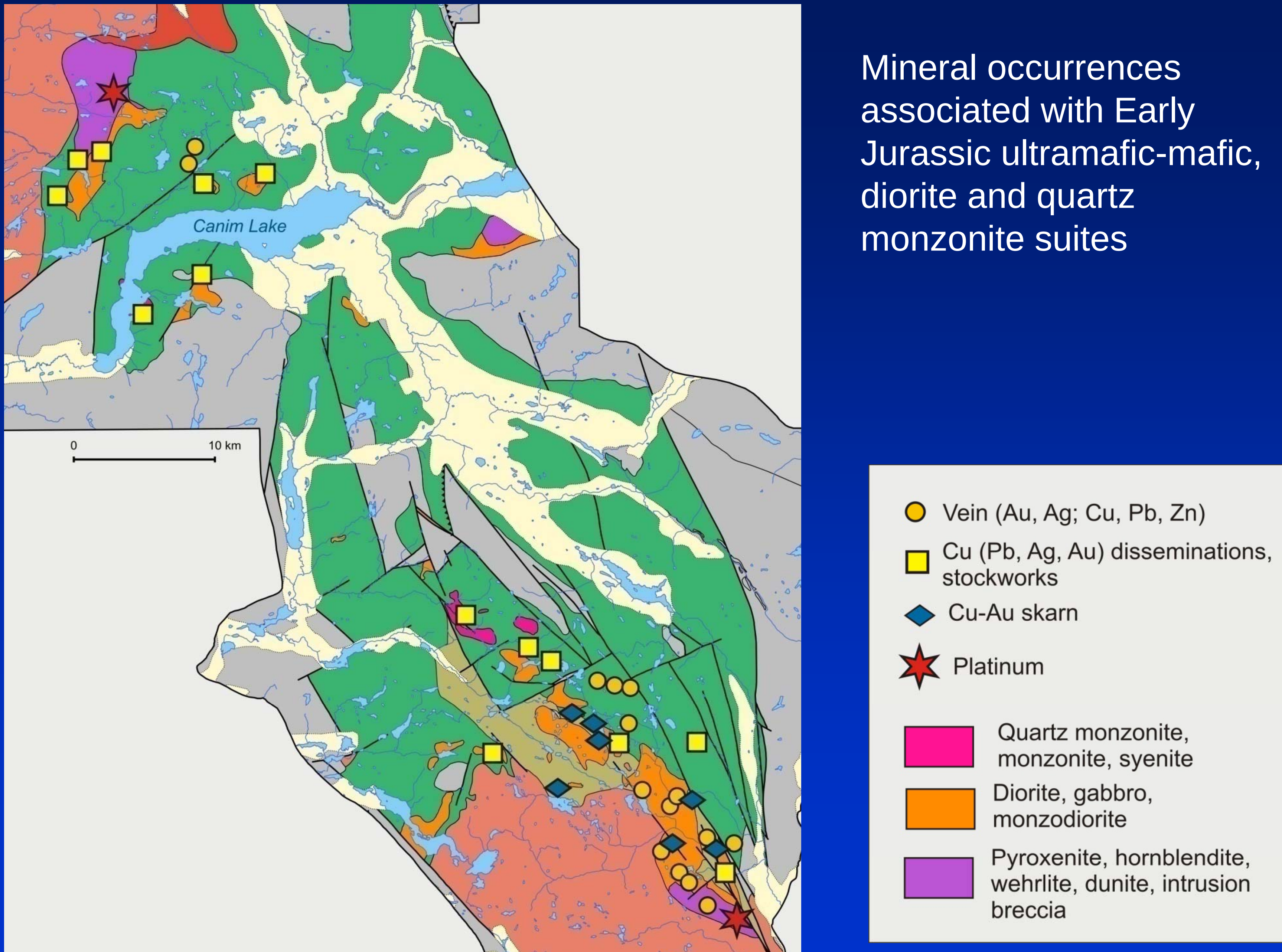


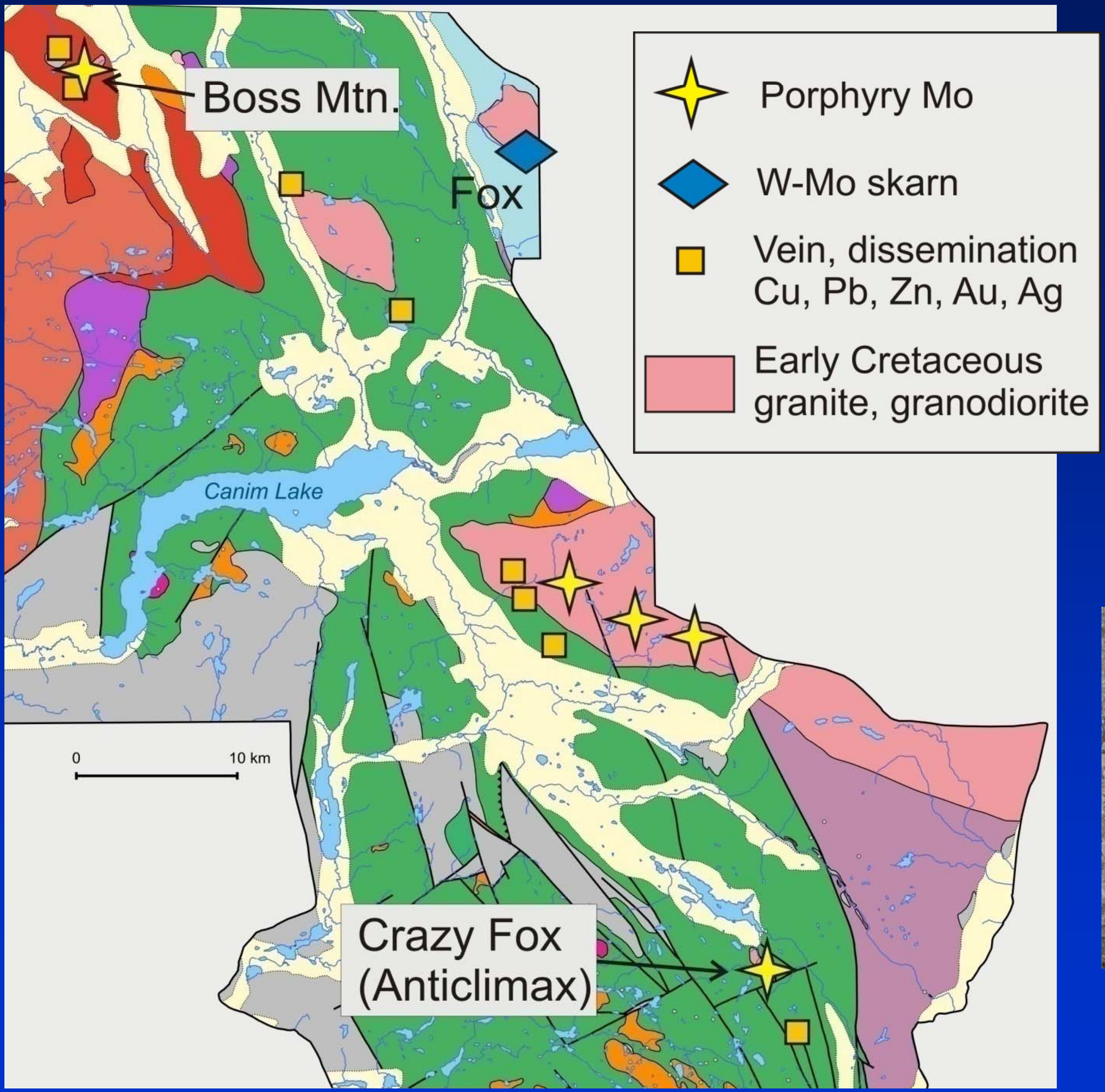
- Alkalic Cu-Au porphyry
- Cu-Au skarn
- Disseminated, fracture-controlled Cu (Au)
- Late Triassic monzodiorite, diorite, monzonite



Mineral occurrences associated with Early Jurassic granodiorite of Takomkane and Thuya batholiths

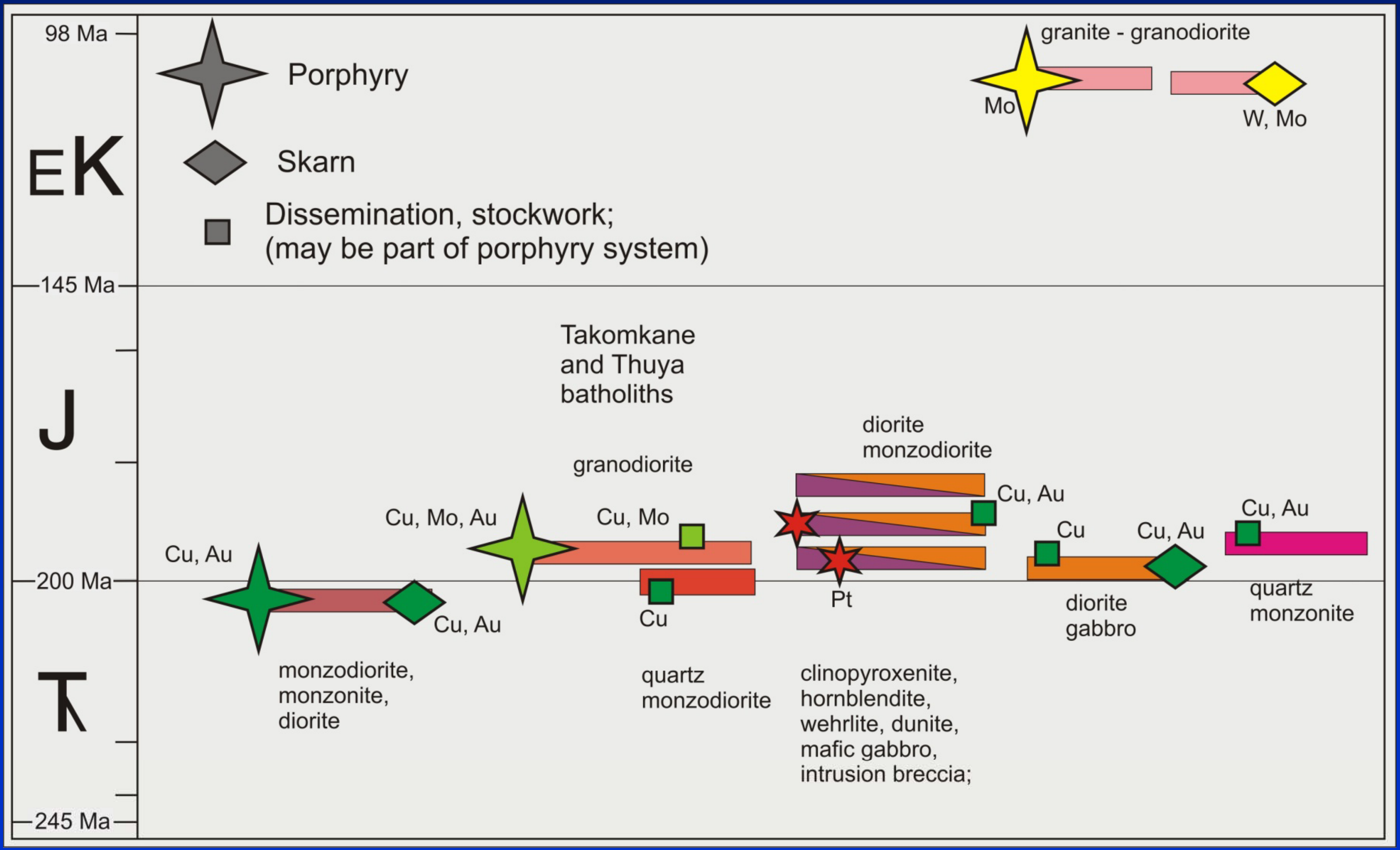
Mineral occurrences associated with Early Jurassic ultramafic-mafic, diorite and quartz monzonite suites

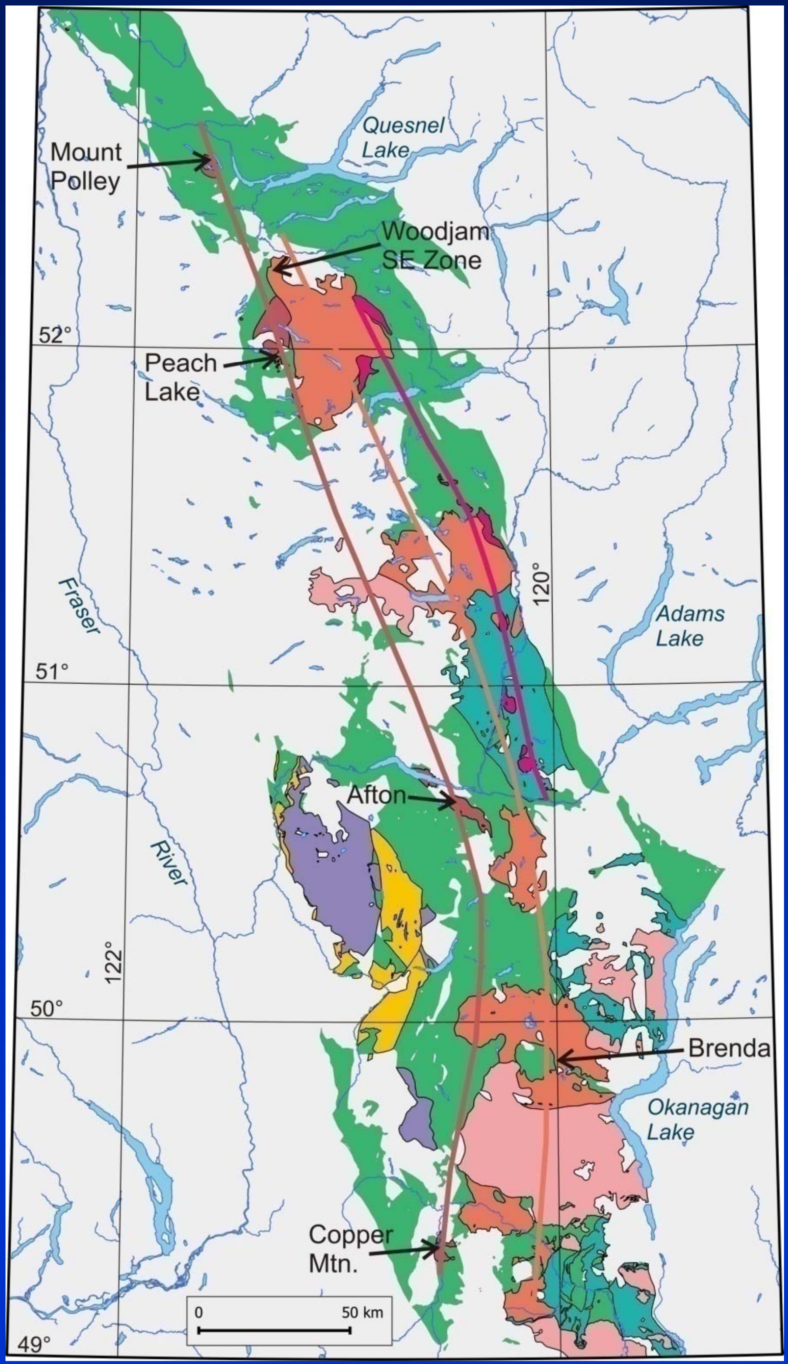




Mineral occurrences associated with Early Cretaceous granitic rocks

Summary of mineralization associated with different plutonic suites



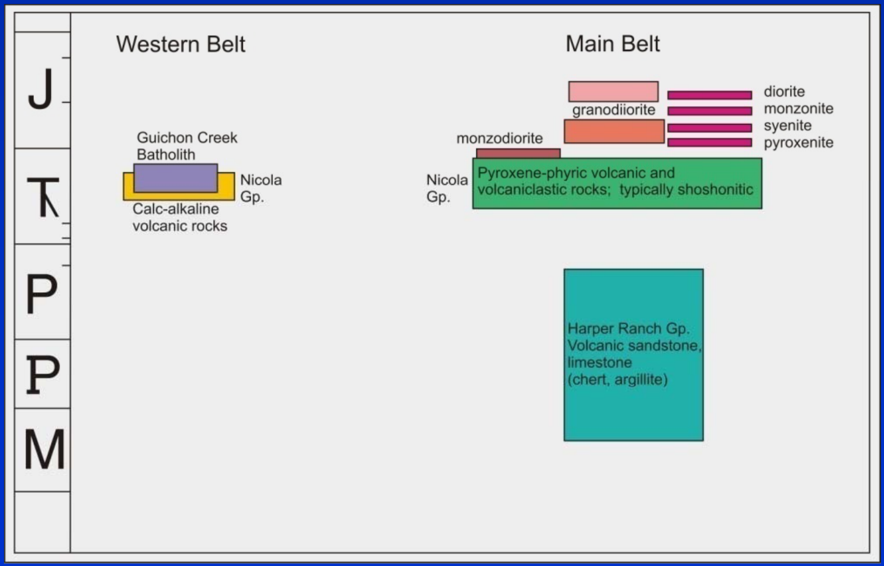


Magmatic patterns in southern Quesnel Terrane

Plutonic suites and spatial patterns of Takomkane-Thuya area continue to south

Important mineral camps associated with Late Triassic monzodiorite suite

Newly discovered Woodjam SE zone suggests that Early Jurassic suite also has significant potential



Cretaceous plutons: part of Bayonne magmatic belt

Mid-Cretaceous Bayonne magmatic belt intersects Quensel Triassic-Jurassic magmatic belts in Thuya-Woodjam map area – adds potential for Mo-W porphyry and skarn occurrences