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Open File 2006-8

Report on the Detailed Mineral Assessment of the Proposed Snafu/Tarfu Natural Environment Park Special Management Area, Yukon

J. vanRanden

YUKON GEOLOGICAL SURVEY

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Preface

This report summarizes the results of geological fieldwork and a detailed mineral assessment of the proposed Snafu/Tarfu Special Management Area. This mineral assessment was done in 2002 by the Department of Energy, Mines and Resources of the Government of Yukon (YTG).

The purpose of this mineral resource assessment was to determine the mineral potential of the region and thereby assist with proposed land planning in the area. The Yukon Geological Survey is pleased to release the results in this report.

The information is being released as originally prepared and may not conform to current Yukon Geological Survey publication standards. Please note that the report does not include information from any studies that may have been carried out in the area since the mineral assessment was conducted. Special Management Area name and boundaries may have changed since the mineral assessment was completed. This report was not previously released to the public due to the confidential nature of the Land Claim negotiation processes.

Report on the

Detailed Mineral Assessment

of the

Proposed Snafu/Tarfu Natural Environment Park Special Management Area

Confidential

February 2003

Internal Report
Jo-Anne vanRanden
YTG, Energy Mines and Resources
Mineral Planning and Development

Executive Summary

The proposed Snafu/Tarfu Special Management Area (SMA) consists of 733 km^2 in southern Yukon on NTS 105C/3, 4, 5 and extreme eastern edge of 105D/8. The Snafu and Tarfu Lakes area was selected as a SMA by the Carcross/Tagish First Nation, with the current proposal designating the area as a Natural Environment Park with no up-front mineral withdrawal upon signing the Final Agreement.

In 2001, the Yukon Department of Economic Development carried out a regional mineral assessment, which reviewed the geologic data for SW Yukon and ranked the (~1000 km^2 sized) tracts. Part of this regional assessment covered the proposed SMA area and the relevant tracts were ranked either moderate or lowest relative regional mineral potential with respect to phase IV (SW Yukon) of the Yukon regional mineral potential map.

The proposed Snafu/Tarfu SMA lies within Cache Creek Terrane and is composed of a complex succession of Mississippian to Permian basalt, shallow water carbonates, chert and greywacke, overlain by Triassic to early Jurassic interbedded chert and greywacke. The area is lacking detailed geological bedrock mapping and structures within the proposed SMA area are poorly constrained.

Prior to fieldwork a compilation and study of available data identified a total of ten targets for follow-up of which all but two were examined in 2002. Targets selected were anomalous Geological Survey of Canada regional geochemical survey samples, aeromagnetic features, and geological structures. An attempt was made to locate and investigate all of the reported Yukon mineral (Minfile) occurrences within the proposed SMA boundary. A total of 12 person days were spent investigating the selected targets. Fieldwork entailed the collection of rock, soil and stream sediment samples, in conjunction with geological mapping and prospecting and examination of the mineral occurrences within the area.

In December 2002, the Yukon Department of Energy Mines and Resources carried out a detailed mineral assessment, which reviewed the geologic data for the proposed SMA and surrounding area (the mineral assessment study area), and an expert panel of industry geologists, consensus ranked the resulting eight tracts. The east-central portion of the mineral assessment study area, and the extreme southwestern corner of the proposed SMA ranked the highest relative mineral potential. Anomalous geochemistry and unexplained geophysical signatures within the area currently mapped as Triassic ribbon chert/greywacke, led to the area being ranked relatively highest. A mapped intrusive body (of the same suit as those located in the Atlin area) on the southwest side of the proposed SMA ranked also ranked relatively highest.

It is recommended that land use planners (including SMA steering committee members) take into account the results of the mineral assessment of the proposed Snafu/Tarfu SMA and use the mineral potential maps in their planning. Ideally land use planners would avoid alienating tracts of highest mineral potential from exploration and future development.

The following additional research is recommended to better constrain the mineral deposit types applicable to the proposed Snafu/Tarfu SMA; follow-up unexplained geochemical anomalies and previously identified targets, further work on the known mineral occurrences, and additional geological mapping in tracts that ranked the highest to identify unmapped units and increase the understanding of the structural history of this belt of rocks.

Table of Contents

page

Tables

Plates

Appendixes

Introduction

This report briefly describes the geology, known mineral occurrences, regional stream sediment geochemistry, regional geophysical data and the results of the 2002 fieldwork carried out by mineral assessment staff of the Yukon Department of Energy, Mines and Resources. The report presents the results of a detailed mineral assessment panel that evaluated the above data and ranked geological tracts relative to one another according to their potential to host metallic mineral deposits for an area including the proposed Snafu/Tarfu Special Management Area.

Land Status

The Carcross/Tagish First Nation proposed Snafu/Tarfu (also called Agay Mene) as a Chapter 10 special management area (SMA) as early as November 1998. The area was originally negotiated as a Habitat Protection Area, however government of Yukon has more recently approved the proposed SMA as a proposed Natural Environment Park with no mineral withdrawal upon effective date of a final agreement with the First Nation. Natural Environment Park is a designation under the Parks and Land Certainty Act and the term "mineral withdrawal" refers to a prohibition of entry order under the Yukon Quartz and Placer Mining Acts. This proposed SMA boundary & designation has been negotiated to date without the benefit of any mineral assessment studies.

The most current outline provided (September 2002) by YTG's Land Claims Secretariat of the proposed SMA covers approximately 733 square kilometers. As of January 2003, the area is not covered by any prohibition of entry orders however, on the Territorial Resource Base Maps at DIAND Lands Resources, two areas are outlined but are not map notations with documented request forms and file numbers. The areas are labeled as "Lubbock River Protection Corridor" located on the western margin of the proposed SMA and "Key Goat Habitat" located over White Mountain in the NW corner of the proposed SMA. An interpretive trail & panels exist on White Mountain as a goat-viewing site.

Plate 1: Interpretive panel @ White Mountain

Plate 2: White Mountain sign

Within the boundaries of the proposed SMA, an active placer operation is located on NTS sheet 105C/4 in the southern portion of the area near the British Columbia/Yukon border.

Carcross/Tagish First Nation currently have site specific land selections interim protected within the proposed SMA along Dalayee Lake, Snafu Lake, and east of the Atlin Road at the northern end of Atlin Lake.

There are private lots (marked on the Territorial Resource Base Maps) located along the western side of the proposed SMA, notable at Hannka Creek and a lot located on the north side of Tarfu Creek where it crosses the Atlin Road.

Work carried out by Energy Mines & Resources, YTG.


Plate 3: Helicopter staging site

During the summer of 2002, the mineral assessment team composed of geologists: Roger Hulstein, Farrell Andersen, Jo-Anne vanRanden and Robert Stroshein spent 12 man-days working in the area. Fieldwork was conducted from the roads and trails that bound and cross the proposed SMA as well as helicopter supported traverses in the more inaccessible areas.

Work included a compilation of all available geological, geochemical and geophysical data to identify target areas for 2002 fieldwork (vanRanden, 2002). This fieldwork consisted of prospecting and assessing regional stream sediment sample anomalies by the collection of rock, soil and silt sediment samples for geochemical analysis. All samples were analyzed for gold plus a suite of 34 elements. An attempt was made at locating all the mineral occurrences within the proposed SMA, and where found, the occurrence was evaluated and sampled.


Plate 4: Mineral Assessment work

A total of 16 rock, 10 soil and 19 silt sediment samples were collected in 2002. The samples were submitted to Northern Analytical Laboratories Ltd. of Whitehorse where they were prepared and the prepared pulp samples were shipped to Acme Analytical Laboratories in Vancouver for analysis. The samples were analyzed by Induced Coupled Plasma – Mass Spectroscopy (ICP-MS) using an Aqua Regia digestion. The details of the laboratory procedures are included in Appendix 1.

Location, access and physiography


Plate 5: Tarfu Lake looking NW

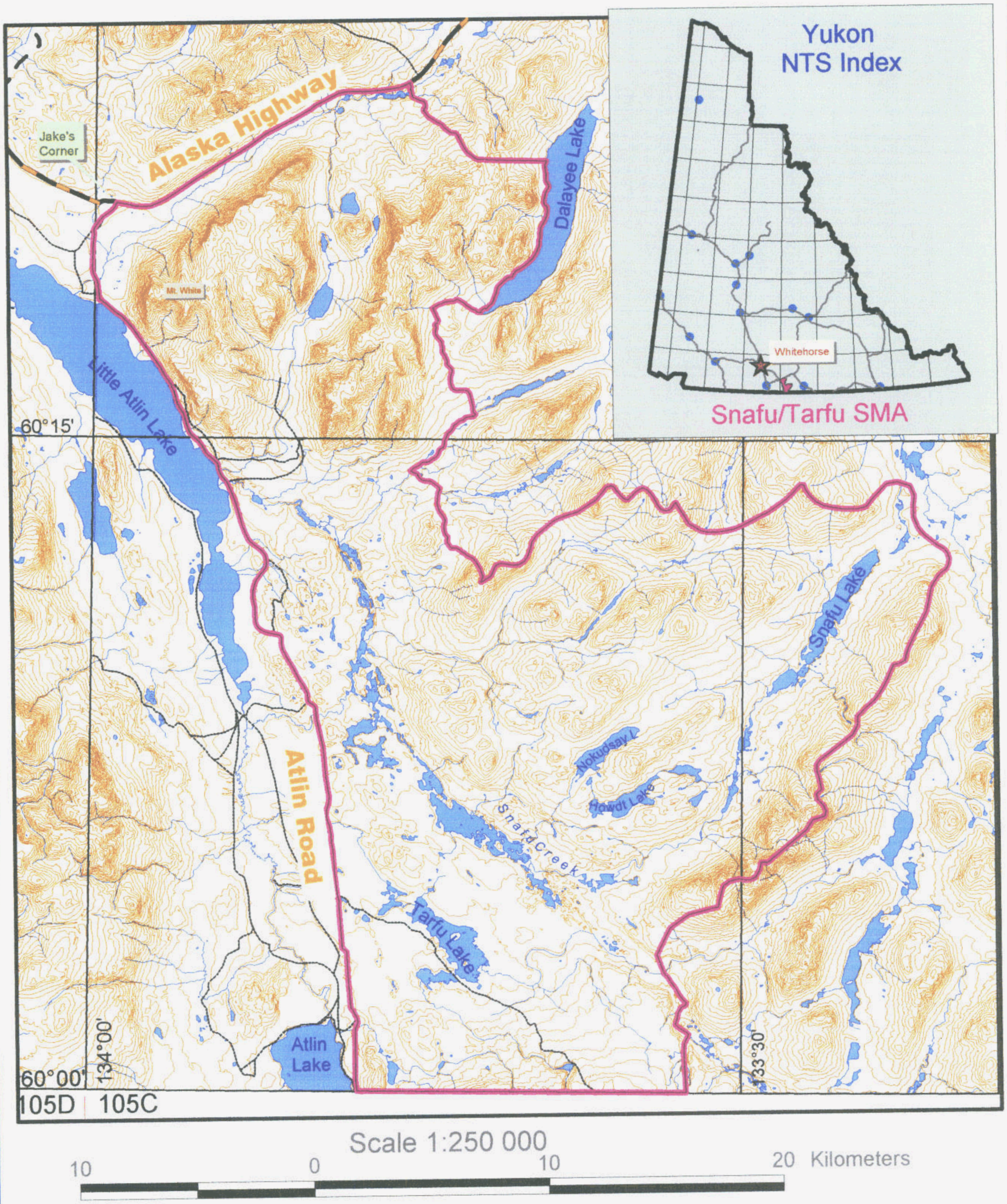
The proposed SMA is located on NTS sheets 105C/3, 4, & 5 southeast of the junction between the Atlin Road (highway # 7) and the Alaska Highway at Jakes Corner. This 733 square kilometer proposed SMA utilizes the Yukon/British Columbia border as its southern extent, Atlin road as its western limit, Alaska Highway as its Northern most extension, and the Western shore of Dalayee Lake as part of its eastern boundary (Figure 1). The proposed SMA encompasses the 5000-foot Mt. White, the Snafu and Tarfu chains of lakes, Snafu Creek, as well as Nokudsay and Hawdt Lakes.


Plate 6: Limestone outcrop in NE of SMA

The proposed Snafu/Tarfu SMA is within the Yukon Southern Lakes Ecoregion(#177) and a small portion of the Boreal Mountains and Plateaus Ecoregion (# 180) of the Boreal Cordillera Ecozone (Figure 2). Each ecoregion shares distinctive regional ecological factors including climate, physiography, vegetation, soil, water and fauna. Broad valleys and large lakes with a dry and cool climate characterize the Yukon Southern Lakes Ecoregion. Soil types tend to be alkaline with wetlands dominated by marl formation in a discontinuous permafrost zone.

Access to the proposed SMA is by helicopter and by foot from both the Atlin Road & Alaska Highway. A four wheel drive road cuts through the southern portion of the proposed SMA from a point approximately 35 kilometers down the Atlin Road and continues past Tarfu Lake south, southeast to the British Columbia border.

Location Map



Proposed Snafu / Tarfu Natural Environment Park Special Management Area

(September 2002 outline)

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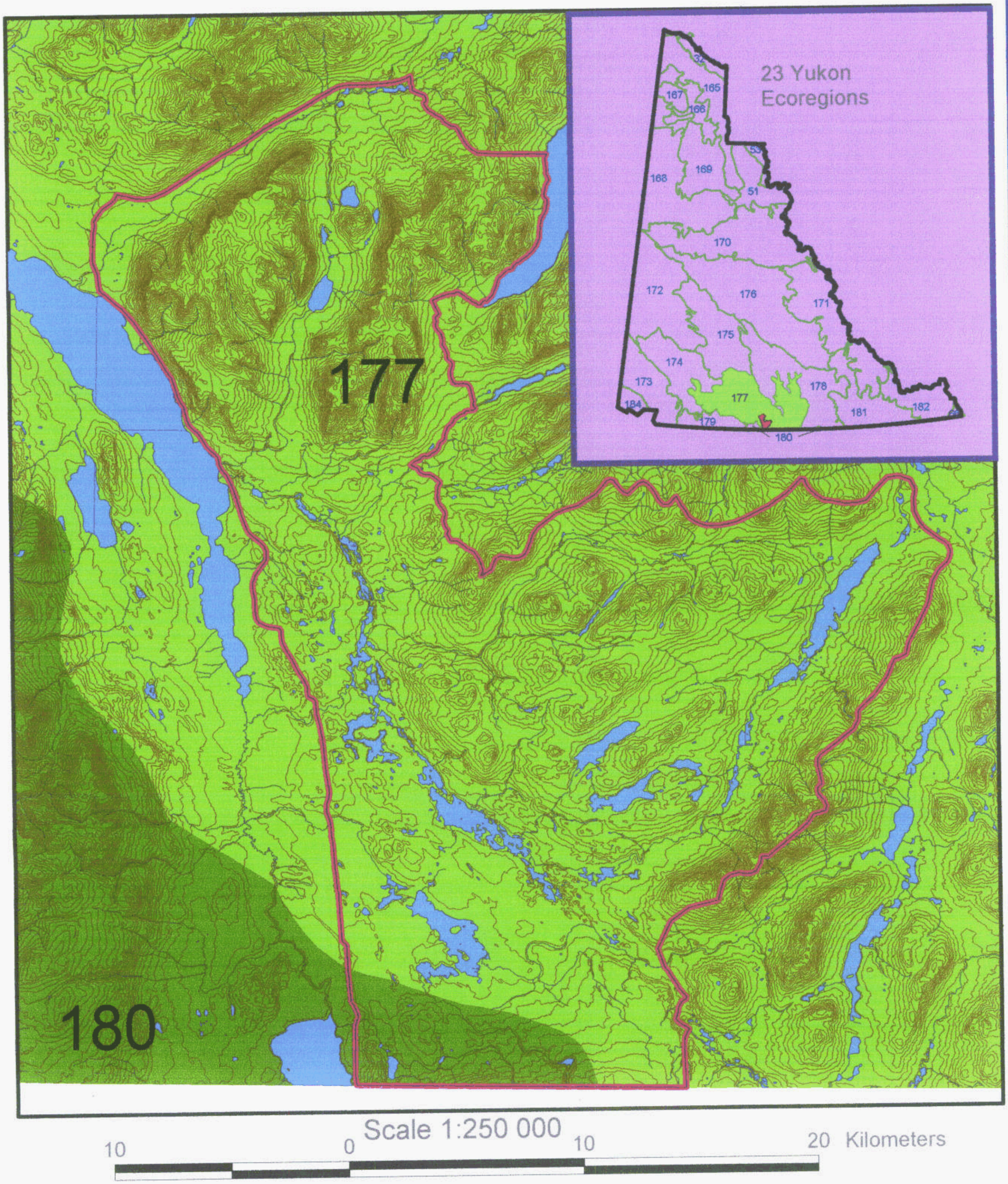
Figure 1

Arcview GIS Version 3.2 - JvR - February 2003

Snafu/Tarfu Area Ecoregions



177 Yukon Southern Lakes Ecoregion

180 Boreal Mountains & Plateaus Ecoregion

Proposed Snafu/Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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Arcview GIS Version 3.2 - JvR - February 2003

Figure 2

Plate 7: Typical glaciated terrain looking East

Glacial History

The proposed SMA area was glaciated by the McConnell (ca 22ka) ice sheet. The generalized ice flow directions are to the northwest and melt water flow directions are largely controlled by topography and form repeated sequences of linear valleys with bounding ridges (Duk-Rodkin, 1999 - 1:1 000 000 scale map). Detailed studies of the glacial history have not been carried out or documented in this area.

Exploration History

Currently, the proposed SMA area covers the Calahan, Big Sqid, and Adam&Erin placer claims in good standing in the south central portion of the proposed SMA (Figure 3). Decin Guidolin is the registered owner of placer claim P42028 and it has an expiry date of 2006/05/29. Work on these properties to date has been exploratory in nature with no reported production figures. Excavator trenching on the properties was conducted in 2001 (M. Burke DIAND, pers com).

Geologists Mike Burke and Jeff Bond of the Yukon Geology Program visited the property in 2000. Jeff conducted a simple terrain analysis study, interpreting the aerial photographs to better define the glacial history of the area for the claim owner. The property is located over a glacial outwash channel composed of mostly intrusive rock debris and native gold placers. The source for these coarse grained gold nuggets is not defined and the glacial history of the area is poorly understood.

At the Tarfu Minfile occurrence (#105C007), quartz claims were held by Kerr-Addison in 1963 & 1964. The company drilled a geophysical target in 1964 but today no hard rock claims are valid in this area. Quartz claims were staked in 1980 at the Lisa Minfile occurrence (#105C039) however they have since lapsed. In 1987, the Hannka Minfile occurrence (#105C053) was held under valid mineral claim and again in 1997 but there are currently no valid claims in this area. A description of each mineral occurrence is located in Appendix 2.

Plate 8: Tarfu drill collar

Plate 9: Drill pad at Tarfu Minfile occurrence

Plate 10: Hannka Minfile area

Geology

Regional Setting

The proposed Snafu/Tarfu SMA is located in oceanic Cache Creek Terrane rocks of south central Yukon. Cache Creek Terrane is composed of a structurally complex succession of Mississippian to Permian basalt, shallow water carbonates, chert and greywacke, and alpine-type ultramafic units. The vast majority of the exotic terrane lies in British Columbia with only the tip of the northern extension exposed in the Snafu area. These rocks are overlain by a package of structurally imbricated interbedded chert and greywacke of Triassic to Early Jurassic age (YEG, 1995). The terrane is bounded on the east by the Teslin and Pinchi faults (Wheeler et al, 1991).

Regional 1:250 000 scale bedrock mapping of the area was carried out by the Geological Survey of Canada (GSC) between 1994 &1997 by S. Gordy and R. Stevens and reported in GSC open file 2886. Their work updated efforts by R. Mulligan in 1950-1953, also 1:250 000 scale mapping (GSC memoir 321). The regional geology is shown on the accompanying Figure 3 and taken from the digital compilation by S. Gordy and A. Makepeace in 2001. To date, no 1:50 000 scale bedrock geological mapping has been carried out in this area.

Geology of proposed Snafu/Tarfu SMA

Plate 11: Brecciated limestone CTrC1

Locally crinoidal Carboniferous to Jurassic grey limestone of the Cache Creek Group underlies the northwestern portion of the proposed SMA. A small roof pendant of strongly magnetic ultramafic Cache Creek group rocks (map unit $CTrC_1$) is exposed in the north, northeast corner of the proposed SMA.

The majority of the proposed SMA is underlain by well-bedded ribbon chert interbedded with shale, siltstone and greywacke that is middle Triassic to lower Jurassic in age (mTrlJC). The southwest corner of the proposed SMA is underlain by Mid-Jurassic Bryde Suite granitic rocks predominantly hornblende +/- biotite monzodioritic in composition (MJgB).

Plate 12: Massive black chert

The 2002 fieldwork identified previously undocumented quartz stringers and veins hosted within rusty weathering argillaceous siltstone in the SW portion of the proposed SMA, as well as altered dykes similar in style to those found at Keno Hill. Felsic submarine volcanic rocks were sampled in the east central portion of the proposed SMA. A sample of a mafic dyke was collected near the thrust contact between the regionally mapped limestone and chert units of the Cache Creek assemblage. A rock hand specimen of volcaniclastic origin was located near the 1460 ppb gold regional stream sediment survey (RGS) sample in the east central tip of the proposed SMA.

Since the proposed SMA borders the British Columbia/Yukon 60° latitude line, a 1:50,000 scale geology map was created (from the B.C. Geological Survey Map Place Website) on the B.C. side to assist in interpretation of the geology of the proposed SMAs southern region. This compilation work also included displaying B.C. minfile occurrences and searching for all deposits (and associated deposit type classification) within the Cache Creek Terrain lithologies.

Plate 13: Looking south into B.C.

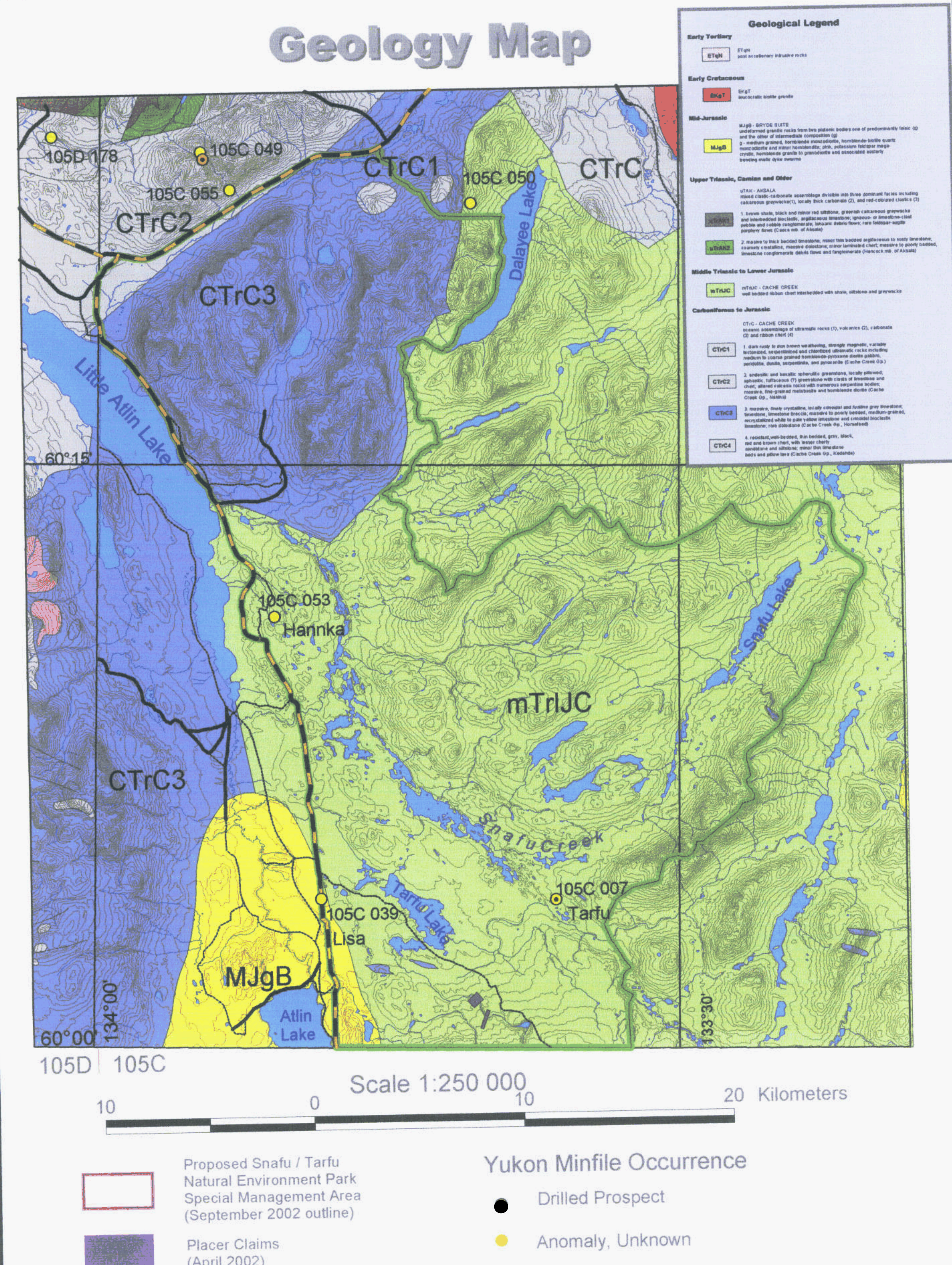

Figure 3

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Arcview GIS Version 3.2 - JvR - February 2003

Mineralization and Potential Metallogeny

Three Yukon Minfile occurrences are within the boundary of the proposed SMA and an active placer operation is located on the access road in the southern end of the proposed SMA boundary. The table below summarizes the status and what is known about the occurrences in the area and a written description from the Minfile database is included in Appendix 2.

Table 1. Minfile Occurrences within the proposed Special Management Area.

Minfile Number	Name	Status	Target	Commodity
105C007	TARFU	Drilled Prospect (Drill core sampled during 2002 work.)	Geophysical anomalies	Unknown
105C039	LISA	Trenched (Occurrence not found in 2002.)	Unknown	Unknown
105C053	HANNKA	Unknown (Occurrence not found in 2002.)	Unknown	Unknown

Mineralization is not well documented for the Minfile occurrences that plot within the proposed SMA boundary however some occurrences located near the area of study have been. At the TOG mineral occurrence (Minfile 105C028), gold bearing quartz veins and quartz carbonate alteration occur in faults associate with tectonically-emplaced ultramafic bodies. Visible gold is associated with malachite, azurite, pyrite, galena and sphalerite (Yukon Exploration, 1990). This occurrence is located north of the proposed SMA but a similar ultramafic body with coincident geochemical anomalies is mapped at the north end of the proposed SMA [Target Area 2, Figure 4].

Diamond drill core (near the bottom of the hole) at the Tarfu occurrence (105C007) was sampled in 2002 and returned anomalous nickel values of 1664 and 1431 ppm Ni with coincident chromium values of 1916 and 1648 ppm Cr respectfully from sheared strongly magnetic dark green serpentenite. The Kerr Addison drill hole was designed to test a coincident electromagnetic, self-potential and magnetic anomaly however according to the Minfile (2001) database "no mineralization was found".

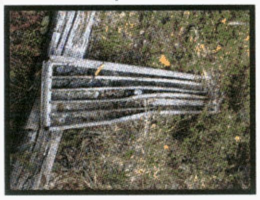


Plate 14: Core box

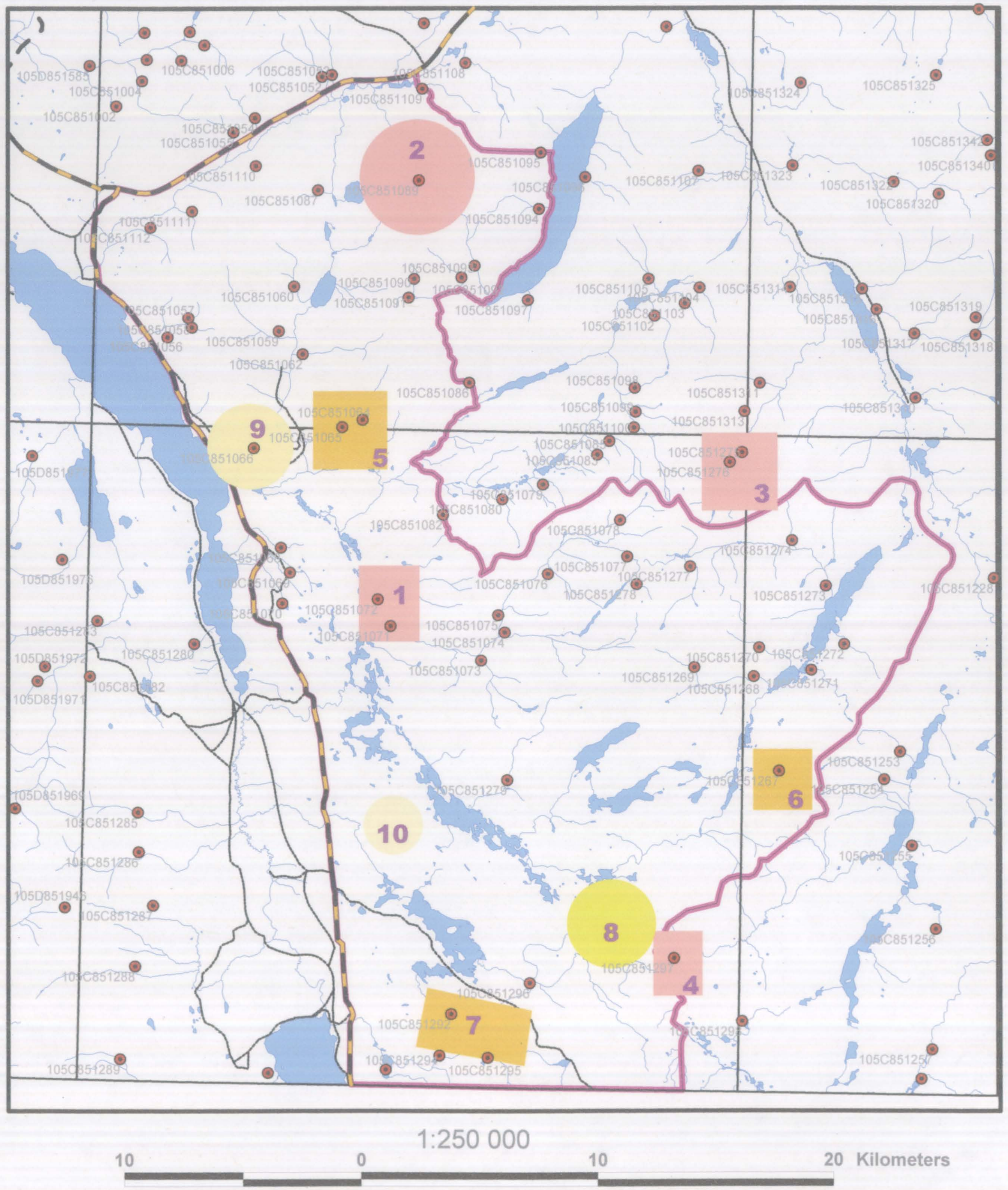
Plate 15: Drill core sampled in 2002

It is probable that the company did not analyze the drill core for nickel or chromium. The assessment report (Sirola, 1964) on exploration activity the property prior to drilling does not list any nickel results. Elevated copper and zinc in soil values were noted from more than 250 soil samples collected in 1963 along 13 miles of cut line. No outcrop was exposed at the drill pad or in the vicinity of the occurrence, only thick glacial drift, and drilling results were not filed with the mining recorders for further assessment credits.

The geological setting of the Snafu area is permissive for various types of deposits. The area is considered by experts to have potential to host gold-quartz veins, copper-gold quartz veins, polymetallic veins, epithermal gold-silver veins, copper skarns, gabbroic nickel, minor podiform chromite, and porphyry molybdenum deposits.

The mid Jurassic Bryde Suite intrusive located in the southwestern corner of the proposed SMA has the potential to host polymetallic veins, plutonic related gold quartz mineralization and gold copper molybdenum porphyry style deposits.

Regional Stream Sediment Sample Locations & 2002 Target Areas



RGS Sample Locations

• Sample Number

2002 Target Areas

1 Anomalous Gold (Not visited in 2002)

2 Anomalous Au, F, ultramafics & Intense Areomag Feature

3 Anomalous Gold (outside proposed SMA)

4 Anomalous Gold (outside proposed SMA)

5 Multi element anomaly (Ni, Cu, Pb, Zn, Fe, As, Sb, F, V, Mo, Ag)

6 Elevated Cu & Hg (Au, Zn, Fe, V, U, Mo)

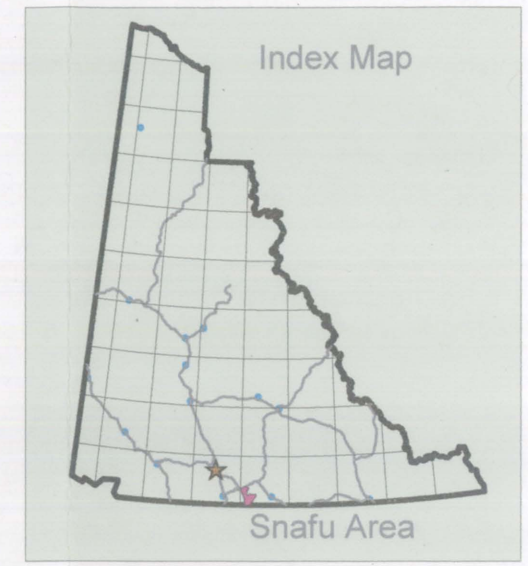
7 Multi element anomaly (As, Sb, Ba, V, U, Mo), Placer Claims

8 Intense Aeromag Feature Minfile 105C007

9 Moderate Aeromag Feature (no o/c found in 2002)

10 Weak Aeromag Feature (Not visited in 2002)

Proposed Snafu/Tarfu Special Management Area (September 2002 outline)



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RGS Sample Locations & 2002 Target Areas

Figure 4

Arcview GIS Version 3.2 - JvR - February 2003

The proximity to the mapped intrusive of a large section of under-explored and poorly exposed rocks in the southern portion of the proposed SMA provides a potential host for polymetallic vein and plutonic related gold-quartz vein systems. Rusty weathering argillaceous siltstone hosts a 1m wide discontinuous quartz vein at station RSTO2 at target 7 (sample location map, figure 5).

Sheeted quartz stingers were discovered and sampled during the 2002 fieldwork in an area regionally mapped as chert. Bright red-rusty weathering massive chert yielded the highest 2002 gold in rock value of 13.1 ppb and 2317 ppm Ba from an argillaceous clay seam (# 97667). Green chlorite and carbonate altered dykes were also located in this area and appear similar style to those found at the Keno Hill camp. Rock sample 97664 collected in the area yielded the highest lead value of 19.3 ppm Pb and elevated copper of 46.6 ppm Cu.

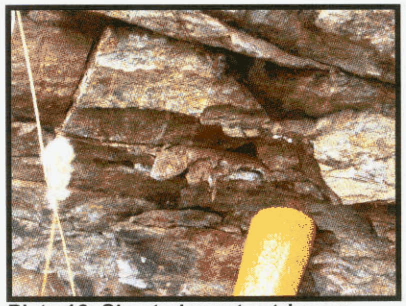


Plate 16: Sheeted quartz stingers

Near the thrust contact between the limestone and chert units, in the central portion of the proposed SMA, buff pink weathering dolomitized limestone with calcite veinlets yielded values of 10.2 ppb Au and the highest cadmium assay of 5.5 ppm as well as an elevated arsenic value.

Geochemistry

Regional Stream Sediment Geochemistry (RGS)

At the compilation phase (prior to fieldwork) of the mineral assessment process, a total of 46 stream sediment samples reported in GSC open file 1217 (Friske, 1985) fell within the proposed boundaries of Snafu/Tarfu SMA. An area slightly larger than the proposed SMA boundary (composed of 122 samples) was statistically manipulated to identify anomalous samples within the local area and identify potential 2002 field targets.

Geochemical plots were generated to display the sample location and analytical results for 20 elements, loss on ignition, and pH in the region. Each plot at 1:250 000 scale shows the detection limit & analytical method used, the maximum & median value and a histogram used to determine color ranges for RGS thematic mapping purposes (Appendix 3).

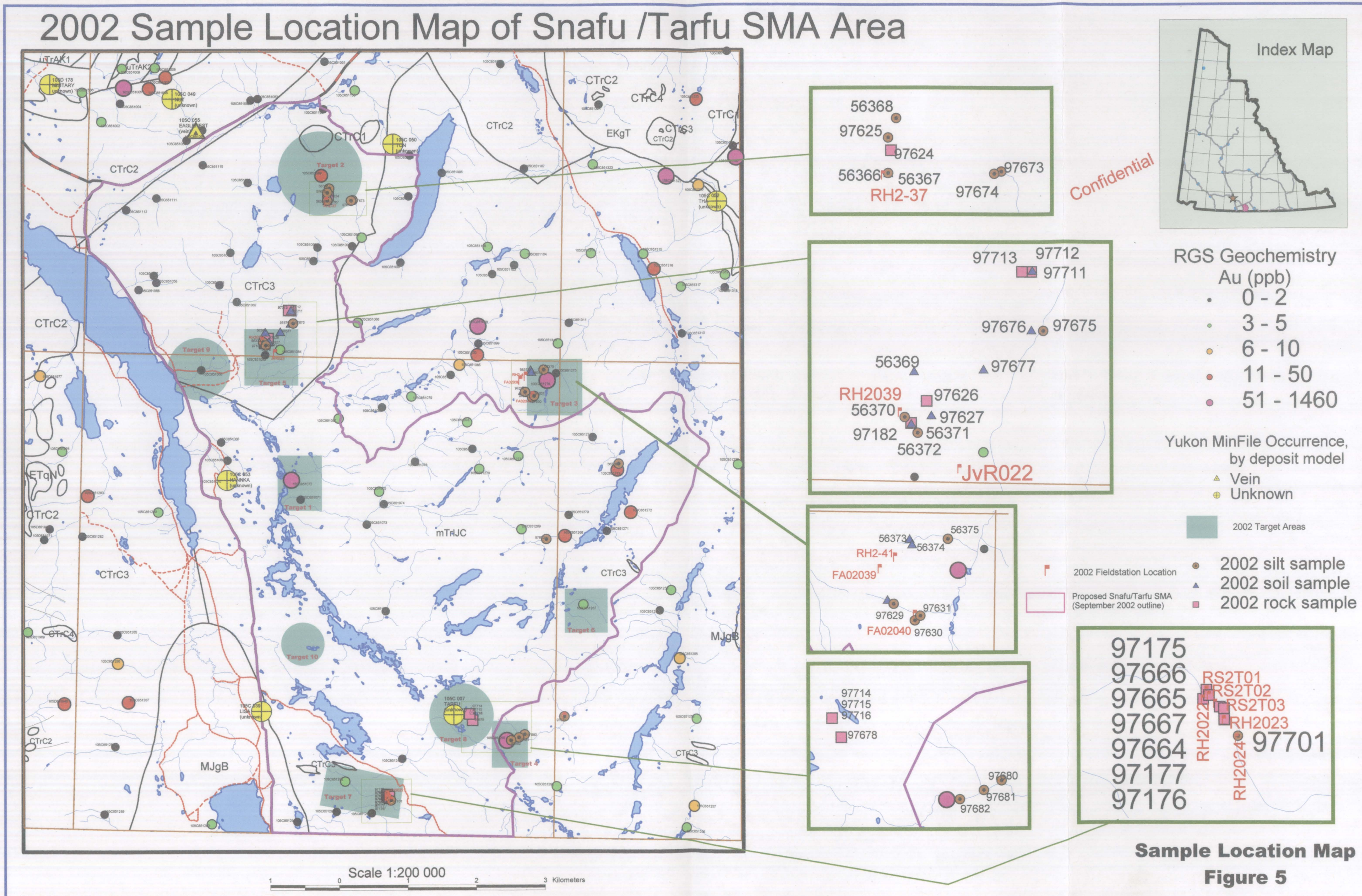
Precious Metals-

An anomalous gold value of 86 ppb Au is reported in the center of the proposed SMA near a chain of lakes [2002 Target Area1]. A cluster of detectable gold (11-12 ppb Au) is located around creeks draining into Snafu Lake on the SE arm of the proposed SMA. A further significant result of 19 ppb Au is located at the northern most point of the proposed SMA in rocks regionally mapped as limestone [2002 Target Area 2].

Plate 17: Target Area 1

Although outside of the proposed SMA boundary, sample 105C851297 located in the extreme southeast corner yielded a value of 761 ppb Au [2002 Target Area 4]. Similarly, a sample just north of the SE arm of the proposed SMA gave a 1460 ppb gold assay [2002 Target Area 3].

Silver values are generally low and range from 0.1 to a high of 2.0 ppm Ag within the proposed SMA. Only 4 samples are reported higher than 0.2 ppm Ag in the SMA area. Relatively high numbers of 0.6 and 2.0 ppm Ag are located within the limestone unit at its southern contact with the chert. Gold and silver values do not correlate well in this area.



2002 Sample Location Map of Snafu /Tarfu SMA Area
Index Map
Confidential
RGS Geochemistry
Au (ppb)
0 - 2
3 - 5
6 - 10
11 - 50
51 - 1460
Yukon MinFile Occurrence,
by deposit model
Vein
Unknown
2002 Target Areas
2002 Fieldstation Location
Proposed Snafu/Tarfu SMA
(September 2002 outline)
2002 silt sample
2002 soil sample
2002 rock sample
56368
97625
97624
56366
56367
RH2-37
97673
97674
97713
97712
97711
97676
97675
56369
97677
RH2039
97626
56370
97627
97182
56371
56372
JvR022
56373
56375
56374
RH2-41
FA02039
97629
97631
FA02040
97630
97714
97715
97716
97678
97680
97681
97682
97175
97666
97665
97667
97664
97177
97176
RS2T01
RS2T02
RS2T03
RH2023
RH2022
RH2024
97701
Target 1
Target 2
Target 3
Target 4
Target 5
Target 6
Target 7
Target 8
Target 9
Target 10
CTrC2
CTrC3
CTrC4
CTrC1
EKgT
mTrJC
MJgB
uTrAK1
uTrAK2
Scale 1:200 000
Kilometers
Sample Location Map
Figure 5

Base Metals –

A coincident anomaly of 60 ppm nickel, 45 ppm copper, 75 ppm zinc, 7 ppm lead, and 3.1% iron is located within the central portion of the proposed SMA, north of Haunka Creek [2002 Target Area 5]. This sample site (#105C851064) is at the contact between the limestone and chert +/- shale, siltstone greywacke unit.

The highest copper value of 65 ppm reported within the proposed SMA is on the SE boundary near Snafu Creek. Three other mid-30 ppm range of copper values are reported along the eastern edge of the proposed SMA.

An area of elevated copper and mercury values with higher than the median gold, zinc, iron, vanadium, uranium, and molybdenum is located south of Snafu Lake on the eastern side of the proposed SMA [2002 Target Area 6].

The highest zinc value within the east margin of the proposed SMA boundary returned 85 ppm Zn with a cluster of slightly elevated values between 61 – 71 ppm reported for the surrounding samples.

No other anomalous samples for nickel and lead fall within the proposed SMA area and values are generally between 15 & 20 ppm Ni and 3 & 4 ppm Pb throughout. The highest iron value of 5.6% falls outside the proposed SMA boundary and values ranging from 0.4% to a high of 3.1% Fe are within the proposed boundary.

Other metals –

An arsenic & antimony anomaly is coincident with the multi element base metal 105C851064 sample previously described as Target Area 5. The same sample produced 1.3 ppm Sb and 11.2 ppm As (both in the highest relative ranges for each element). A second arsenic/antimony anomaly of 9.2 ppm As & 0.8 ppm Sb is located on the eastern margin of the mid Jurassic monzodioritic body.

An area of elevated arsenic, antimony, barium, vanadium, uranium, and molybdenum values is located south of Tarfu Lake in the south central portion of the proposed SMA [2002 Target Area 7].

Tin values are very low overall with values of 1 or 2 ppm except for a site north of Snafu Lake that yielded 4 ppm Sn.

Indicators –

The pH values for the area are generally neutral with results ranging from 6 to 8.2 with the vast majority being slightly basic. On the pH figure, blue indicates samples above the neutral level while red indicates samples below the neutral level (all values below neutral plot outside the proposed SMA area).

The Loss on Ignition (LOI) plot shows three sample sites within the proposed SMA as having values greater than 25% indicating higher organic content at these sites. Two of these sites are located in the central portion of the proposed SMA with a third located on the SE arm of the proposed SMA near Snafu Creek. The vast majority of the sites however, have low LOI values.

2002 Geochemistry

During the 2002 field investigations of proposed Snafu/Tarfu area, a total of 16 rock, 10 soil and 19 silt sediment samples were collected and subsequently analyzed. The samples were submitted to Northern Analytical Laboratories Ltd. of Whitehorse where they were prepared and the pulp samples were shipped to Acme Analytical Laboratories in Vancouver for geochemical analysis. The samples were analyzed by Induced Coupled Plasma – Mass Spectroscopy (ICP-MS) technique using an Aqua Regia digestion.

Sample descriptions and analytical results for rock, soil and stream sediment silt samples collected in 2002 are presented in table 2.

Quality control to ensure the integrity of the 2002 geochemical data was done for all samples, from all projects, submitted by mineral assessments in 2002 as one data set for the 215 rock samples and one set for the 667 stream sediment and soil samples. Data pertaining to the proposed Snafu/Tarfu SMA is included within these sample sets. Analysis of the quality control data showed that the 2002 analytical results are reliable. Analytical procedures and geochemical statistics for quality control are summarized in Appendix 1 and further details can be found in a separate document (Hulstein et al, 2003).

Plate 18: 2002 rock sample

Significant results for rock samples are discussed above in the Mineralization and Potential Metallogeny section of this report.

The results for the soils and silts collected in 2002 are generally low with few elevated values relative to the small population of specimens. A coincident nickel, copper, zinc, arsenic, and antimony soil anomaly (# 56371 - described as containing red hematitic granules at a gossan patch-fault zone, with calcite float) yielded 56.2 ppm Ni, 54.4 ppm Cu, 151 ppm Zn, 57.8 ppm As, and 8.4 ppm Sb. This sample site is located at target 5 on a steep south-facing slope (sample location map, Figure 5).

The highest 2002 gold in soil result of 7.1 ppb Au is within target area 3, in the east central portion of the proposed SMA (designed to investigate the 1460 ppb Au result from a regional stream sediment sample). The sample (# 97628) is described as being collected in a dry stream bed and consisting of brown fine sand. Located further down the same drainage, the highest values for lead and zinc in 2002 silts was collected from the moss mat at the side of the steep grade, fast-flowing creek. This sample (# 97631) yielded 38.4 ppm Pb, 106 ppm Zn, elevated copper at 45.3 ppm Cu, and detectable gold of 5.5 ppb Au.

Geophysics

The regional aeromagnetic survey (as shown in the attached Figure 6) is part of the digital Areomagnetic Data Over the Yukon Territory included in Yukon Digital Geology CD by Gordey and Makepeace, 2001. The geophysical data pertinent to this report was originally flown as part of the 1961 analogue survey #61-43 at a height of 305m in an East West direction with 1207 meter line spacing. Individual Yukon survey data was subjected to a variety of filtering, processing, and enhancement procedures to generate a single, leveled, seamless residual magnetic anomaly data set for the entire Yukon Territory (Miles, 1999).

Figure 6 displays a strong magnetic high centered over the mapped ultramafic body in the northeast corner of the proposed SMA [2002 Target Area 2]. A positive magnetic halo around the anomalous magnetic feature trends to the south and northeast.

A second smaller zone of increased magnetic susceptibility is located in the south, southeast corner of the proposed SMA [2002 Target Area 8]. This anomaly is coincident with the TARFU minfile occurrence (105C007). This distinct feature has a very weak elevated magnetic halo associated with it that trends north, northwest which roughly parallels the chain of lakes in the area. No mapped geological feature explains this magnetic signature.

A further notable feature on the areomagnetic map is a weak magnetic high with an associated "tail" which trends to the west northwest, located near the Atlin Road north of the southern contact of the limestone and chert units. This feature has a weaker yet similar geophysical signature to the anomaly centered at the Minfile 105C007.

The first vertical derivative thematic map (figure 7) of the regional areomagnetic data was used to enhance detail and to allow interpretation of subtle features not visible on the residual magnetics map.

Table 2. 2002 Geochemical Results

Snafu Area 2002 Rock Geochemistry

Number	Ag (ppm)	Al %	As (ppm)	Au (ppb)	B (ppm)	Ba (ppm)	Bi (ppm)	Ca %	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe %	Ga (ppm)	Hg (ppm)	K %	La (ppm)	Mg %	Mn (ppm)	Mo (ppm)	Na %	Ni (ppm)	P %	Pb (ppm)	S %	Sb (ppm)	Sc (ppm)	Sr (ppm)	Th (ppm)	Ti %	Tl (ppm)	U (ppm)	V (ppm)	W (ppm)	Zn (ppm)	Description
97175	0.10	0.73	2.1	6.70	3.0	369	0.20	0.06	0.10	2.4	85	60.3	1.610	3	0.03	0.18	13	0.53	103	1.50	0.0050	7.90	0.016	8.2	0.080	0.20	1.6	11	3.80	0.0050	0.1	0.40	12	0.10	38	Grey Mudst-chert, trace-0.5% dis fine grained bright py, hairline fractures.
97176	0.05	0.10	1.0	0.25	1.0	86	0.05	1.31	0.30	1.6	196	7.4	0.580	0	0.07	0.02	1	0.23	314	1.20	0.0030	5.70	0.015	1.9	0.025	0.30	1.0	73	0.10	0.0010	0.1	0.05	4	0.10	27	White quartz veins, <10cm thick, approx horizontal, irregularly spaced and thickness, crossing green carb alt andesite dyke, coxcomb textures, vuggy.
97177	0.10	1.49	2.8	0.25	3.0	511	0.10	1.43	0.40	17.0	213	42.5	3.070	5	0.03	0.16	6	2.31	647	2.60	0.0310	35.10	0.062	2.6	0.260	0.20	4.8	52	1.40	0.0090	0.1	0.70	35	0.10	82	Random grab over 2m width of green chl-carb alt dyke with tr-o.5% dis arspy and tr py. Very similar to dykes in keno hill camp.
97182	0.05	0.02	5.2	0.25	0.5	16	0.05	25.27	1.00	1.0	14	2.9	0.040	0	0.06	0.01	3	12.27	124	0.10	0.0070	5.40	0.037	1.1	0.025	0.10	0.1	79	0.05	0.0005	0.1	0.50	1	0.05	33	Subcrop of rusty hem rich-clay alt lst
97624	0.10	0.06	2.3	0.25	1.0	61	0.05	25.96	0.40	1.5	17	36.5	0.300	0	0.14	0.03	5	0.19	93	0.50	0.0010	5.30	0.011	1.7	0.025	0.50	1.0	269	0.30	0.0010	0.1	1.20	3	0.05	13	Reddish weathering-stained, light-dark grey limestone, locally brecciated with dark grey calcite veinlets.
97626	0.05	1.21	3.7	0.60	1.0	133	0.10	1.92	0.10	6.4	14	23.2	2.890	5	0.50	0.14	27	0.41	464	1.30	0.0400	0.05	0.204	2.2	0.025	0.10	7.4	20	4.60	0.1520	0.1	1.00	47	0.05	92	beige/buff ash tuff outcrop. Yellow/orange oxide stains on fractures.
97664	0.50	0.88	5.4	2.70	3.0	1042	0.40	0.06	0.05	1.2	62	46.6	2.400	6	0.06	0.30	23	0.65	125	3.00	0.0110	9.20	0.034	19.3	0.100	0.90	3.2	14	6.50	0.0070	0.2	0.90	41	0.10	65	Carbonaceous rusty weathering black argillite. Mod. Well foliated. Chert bands. Cleavage 85/20s
97665	0.05	0.47	0.9	0.25	1.0	725	0.20	0.09	0.10	3.9	166	44.8	1.230	4	0.02	0.09	5	0.35	338	0.80	0.0110	15.70	0.016	5.6	0.025	0.20	3.3	16	1.40	0.0040	0.1	0.20	11	0.10	37	Discontinuous outcrop of rusty weathering argillaceous siltstone with boudins of chert becoming light grey-green mudstone. Sample of qz vnlets. Foliation 100/?
97666	0.10	0.32	1.7	4.10	1.0	113	0.10	0.16	0.10	4.3	124	35.5	1.190	2	0.04	0.02	5	0.26	338	0.50	0.0200	15.80	0.026	9.9	0.025	0.50	3.6	13	1.20	0.0020	0.1	0.10	23	0.10	36	Grab of 1 cm white qz stringers spaced at 10 - 20 cm in grey banded phyllite (siltstone). Cleavage 70/62s
97667	0.10	0.24	5.5	13.10	1.0	2317	0.30	0.15	0.05	1.0	212	44.9	1.240	3	0.04	0.11	2	0.05	21	5.20	0.0070	6.10	0.008	3.0	0.110	0.90	3.6	18	0.90	0.0010	0.1	0.05	18	0.10	17	Bright Red-rusty weathered massive chert. Agrillaceous clay seam
97678	0.20	0.07	6.5	0.25	3.0	353	0.05	0.56	0.10	0.9	232	9.2	0.420	0	0.09	0.02	4	0.29	75	3.90	0.0010	11.90	0.051	1.7	0.025	0.40	0.5	33	0.30	0.0010	0.1	0.70	7	0.10	26	Rusty weathering very fine grained black chert. Massive and massive bedded. Mag sus 0.01.
97712	0.05	1.70	2.3	1.50	3.0	162	0.05	1.27	0.10	40.1	135	47.5	6.320	9	0.50	0.60	20	3.31	999	2.30	0.3270	138.90	0.187	2.3	0.025	0.10	0.9	66	2.40	0.6840	0.1	0.80	108	0.10	105	subcrop of brown weathering dark gray fine grained matrix ?diorite dyke trending 350/40NE
97713	0.10	0.02	4.0	10.20	0.5	21	0.05	41.83	5.50	1.0	9	3.3	0.040	0	0.15	0.01	1	0.37	18	0.10	0.0005	7.50	0.010	0.7	0.025	0.80	0.3	100	0.05	0.0020	0.1	0.20	1	0.10	80	buff pink weathering dolomitized limestone with calicite veinlets and fracture coatings; subcrop
97714	0.05	0.59	0.3	1.50	40.0	2	0.05	0.24	0.05	87.5	1916	9.0	4.470	1	0.50	0.01	0	23.66	598	0.40	0.0010	1664.60	0.003	0.2	0.025	0.05	10.1	1	0.05	0.0030	0.1	0.05	38	0.05	20	grab of drill core at Tarfu Minfile Occurrence (105C007) at bottom of 1964 drillhole, dark green serpentinite, whole 15 cm pieces but ground at ends
97715	0.05	0.72	1.1	0.80	34.0	12	0.05	2.64	0.10	88.3	1648	8.2	4.580	1	0.01	0.01	1	21.62	761	0.30	0.0010	1431.60	0.016	0.4	0.025	0.10	10.8	130	0.20	0.0110	0.1	0.50	42	0.10	27	grab of drill core at Tarfu Minfile Occurrence (105C007) further down hole than 97714 (at bottom of 1964 drillhole), dark green serpentinite?, intensley sheared with fragments <1cm wide
97716	0.05	0.46	3.8	0.70	2.0	357	0.10	5.94	0.40	4.9	109	21.2	1.090	3	0.06	0.06	6	0.74	432	2.40	0.0120	21.20	0.016	4.1	0.710	0.30	2.8	189	1.90	0.0950	0.1	0.40	20	0.30	51	grab of drill core at Tarfu Minfile Occurrence (105C007) further down hole than 97715 (at very bottom of 1964 drillhole), intensley sheared with fragments <1cm wide fine grained felsic intrusion with pervasive rust stain on fractures. 1% py as patches and disseminations.

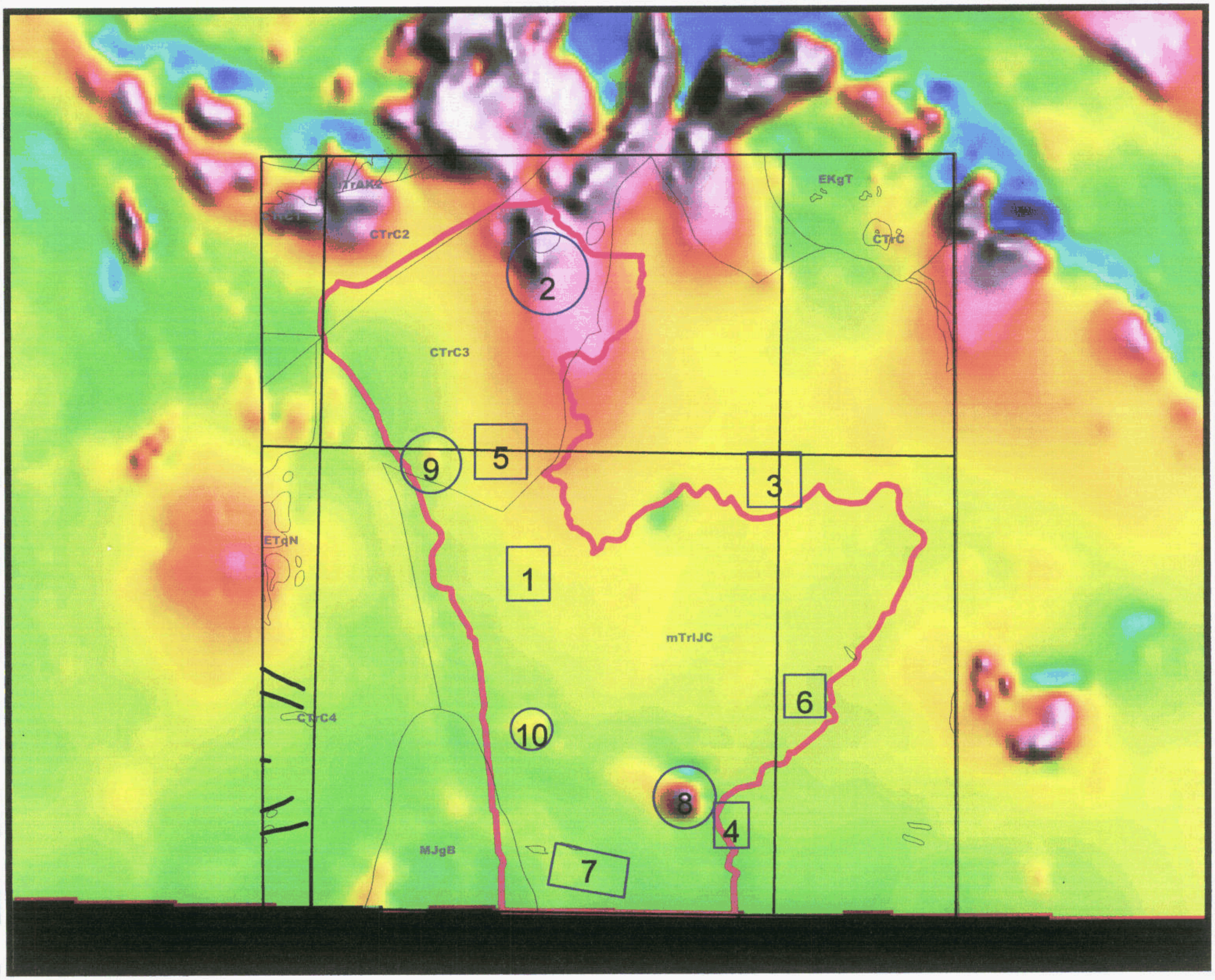
Snafu Area 2002 Soil Geochemistry

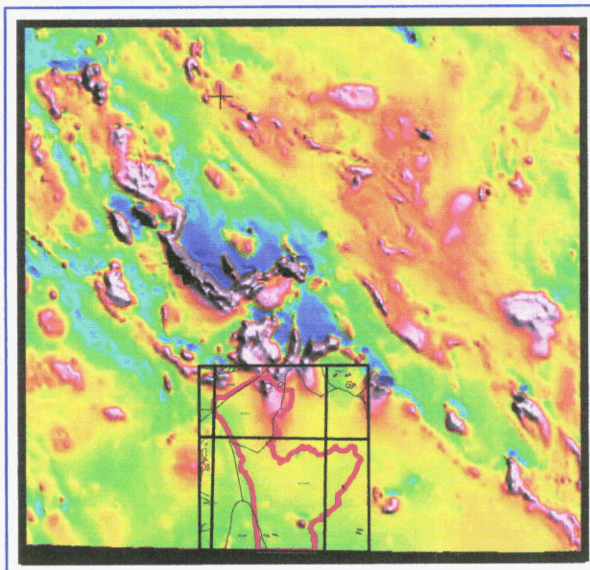
Number	Ag (ppm)	Al %	As (ppm)	Au (ppb)	B (ppm)	Ba (ppm)	Bi (ppm)	Ca %	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe %	Ga (ppm)	Hg (ppm)	K %	La (ppm)	Mg %	Mn (ppm)	Mo (ppm)	Na %	Ni (ppm)	P %	Pb (ppm)	S %	Sb (ppm)	Sc (ppm)	Sr (ppm)	Th (ppm)	Ti %	Tl (ppm)	U (ppm)	V (ppm)	W (ppm)	Zn (ppm)	Description
56367	0.20	1.98	11.8	2.70	2.0	327	0.20	0.31	5.60	13.4	16	32.4	2.260	6	0.43	0.03	20	0.09	1581	0.70	0.0050	31.50	0.047	22.1	0.025	1.50	5.4	9	4.60	0.0620	0.3	1.20	38	0.10	115	"red brown soil next to creek. Clay rich, lst float."
56369	0.20	5.41	7.1	4.30	1.0	496	0.30	0.91	1.70	14.8	23	18.0	3.800	21	0.35	0.04	26	0.09	489	0.80	0.0050	29.60	0.041	32.7	0.025	0.70	9.5	19	11.70	0.0980	0.9	2.50	70	0.05	193	"yellow patch 2X10m of clay rich soil in minor -modest depression with lst on both sides, trends approx E-W."
56371	0.10	1.14	57.8	1.40	6.0	212	0.20	2.62	1.20	9.4	47	54.4	2.970	4	0.15	0.18	18	0.73	448	0.70	0.0110	56.20	0.142	11.7	0.025	8.40	4.5	43	2.30	0.0400	0.1	0.90	68	1.30	151	"sample of red-hem granules at gossan patch, fault zone, dogstooth calcite float in zone."
56373	0.10	1.13	5.5	2.00	2.0	141	0.10	0.30	0.80	5.8	28	23.9	1.960	4	0.50	0.06	10	0.38	223	1.60	0.0080	25.90	0.049	8.7	0.025	0.50	2.8	16	2.00	0.0680	0.1	0.40	44	0.20	87	*"soil-till, mixed rounded glacial till float."*
56374	0.10	0.79	4.7	2.50	2.0	215	0.10	0.37	0.10	5.1	24	21.2	1.430	3	0.03	0.05	11	0.35	231	1.30	0.0110	17.60	0.063	6.7	0.025	0.40	2.4	25	2.20	0.0560	0.1	0.60	37	0.20	34	"sandy till, glacial outwash?"
97627	0.10	1.24	6.4	0.70	5.0	191	0.20	1.09	0.70	7.5	33	22.7	1.970	4	0.03	0.15	14	0.50	380	0.70	0.0150	29.50	0.081	13.1	0.025	0.60	3.9	24	2.50	0.0600	0.1	0.50	45	0.10	67	minor soil from gully overtop limestone bedrock.
97628	0.10	0.78	3.8	7.10	3.0	156	0.10	0.48	0.20	4.9	27	21.0	1.500	3	0.06	0.07	12	0.28	275	0.90	0.0090	18.90	0.085	6.3	0.025	0.40	3.1	31	2.50	0.0600	0.1	0.70	43	0.20	34	dry stream bed. Collected brown fine sand.
97676	0.10	1.41	5.9	2.30	3.0	212	0.10	0.53	0.50	8.3	37	20.4	1.980	5	0.02	0.09	13	0.52	164	0.90	0.0110	28.60	0.049	7.8	0.025	0.50	3.2	23	1.30	0.0650	0.1	1.00	52	0.20	54	"Brown soil in west drainage catchment (no stream bed) Limestone, green volcanics and granodiorite cobbles and pebbles. 30 cm depth"
97677	0.10	1.32	6.6	2.10	3.0	197	0.20	1.13	2.20	8.6	44	23.8	2.170	4	0.02	0.08	14	0.48	434	0.70	0.0140	36.00	0.068	8.2	0.025	0.60	3.3	23	1.30	0.0520	0.1	0.70	53	0.30	109	Brown soil in west drainage catchment (no stream bed) Limestone and calcite cobbles and pebbles. 20 cm depth
97711	0.10	2.23	5.9	0.90	2.0	265	0.20	1.47	6.80	13.3	44	21.2	3.010	8	0.03	0.04	20	0.55	1008	0.60	0.0190	34.60	0.125	9.0	0.070	0.50	3.5	27	1.60	0.1760	0.1	4.60	65	0.20	97	"red and black soil in 10 meter wide gully on ridge line (?fault structure), recessive unit? Trending 360 degrees, 25 cm deep"

Snafu Area 2002 Silt Geochemistry

Number	Ag (ppm)	Al %	As (ppm)	Au (ppb)	B (ppm)	Ba (ppm)	Bi (ppm)	Ca %	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe %	Ga (ppm)	Hg (ppm)	K %	La (ppm)	Mg %	Mn (ppm)	Mo (ppm)	Na %	Ni (ppm)	P %	Pb (ppm)	S %	Sb (ppm)	Sc (ppm)	Sr (ppm)	Th (ppm)	Ti %	Tl (ppm)	U (ppm)	V (ppm)	W (ppm)	Zn (ppm)	Description
56366	0.10	0.92	6.2	1.20	2.0	160	0.10	1.26	0.90	6.5	41	18.6	2.250	4	0.08	0.06	15	0.59	282	0.70	0.0120	24.90	0.077	7.6	0.025	0.70	3.0	24	3.10	0.0650	0.1	1.40	65	0.40	65	"Near head of creek, lst float, lst brx."
56368	0.10	0.95	8.5	2.70	3.0	164	0.10	3.87	1.60	7.7	27	24.4	1.740	3	0.11	0.07	15	0.50	512	0.90	0.0120	28.50	0.080	9.4	0.025	1.00	2.8	34	2.00	0.0460	0.1	0.80	40	0.20	72	"at base of cliff, very steep creek."
56370	0.10	0.88	7.0	1.60	3.0	164	0.10	1.04	0.20	8.1	36	22.4	1.680	3	0.03	0.10	11	0.66	373	0.60	0.0220	31.70	0.070	6.2	0.025	0.50	3.5	38	3.10	0.0610	0.1	0.50	45	0.20	42	"dry gully, lst and glacial exotic float. Below glacial till."
56372	0.10	0.90	7.2	5.60	3.0	172	0.20	1.09	0.30	7.6	39	29.3	1.720	3	0.02	0.11	12	0.76	366	0.70	0.0200	28.90	0.072	6.6	0.025	0.70	3.8	29	2.90	0.0620	0.1	0.50	50	0.30	45	"dry gully, lst and glacial exotic float. Below glacial till."
56375	0.10	0.93	5.0	9.70	2.0	176	0.10	0.51	0.30	8.7	39	28.5	1.620	4	0.05	0.09	14	0.50	337	0.90	0.0220	25.10	0.074	9.0	0.025	0.50	3.7	35	3.50	0.0840	0.1	0.80	44	0.20	43	"head of tiny creek draining glacial till, clay rich."
56376	0.10	0.71	15.3	3.40	4.0	246	0.10	1.22	0.30	6.3	27	14.6	1.860	3	0.04	0.07	11	0.38	1903	1.90	0.0150	18.50	0.089	6.0	0.025	0.50	2.3	39	2.20	0.0510	0.1	1.10	38	0.90	41	"Glacial till filled valley, creek between two lakes."
97625	0.10	0.84	5.8	2.00	3.0	141	0.10	2.87	0.90	6.6	29	17.5	1.680	3	0.09	0.06	13	0.58	329	0.60	0.0120	25.70	0.067	7.4	0.025	0.70	2.6	29	2.40	0.0510	0.1	0.70	41	0.20	59	overspill from plungepool.Steep grade to creek with moderate water flow.Grey limestone and subordinte diorite.
97629	0.30	1.11	4.5	12.40	3.0	173	0.10	0.52	0.10	6.3	29	29.2	1.710	3	0.21	0.09	13	0.36	262	2.30	0.0110	20.30	0.092	10.6	0.025	0.60	3.7	44	2.20	0.0630	0.1	1.30	43	0.20	48	multiple channels merge into one. Steep grade but low water flow makes good sample site. Same rock as FA02039.
97630	0.30	1.39	4.9	1.80	4.0	273	0.10	0.65	0.40	8.0	28	33.9	1.930	4	0.16	0.09	13	0.42	427	1.60	0.0120	25.70	0.074	12.4	0.070	0.50	4.0	53	1.90	0.0430	0.1	1.40	38	0.20	83	"steep grade, low flow. Rounded cobbles of metasediments."
97631	0.60	1.62	5.4	5.50	5.0	368	0.20	0.88	0.50	9.2	33	45.3	2.100	4	0.25	0.11	15	0.47	431	1.70	0.0140	35.20	0.092	38.4	0.070	0.70	4.7	77	1.50	0.0420	0.1	1.70	36	0.20	106	moss mat from side of creek. Steep grade and fast flow leaves only boulders to form streambed.
97632	0.10	0.84	6.0	3.50	6.0	448	0.20	1.22	0.20	8.5	28	48.0	2.070	3	0.04	0.07	10	0.42	4964	1.90	0.0190	18.30	0.083	10.1	0.090	0.30	2.8	107	1.80	0.0490	0.1	0.80	33	0.20	55	organic silty slime from creek bottom. No rocks.
97673	0.10	0.80	5.0	6.40	2.0	139	0.10	1.43	0.40	6.7	36	15.4	1.670	3	0.02	0.05	13	0.57	316	0.60	0.0140	25.70	0.062	5.1	0.025	0.50	2.6	24	2.90	0.0580	0.1	0.50	49	0.30	45	"Dry stream bed below forks. Lmst otc and boulders, rounded green volc., grano, calcite and quartz cobbles"
97674	0.10	0.80	5.0	1.80	3.0	134	0.10	1.67	0.50	6.4	35	14.9	1.710	3	0.06	0.06	13	0.54	290	0.50	0.0130	25.90	0.067	5.4	0.025	0.40	2.5	24	3.00	0.0560	0.1	0.60	49	0.20	46	"Dry stream bed on south fork upstream of jct. Grey lst otc and boulders, rounded granodiorite, green volc., orange dolostone, black chert"
97675	0.10	1.12	5.9	0.80	6.0	260	0.10	1.78	0.80	7.6	44	35.7	1.950	4	0.05	0.12	12	0.75	254	0.60	0.0180	34.00	0.084	7.7	0.025	0.60	3.3	30	2.20	0.0660	0.1	0.60	49	0.30	80	"intermittent stream, sample of old silt, sand and gravel in dry stream bed, some moss growth. Limestone boulders"
97679	0.10	0.91	4.6	1.00	7.0	186	0.10	0.72	0.30	7.7	36	45.0	1.800	3	0.06	0.13	11	0.44	424	1.40	0.0150	30.90	0.069	10.9	0.025	0.60	3.3	52	1.60	0.0470	0.1	1.20	47	0.20	66	"Dry stream bed, scavenged silt from gravel bar. Green volc. Granodiorite boulders and chert pebbles"
97680	0.10	0.76	8.1	1.70	4.0	232	0.10	0.74	0.10	6.4	28	24.9	1.360	3	0.04	0.07	10	0.39	788	2.40	0.0210	19.60	0.065	6.7	0.310	0.30	2.5	50	2.40	0.0580	0.1	2.30	29	0.20	37	Active silt in organic based main creek. Rounded granodiorite boulders and cobbles
97681	0.10	0.74	4.5	1.20	4.0	160	0.10	0.61	0.10	5.8	26	16.9	1.180	3	0.03	0.06	10	0.36	485	0.60	0.0160	18.40	0.066	4.2	0.025	0.30	2.4	40	2.50	0.0560	0.1	1.20	30	0.20	34	"Main creek near at mouth of creeklet from north. Active silt, organic banks to creek. Rounded granodiorite cobbles and gravel"
97682	0.05	0.56	2.7	1.20	2.0	151	0.05	0.38	0.05	4.6	19	6.8	0.850	2	0.02	0.04	8	0.29	532	0.40	0.0120	12.70	0.054	2.3	0.025	0.10	1.6	26	1.80	0.0450	0.1	0.70	21	0.20	26	"Main creek above beaver ponds. Organic banks. Active silt bar. Granodiorite boulders and green volc. Boulders, rounded."
97701	0.05	0.56	23.5	1.70	3.0	289	0.10	0.58	0.10	5.5	29	11.7	1.960	2	0.02	0.06	10	0.33	2290	2.50	0.0160	15.20	0.104	2.9	0.025	0.40	1.9	41	2.10	0.0450	0.1	1.70	44	0.90	29	"west draining creek on Calahan Discovery placer claims?, low velocity creek with lots of beaver dams, good dark brown silt accumulations"

Regional Residual Aeromagnetic Image





Proposed Snafu/Tarfu SMA
(September 2002 outline)

2002 Target Areas, number

Confidential

Geological Legend (simplified)

Early Tertiary
ETqN — ETqN post accetionary intrusive rocks

Early Cretaceous
EKgT — granite

Mid-Jurassic
MJgB — BRYDE SUITE undeformed granitic rocks from two plutonic bodies

Middle Triassic to Lower Jurassic
mTrJC — CACHE CREEK well bedded ribbon chert

Carboniferous to Jurassic
CTrC1, CTrC2, CTrC3, CTrC4 — CACHE CREEK oceanic assemblage of ultramafic rocks (1), volcanics (2), carbonate (3) and ribbon chert (4)

Magnetic Residual Anomaly (nT)

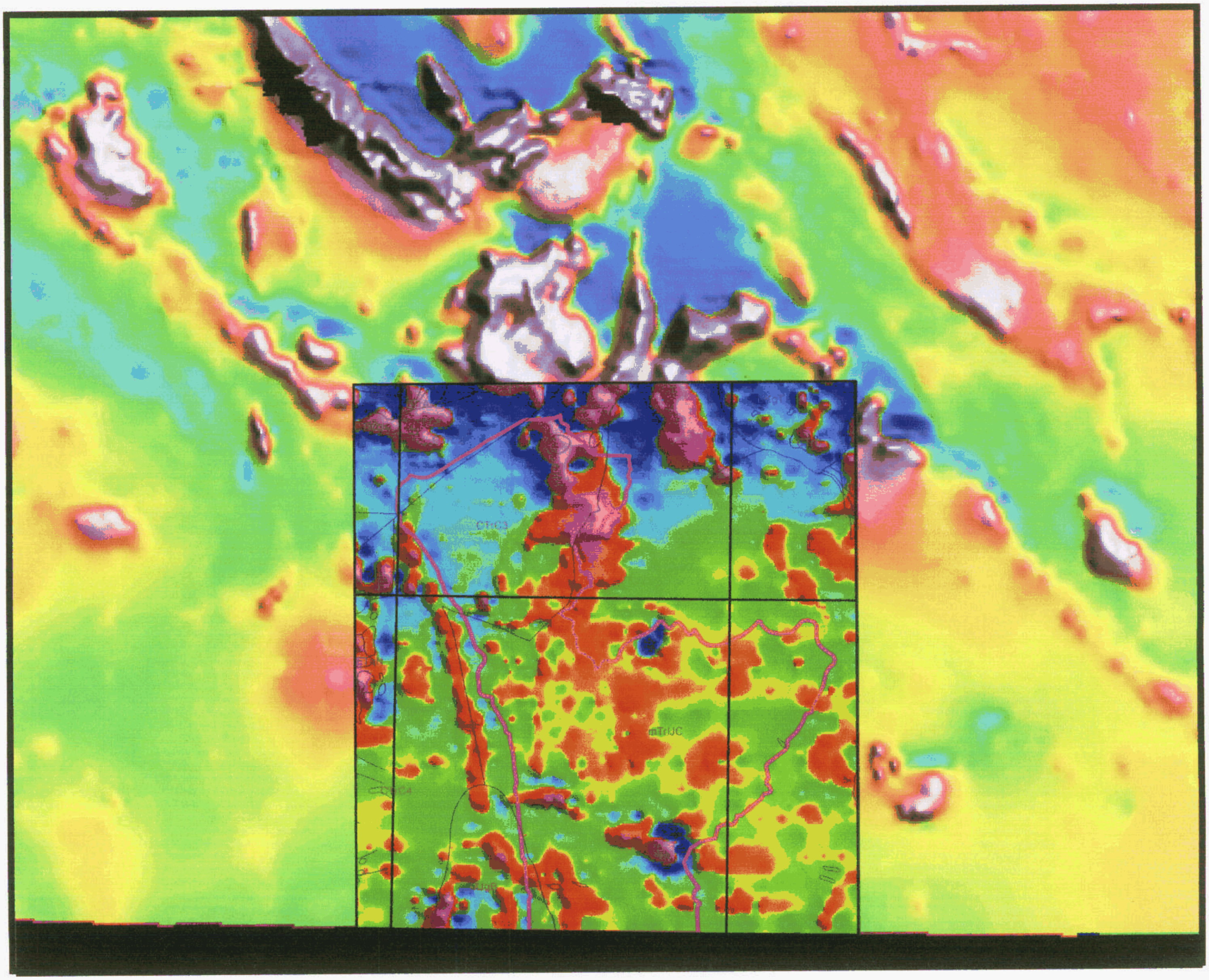
4300, 700, 570, 460, 390, 340, 295, 280, 260, 230, 215, 190, 160, 140, 115, 100, 75, 55

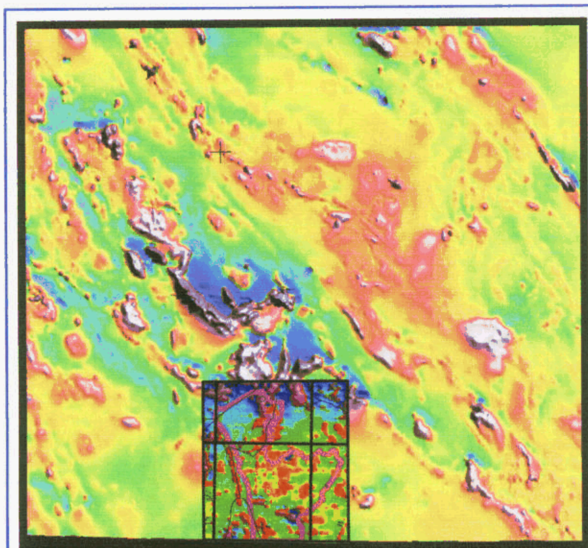
35, 15, 0, -20, -35, -50, -55, -65, -85, -95, -105, -125, -135, -145, -160, -190, -220, -280

ArcView 3.2 · Albers Custom Projection · JvR · February, 2003

Figure 6

First Verticle Derivative & Residual Aeromagnetic Image





Proposed Snafu/Tarfu SMA
(September 2002 outline)

Confidential

Geological Legend (simplified)

Early Tertiary
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CTrC1, CTrC2, CTrC3, CTrC4 — CACHE CREEK
oceanic assemblage of ultramafic rocks (1), volcanics (2), carbonate (3) and ribbon chert (4)

Magnetic Residual Anomaly (nT)

4300, 700, 570, 460, 390, 340, 295, 280, 260, 230, 215, 190, 160, 140, 115, 100, 75, 55

35, 15, 0, -20, -35, -50, -55, -65, -85, -95, -105, -125, -135, -145, -160, -190, -220, -280

ArcView 3.2 - Albers Custom Projection - JvR - February, 2003

Figure 7

The contact between the chert (mTrIJC unit) and the Cache Creek limestone (CTrC3 unit) near the western boundary of the proposed SMA became a distinct linear magnetic high feature on the first vertical derivative image compared to a subtle and very weak feature on the residual aeromagnetic image.

Indistinct anomalies on the residual image near the Bryde Suite intrusion in the southwestern corner of the proposed SMA are augmented and the area of the placer claims (target 7) are within a band of higher magnetic susceptibility that trends NW-SE from the mapped intrusion.

The central portion of the proposed SMA has an uneven magnetic signature on the first vertical derivative image that was interpreted to indicate potential of a more complex bedrock geological history than what is currently mapped.

Mineral Assessments

Regional Mineral Potential

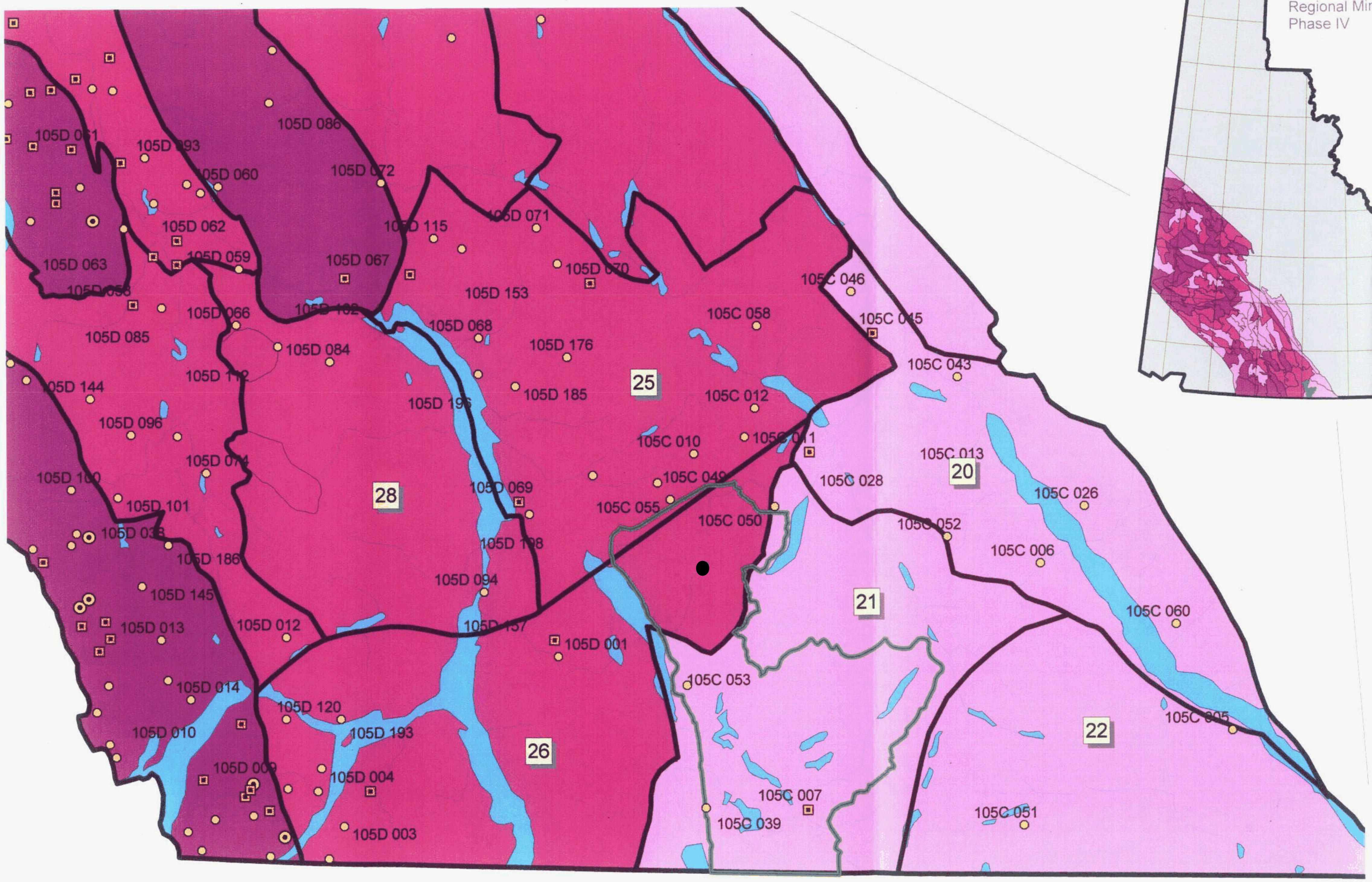
A regional mineral assessment study of the southwest Yukon (including the proposed SMA area) was completed in December of 2001 by YTG's Mineral Resources Branch of the Department of Economic Development. During the regional mineral assessment process, tracks composed of similar geological units (consisting of approximately 1000 km² in area) were ranked with respect to each other. The proposed SMA covers portion of three tracts ranked moderate to lowest relative regional mineral potential (Figure 8).

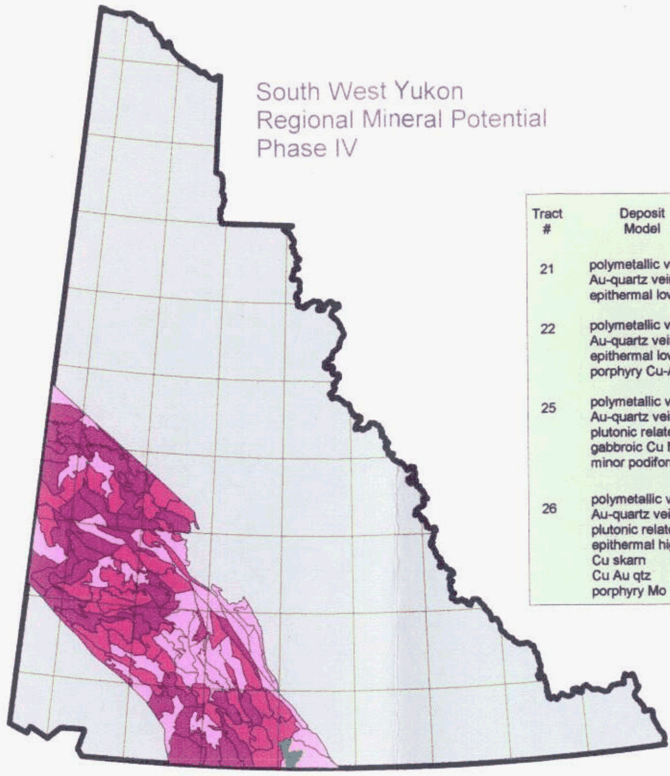
Expert panelists assessed the area covered by the proposed SMA for the potential to host the following deposit types: gold-quartz vein, copper-gold quartz vein, polymetallic vein, epithermal gold-silver, copper skarn, gabbroic nickel, minor podiform chromite, and porphyry molybdenum deposits. Descriptions of the deposit models used are appended (Appendix 4) to this report (Lefebure and Hoy, 1996).

Table 3. Regional mineral potential tract results for the proposed SMA area.

Tract #	Deposit Model	Median Tonnage	Median Deposit	Relative Tract Rank
21	Polymetallic Veins Au-quartz Veins Epithermal (low S)	160,987 290,751 1,080,000	Union – BC Georgia River – BC Paquilla - Mexico	Lowest
22	Polymetallic Veins Au-quartz Veins Epithermal (low S) Porphyry Cu-Au (alkalic)	160,987 290,751 1,080,000 115,000,000	Union – BC Georgia River – BC Paquilla – Mexico Kemess - BC	Lowest
25	Polymetallic Veins Au-quartz Veins Plutonic Related Au qtz Gabbroic Cu Ni Minor Podiform Cr	160,987 290,751 16,500,000 700,000 13,000	Union – BC Georgia River – BC True North – Ak Canalask – YT Karageban - Turkey	Moderate
26	Polymetallic Veins Au-quartz Veins Plutonic Related Au qtz Epithermal (high S) Cu Skarn Cu Au quartz Porphyry Mo	160,987 290,751 16,500,000 294,500 323,514 500,000 76,750,000	Union – BC Georgia River – BC True North – Ak Black Dome – BC Keewenaw – YT Golden Stranger – BC Mt. Tomlison - BC	Moderate

Regional Mineral Potential





Tract #	Deposit Model	Median tonnage	median deposit
21	polymetallic veins	160,987	Union - BC
	Au-quartz veins	290,751	Georgia River - BC
	epithermal low S	1,080,000	Paquilla - Mexico
22	polymetallic veins		
	Au-quartz veins		
	epithermal low S		
	porphyry Cu-Au (alkalic)	115,000,000	Kemess - BC
25	polymetallic veins		
	Au-quartz veins		
	plutonic related Au qtz	16,500,000	True North - AK
	gabbroic Cu Ni	700,000	Canalask - YT
	minor podiform Cr	13,000	Karageban - Turkey
26	polymetallic veins		
	Au-quartz veins		
	plutonic related Au qtz		
	epithermal highS	294,500	Black Dome - BC
	Cu skarn	323,514	Keewenaw - YT
	Cu Au qtz	500,000	Golden Stranger - BC
	porphyry Mo	76,750,000	Mt. Thomlison - BC

Scale 1:500 000

10 0 10 20 30 40 50 Kilometers

Confidential

Arcview 3.1 - December 2002 - JvR

Regional Mineral Potential

Figure 8

Detailed Mineral Potential

A detailed mineral assessment of the proposed Snafu/Tarfu area took place in Whitehorse, on December 13th and final analysis concluded in the morning of the 14th, 2002. The detailed mineral potential map (Figure 9) is the result of the assessment workshop.

Methodology

A study area slightly larger than the proposed SMA was demarcated to ensure all portions of the proposed SMA would be assessed during the workshop. The study area was divided into eight tracts, each representing a package of rocks that constitute a domain with unique lithological, geophysical or physiographic characteristics.

Tracts were delineated over the proposed SMA area using primarily bedrock geology, as well as geophysical data and physiographic features such as major drainages. Tracts 1 and 2 are underlain by Carboniferous to Permian aged finely crystalline grey limestone. Tract 2 hosts two mapped ultramafic bodies in the northern portion of the proposed SMA. Tract 7 consists of the northern most extension of the Fourth of July Batholith and is described as a leucocratic biotite granite body of early Cretaceous age. Tracts 3 to 6 and 8 are mapped regionally as undivided Cache Creek ribbon chert interbedded with shale, siltstone and greywacke. These tracts were separated on physiographic breaks and aeromagnetic features to make 5 tracts of similar size.

Plate 19: Panelists examine data

Five panelists were chosen for their expertise in the geology and mineral deposits of the Yukon and the study area: Rob Carne (consultant), Gerald Bidwell (consultant), Al Doherty (consultant), Mark Baknes (consultant) and Anna Fonseca (consultant). The Snafu assessment lasted two thirds of one day, with final discussions the following morning. After examining and discussing all the geoscientific information available for each tract, the panelists decided upon a list of deposit models pertinent to the tract and filled in evaluation forms for the likelihood of new discoveries of the median tonnage for each deposit type in the tract. The forms were utilized to maintain the focus on mineral deposit models and explorability of the tract and to reduce personal biases. The forms are not used for a statistical analysis.

At the end of the assessment, the panelists ranked the tracts relative to each other unanimously, from highest to lowest detailed mineral potential.

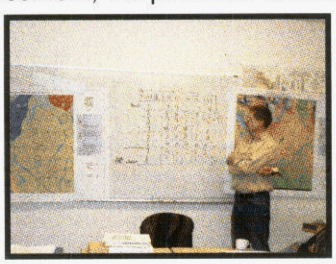
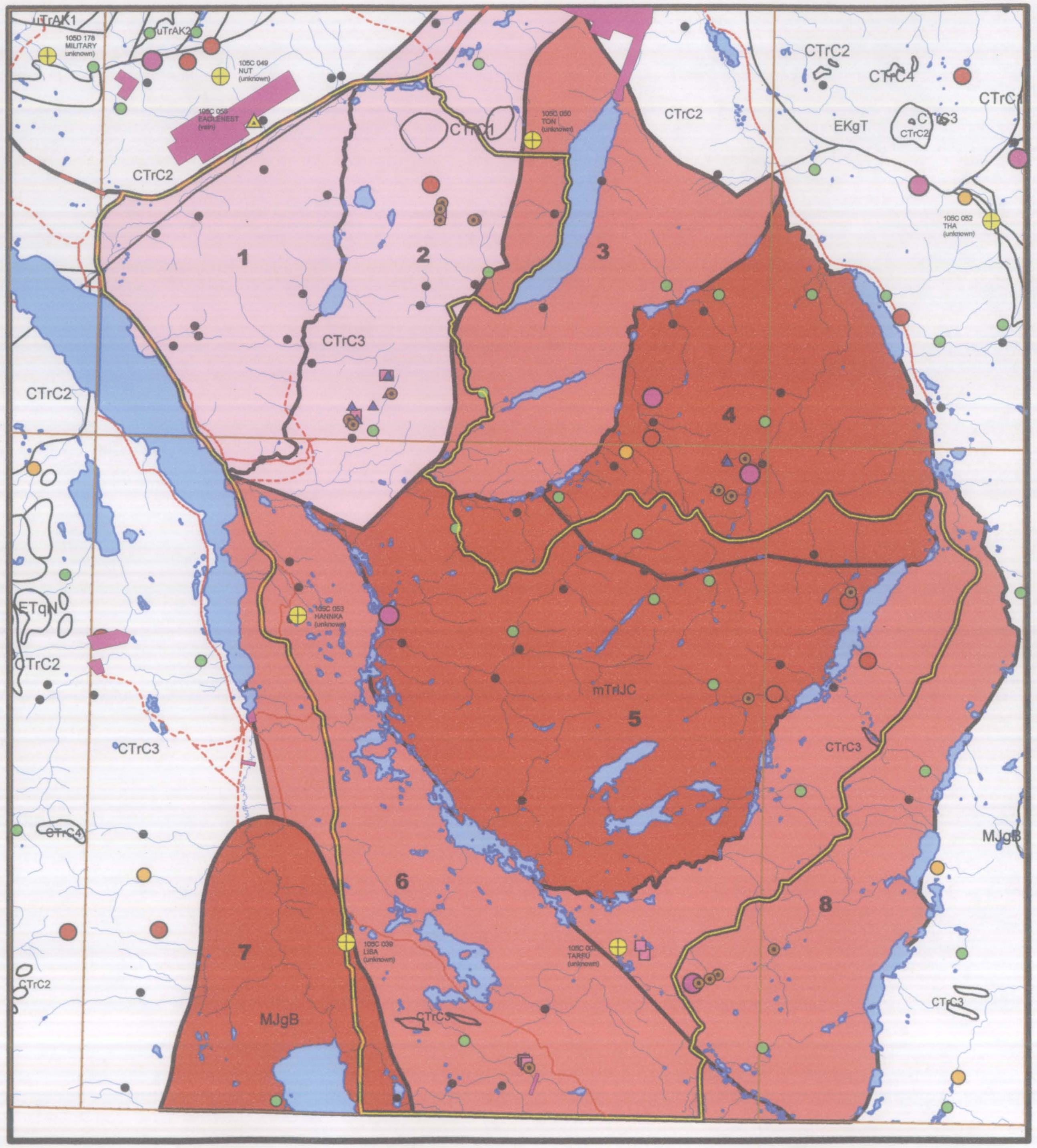


Plate 20: Final ranking of tracts

Limitations

Mineral potential maps portray the best estimation at the time of the assessment workshop. Since expert panalists are evaluating a hidden resource, it is important to realize that the geological knowledge base is in a constant state of growth, and mineral deposits may one day be found in rocks that were once thought to have lower relative potential.

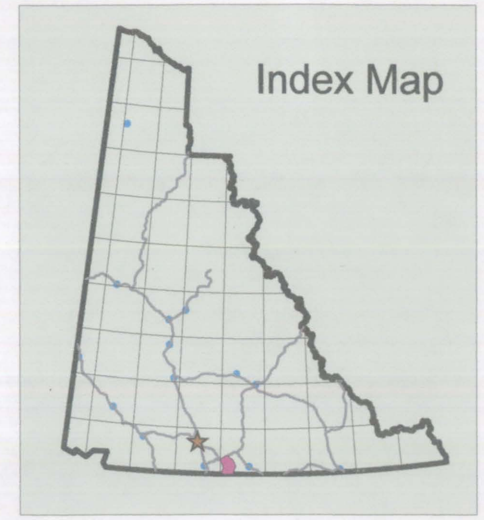
Detailed Mineral Potential Snafu Study Area



Scale 1:250 000

5 0 5 10 15 Kilometers

ArcGIS version 8.1
Albers Custom Yukon Projection
December 14, 2002
JvR Yukon Geology Program YTG



Confidential

Geological Legend

Early Tertiary

ETqN — ETqN
post accetionary intrusive rocks

Early Cretaceous

EKgT — EKgT
leucocratic biotite granite

Mid-Jurassic

MJgB — MJgB - BRYDE SUITE
undeformed granitic rocks from two plutonic bodies one of predominantly felsic (q) and the other of intermediate composition (g)
g - medium grained, hornblende monzodiorite, hornblende-biotite quartz monzodiorite and minor hornblendite; pink, potassium feldspar mega-crystic, hornblende granite to granodiorite and associated easterly trending mafic dyke swarms

Upper Triassic, Carnian and Older

uTAK - AKSALA
mixed clastic-carbonate assemblage divisible into three dominant facies including calcareous greywacke(1), locally thick carbonate (2), and red-coloured clastics (3)

uTrAK1 — 1. brown shale, black and minor red siltstone, greenish calcareous greywacke and interbedded bioclastic, argillaceous limestone; igneous- or limestone-clast pebble and cobble conglomerate; lahaaric debris flows; rare feldspar-augite porphyry flows (Casca mb. of Aksala)

uTrAK2 — 2. masive to thick bedded limestone; minor thin bedded argillaceous to sooty limestone; coarsely crystalline, massive dolostone; minor laminated chert; massive to poorly bedded, limestone conglomerate debris flows and fanglomerate (Hancock mb. of Aksala)

Middle Triassic to Lower Jurassic

mTrJC — mTrJC - CACHE CREEK
well bedded ribbon chert interbedded with shale, siltstone and greywacke

Carboniferous to Jurassic

CTrC - CACHE CREEK
oceanic assemblage of ultramafic rocks (1), volcanics (2), carbonate (3) and ribbon chert (4)

CTrC1 — 1. dark rusty to dun brown weathering, strongly magnetic, variably tectonized, serpentinized and chloritized ultramafic rocks including medium to coarse grained hornblende-pyroxene diorite gabbro, peridotite, dunite, serpentinite, and pyroxenite (Cache Creek Gp.)

CTrC2 — 2. andesitic and basaltic spherulitic greenstone, locally pillowed; aphanitic, tuffaceous (?) greenstone with clasts of limestone and chert; altered volcanic rocks with numerous serpentine bodies; massive, fine-grained metabasite and hornblende diorite (Cache Creek Gp., Nakina)

CTrC3 — 3. massive, finely crystalline, locally crinoidal and fusiline grey limestone; limestone, limestone breccia; massive to poorly bedded, medium-grained, recrystallized white to pale yellow limestone and crinoidal bioclastic limestone; rare dolostone (Cache Creek Gp., Horsefeed)

CTrC4 — 4. resistant,well-bedded, thin bedded, grey, black, red and brown chert, with lesser cherty sandstone and siltstone; minor thin limestone beds and pillow lava (Cache Creek Gp., Kedahda)

Yukon MinFile Occurrence, by deposit model
- Vein
- Unknown

Tract, number

RGS Geochemistry Au (ppb)
- 0 - 2
- 3 - 5
- 6 - 10
- 11 - 50
- 51 - 1460

- 2002 silt sample
- 2002 soil sample
- 2002 rock sample

Qtz & Placer Claims (March 2002)

Proposed Snafu SMA (Sept2002 outline)

Relative Detailed Mineral Potential
- Highest
- Lowest

Detailed Mineral Potential
Figure 9

Results and Conclusions

The results of the detailed mineral assessment workshop for the proposed Snafu/Tarfu SMA area are summarized in Table 4 below.

Table 4. Detailed mineral potential tract results.

Tract #	Deposit Models considered	Geology	Significant features	Relative Tract Rank
1	Polymetallic Veins Au-quartz Veins	CTrC3 - Limestone; red gossans noted	Ag, Cd, F, Mo, U, Co RGS anomalies	Lowest (8)
2	Polymetallic Veins Au-quartz Veins Pb Zn Skarn Gabbroic Cu Ni	CTrC3 - Limestone & ultramafic units; 2002 sample 97712 – ?gabbro or lamprophyre	Aeromagnetic feature; Ag, Cd, Co, Cr, F, Mo, Pb, Sb, Ni, V, Zn RGS; Small shear zone	Lowest (7)
3	Polymetallic Veins Plutonic Related Au qtz Porphyry Cu Mo Au Fluorine Vein	MTrlJC –chert with shale, siltstone, & greywacke; thrust contact with limestone units to north	Minfile 105C050- *unknown status*; Highest F RGS value; Sn, Ag, Co, F, U_H2O RGS	Moderate (6)
4	Polymetallic Veins Plutonic Related Au qtz Porphyry Cu Mo Au	MTrlJC –chert with shale, siltstone, & greywacke; greywacke unit with volcanic component; Possible Cretaceous granite (interpreted from geophysics)	Anomalous geochemistry: 1460 ppb Au RGS; 11 & 81 ppb Au RGS; Cu, Ag, Cd, Hg, Mo, Pb, Sb, U, Zn, F, Fe, low pH; mag low - ? granite body	Highest (1)
5	Polymetallic Veins Plutonic Related Au qtz Epithermal (low S)	MTrlJC –chert with shale, siltstone, & greywacke; north ½ of tract could be related to mag low; possibly related to porphyry in tract number 4	86 ppb Au; 11 & 10 ppb Au RGS; Hg, Pb, Co, Cd, Mn, F_H2O RGS; bumpy magnetic signature	Highest (2)
6	Au-quartz Veins Epithermal (low S)	MTrlJC –chert with shale, siltstone, & greywacke; contact with intrusive MJgB; andesite dykes, qtz veins; thick accumulations of drift/till cover	Minfile 105C 053; Placer claims; 2002 sheeted veins & dykes with qtz/carb alt; Au, As, Ba, Mo, F_H2O, LOI, Mo, U_H2O RGS	Moderate (5)
7	Polymetallic Veins Plutonic Related Au qtz Porphyry Cu Mo Au	MJgB- biotite granite Correlate with BC geology- lots of porphyries & veins;	Minfile 105C 039; Only 2 RGS samples within tract but weak Au, As, Mo, Pb, Sb, V, Ba, Ni, Pb, Zn anomalies	Highest (3)
8	Au-quartz Veins Minor podiform Cr	MTrlJC –chert with shale, siltstone, & greywacke; Sepentinite sampled (2002) in core at Tarfu Minfile occurrence	Minfile 105C 007 – high Ni, Pb Sn in drill core; High aeromag signature; Cu, Hg, LOI, Au, F_H2O RGS anomalies	Moderate (4)

Tracts 4 and 5 were ranked in the highest relative mineral potential category due to unexplained anomalous geochemistry in both regional stream sediment surveys and 2002 samples collected. The areomagnetic signature over these tracts was interpreted as potential for Cretaceous intrusions with associated mineralization. The under-explored nature of these tracts and lack of detailed bedrock geology was interpreted as increased mineral potential.

Tract 7 was ranked relatively higher due to the underlying mapped granite with potential to host polymetallic veins, plutonic related quartz veins and gold, copper, molybdenum porphyry deposits and RGS anomalies. The known deposits hosted within the same intrusive package in British Columbia, directly south of the proposed SMA, augmented the tract's potential.

Similar bedrock geology to the highest ranking tracts, geochemical and geophysical signatures and/or proximity to mapped intrusive rocks, resulted in tracts 3, 6, and 8 being ranked relatively higher than tracts 1 and 2 which are underlain by limestone.

Several previously undocumented bedrock units were identified during the fieldwork conducted in 2002 indicating that the geology is far more complex that what is currently mapped. Significant geochemical anomalies were generated from the samples collected in 2002. In target areas of RGS highs, the 2002 follow-up sampling located additional anomalies.

Recommendations and Future Work

It is recommended that all land use planners and the Steering Committees of SMA management plans take into account the results of the mineral assessment of the proposed Snafu/Tarfu SMA and use the mineral potential maps in their planning. Ideally land use planners would avoid alienating mineral exploration and development in the tracts identified as having high mineral potential.

Any recommendations, by a Steering Committee, respecting prohibition of entry orders under the Quartz and Placer Mining Acts or designation of the proposed SMA as a park, and/or the division of the proposed park into zones should be done only after considering the mineral potential of the area.

Access to the area, existing placer claims, and land adjacent to the proposed SMA which is considered highest relative mineral potential should not be hindered by land use planning decisions without due consideration to the economic impacts.

The following additional research is recommended to better constrain the mineral deposit types applicable to the proposed Snafu/Tarfu SMA.

Numerous RGS stream sediment sample anomalies require follow-up and now, following the 2002 fieldwork, additional anomalies require follow-up. Three of the original targets identified prior to the 2002 fieldwork were not visited during last summer and require investigation. Work in Target areas 3 and 4 is essential to characterize possible mineral deposit models that can explain the anomalous stream geochemistry.

Further study is recommended on the Tarfu Minfile occurrence including obtaining and reviewing the 1964 Kerr Addison diamond drill logs and mapping the area to better determine their mode and potential of the occurrence and explain the high nickel and chromium 2002 assays from the drill core.

Additional work is required to match aeromagnetic features with geology. Aeromagnetic anomalies cut lithologic units or are found in units mapped as homogeneous and undifferentiated. The chert unit (mTrIJC) for example has unexplained aeromagnetic anomalies and very little geological structure is documented in this area.

Acknowledgements

Amy Stuart, Panya Lipovsky and Gary Stonghill provided technical support during preparation of the data for the fieldwork and assessment panel as well as base data for the areas of interest. Rod Hill and Monique Shoniker performed the diplomatic and administrative services that allowed fieldwork to proceed. Capital Helicopters of Whitehorse provided safe, reliable and enjoyable transportation.

The fieldwork, mineral assessment workshop, and report would not have been completed without the expertise support and help from my colleagues; Robert Stroshein, Roger Hulstein, and Farrell Andersen. I recommend them for their companionship, perseverance and dedication to carrying out the best quality work that is possible.

Thank you to the expert panel; Mark Bakness, Gerald Bidwell, Rob Carne, Al Doherty and Anna Fonseca, for sharing and applying their expertise in Yukon geology and mineral deposits with diligence and good humor.

Plate 21: 2002 Mineral Assessment Crew

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Yukon Minfile-Mineral Occurrence Map: 105C – Teslin (1:250 000 scale), 2001. Exploration and Geological Services Division, Yukon Indian and Northern Affairs Canada.

Appendix I: Analytical Procedures and Quality Control

Energy Mines and Resources, Yukon Geology Program
2002 Mineral Assessment

Geochemical Analysis

Laboratory Procedures

Northern Analytical Laboratories Ltd., of Whitehorse, secured the 2002 contract to supply geochemical analysis to the Mineral Assessment branch of the Yukon Geology Program. Northern Analytical Laboratories Ltd. in turn subcontracted Analytical Laboratories Limited, of Vancouver, B.C. to carry out the geochemical determinations. All samples; rock, soil and steam sediment were submitted to Northern Analytical Laboratories Ltd. for sample preparation and then shipped to Acme Analytical Laboratories Limited for analysis by ICP-MS.

The attached sheets supplied by Acme Analytical Laboratories Limited and Northern Analytical Laboratories Ltd. summarizes the analytical methodology and sample preparation procedures respectively. Also shown are the elements analyzed for and their detection limits. Gold analysis was ideally done on 30gm pulps but where there was insufficient material Au analysis was done on a 15gm, 7.5gm or 5gm sample (as applicable). Analytical results were sent to the Yukon Geology Program in both digital and paper form. The digital results were merged with the digital sample location data and converted from MS Excel file to an MS Access database.

Quality Control

In addition to Acme Analytical Laboratories Limited's internal sample standards and duplicates Yukon Geology Program - Mineral Assessments inserted standards prepared by CANMET (Natural Resources Canada) and locally collected material as sample checks. The local material consisted of marble rock (used a blank) and mineralized copper-magnetite skarn used with rock sample submissions. Local material consisting of unlithified silt ('clay cliff') and tailings from the Whitehorse copper mine (milled copper-magnetite skarn rock) were inserted with the soil and stream sediment samples. Duplicates of the soil samples and occasionally the stream sediment samples were collected in the field or a sample was split later and inserted with the same number with a 'B' appended to the sample number denoting a duplicate. The result is that analysis were carried out on duplicate samples approximately every 20-25 samples. Check samples and standards inserted into the sample stream can be determined by the letters appended to the sample number as, where xxx is the sample number:

XXXa = Whitehorse 'clay cliff' check
XXXb = duplicate sample split
XXXc = Whitehorse copper mine tailings check
XXXd = marble rock, blank (collected at the Grafter occurrence)
XXXe = magnetite copper skarn rock (collected from Best Chance occurrence)
XXXf = Canmet standard STSD-3 (derived from stream sediment samples)

In addition Acme Analytical Laboratories Limited carried out their in house internal duplicate checks as; reXXX (re-assay of sample XXX) and inserted their own standard, standard DS4.

Rock Sample Quality Control Results

Marble Blanks

Results from 14 marble blanks show that values are mostly uniform and the variation could be due to the marble rock which had visible impurities (trace sulfides?) once it was crushed and homogenized (using cone on cone method). Variations are restricted to only a few (or one) element per sample. The highest gold value coincides with a high As and Pb value (sample 176535D). For almost all the samples and all elements the samples returned low ('blank') values. The variation in analytical results could be due to contamination or lack of analytical precision.

Magnetite Copper Skarn

Results from the 15 magnetite copper skarn samples show highly variable results for most elements. Following crushing, the sample was homogenized (cone on cone method) but homogeneity was not achieved. The samples do show that anomalous values were determined but precision and accuracy are very questionable due to the variably mineralized material. This results in a very high percent relative standard deviation and shown graphically by univariante scatterplots for 6 selected elements.

Acme Analytical Laboratories Limited – Duplicate Analysis

Most elements for all the splits correlated very closely (visually <10% difference).

Acme Analytical Laboratories Limited – In-house Standard DS4)

The 12 standards analyzed with the rock samples returned very consistent values, so consistent that descriptive statistics were not calculated.

Soil and Stream Sediment Quality Control Results

Over all the analytical results are acceptable although questions about the accuracy and precision of the data are raised by variations in the Canmet standards. The check samples of Whitehorse copper tailings and Whitehorse clay cliff material served their purpose and returned anomalous and low values respectively.

Canmet Standard STSD-4

Results for the Cannmet standards show an acceptable range of values. The univariate scattergrams for Au, Cu, Zn, Pb, Ni and As illustrate that it is the occasional and random (not restricted to one sample or sample batch) 'flyer' that results in the higher percent relative standard deviation values (values >10%). Results for Au analysis are disturbing as two samples returned values that could be considered anomalous at 18ppb and 29ppb. Analysis of the standard only tests the analytical techniques for accuracy and precision as the standard is received in a pulped form (<-200 mesh, -74um) it is not prepared (dried, sieved or split). The percent relative standard deviation was calculated for Au, Cu, As, Zn, Pb, Ni, and As. Values were below <10% for Z, Pb, Ni (acceptable) and <16% As and Cu (marginally acceptable) and a high 128% for Au due to the two high values mentioned above.

Whitehorse Copper Mine Tailings

A total of 20 copper mine tailing samples were inserted into the sample stream with two purposes in mind; one was to confirm that obviously anomalous samples (for Cu, Au, Ag, Bi) were being detected and secondly, to test for analytical precision and accuracy. As the samples were prepared at Northern Analytical they also test the preparation procedures. All the samples returned anomalous values for the above elements although the variation for Au exceeded the preferred 10% maximum (at 32%) for the percent relative standard deviation. Other elements where the percent relative standard deviation was calculated (Cu, Ag, As, Pb, Zn, Mo, Bi) returned a close to or less than a 10% percent relative standard deviation.

Whitehorse Clay Cliff Silt

A total of 25 clay cliff silt samples were inserted into the sample stream for two purposes; one was to ensure that material considered to have background values did indeed return background values and to test for analytical precision and accuracy. As the samples were prepared at Northern Analytical they also test the preparation procedures. All the samples exceeded the preferred 10% maximum for the percent relative standard deviation for Au (31%), Cu 11%, Pb (38%), Zn (13%), As (26%) and Ni (12%). The variations in the gold values are quite acceptable as the highest value was 4.7ppb. Most of the variation in the other samples is due to two samples that yielded inconsistent values. Variation in the 'clay cliff' material is expected and is likely responsible for the variation. Laboratory error is not suspected as other check samples and standards from the same batches did not produce similar errors.

EMR Duplicate Check Samples

A total of 29 duplicate pairs were submitted to check for reproducibility – accuracy. A visual scan reveals a close approximation. All of the seven elements (Au, Cu, As, Ni, Pb, Zn and U) display a linear trend on scatterplots. The only errant value was for gold in one stream sediment (silt) sample pair. This is not unexpected given gold's nugget effect.

Acme Analytical Laboratories Limited – In-house duplicate pairs

Acme Analytical analyzed 20 duplicate pairs. The scatter plot results are as close for Cu and Pb as for the duplicate pairs submitted by EMR. Gold values were less than 7.4ppb so significant variation for anomalous samples can't be determined. Interestingly, the Acme duplicates included 5 duplicate pairs of clay cliff material, presumably because there was abundant sample to split, but no Whitehorse copper tailing samples.

Acme Analytical Laboratories Limited – In-house Standard DS4)

The 27 standards analyzed with the stream sediment and soil samples returned very consistent values, so consistent that descriptive statistics were not calculated.

Statistical Analysis Procedures used in 2002

Following computer listing of the data, statistical parameters such as arithmetic mean, median and mode, standard deviation and sample variance were calculated using MS Excel. Histograms of selected elements from data subsets were generated by MS Excel for specific projects to aid in establishing five ranges for the results, ideally; background, slightly above background, weakly anomalous, moderately anomalous and anomalous.

The stream sediment data procured from the Geological Survey of Canada's, 'Regional Stream Sediment and Water Geochemical Data', open files were also statistically analyzed in a similar manner using MS Excel. Histograms and calculated thresholds for project areas, where applicable, are attached.

Where Histograms and statistical were not used in generating geochemical plots, ESRI Arview 3.2a was used utilizing natural breaks in the data. Occasionally where there was a large number of values below, at or near the detection limit, or obviously anomalous samples were observed, threshold were adjusted visually, either in Arcview 3.2a or from a MS Excel histogram that was not printed.

Appendix II: Minfile Descriptions

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 007
NAME: TARFU
DEPOSIT TYPE: UNKNOWN
STATUS: DRILLED PROSPECT
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\4
LATITUDE: 60° 3' 48" N
LONGITUDE: 133° 36' 27" W

OTHER NAME(S):
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

WORK HISTORY

Staked on a GSC aeromag anomaly as Cat and Work cl (85016) in Jan/63 by Kerr-Addison ML, which explored with SP, mag and EM surveys in 1963 and one hole (77.1 m) in 1964.

GEOLOGY

The hole was drilled to test a coincident SP, mag and EM anomaly. The hole intersected brecciated serpentinite body in graphite schist, but no mineralization was found.

REFERENCES

KERR ADDISON ML, Jul/64. Assessment Report #017623 by W.M. Sirola.

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 039
NAME: LISA
DEPOSIT TYPE: UNKNOWN
STATUS: UNKNOWN
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\4
LATITUDE: 60° 3' 48" N
LONGITUDE: 133° 48' 30" W

OTHER NAME(S):
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

WORK HISTORY

Staked as Lisa cl (YA48562) in Mar/80 by N. Naharniak, who trenched later in the year.

GEOLOGY

The claims are probably underlain by Permian siltstone and greywacke near the contact with Cretaceous granodiorite.

REFERENCES

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 049
NAME: NUF
DEPOSIT TYPE: UNKNOWN
STATUS: ANOMALY
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\5
LATITUDE: 60° 23' 0" N
LONGITUDE: 133° 54' 54" W

OTHER NAME(S): NUT
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

WORK HISTORY

Staked as NUF cl (YA95503) in Aug/86 by Hudson Bay Mg & S CL, which transferred them to Mingold Res Inc in Mar/87. In Dec/92 R. Hamel staked Ore cl (1-36) (YB37691) 1 km northwest of the anomaly. The following March, Hamel added Ore cl (37-80) (YB37932) which covered the area of the anomaly. In May/94 Hamel added Ore cl (81-108) (YB47848) to the western side of the claim block.

GEOLOGY

The claims, which cover Permo-Triassic volcanic rocks, were staked to cover a 45 ppb gold silt geochemical anomaly located by DIAND sampling.

REFERENCES

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 050
NAME: TON
DEPOSIT TYPE: UNKNOWN
STATUS: UNKNOWN
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\5
LATITUDE: 60° 21' 43" N
LONGITUDE: 133° 40' 53" W

OTHER NAME(S):
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

NITA

WORK HISTORY

Staked as Ton & Tom cl (YA96664) in Jan/87 by the Dunvegan Synd. T. Thompson staked Nita cl 1-12 (YB57301) 5 km northwest of occurrence in Nov/94.

GEOLOGY

The claims overlie the north-trending faulted contact between limestone (to the west) and conglomerate and greywacke (to the east).

REFERENCES

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 052
NAME: THA
DEPOSIT TYPE: UNKNOWN
STATUS: UNKNOWN
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\6
LATITUDE: 60° 20' 4" N
LONGITUDE: 133° 20' 17" W

OTHER NAME(S):
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

WORK HISTORY

Staked as THA cl (YB8283) in Sep/87 by Tha Res L.

GEOLOGY

The claims are underlain by sedimentary rocks of the Permian Cache Creek Group.

REFERENCES

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105C 055
NAME: EAGLENEST
DEPOSIT TYPE: VEIN
STATUS: SHOWING
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105C\5
LATITUDE: 60° 22' 2" N
LONGITUDE: 133° 53' 22" W

OTHER NAME(S):
MAJOR COMMODITIES: GOLD, SILVER
MINOR COMMODITIES: ANTIMONY, BARITE, MERCURY
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

EAGLE, NEST

WORK HISTORY

Staked as Eagle and Nest cl (YB20183) in June and Aug/88 and Jun/90 by E. Johnson, who performed blast trenching in 1989 and road work in 1992. D. MacDonald staked Cus cl (YB13964) 5 km to the east in Jun/88.

D. Gilbert staked Gopher cl (YB24610) less than 1 km southwest of the Eaglenest property in Dec/88, and sampled in 1989, and L. Gilbert added Jake cl (YB35647) in Mar/91. The Ore cl (YB37932) were added to the northwest side of the Eagle cl by R. Hamel in March/93. In Jun/93, E. Johnson performed trenching and drilling on the Eagle and Nest claims. R. Hamel trenched on the Ore cl in Dec/93.

GEOLOGY

On the Eagle and Nest claims, quartz veins containing fine grained sulphides occur in silicified greenstone along a northeast-trending lineament which cuts chert and metavolcanic rocks of the Cache Creek Group. Johnson obtained assays of up to 0.41 g/t Au and 2.4 g/t Ag.

Blast trenching on the west end of the property in 1989 exposed quartz-calcite veins 1.2 to 3 m wide which contain variable amounts of sulphide minerals, barite and magnetite. The veins have minor clay alteration haloes, and appear to form two sets, related to the dominant northeast lineament and crosscutting north and northwest-trending fractures. The dominant northeast veins have a slickensided hanging wall and greenstone in the footwall is silicified. Specimens of quartz and calcite vein material and silicified pyritic wall rock contained up to 21 ppm Sb, 3100 ppm Ba and 310 ppb Hg.

On the Gopher property, quartz-carbonate veins cutting metavolcanic rocks are exposed in the floor of a gravel pit. Samples contained up to 44 ppb Au.

REFERENCES

YUKON MINFILE
YUKON GEOLOGY PROGRAM
WHITEHORSE

MINFILE: 105D 178
NAME: MILITARY
DEPOSIT TYPE: VEIN
STATUS: ANOMALY
TECTONIC ELEMENT: CACHE CREEK TERRANE

NTS MAP SHEET: 105D\8
LATITUDE: 60° 23' 22" N
LONGITUDE: 134° 2' 38" W

OTHER NAME(S): PHIL
MAJOR COMMODITIES:
MINOR COMMODITIES:
TRACE COMMODITIES:

CLAIMS (PREVIOUS & CURRENT)

BON, ICO, LYNN, MART, MEX, NLC, ORE, PHIL

WORK HISTORY

Staked as Phil cl 1-12 (YA96636) in Jan/87 by the Dunvegan Syndicate, which prospected and sampled later in the year. The Phil claims were transferred to Dunvegan Explorations Ltd in May/89; restaked by A. MacDonald as Phil cl 1-12 (YB36191) in Jul/91; transferred back to Dunvegan in Jan/92 and allowed to lapse in Aug/92.

L. Lebedoff staked the NLC cl 1-52 (YB24538) 6 km to the south in Nov/88 and carried out magnetic surveying in 1989. B. Kreft staked the Lynn cl 1-4(YB27704) 1 k m to the east in Jul/90. R. Hamel staked Ore cl 1-36 (YB37691) immediately east of the former Phil claim block in Dec/92 and performed a ground magnetic survey in the winter of 1992-93. In Jul/94, Hamel staked Bon cl 1-14 (YB46944) 5 km northwest of the occurrence.

In April and May/94 M. Sherman staked the Mex cl 1-10 (YB46669) and Ico cl 1-10 (YB46750) 3 km to the south. In Apr/95 Mex cl 1-7 (YB46669) and Ico cl 1-10 (YB46750) were transferred to Wilson Creek Placer Ltd. Sherman carried out VLF-EM and magnetic geophysical surveing on the Mex and Ico claims between March and May/95. In May/95 Sherman restaked Mex cl 8-10 (YB57515). In Jun/95 Mex cl 1-7 (YB46669) and Ico cl 1-10 (YB46750) were transferred back to Sherman. In May/96 and Aug/99 Sherman carried out additional VLF-EM and magnetic geophysical surveying on the Mex and Ico claims.

Restaked as Mart cl 1-44 (YB97705) in Jun/97 by High Valley Explorations Ltd, which immediately constructed an access road to the claims and carried out VLF-EM and magnetic surveying, geological mapping, prospecting, rock geochemical sampling and bulldozer trenching later in the year.

GEOLOGY

Glaciofluvial sediments cover most of the area. Bedrock consists of Permian to Triassic Cache Creek Terrane volcanic rocks, serpentinite and sedimentary rocks, mainly dolomite with minor chert.

The Phil claims covered a magnetic high and scattered gold soil geochemical anomalies. Near the south end of the property, serpentinite containing minor magnetite and chromite outcrop along the banks of a small stream. In 1987 soil sampling returned several anomalous values up to 510 ppb Au, but re-sampling failed to confirm these anomalies. In 1998 mapping and geophysics identified an area of interest near the fault contact between ultramafic rocks to the north and dolomite and chert to the south. Trenching exposed a 40 m by 15 m area containing chert hosting seams of black graphitic clay and quartz-carbonate breccia veins with graphite-mariposite-ankerite alteration halos. Chip sampling in the area produced erractic, weakly anomalous gold values.

The Ore claims cover a 1 000 gamma aeromagnetic anomaly and an area of elevated gold values in soil in an area of outcropping volcanic rocks. A ground magnetic survey in the winter of 1992-93 indicated a magnetic structure trending north-northwest which coincides with a structural lineament along the creek.

Sherman's geophysical program on the Mex and Ico claims, outlined 9 geophysical anomalies of varying strength. Anomaly G was located near a bedrock anomaly identified in a government airborne EM and magnetic survey. Three additional conductors were identified but their exact location could not be determined because two VLF stations required to accurately locate the position of the conductors, were off the air for an indefinite period of time. The 1996 geophysical survey covered areas missed in the 1995 survey, while the 1999 survey covered the central section of the claim group.

REFERENCES

DIGHEM I POWER, 1994. Airborne EM and MAG Surveys, Jakes Corner Project. DIAND Open File 1994-10 (G).

DUNVEGAN EXPLORATIONS LTD, May/88. Assessment Report #092134 by G.S. Davidson.

DUNVEGAN EXPLORATIONS LTD, Sep/89. Prospectus Report #092869 by D. Copeland et al.

HIGH VALLEY EXPLORATIONS LTD, May/98. Assessment Report #093841 by M.A. Beauregard.

HUNT, J.A., et al., 1995. Interpretive Geology of the Jakes Corner Geophysical Survey (105 C 5, 105 D 8, and 105 D 9). DIAND Open File 1995-6 (G).

WILSON CREEK PLACERS, Jun/95. Assessment Report #093285 by G.C. Lee.

WILSON CREEK PLACERS, Jun/96. Assessment Report #093483 by G.C. Lee.

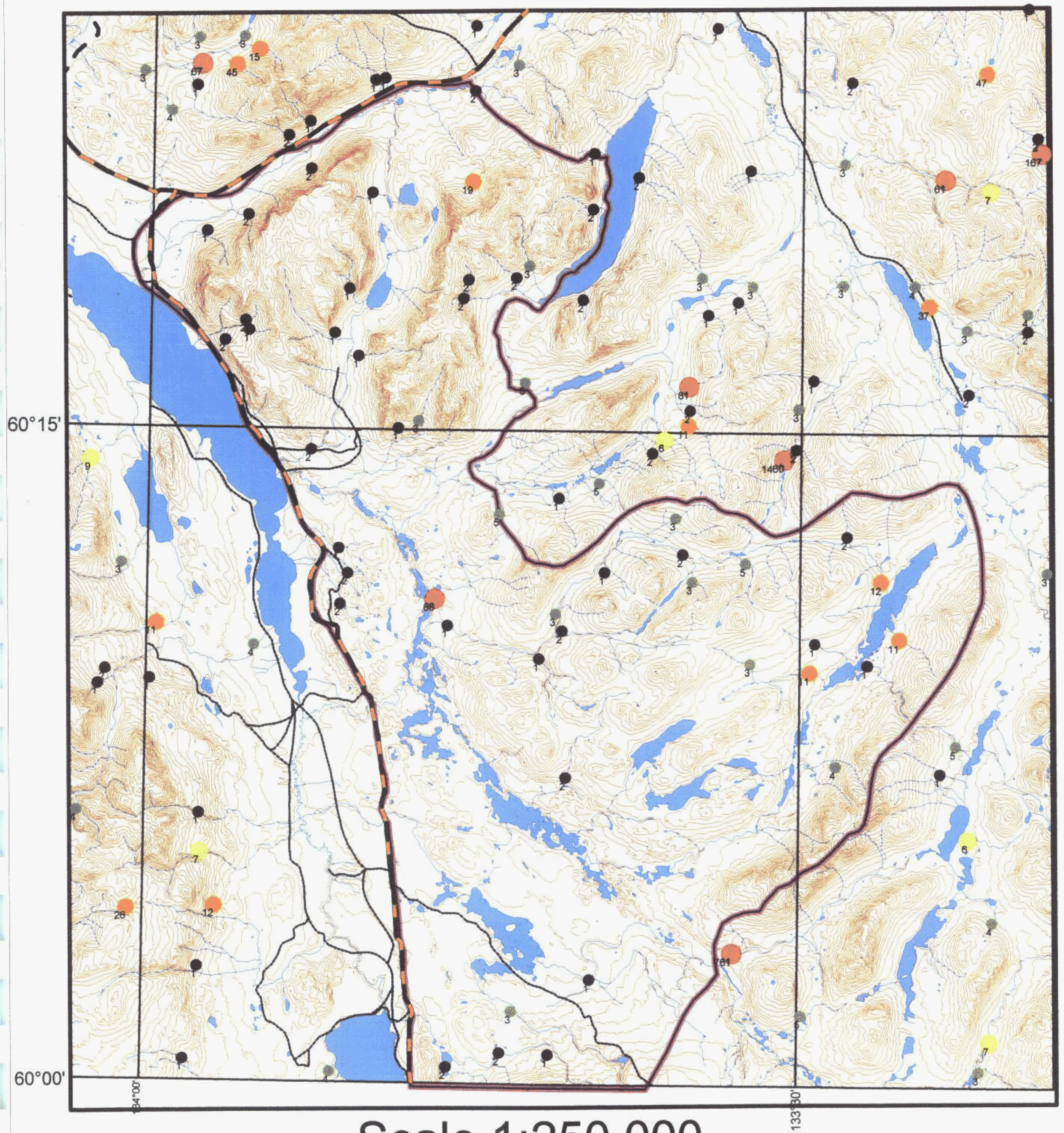
WILSON CREEK PLACERS, Aug/2000. Assessment Report #094177 by G.C. Lee.

YUKON EXPLORATION 1989, p. 35.

YUKON EXPLORATION AND GEOLOGY 1997, p. 36.

Appendix III: RGS Geochemical Plots

Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area



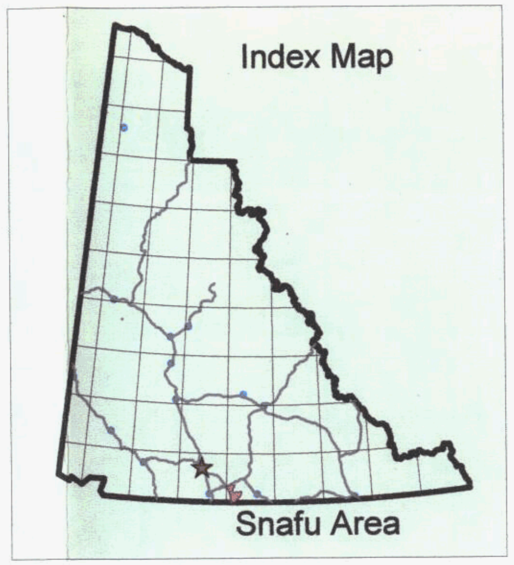
Scale 1:250 000

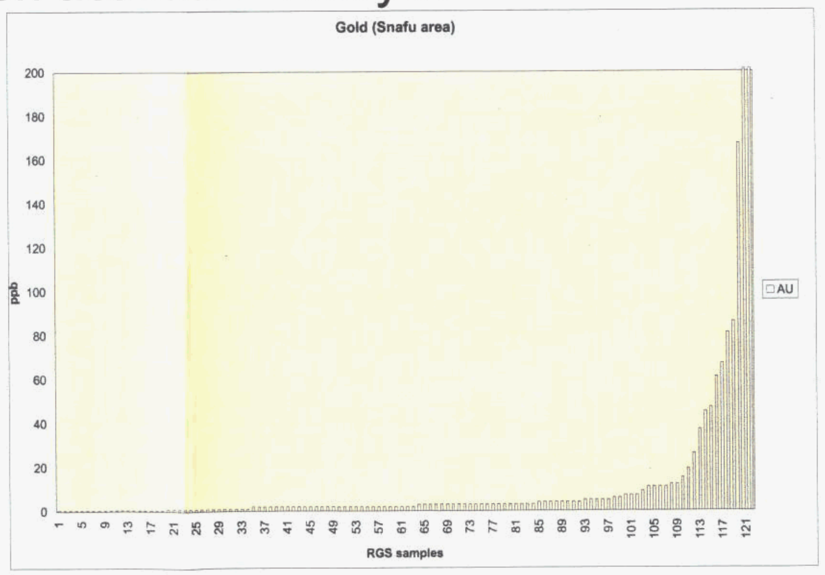
10 0 10 20 Kilometers

Gold - Au

- 0 - 2 ppb
- 3 - 5 ppb
- 6 - 10 ppb
- 11 - 50 ppb
- 51 - 1460 ppb

Detection Limit: 2 ppb
Method: INAA- instrumental neutron activation analysis





# Samples	(n)	122
Maximum		1460
Median		2

GSC Open File 1217

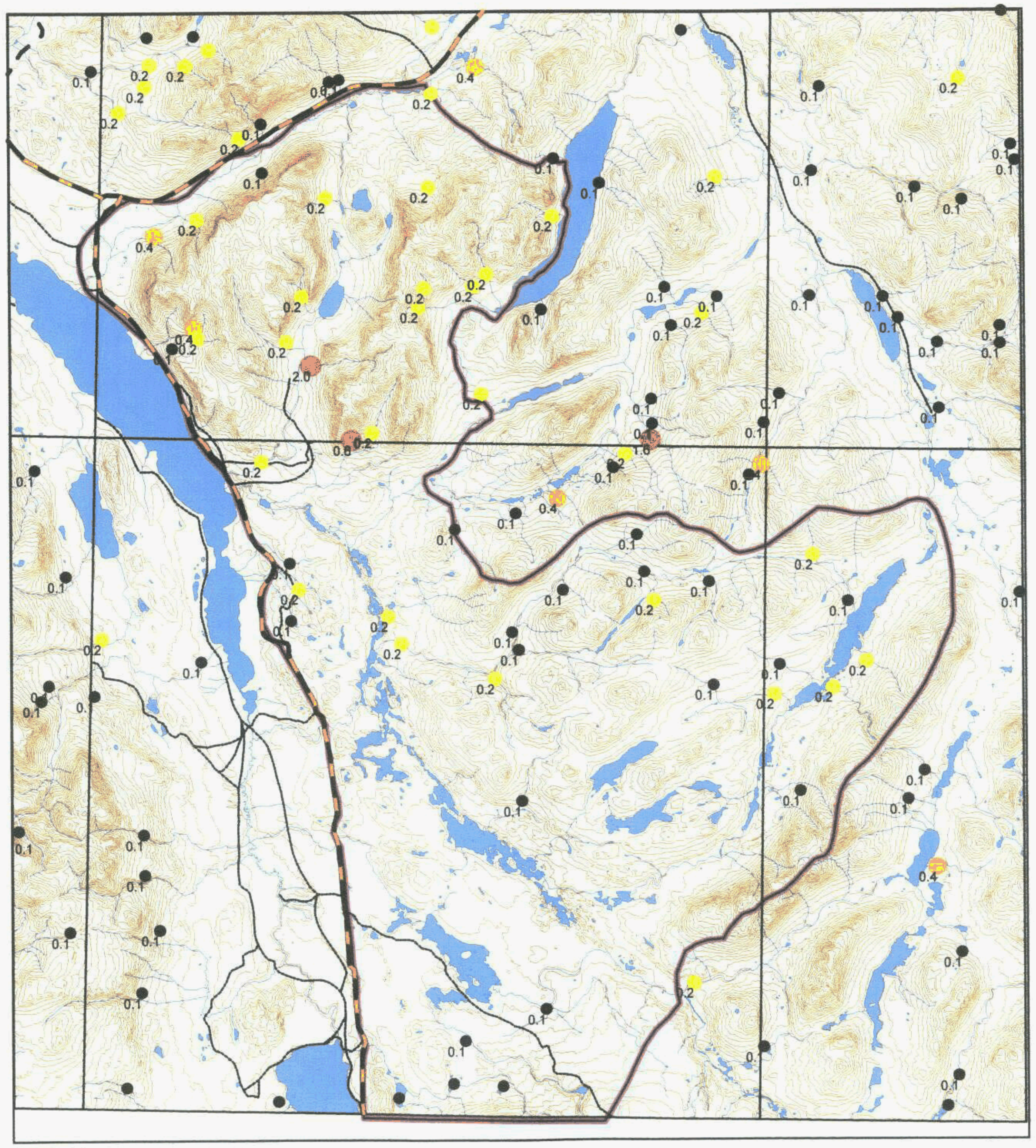
Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

Confidential

RGS
Gold - Au

Arcview GIS Version 3.2 - JvR - February 2003

Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

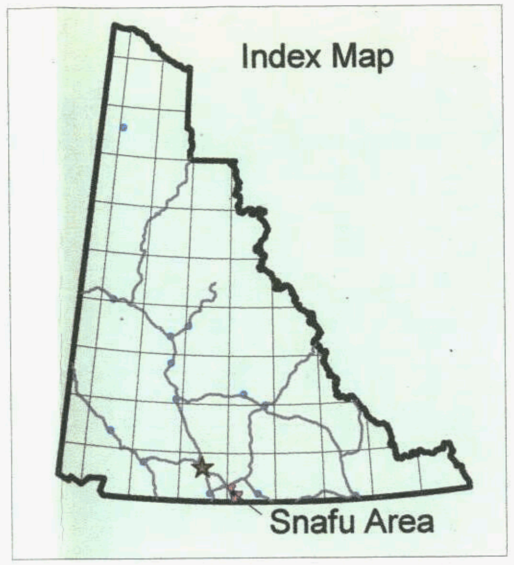


Scale 1:250 000

10 0 10 20 Kilometers

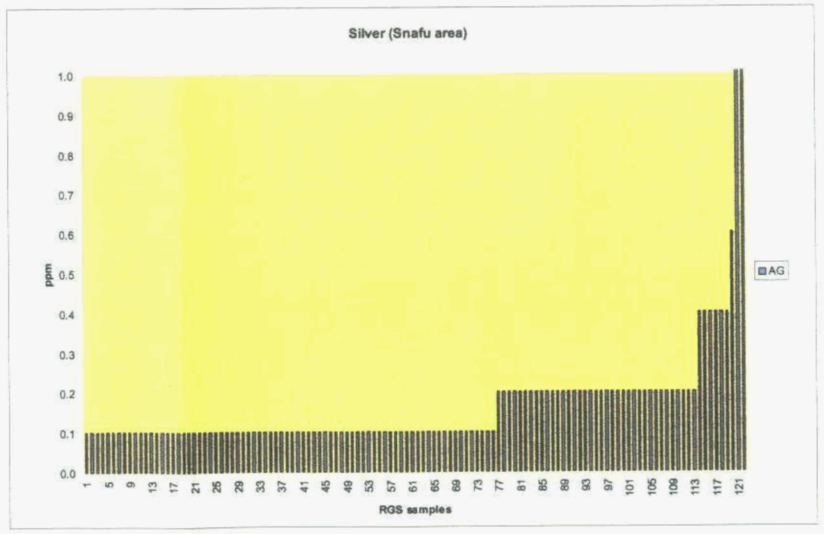
Silver - Ag

- 0 - 0.1 ppm
- 0.2 - 0.3 ppm
- 0.4 - 0.5 ppm
- 0.6 - >2 ppm



Detection Limit: 0.2 ppm
Method: AAS - atomic absorption spectrometry

# Samples (n)	122
Maximum	2
Median	0.1



GSC Open File 1217

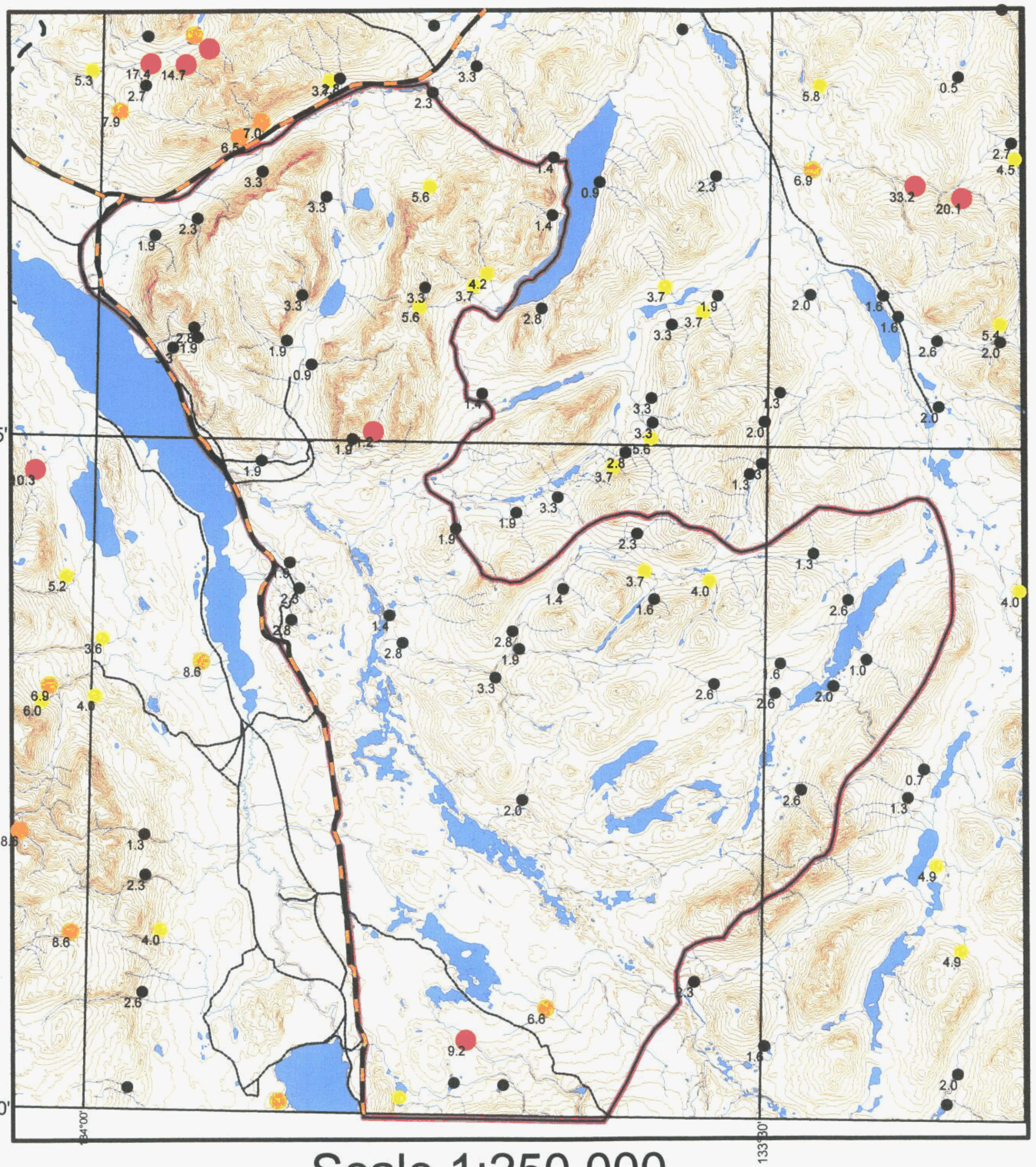
Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

Confidential

RGS
Silver - Ag

Arcview GIS Version 3.2 - JvR - February 2003

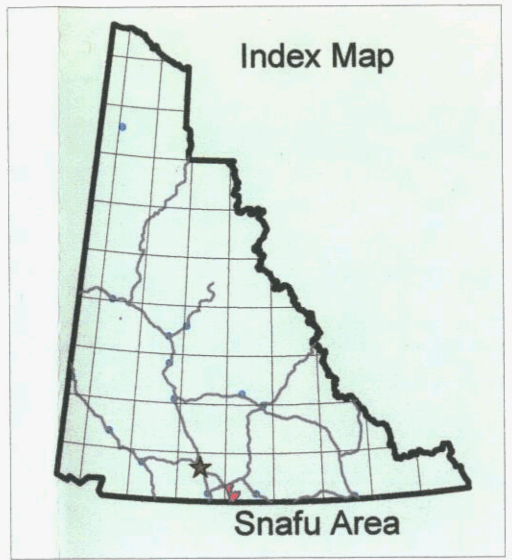
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area



Scale 1:250 000

10 0 10 20 Kilometers

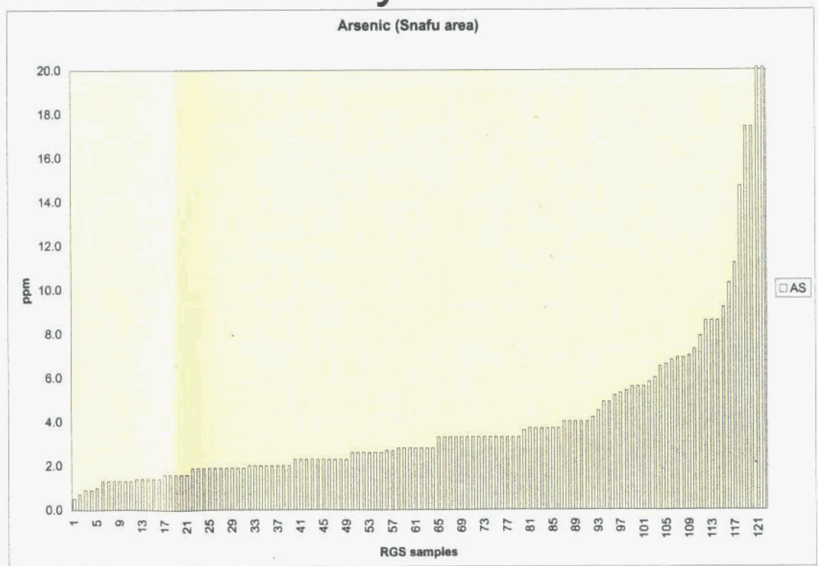
Arsenic - As



- 0 - 3.5 ppm
- 3.5 - 6 ppm
- 6.1 - 9 ppm
- 9.1 - 33.2 ppm

Detection Limit: 0.5 ppm
Method: INAA- instrumental neutron activation analysis

# Samples (n)	122
Maximum	33.2
Median	2.8



GSC Open File 1217

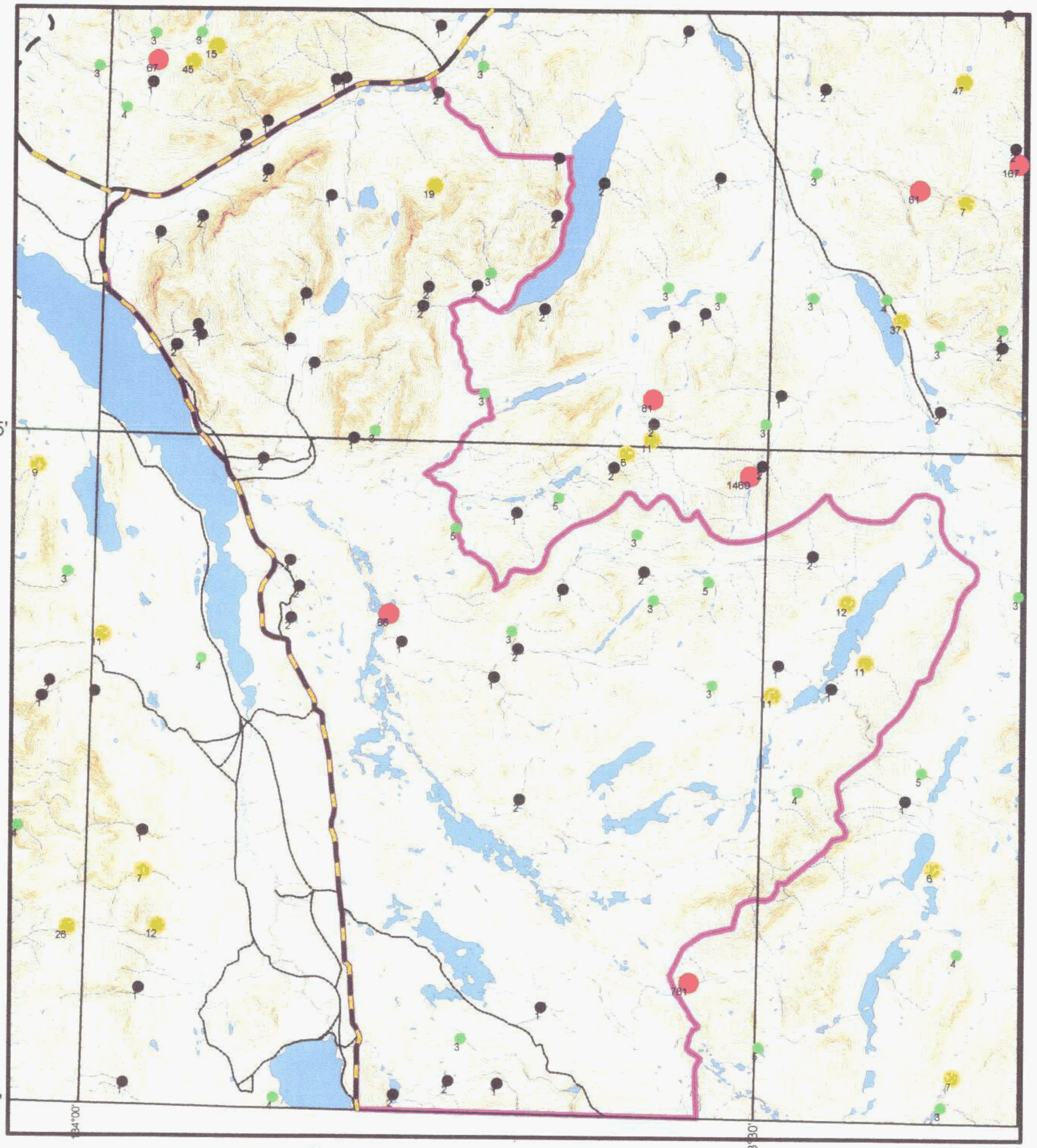
Proposed Snafu / Tarfu
Natural Environment Park
Special Management Area
(September 2002 outline)

Confidential

RGS
Arsenic - As

Arcview GIS Version 3.2 - JvR - February 2003

Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

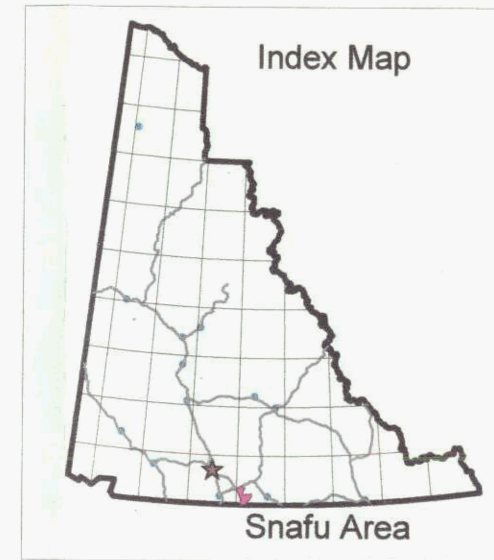


Scale 1:250 000

10 0 10 20 Kilometers

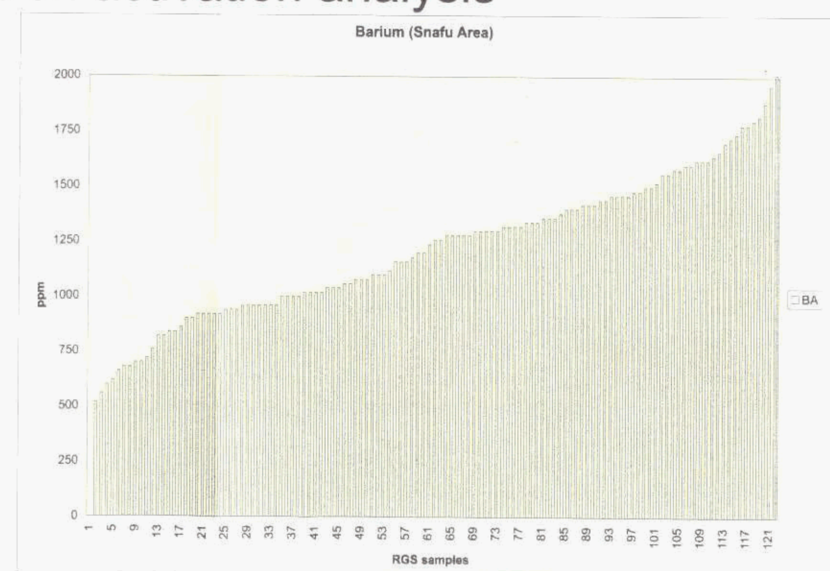
Barium - Ba

- 0 - 1300 ppm
- 1301 - 1500 ppm
- 1501 - 1700 ppm
- 1701 - 2060 ppm



Detection Limit: 50 ppm
Method: INAA- instrumental neutron activation analysis

# Samples	(n)	122
Maximum		2060
Median		1250



GSC Open File 1217

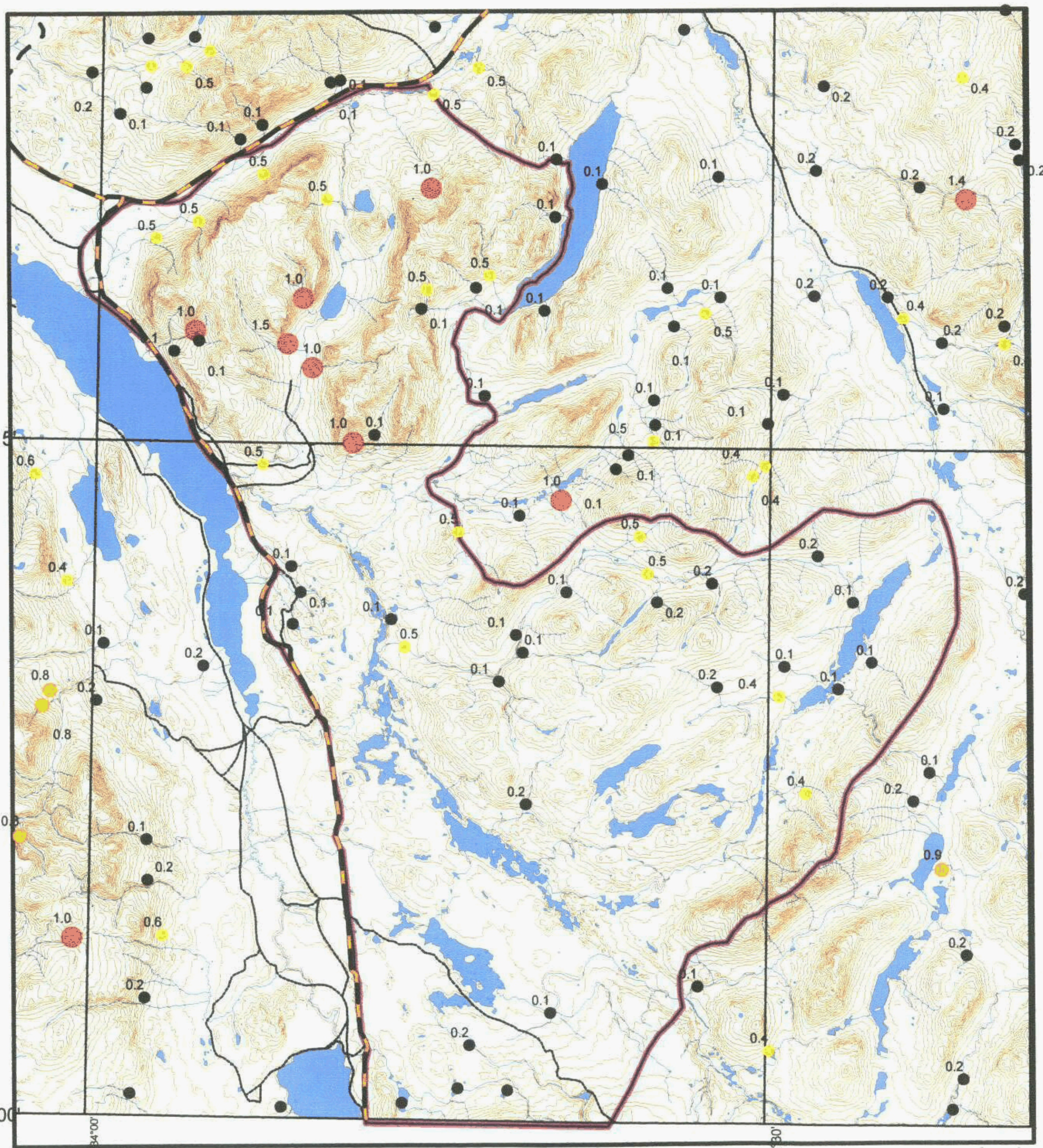
Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2003 outline)

Confidential

RGS
Barium - Ba

Arcview GIS Version 3.2 - JvR - February 2003

Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

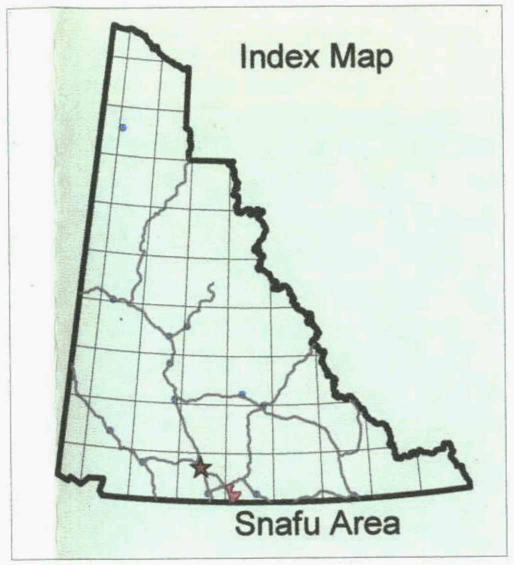


Scale 1:250 000

10 0 10 20 Kilometers

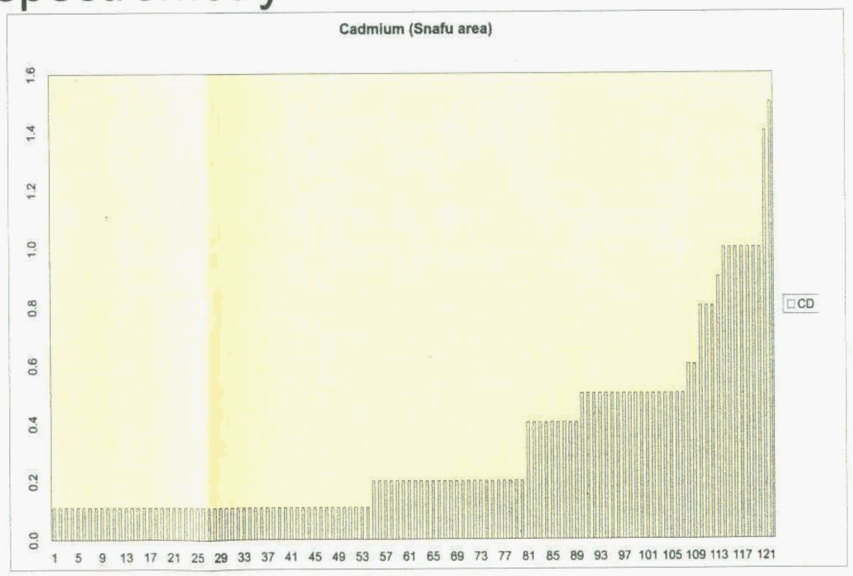
Cadmium - Cd

- 0 - 0.3 ppm
- 0.31 - 0.6 ppm
- 0.61 - 0.9 ppm
- 0.91 - 1.5 ppm



Detection Limit: 0.2 ppm
Method: AAs- atomic absorption spectrometry

# Samples	(n)	122
Maximum		1.5
Median		0.2



GSC Open File 1217

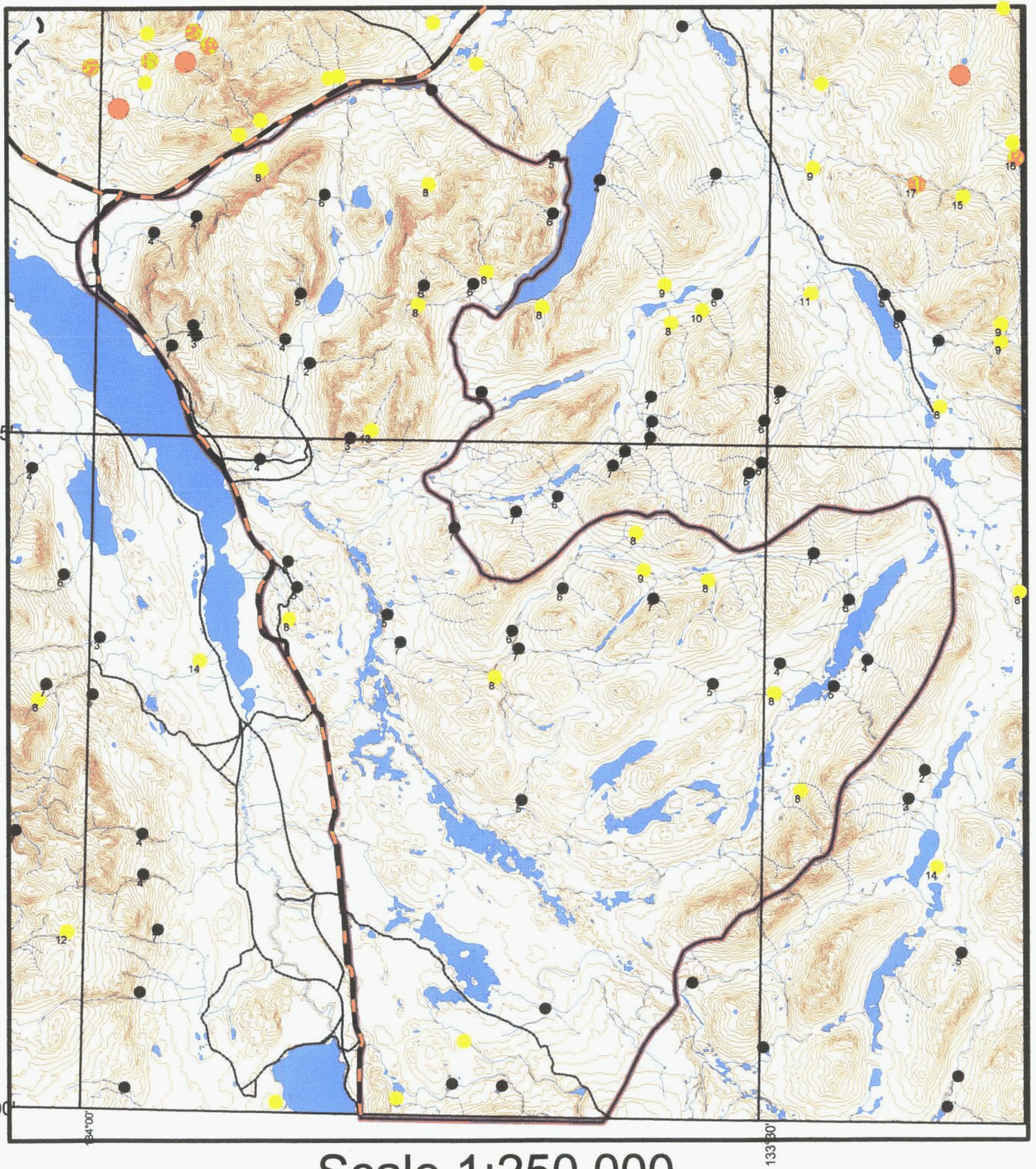
Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

Confidential

RGS
Cadmium - Cd

Arcview GIS Version 3.2 - JvR - February 2003

Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

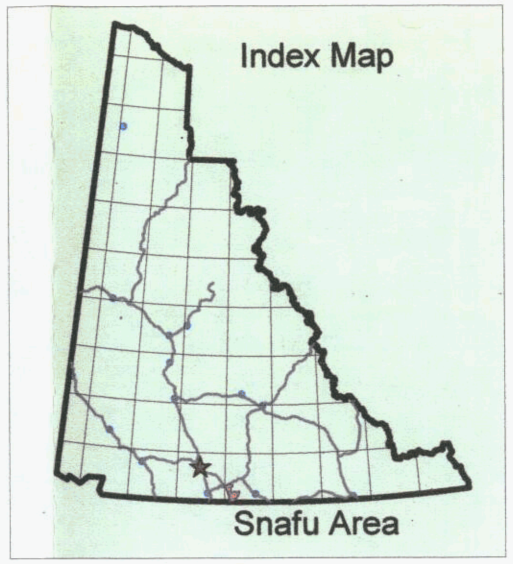


Scale 1:250 000

10 0 10 20 Kilometers

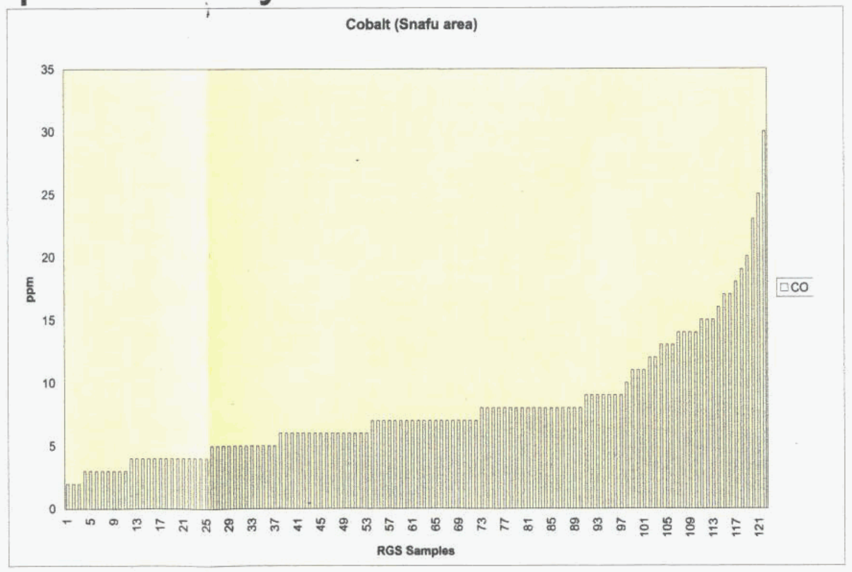
Cobalt - Co

- 0 - 7 ppm
- 7.1 - 15 ppm
- 15.1 - 20 ppm
- 20.1 - 30 ppm



Detection Limit: 2 ppm
Method: AAs- atomic absorption spectrometry

# Samples (n)	122
Maximum	30
Median	7



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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

Confidential

RGS
Cobalt - Co

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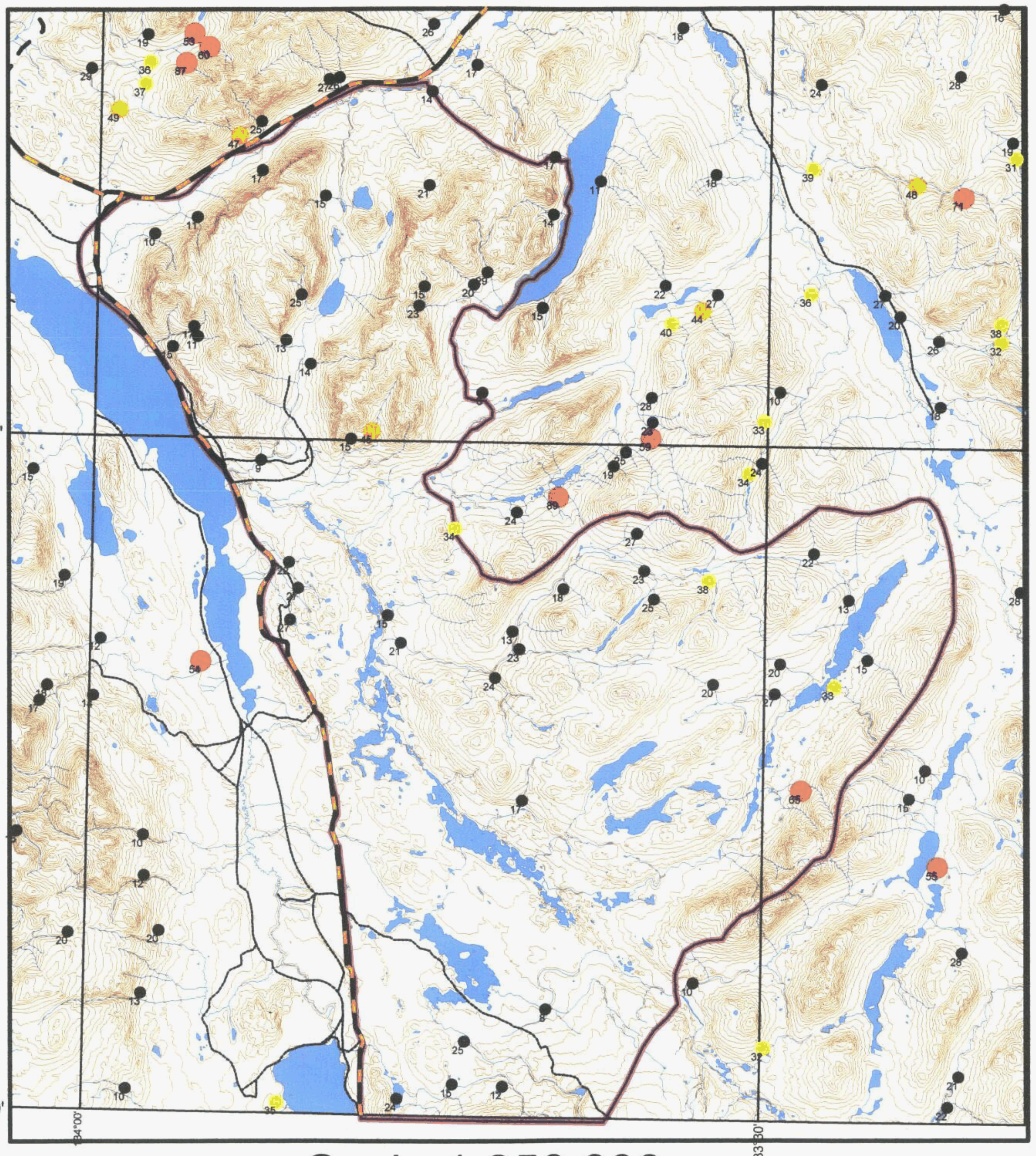
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

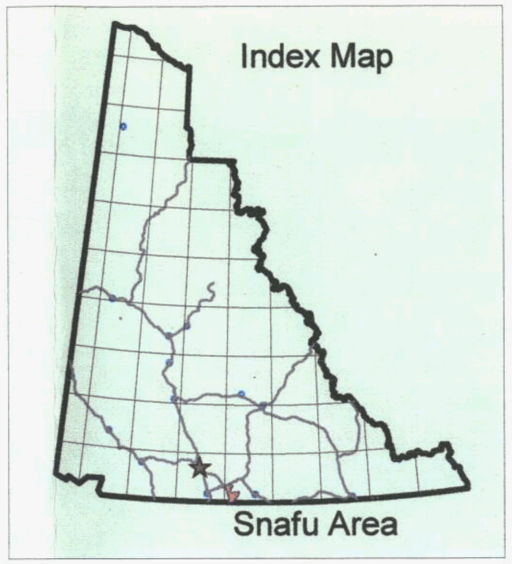


Scale 1:250 000

10 0 10 20 Kilometers

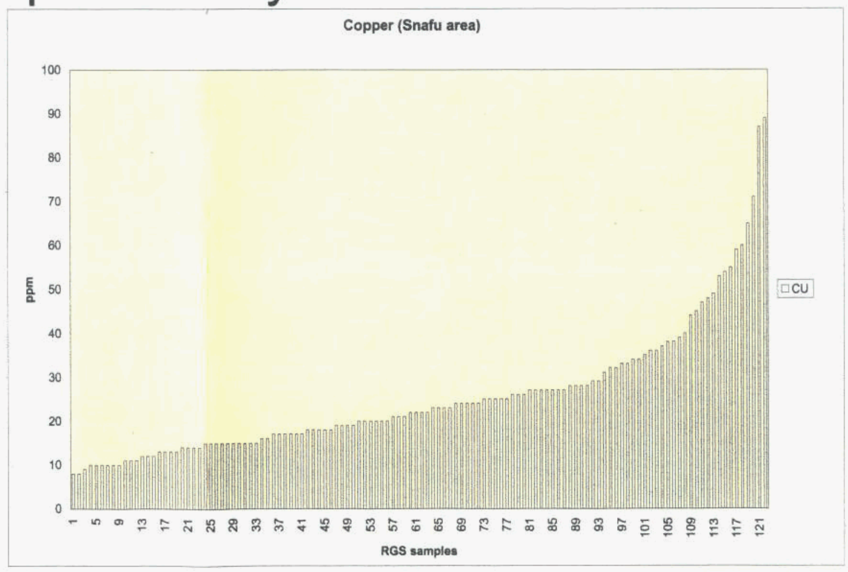
Copper - Cu

- 0 - 30 ppm
- 30.1 - 40 ppm
- 40.1 - 50 ppm
- 50.1 - 89 ppm



Detection Limit: 2 ppm
Method: AAS- atomic absorption spectrometry

# Samples (n)	122
Maximum	89
Median	22



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Proposed Snafu / Tarfu
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Special Management Area
(September 2002 outline)

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RGS
Copper - Cu

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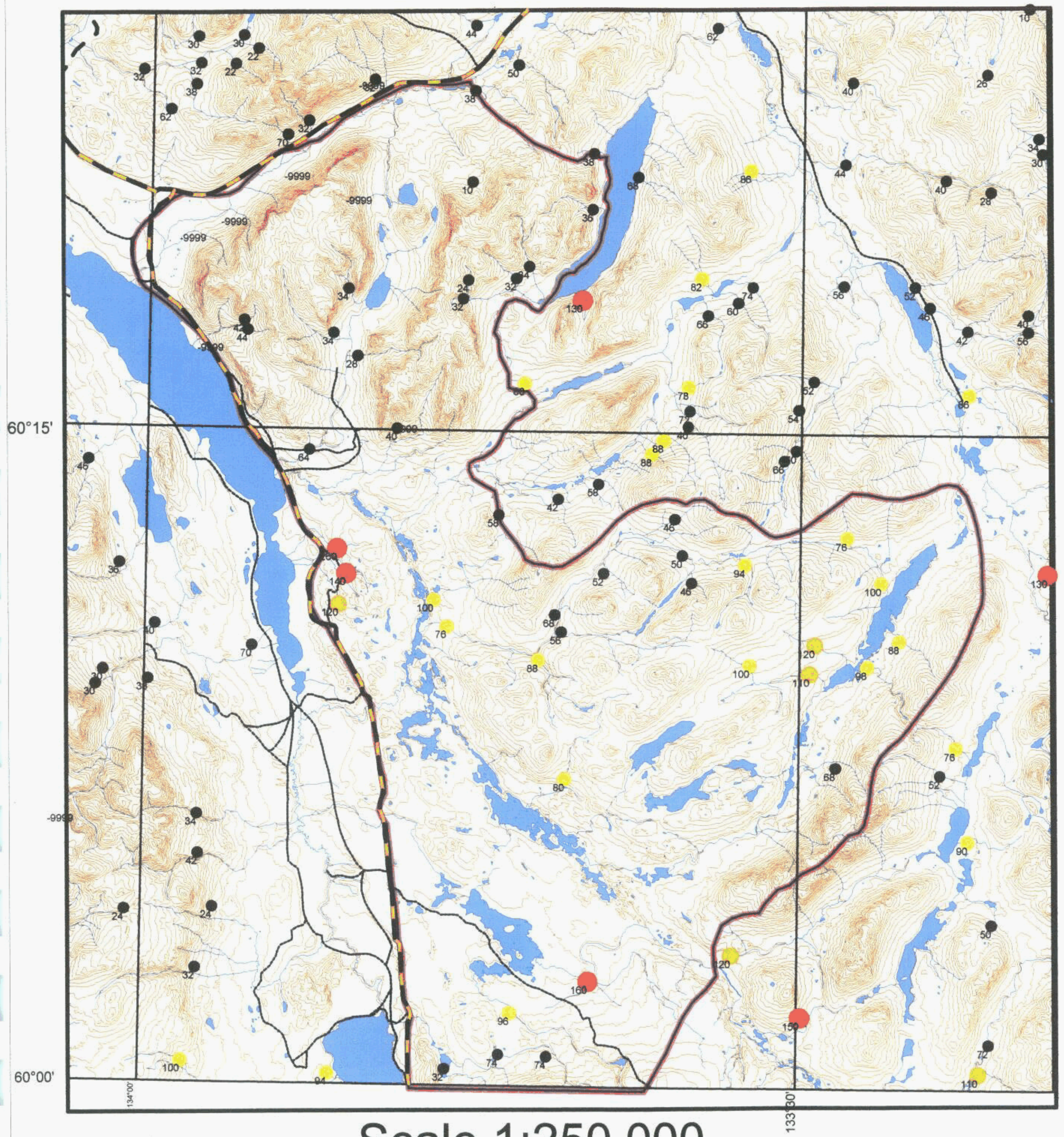
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

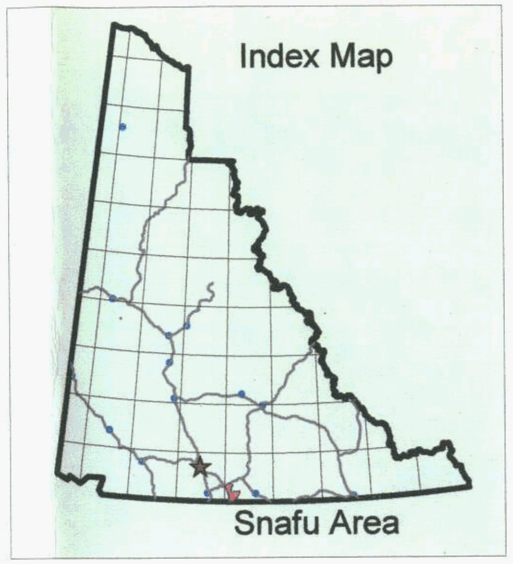


Scale 1:250 000

10 0 10 20 Kilometers

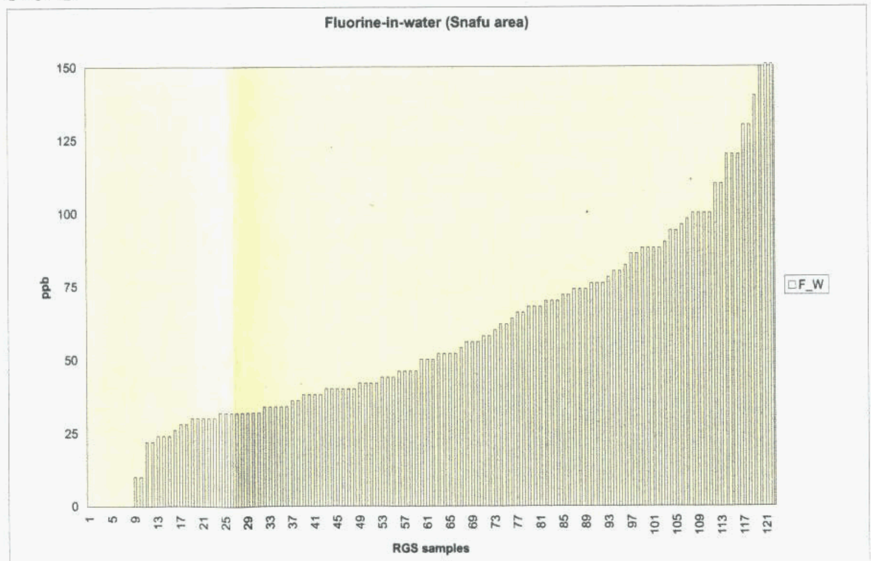
Fluorine in water - F_w

- 0 - 75 ppb
- 75.1 - 100 ppb
- 100.1 - 125 ppb
- 100.1 - 260 ppb



Detection Limit: 20 ppb
Method: ISE - ion selective electrode

# Samples (n)	122
Maximum	260
Median	50



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Fluorine in water - F_w

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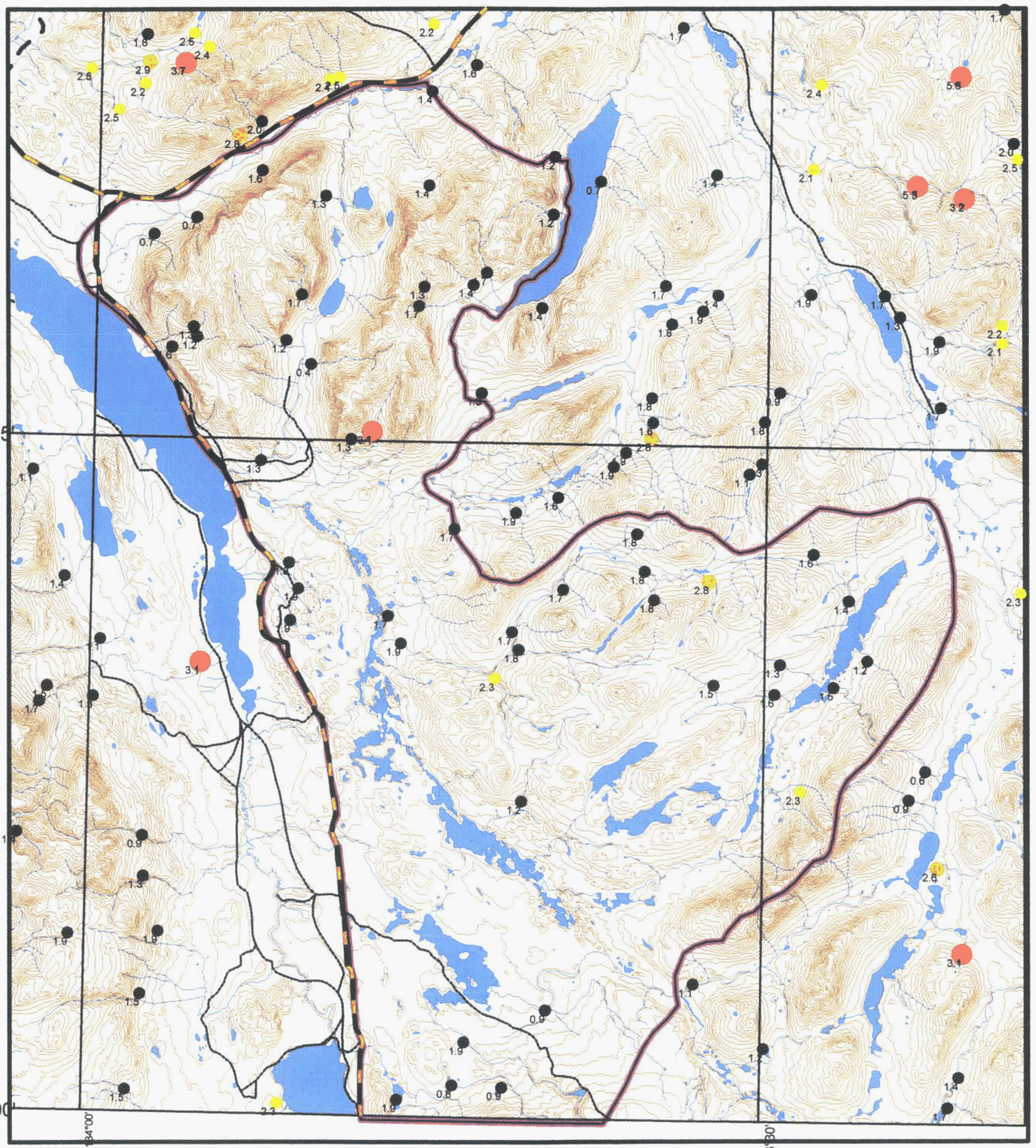
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

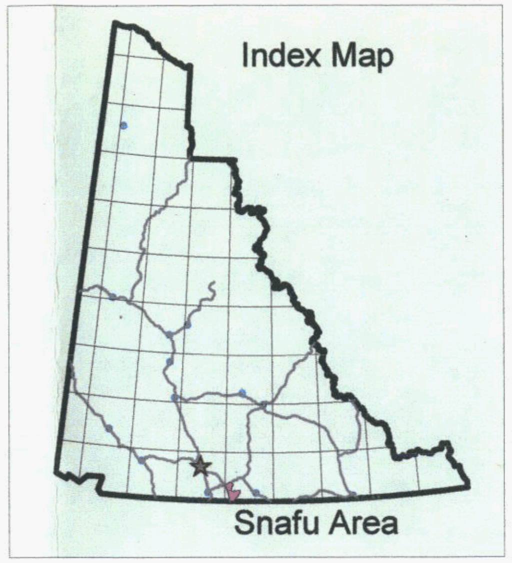


Scale 1:250 000

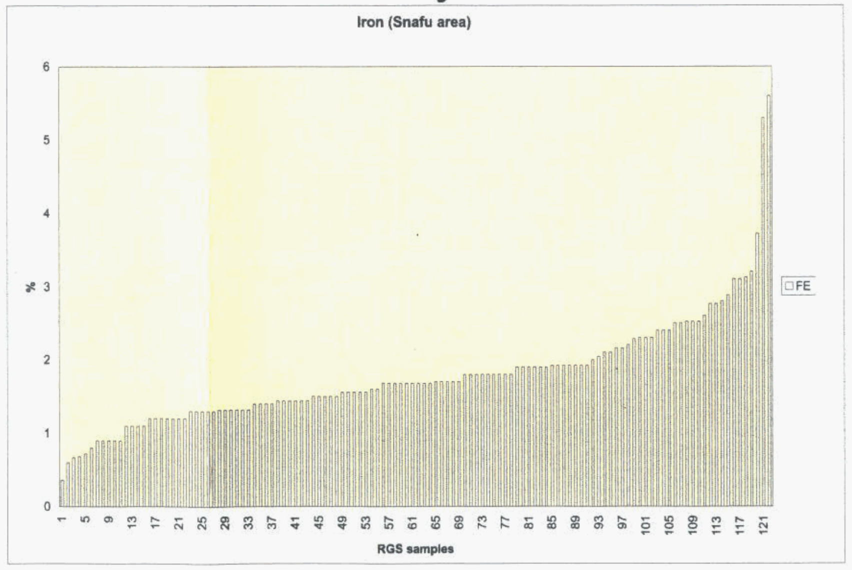
10 0 10 20 Kilometers

Iron - Fe

- 0 - 2 %
- 2.1 - 2.5 %
- 2.6 - 3 %
- 3.1 - 5.6 %



Detection Limit: 0.2 %
Method: INAA - Instrumental Neutron Activation Analysis



# Samples (n)	122
Maximum	5.6
Median	1.68

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RGS
Iron - Fe

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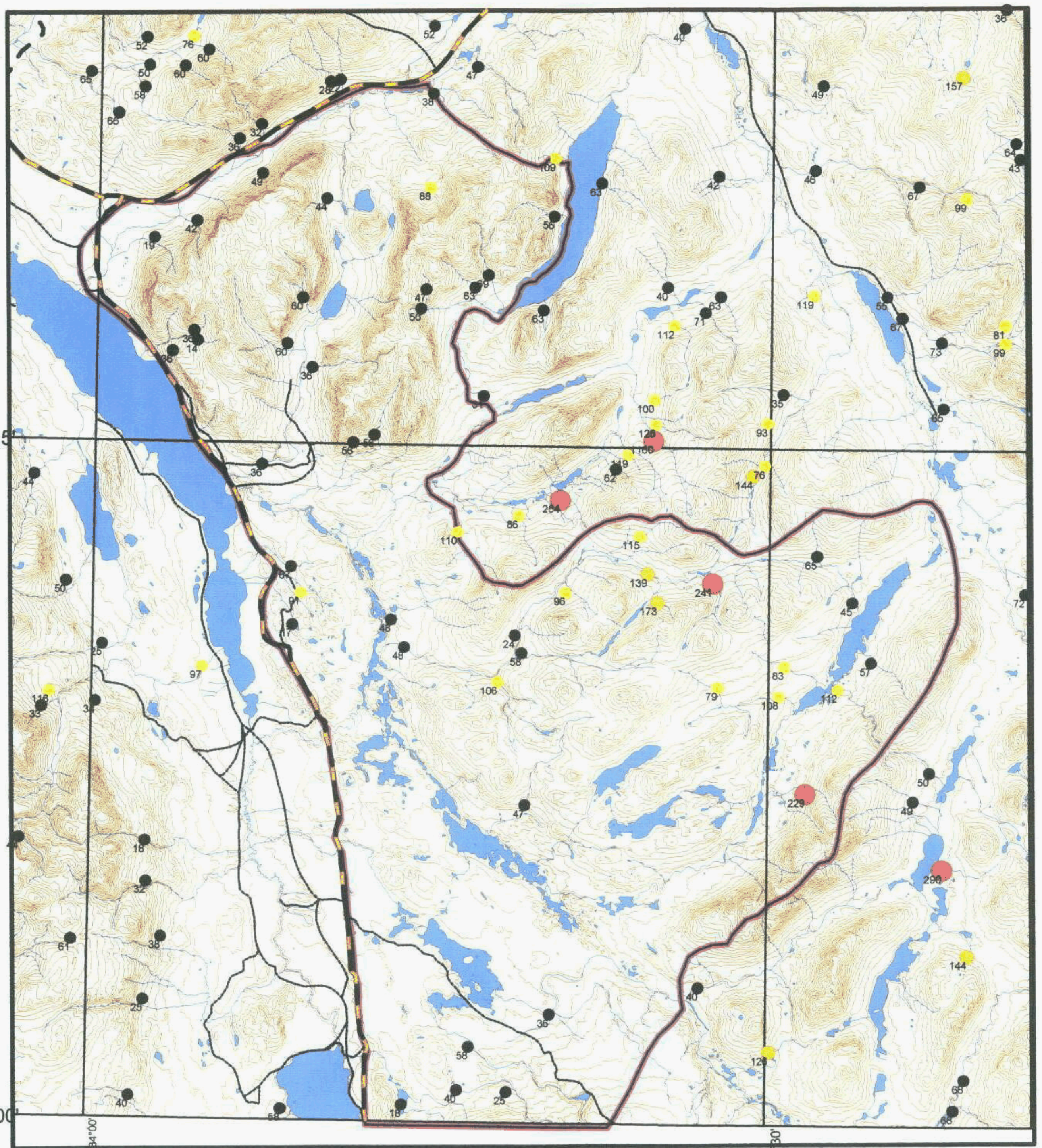
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

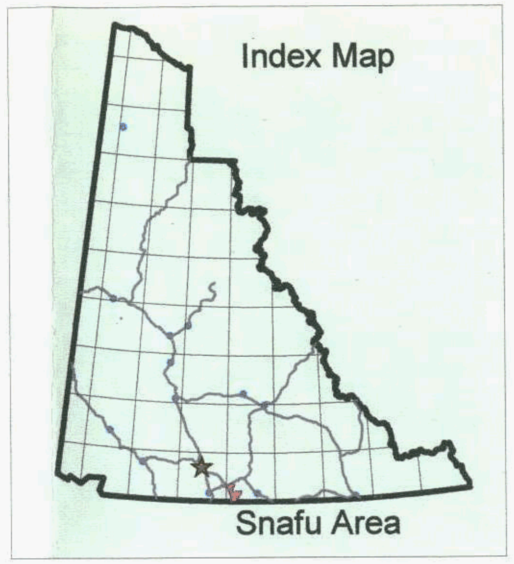


Scale 1:250 000

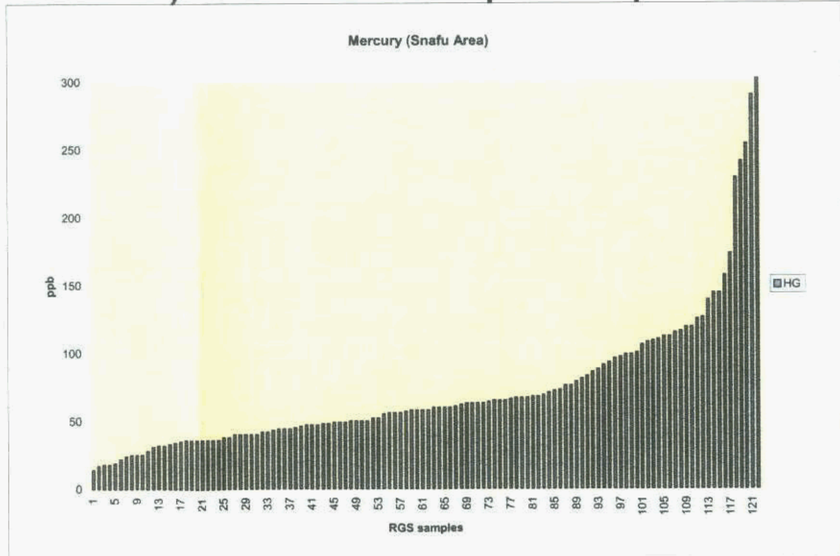
10 0 10 20 Kilometers

Mercury - Hg

- 0 - 75 ppb
- 76 - 125 ppb
- 126 - 175 ppb
- 176 - 1160 ppb



Detection Limit: 5 ppb
Method: CV-AAS - cold vapour (flameless) atomic absorption spectrometry



# Samples (n)	122
Maximum	1160
Median	58

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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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RGS
Mercury - Hg

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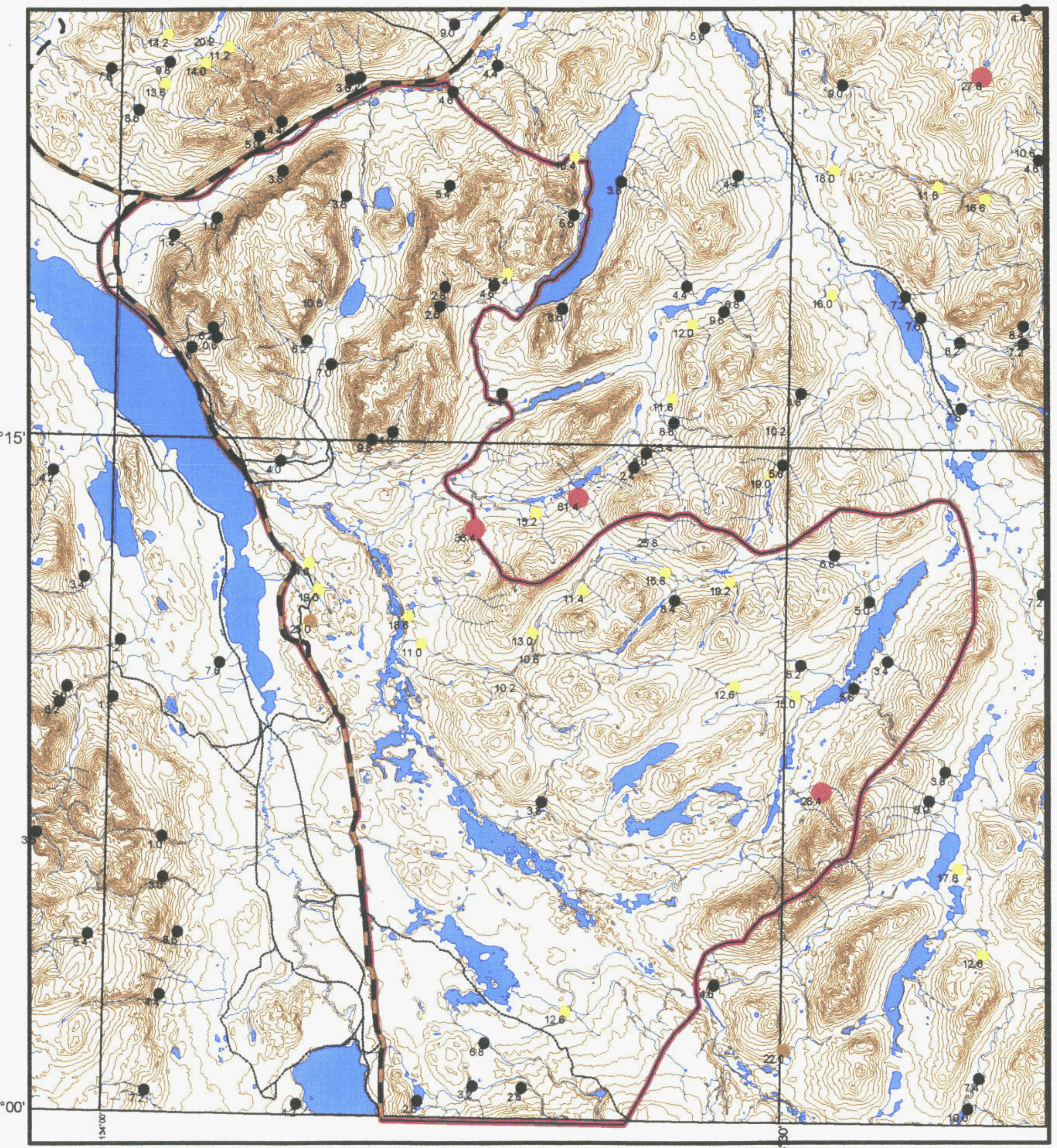
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

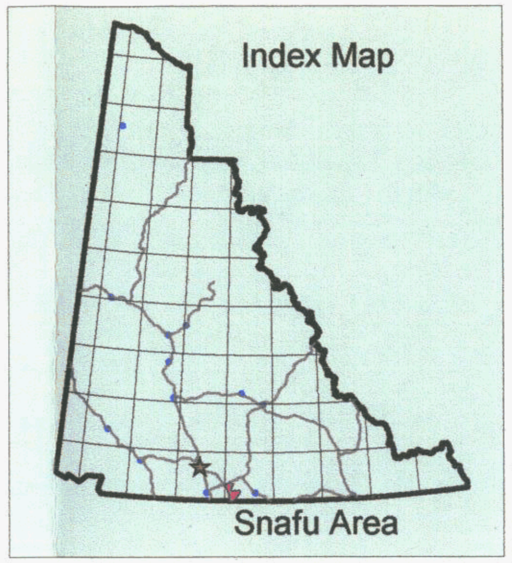


Scale 1:250 000

10 0 10 20 Kilometers

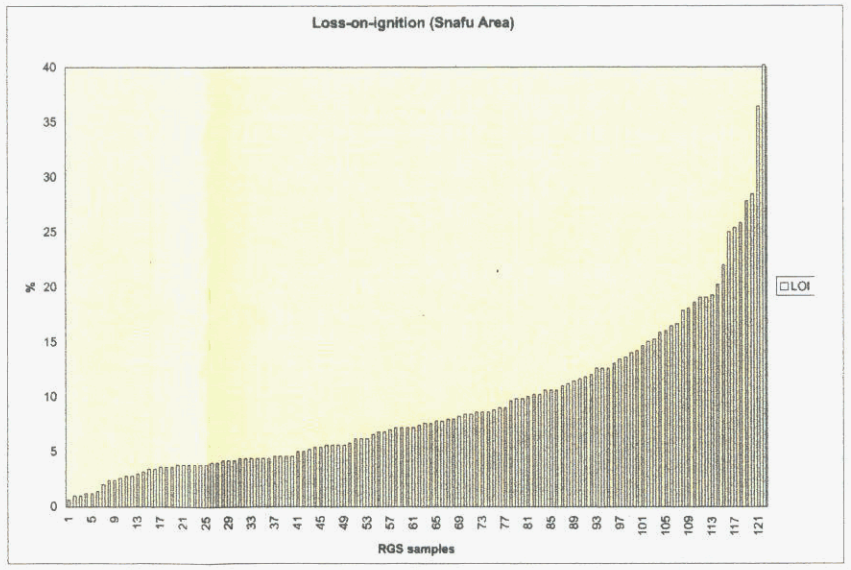
Loss-on-ignition

- 0 - 10 %
- 11 - 20 %
- 21 - 25 %
- 26 - 62 %



Detection Limit: 1 %
Method: GRAV - gravimetry

# Samples	(n)	122
Maximum		61.4
Median		7.3



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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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RGS
Loss-on-ignition

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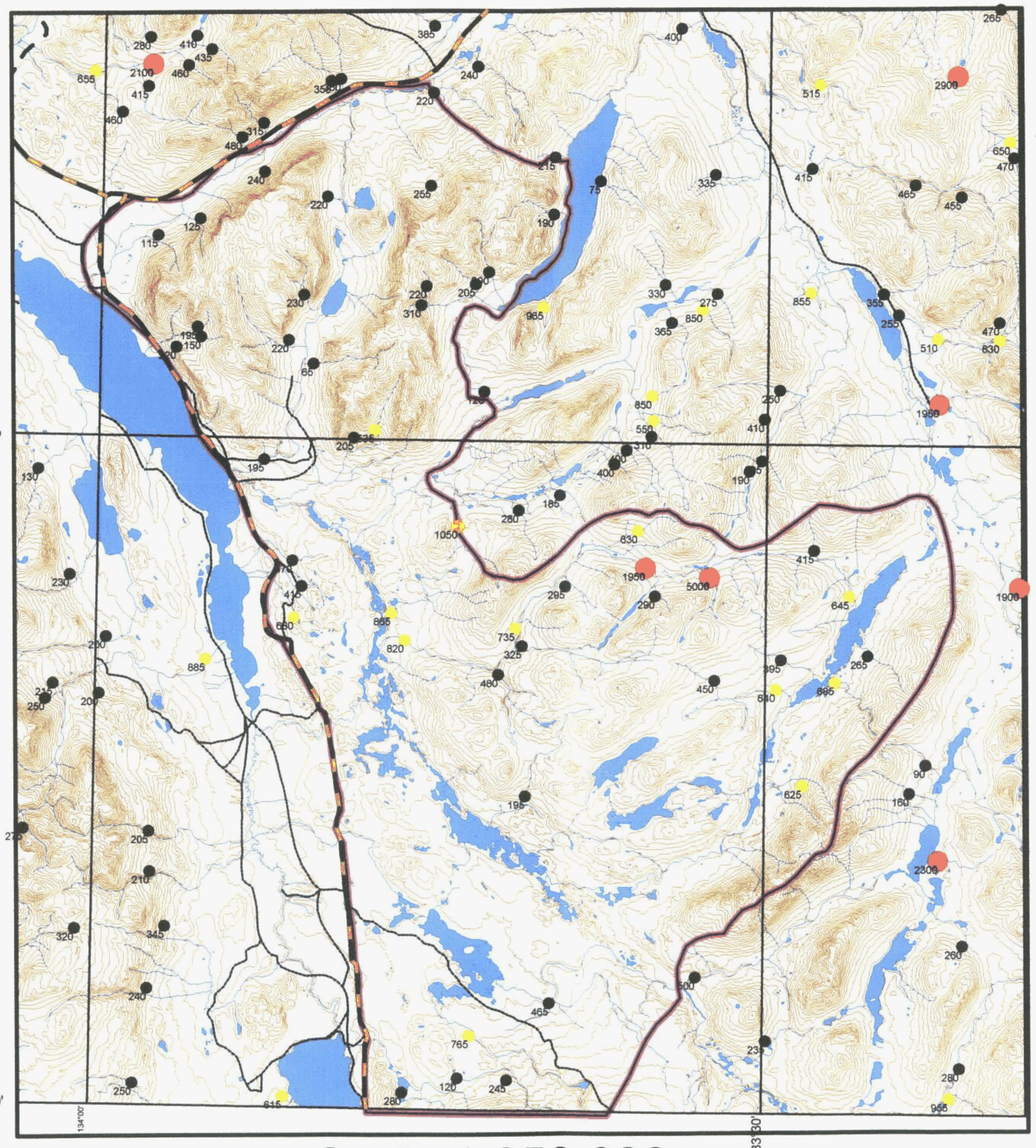
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

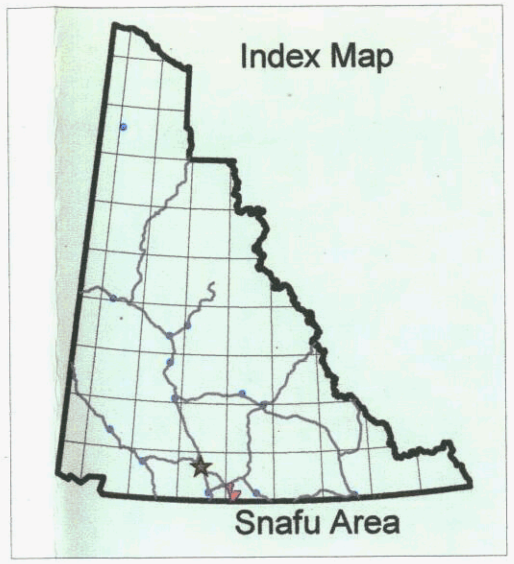


Scale 1:250 000

10 0 10 20 Kilometers

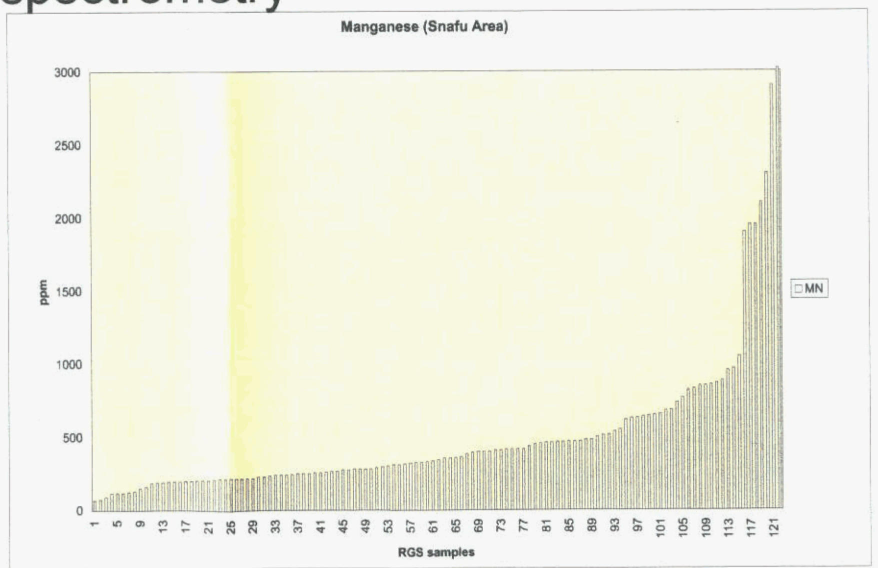
Manganese - Mn

- 0 - 500 ppm
- 501 - 1000 ppm
- 1001 - 1500 ppm
- 1501 - 5000 ppm



Detection Limit: 5 ppm
Method: AAS- atomic absorption spectrometry

# Samples (n)	122
Maximum	5000
Median	340



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Manganese - Mn

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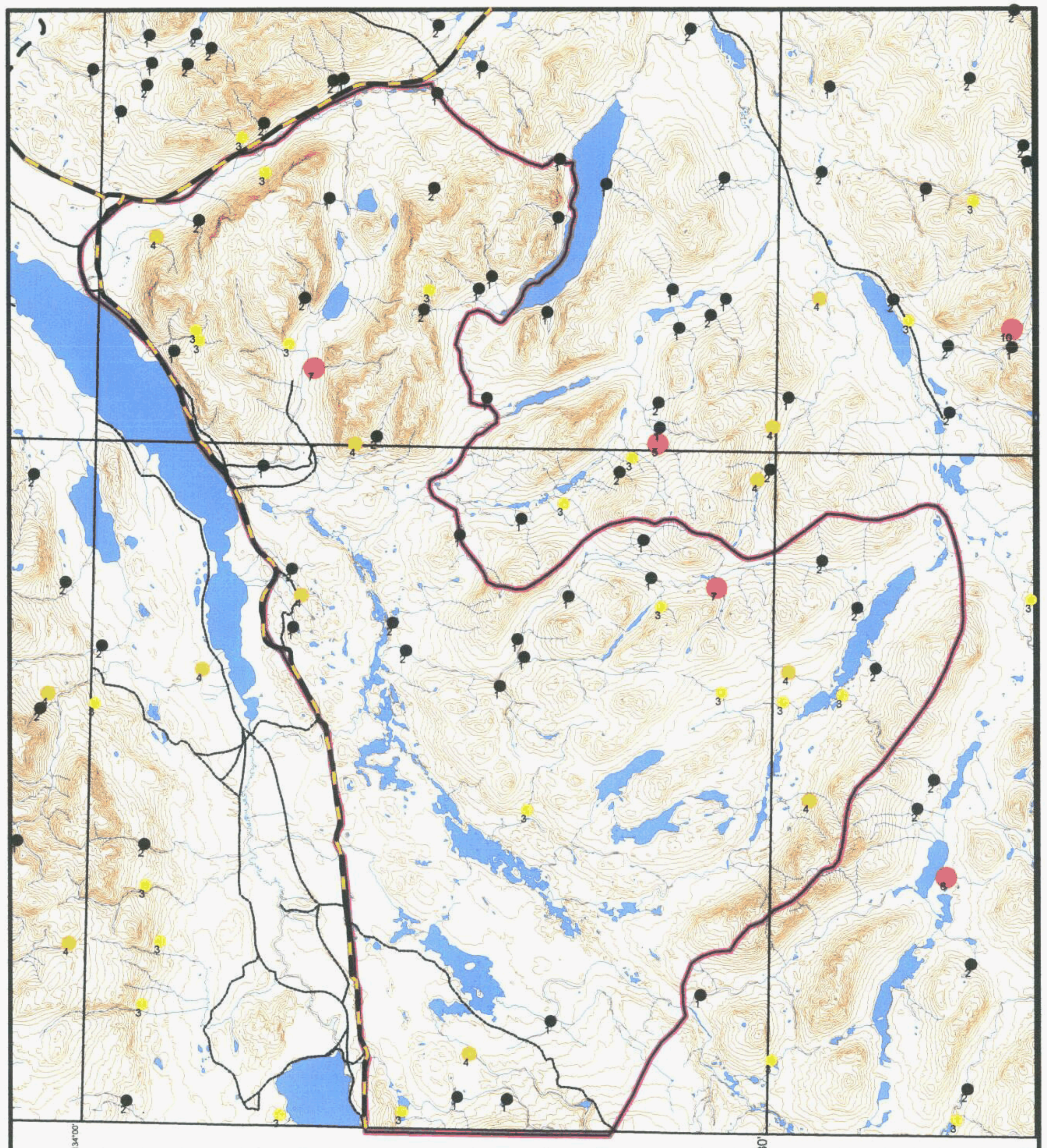
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

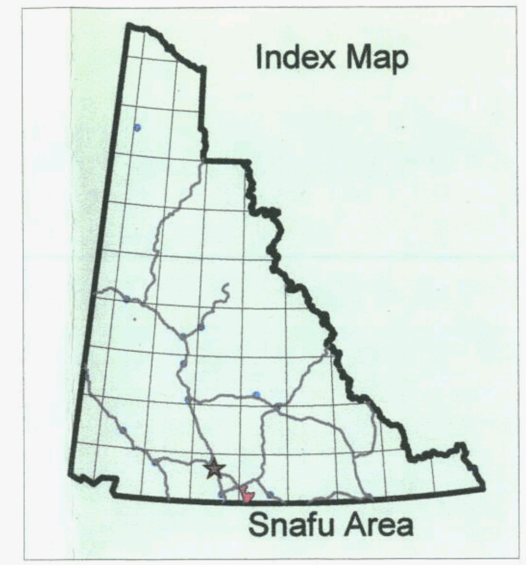


Scale 1:250 000

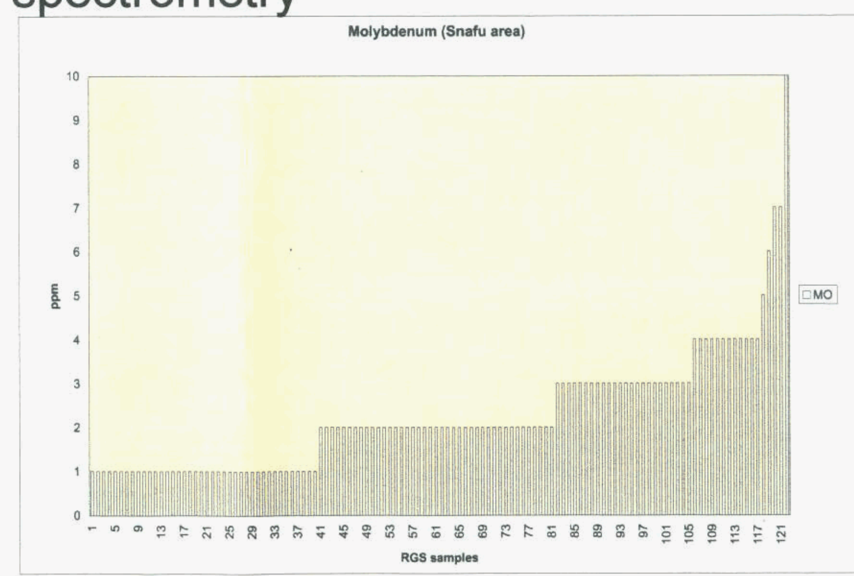
10 0 10 20 Kilometers

Molybdenum - Mo

- 0 - 2 ppm
- 2.1 - 3 ppm
- 3.1 - 4 ppm
- 4.1 - 10 ppm



Detection Limit: 2 ppm
Method: AAS- atomic absorption spectrometry



# Samples (n)	122
Maximum	10
Median	2

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Natural Environment Park
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RGS
Molybdenum - Mo

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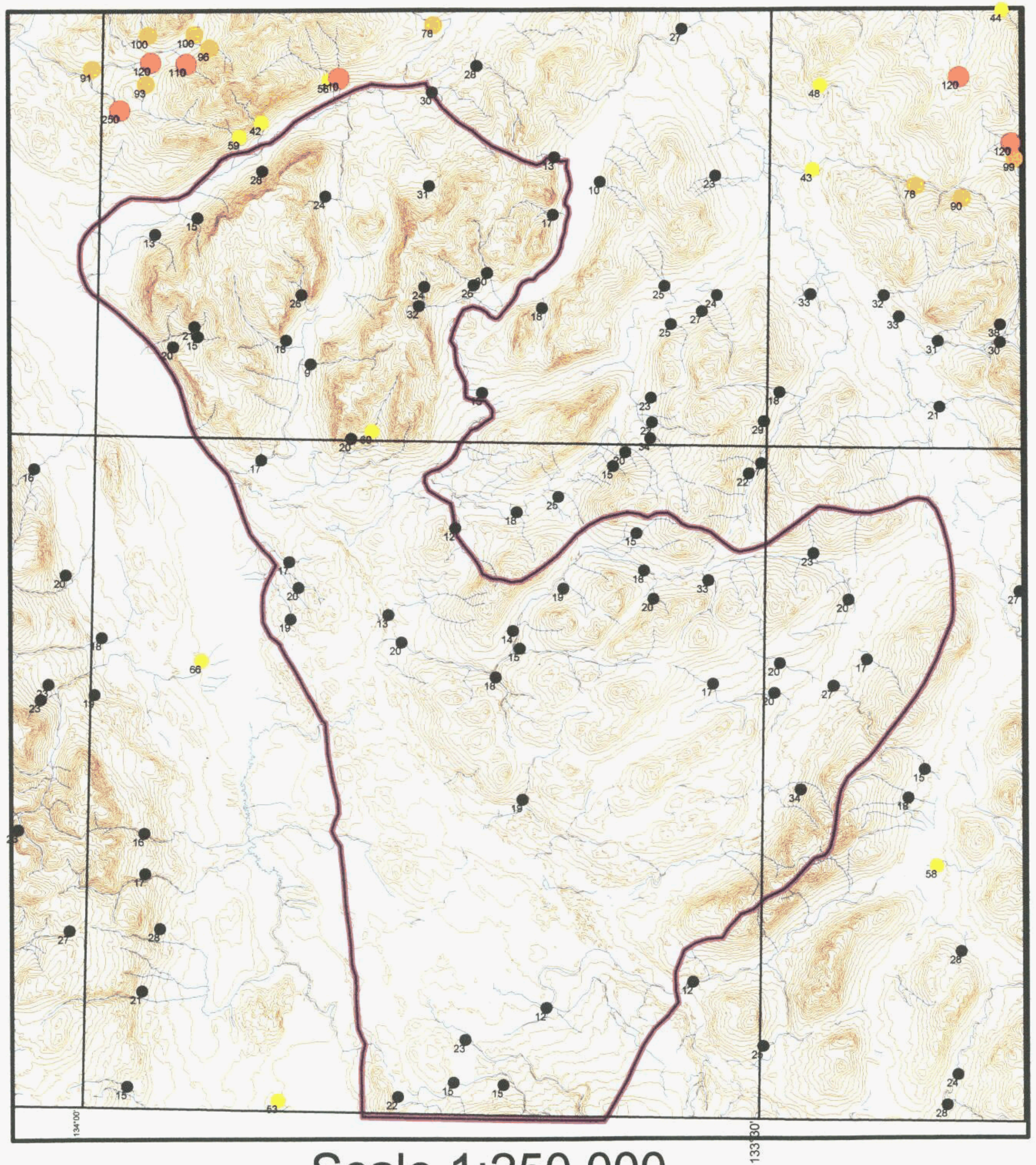
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

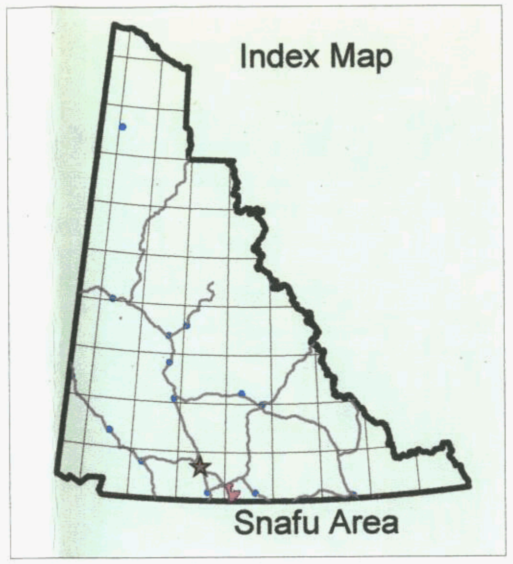


Scale 1:250 000

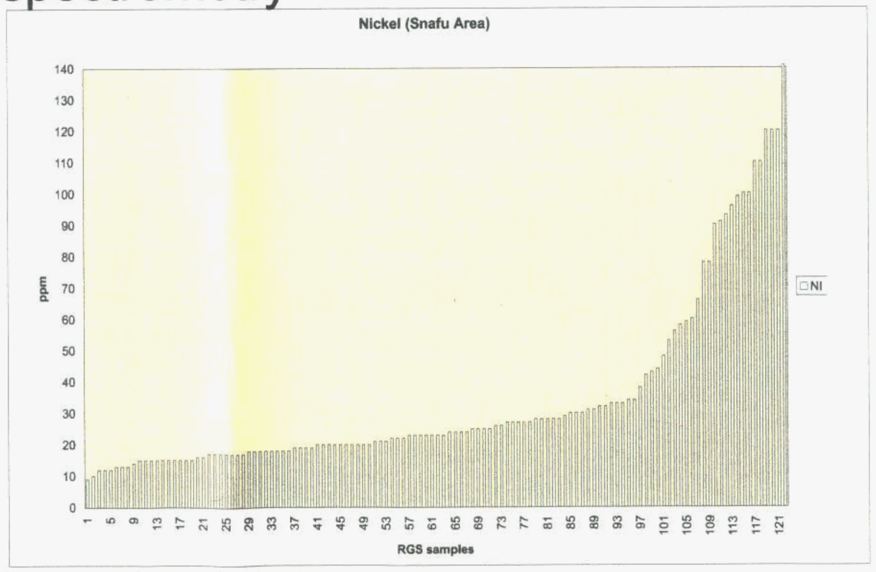
10 0 10 20 Kilometers

Nickel - Ni

- 0 - 40 ppm
- 40.1 - 70 ppm
- 70.1 - 100 ppm
- 100.1 - 250 ppm



Detection Limit: 2 ppm
Method: AAS- atomic absorption spectrometry



# Samples	(n)	122
Maximum		250
Median		23

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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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RGS
Nickel - Ni

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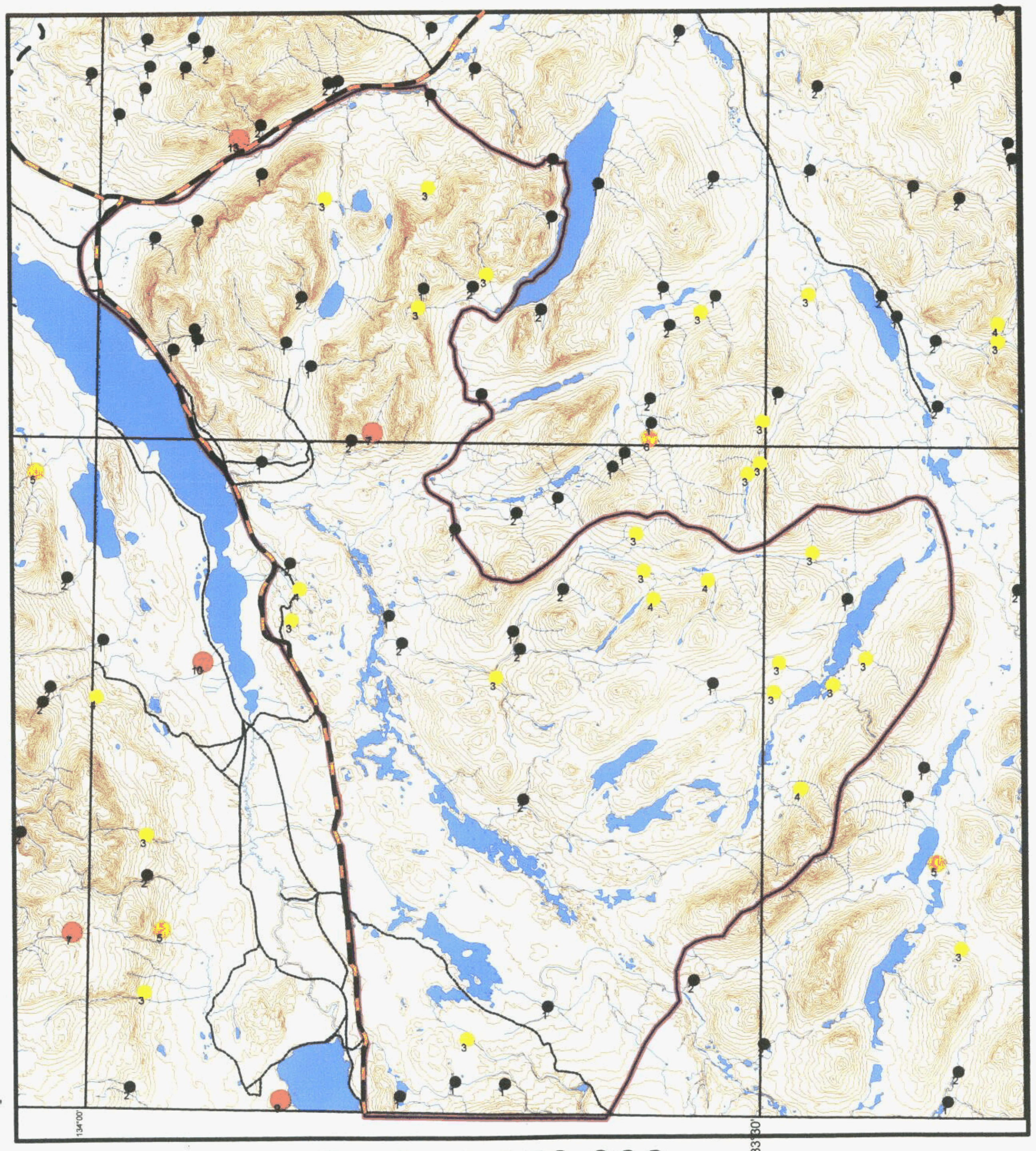
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

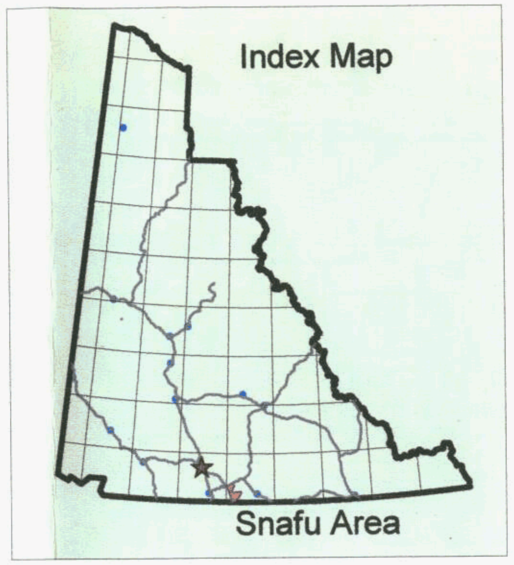


Scale 1:250 000

10 0 10 20 Kilometers

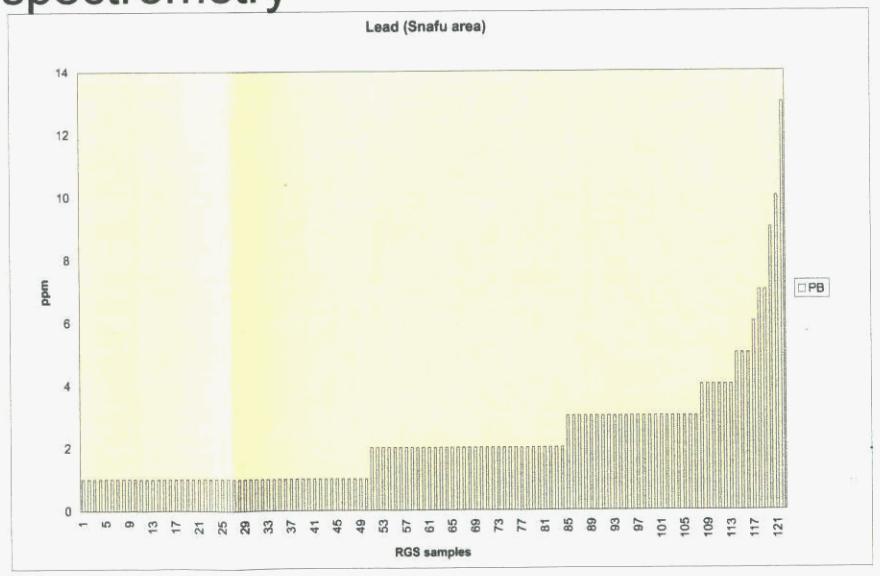
Lead - Pb

- • 0 - 2 ppm
- • 2.1 - 4 ppm
- • 4.1 - 6 ppm
- • 6.1 - 13 ppm



Detection Limit: 2 ppm
Method: AAS- atomic absorption spectrometry

# Samples (n)	122
Maximum	13
Median	2



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Proposed Snafu / Tarfu
Natural Environment Park
Special Management Area
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RGS
Lead - Pb

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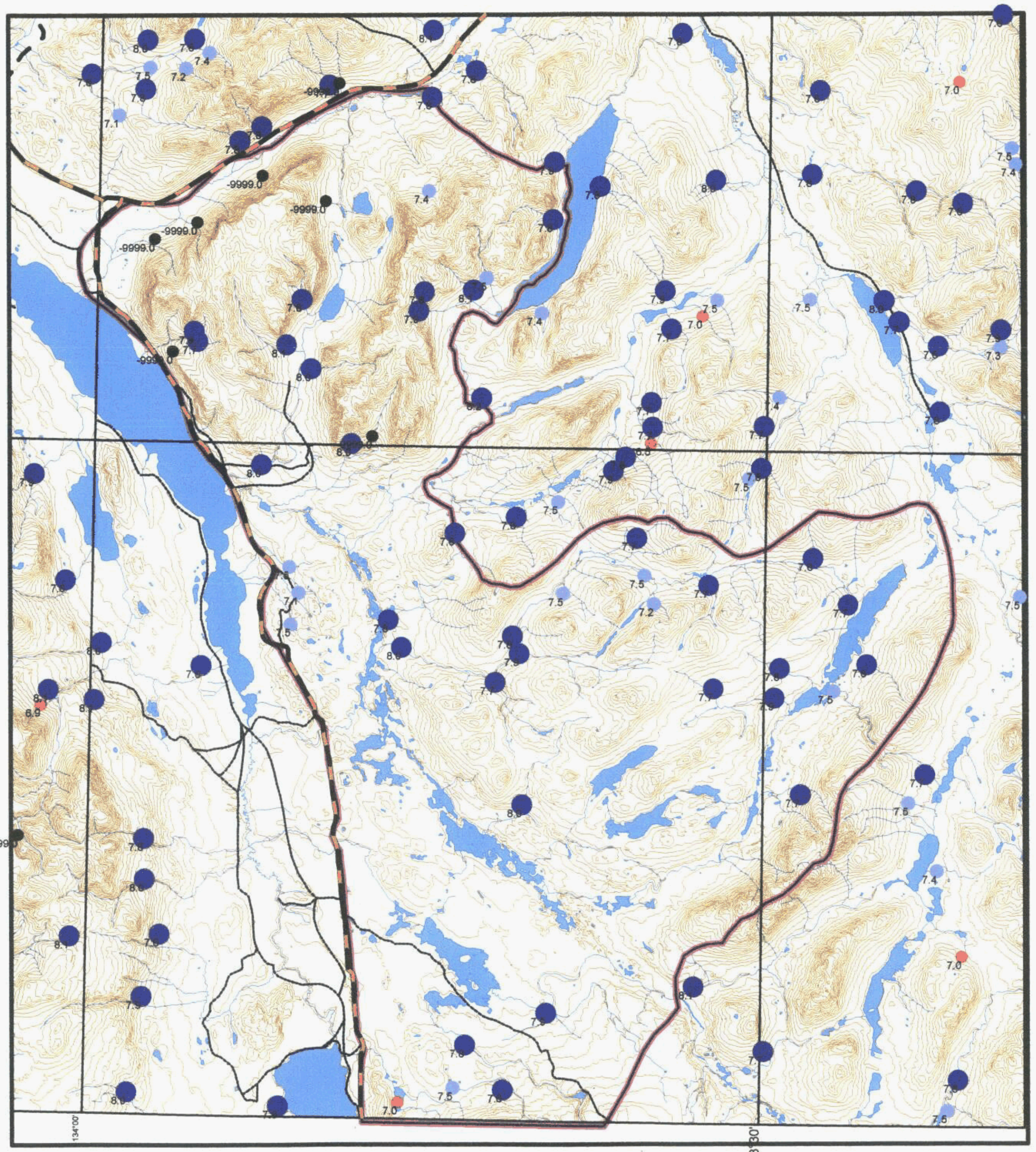
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

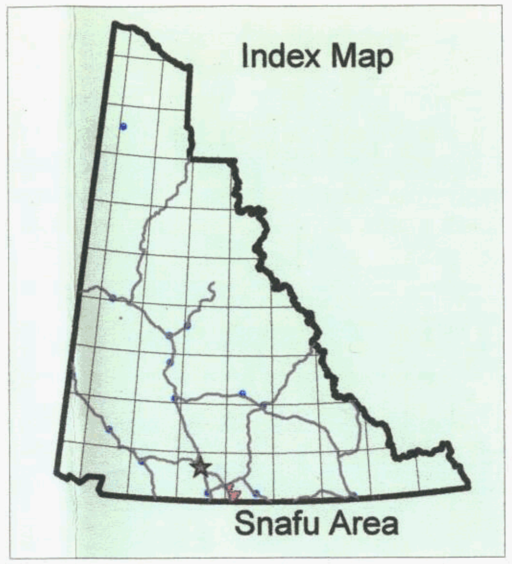


Scale 1:250 000

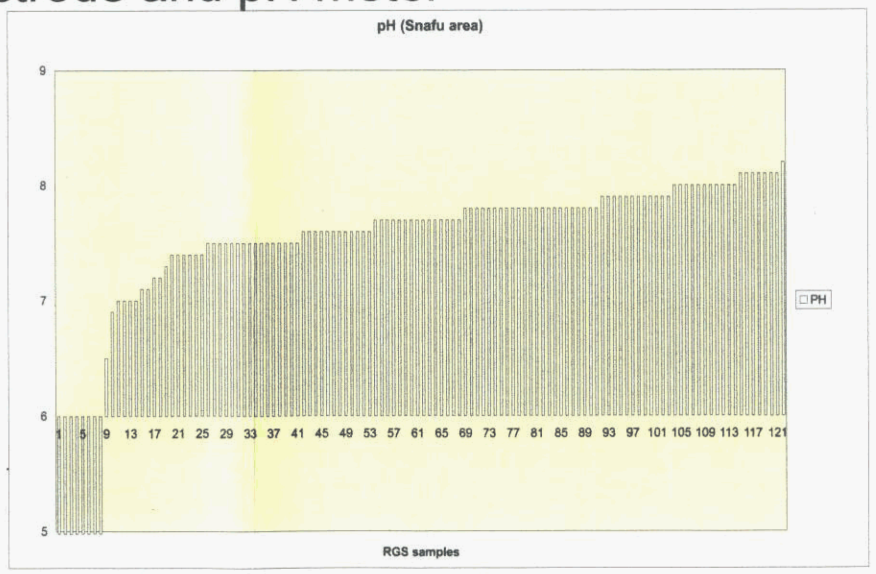
10 0 10 20 Kilometers

pH

- -9999 values
- 6 - 7 (acidic)
- 7.1 - 7.5 (basic)
- 7.6 - 8.2 (basic)



Detection Limit: --
Method: GCM-glass Calomel electrode and pH meter



# Samples	(n)	122
Maximum		8.2
Median		7.7

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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

Confidential

RGS
pH

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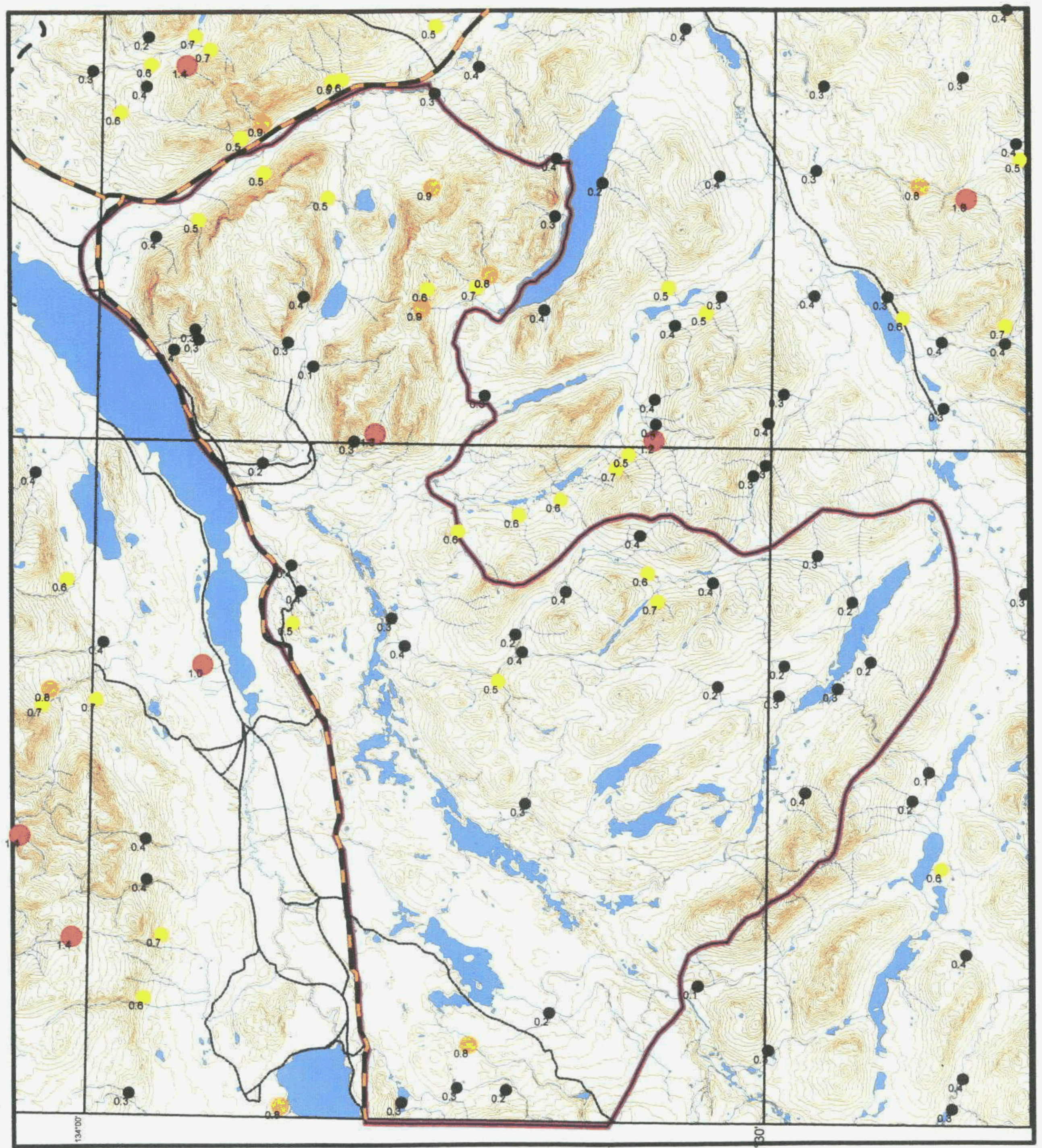
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area

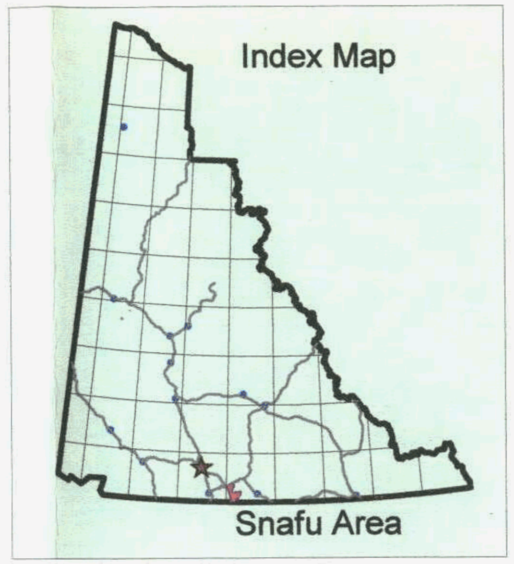


Scale 1:250 000

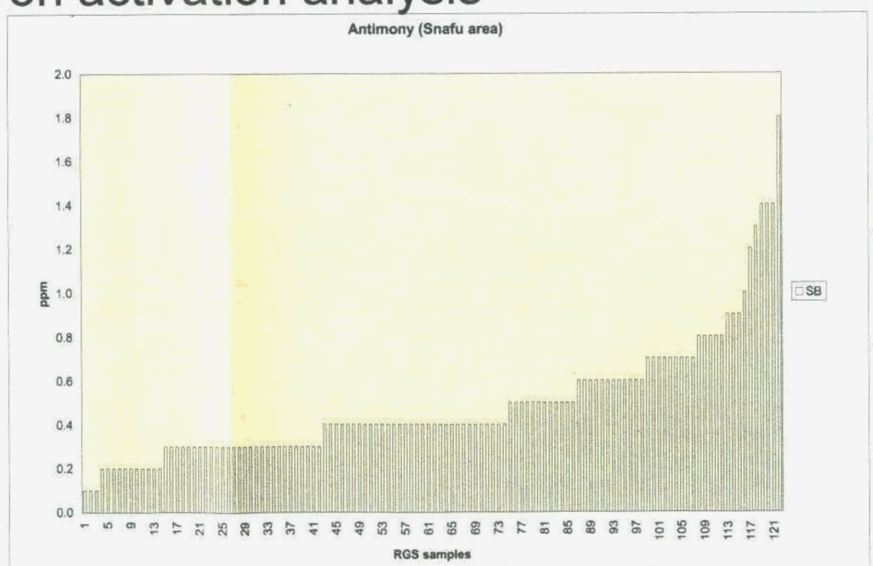
10 0 10 20 Kilometers

Antimony - Sb

- 0 - 0.4 ppm
- 0.41 - 0.7 ppm
- 0.71 - 0.9 ppm
- 0.91 - 1.8 ppm



Detection Limit: 0.1 ppm
Method: INAA- instrumental neutron activation analysis



# Samples (n)		122
Maximum		1.8
Median		0.4

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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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RGS
Antimony - Sb

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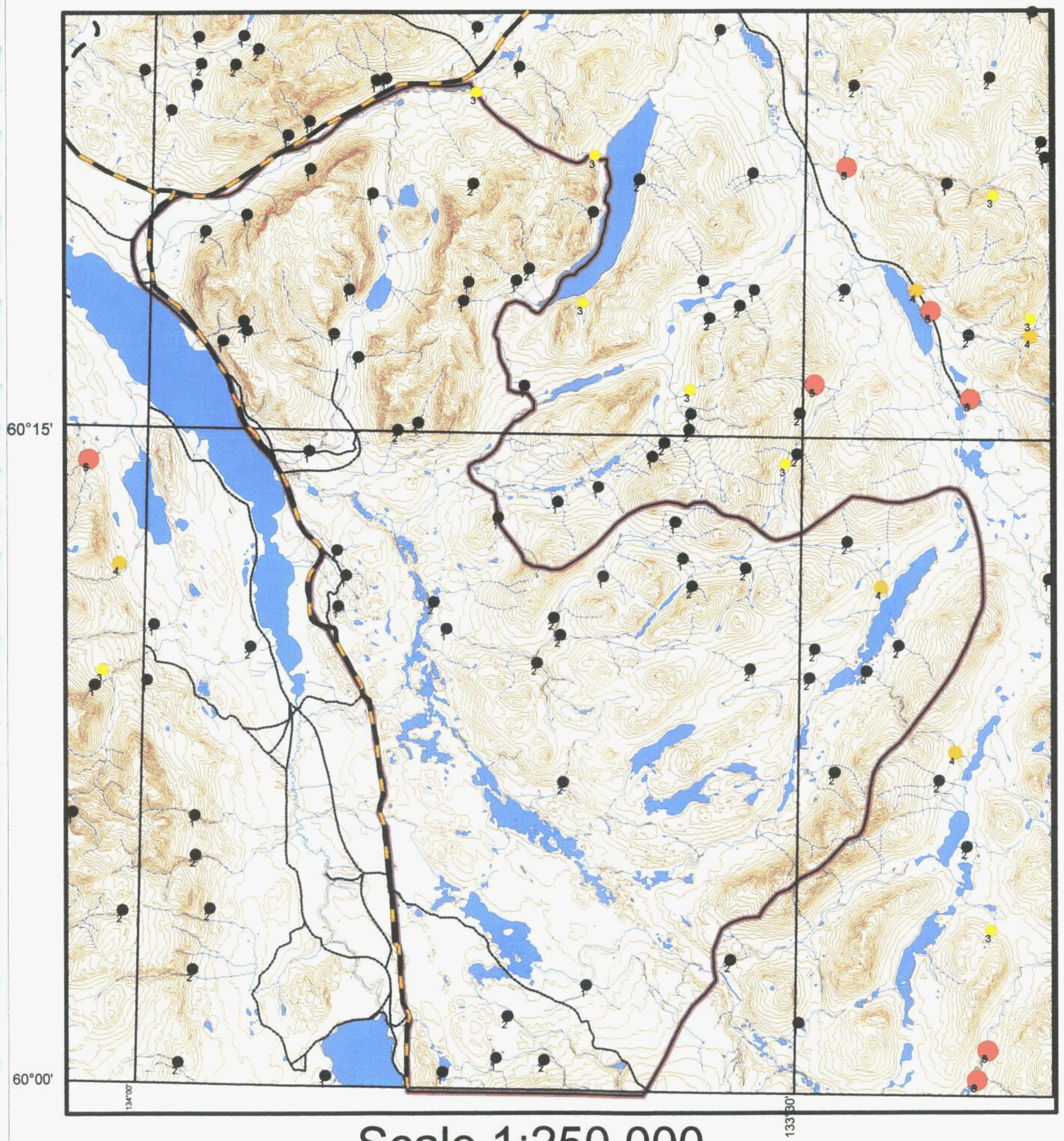
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

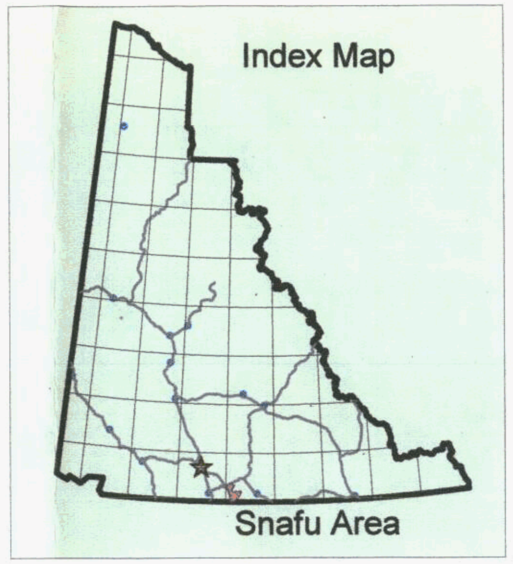


Scale 1:250 000

10 0 10 20 Kilometers

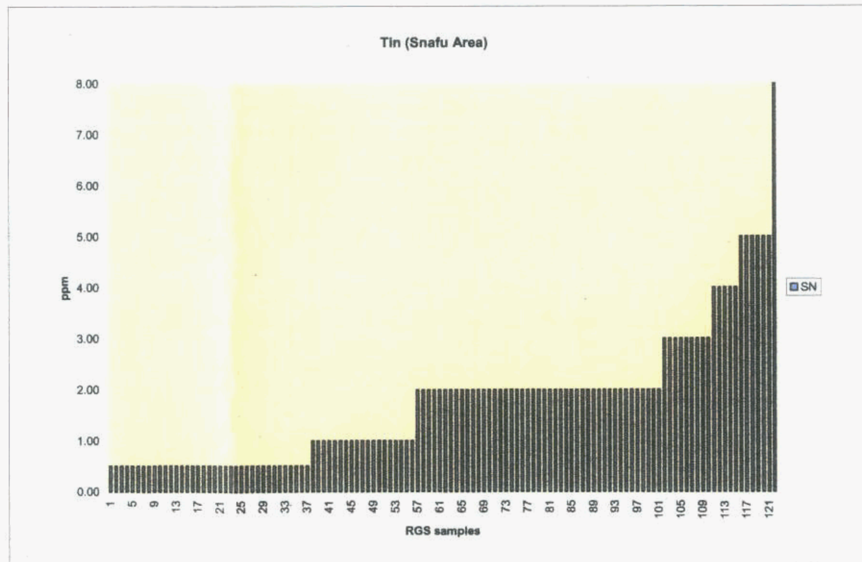
Tin - Sn

- 0 - 2 ppm
- 2.1 - 3 ppm
- 3.1 - 4 ppm
- 4.1 - 8 ppm



Detection Limit: 1 ppm
Method: FUS - NH4I fusion

# Samples	(n)	122
Maximum		8
Median		2



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Proposed Snafu / Tarfu Natural Environment Park Special Management Area (September 2002 outline)

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RGS
Tin - Sn

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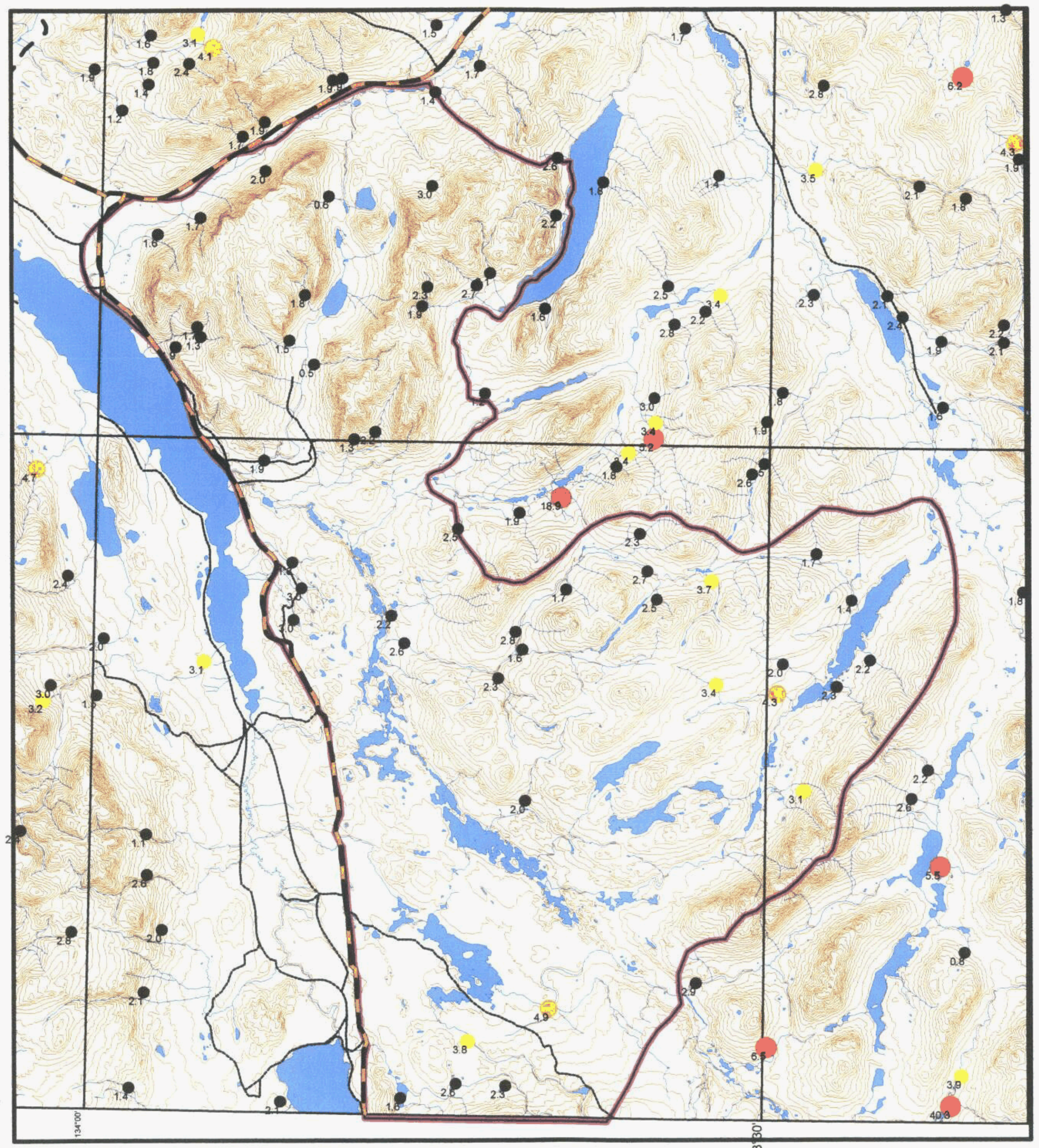
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

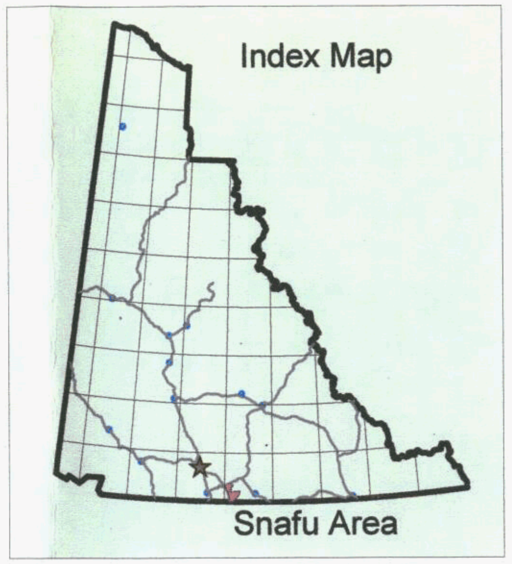


Scale 1:250 000

10 0 10 20 Kilometers

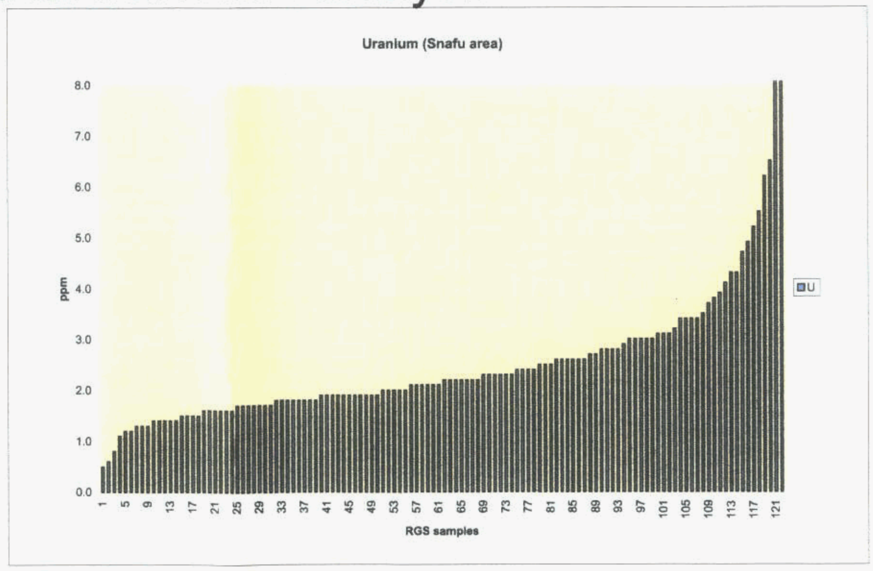
Uranium - U

- 0 - 3 ppm
- 3.1 - 4 ppm
- 4.1 - 5 ppm
- 5.1 - 40.3 ppm



Detection Limit: 0.2 ppm
Method: INAA - instrumental neutron activation analysis

# Samples	(n)	122
Maximum		40.3
Median		2.2



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Proposed Snafu / Tarfu
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RGS
Uranium - U

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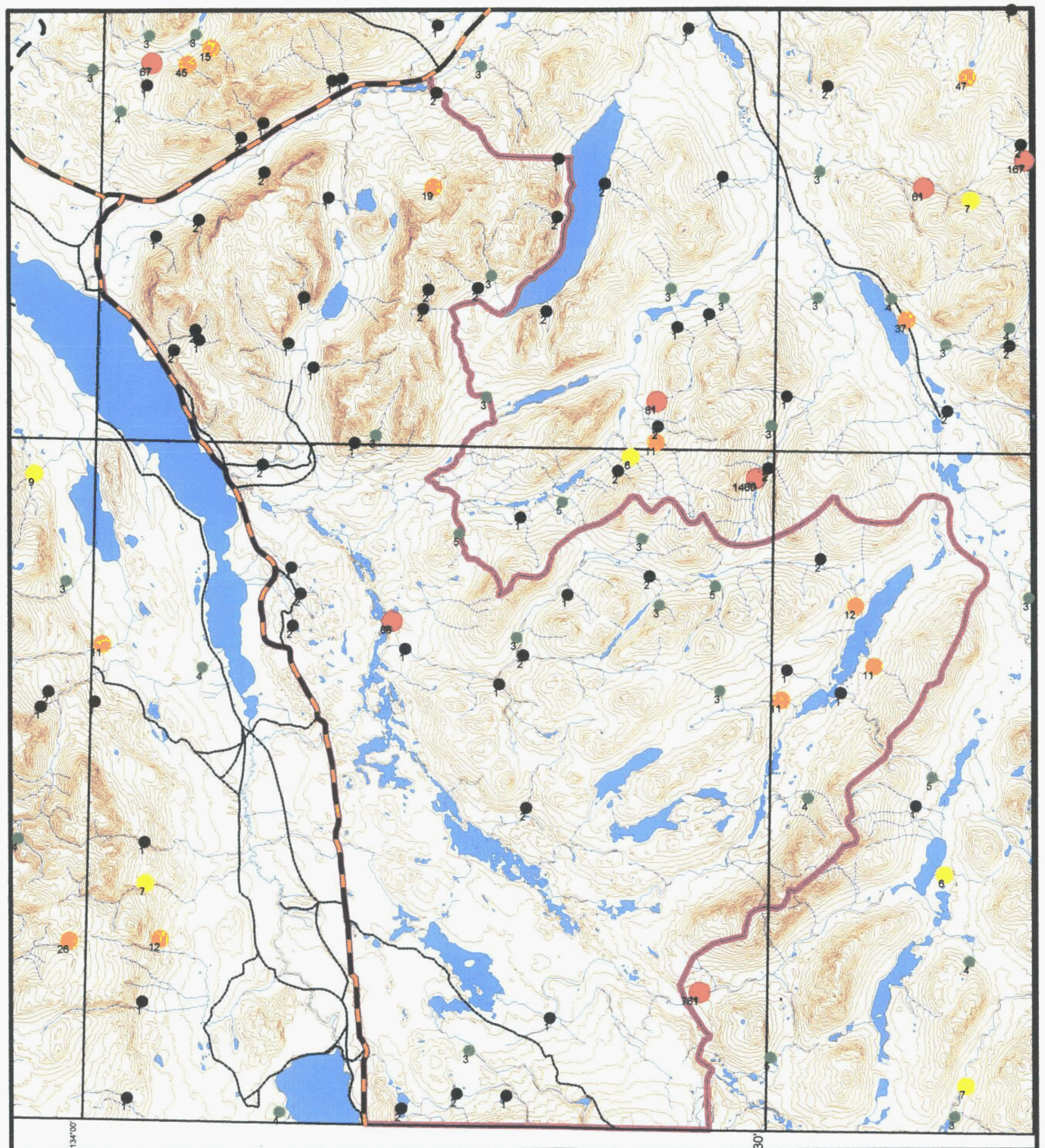
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

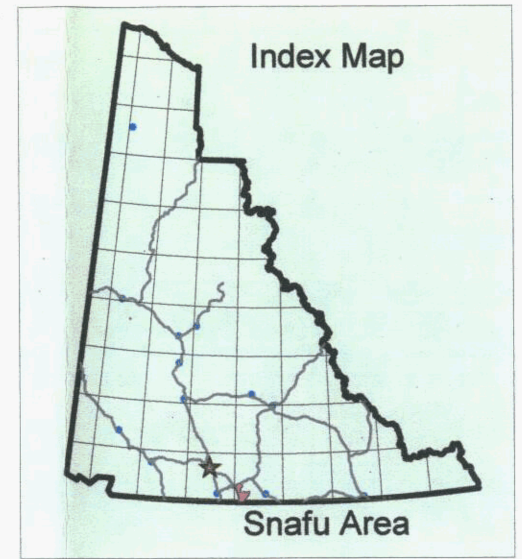


Scale 1:250 000

10 0 10 20 Kilometers

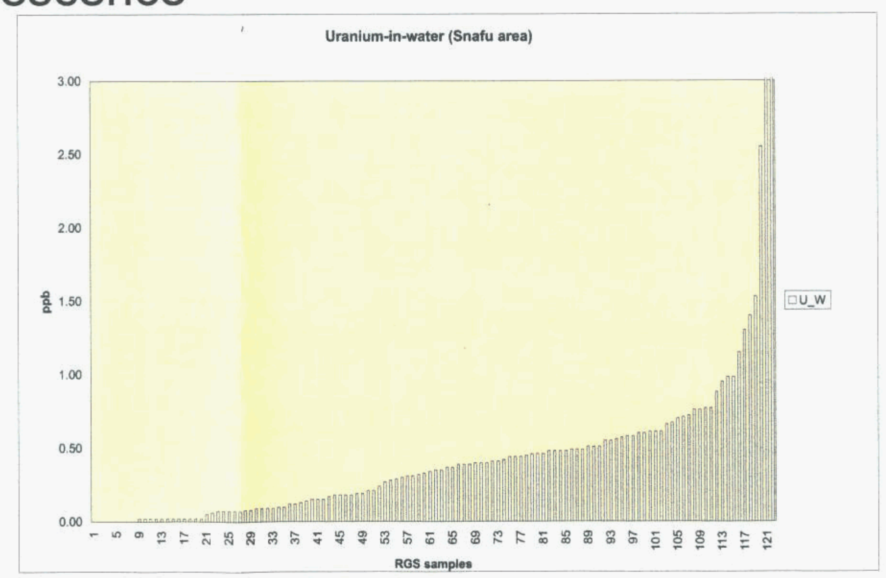
Uranium in water - U_w

- 0 - 0.5 ppb
- 0.51 - 1.0 ppb
- 1.01 - 1.5 ppb
- 1.51 - 4.25 ppb



Detection Limit: 0.5 ppb
Method: LIF - laser-induced fluorescence

# Samples (n)	122
Maximum	4.25
Median	0.34



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Uranium in water - U_w

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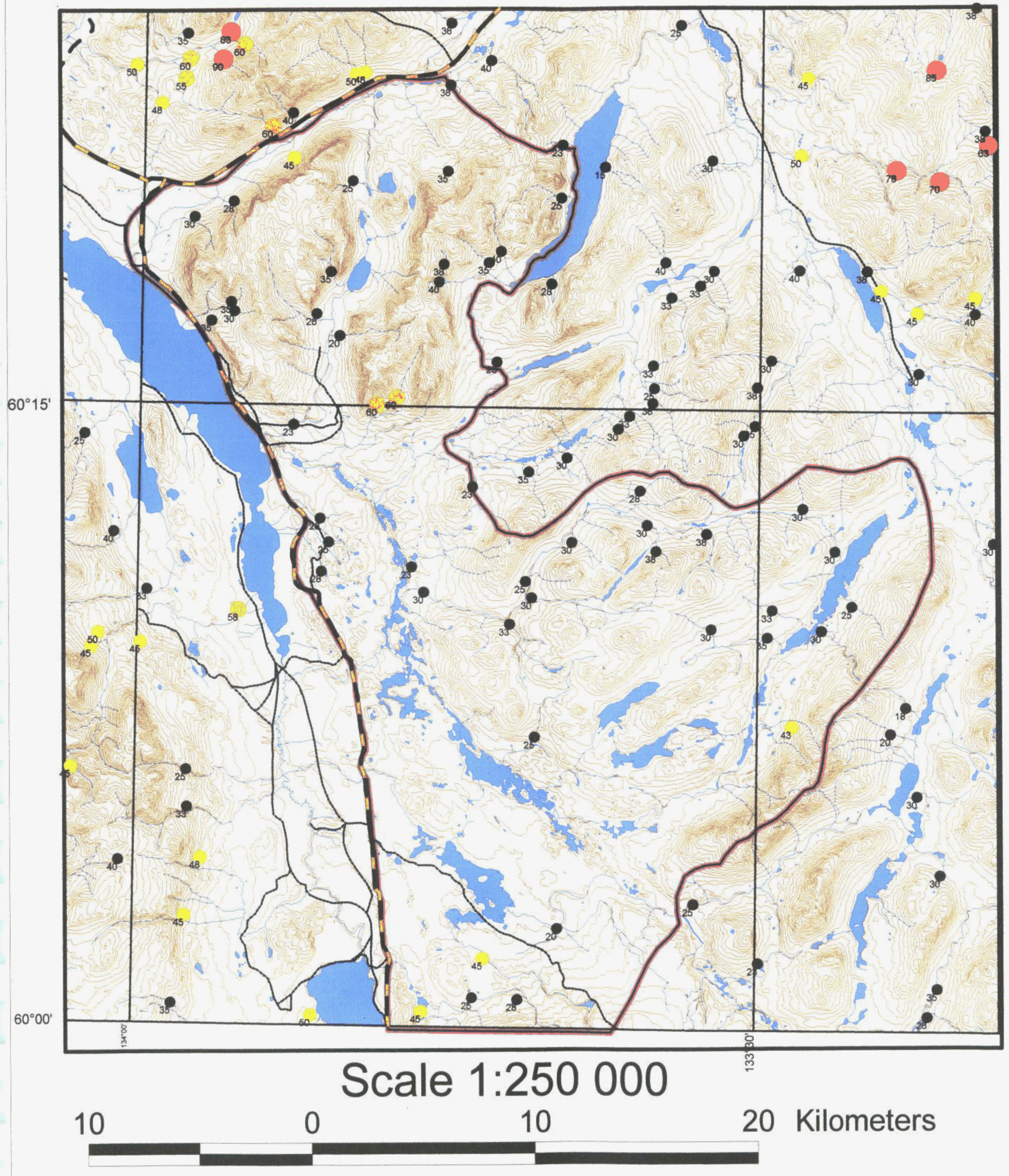
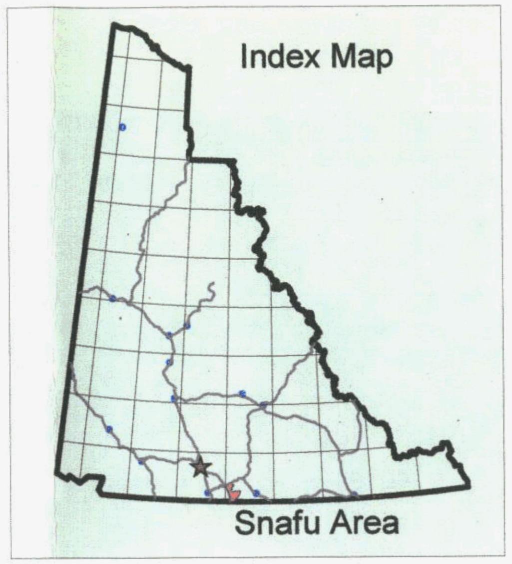
Regional Stream Sediment Geochemistry in Proposed Snafu /Tarfu SMA Area



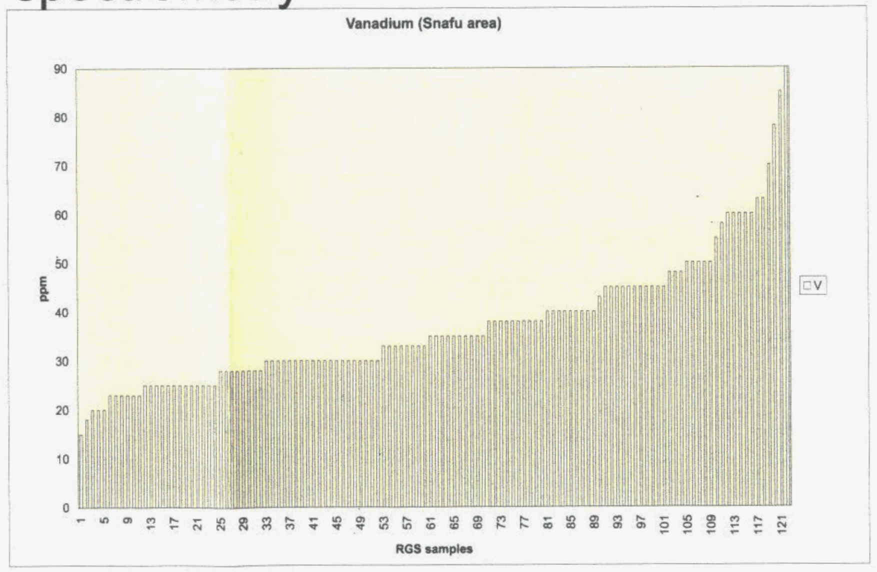
Vanadium - V

- 0 - 40 ppm
- 40.1 - 50 ppm
- 50.1 - 60 ppm
- 60.1 - 90 ppm



Detection Limit: 5 ppm
Method: AAS - atomic absorption spectrometry

# Samples	(n)	122
Maximum		90
Median		35



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RGS
Vanadium - V

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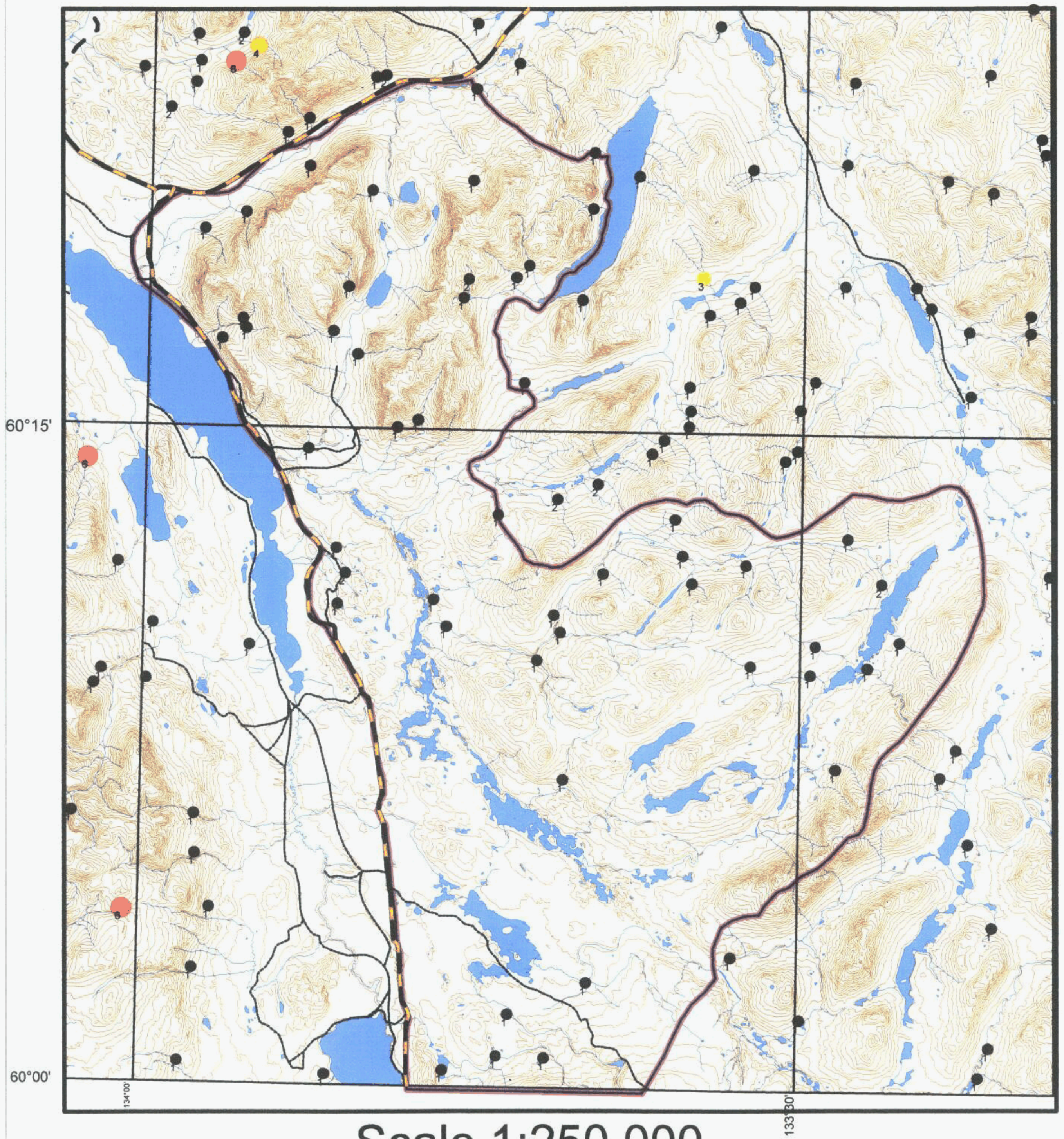
Regional Stream Sediment Geochemistry in Proposed Snafu/Tarfu SMA Area

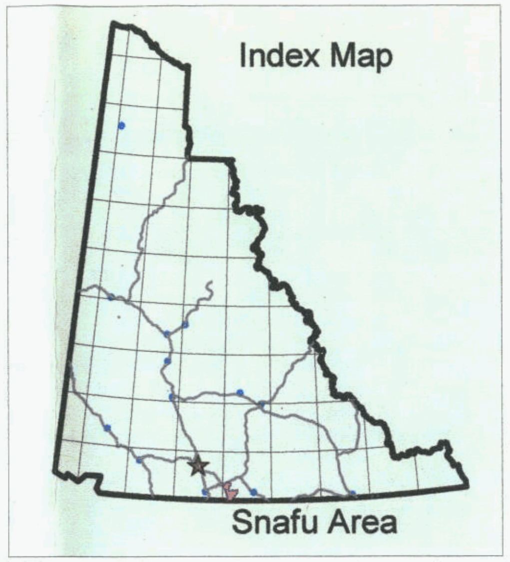


Scale 1:250 000

10 0 10 20 Kilometers

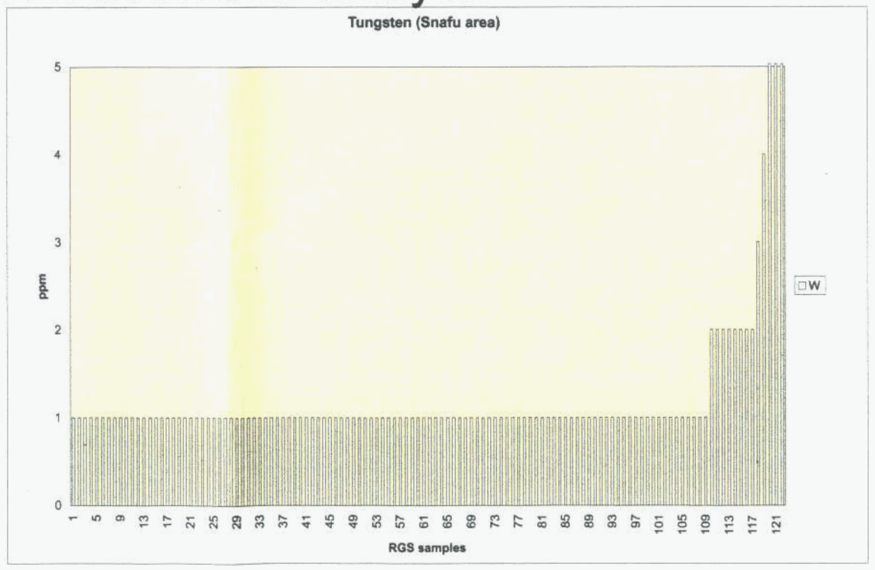
Tungsten - W

- 0 - 2 ppm
- 2.1 - 3 ppm
- 3.1 - 4 ppm
- 4.1 - 6 ppm



Detection Limit: 1 ppm
Method: INAA - instrumental neutron activation analysis

# Samples	(n)	122
Maximum		6
Median		1



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Proposed Snafu / Tarfu
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RGS
Tungsten - W

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Appendix IV: Mineral Deposit Models

Au-QUARTZ VEINS I01

by Chris Ash and Dani Alldrick

IDENTIFICATION

SYNONYMS: Mother Lode veins, greenstone gold, Archean lode gold, mesothermal gold-quartz veins, shear-hosted lode gold, low-sulphide gold-quartz veins, lode gold.

COMMODITIES (*BYPRODUCTS*): Au (Ag, Cu, Sb).

EXAMPLES (British Columbia (MINFILE #) - *Canada/ International*):

- Phanerozoic: Bralome-Pioneer (092JNE001), Erickson (104P029), Taurus (104P012), Polaris-Taku (104K003), Mosquito Creek (093H010), Cariboo Gold Quartz (093H019), Midnight (082FSW119); *Carson Hill, Jackson-Plymouth, Mother Lode district; Empire Star and Idaho-Maryland, Grass Valley district (California, USA); Alaska-Juneau, Jualin, Kensington (Alaska, USA), Ural Mountains (Russia).*
- Archean: *Hollinger, Dome, McIntyre and Pamour, Timmins camp; Lake Shore, Kirkland Lake camp; Campbell, Madsen, Red Lake camp; Kerr-Addison, Larder Lake camp (Ontario, Canada), Lamaque and Sigma, Val d'Or camp (Quebec, Canada); Granny Smith, Kalgoorlie and Golden Mile (Western Australia); Kolar (Karnataka, India), Blanket-Vubachikwe (Zimbabwe, Africa).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Gold-bearing quartz veins and veinlets with minor sulphides crosscut a wide variety of hostrocks and are localized along major regional faults and related splays. The wallrock is typically altered to silica, pyrite and muscovite within a broader carbonate alteration halo.

TECTONIC SETTINGS:

- Phanerozoic: Contained in moderate to gently dipping fault/suture zones related to continental margin collisional tectonism. Suture zones are major crustal breaks which are characterized by dismembered ophiolitic remnants between diverse assemblages of island arcs, subduction complexes and continental-margin clastic wedges.
- Archean: Major transcrustal structural breaks within stable cratonic terranes. May represent remnant terrane collisional boundaries.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins form within fault and joint systems produced by regional compression or transpression (terrane collision), including major listric reverse faults, second and third-order splays. Gold is deposited at crustal levels within and near the brittle-ductile transition zone at depths of 6-12 km, pressures between 1 to 3 kilobars and temperatures from 200° to 400 °C. Deposits may have a vertical extent of up to 2 km, and lack pronounced zoning.

AGE OF MINERALIZATION: Mineralization is post-peak metamorphism (*i.e.* late syncollisional) with gold-quartz veins particularly abundant in the Late Archean and Mesozoic.

- Phanerozoic: In the North America Cordillera gold veins are post-Middle Jurassic and appear to form immediately after accretion of oceanic terranes to the continental margin. In British Columbia deposits are mainly Middle Jurassic (~ 165-170 Ma) and Late Cretaceous (~ 95 Ma). In the Mother Lode belt they are Middle Jurassic (~ 150 Ma) and those along the Juneau belt in Alaska are of Early Tertiary (~56-55 Ma).
- Archean: Ages of mineralization for Archean deposits are well constrained for both the Superior Province, Canadian Shield (~ 2.68 to 2.67 Ga) and the Yilgarn Province, Western Australia (~ 2.64 to 2.63 Ga).

Au-QUARTZ VEINS I01

HOST/ASSOCIATED ROCK TYPES: Lithologically highly varied, usually of greenschist metamorphic grade, ranging from virtually undeformed to totally schistose.

- Phanerozoic: Mafic volcanics, serpentinite, peridotite, dunite, gabbro, diorite, trondhjemite/plagiogranites, graywacke, argillite, chert, shale, limestone and quartzite, felsic and intermediate intrusions.
- Archean: Granite-greenstone belts - mafic, ultramafic (komaitiitic) and felsic volcanics, intermediate and felsic intrusive rocks, graywacke and shale.

DEPOSIT FORM: Tabular fissure veins in more competent host lithologies, veinlets and stringers forming stockworks in less competent lithologies. Typically occur as a system of en echelon veins on all scales. Lower grade bulk-tonnage styles of mineralization may develop in areas marginal to veins with gold associated with disseminated sulphides. May also be related to broad areas of fracturing with gold and sulphides associated with quartz veinlet networks.

TEXTURE/STRUCTURE: Veins usually have sharp contacts with wallrocks and exhibit a variety of textures, including massive, ribboned or banded and stockworks with anastamosing gashes and dilations. Textures may be modified or destroyed by subsequent deformation.

ORE MINERALOGY: [Principal and *subordinate*]: Native gold, pyrite, arsenopyrite, *galena, sphalerite, chalcopyrite, pyrrhotite, tellurides, scheelite, bismuth, cosalite, tetrahedrite, stibnite, molybdenite, gersdorffite (NiAsS), bismuthimite* (Bi_2S_3), *tetradymite* (Bi_2Te_2S).

GANGUE MINERALOGY: [Principal and *subordinate*]: Quartz, carbonates (ferroan-dolomite, ankerite ferroan-magnesite, calcite, siderite), *albite, mariposite (fuchsite), sericite, muscovite, chlorite, tourmaline, graphite.*

ALTERATION MINERALOGY: Silicification, pyritization and potassium metasomatism generally occur adjacent to veins (usually within a metre) within broader zones of carbonate alteration, with or without ferroan dolomite veinlets, extending up to tens of metres from the veins. Type of carbonate alteration reflects the ferromagnesian content of the primary host lithology; ultramafics rocks - talc, Fe-magnesite; mafic volcanic rocks - ankerite, chlorite; sediments - graphite and pyrite; felsic to intermediate intrusions - sericite, albite, calcite, siderite, pyrite. Quartz-carbonate altered rock (listwanite) and pyrite are often the most prominent alteration minerals in the wallrock. Fuchsite, sericite, tourmaline and scheelite are common where veins are associated with felsic to intermediate intrusions.

WEATHERING: Distinctive orange-brown limonite due to the oxidation of Fe-Mg carbonates cut by white veins and veinlets of quartz and ferroan dolomite. Distinctive green Cr-mica may also be present. Abundant quartz float in overburden.

ORE CONTROLS: Gold-quartz veins are found within zones of intense and pervasive carbonate alteration along second order or later faults marginal to transcrustal breaks. They are commonly closely associated with, late syncollisional, structurally controlled intermediate to felsic magmatism. Gold veins are more commonly economic where hosted by relatively large, competent units, such as intrusions or blocks of obducted oceanic crust. Veins are usually at a high angle to the primary collisional fault zone.

- Phanerozoic: Secondary structures at a high angle to relatively flat-lying to moderately dipping collisional suture zones.
- Archean:. Steep, transcrustal breaks; best deposits overall are in areas of greenstone.

ASSOCIATED DEPOSIT TYPES: Gold placers (C01, C02), sulphide manto Au (J04), silica veins (I07); iron formation Au (I04) in the Archean.

Au-QUARTZ VEINS

GENETIC MODEL: Gold quartz veins form in lithologically heterogeneous, deep transcrustal fault zones that develop in response to terrane collision. These faults act as conduits for CO_2-H_2O-rich (5-30 mol% CO_2), low salinity (<3 wt% NaCl) aqueous fluids, with high Au, Ag, As, (±Sb, Te, W, Mo) and low Cu, Pb, Zn metal contents. These fluids are believed to be tectonically or seismically driven by a cycle of pressure build-up that is released by failure and pressure reduction followed by sealing and repetition of the process (Sibson *et al.*, 1988). Gold is deposited at crustal levels within and near the brittle-ductile transition zone with deposition caused by sulphidation (the loss of H_2S due to pyrite deposition) primarily as a result of fluid-wallrock reactions, other significant factors may involve phase separation and fluid pressure reduction.

The origin of the mineralizing fluids remains controversial, with metamorphic, magmatic and mantle sources being suggested as possible candidates. Within an environment of tectonic crustal thickening in response to terrane collision, metamorphic devolitization or partial melting (anatexis) of either the lower crust or subducted slab may generate such fluids.

COMMENTS: These deposits may be a difficult deposit to evaluate due to "nugget effect", hence the adage, "Drill for structure, drift for grade". These veins have also been mined in British Columbia as a source of silica for smelter flux.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values of Au, Ag, As, Sb, K, Li, Bi, W, Te and B ± (Cd, Cu, Pb, Zn and Hg) in rock and soil, Au in stream sediments.

GEOPHYSICAL SIGNATURE: Faults indicated by linear magnetic anomalies. Areas of alteration indicated by negative magnetic anomalies due to destruction of magnetite as a result of carbonate alteration.

OTHER EXPLORATION GUIDES: Placer gold or elevated gold in stream sediment samples is an excellent regional and property-scale guide to gold-quartz veins. Investigate broad 'deformation envelopes' adjacent to regional listric faults where associated with carbonate alteration. Alteration and structural analysis can be used to delineate prospective ground. Within carbonate alteration zones, gold is typically only in areas containing quartz, with or without sulphides. Serpentinite bodies, if present, can be used to delineate favourable regional structures. Largest concentrations of free gold are commonly at, or near, the intersection of quartz veins with serpentinized and carbonate-altered ultramafic rocks.

ECONÔMIC FACTORS

TYPICAL GRADE AND TONNAGE: Individual deposits average 30 000 t with grades of 16 g/t Au and 2.5 g/t Ag (Berger, 1986) and may be as large as 40 Mt. Many major producers in the Canadian Shield range from 1 to 6 Mt at grades of 7 g/t Au (Thorpe and Franklin, 1984). The largest gold-quartz vein deposit in British Columbia is the Bralorne-Pioneer which produced in excess of 117 800 kilograms of Au from ore with an average grade of 9.3 g/t.

ECONOMIC LIMITATIONS: These veins are usually less than 2m wide and therefore, only amenable to underground mining.

IMPORTANCE: These deposits are a major source of the world's gold production and account for approximately a quarter of Canada's output. They are the most prolific gold source after the ores of the Witwatersrand basin.

Au-QUARTZ VEINS 101

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POLYMETALLIC VEINS Ag-Pb-Zn±Au

105

by David V. Lefebure and B. Neil Church

IDENTIFICATION

SYNONYMS: Clastic metasediment-hosted silver-lead-zinc veins, silver/base metal epithermal deposits.

COMMODITIES (BYPRODUCTS): Ag, Pb, Zn (Cu, Au, Mn).

EXAMPLES (British Columbia (MINFILE # - *Canada/International*):

- Metasediment host: Silvana (082FNW050) and Lucky Jim (082KSW023), Slocan-New Denver-Ainsworth district, St. Eugene (082GSW025), Silver Cup (082KNW027), Trout Lake camp; *Hector-Calumet and Elsa,* Mayo *district (Yukon, Canada), Coeur d'Alene district (Idaho, USA), Harz Mountains and Freiberg district (Germany), Príbram district (Czechoslavakia).*
- Igneous host: Wellington (082ESE072) and Highland Lass - Bell (082ESW030, 133), Beaverdell camp; Silver Queen (093L002), Duthie (093L088), Cronin (093L127), Porter-Idaho (103P089), Indian (104B031); *Sunnyside and Idorado, Silverton district and Creede (Colorado, USA), Pachuca (Mexico).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Sulphide-rich veins containing sphalerite, galena, silver and sulphosalt minerals in a carbonate and quartz gangue. These veins can be subdivided into those hosted by metasediments and another group hosted by volcanic or intrusive rocks. The latter type of mineralization is typically contemporaneous with emplacement of a nearby intrusion.

TECTONIC SETTINGS: These veins occur in virtually all tectonic settings except oceanic, including continental margins, island arcs, continental volcanics and cratonic sequences.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING:

- Metasediment host: Veins are emplaced along faults and fractures in sedimentary basins dominated by clastic rocks that have been deformed, metamorphosed and intruded by igneous rocks. Veins postdate deformation and metamorphism.
- Igneous host: Veins typically occur in country rock marginal to an intrusive stock. Typically veins crosscut volcanic sequences and follow volcano-tectonic structures, such as caldera ring-faults or radial faults. In some cases the veins cut older intrusions.

AGE OF MINERALIZATION: Proterozic or younger; mainly Cretaceous to Tertiary in British Columbia.

HOST/ASSOCIATED ROCK TYPES: These veins can occur in virtually any host. Most commonly the veins are hosted by thick sequences of clastic metasediments or by intermediate to felsic volcanic rocks. In many districts there are felsic to intermediate intrusive bodies and mafic igneous rocks are less common. Many veins are associated with dikes following the same structures.

DEPOSIT FORM: Typically steeply dipping, narrow, tabular or splayed veins. Commonly occur as sets of parallel and offset veins. Individual veins vary from centimetres up to more than 3 m wide and can be followed from a few hundred to more than 1000 m in length and depth. Veins may widen to tens of metres in stockwork zones.

POLYMETALLIC VEINS Ag-Pb-Zn±Au — I05

TEXTURE/STRUCTURE: Compound veins with a complex paragenetic sequence are common. A wide variety of textures, including cockade texture, colloform banding and crustifications and locally druzy. Veins may grade into broad zones of stockwork or breccia. Coarse-grained sulphides as patches and pods, and fine-grained disseminations are confined to veins.

ORE MINERALOGY [Principal and *subordinate*]: Galena, sphalerite, tetrahedrite-tennantite, *other sulphosalts including pyrargyrite, stephanite, bournonite and acanthite, native silver, chalcopyrite, pyrite, arsenopyrite, stibnite*. Silver minerals often occur as inclusions in galena. *Native gold and electrum in some deposits.* Rhythmic compostional banding sometimes present in sphalerite. Some veins contain more chalcopyrite and gold at depth and Au grades are normally low for the amount of sulphides present.

GANGUE MINERALOGY [Principal and *subordinate*]:

- Metasediment host: Carbonates (most commonly siderite with minor dolomite, ankerite and calcite), quartz, *barite, fluorite, magnetite, bitumen*.
- Igneous host: Quartz, carbonate (rhodochrosite, siderite, calcite, dolomite), *sometimes specular hematite, hematite, barite, fluorite*. Carbonate species may correlate with distance from source of hydrothermal fluids with proximal calcium and magnesium-rich carbonates and distal iron and manganese-rich species.

ALTERATION MINERALOGY: Macroscopic wall rock alteration is typically limited in extent (measured in metres or less). The metasediments typically display sericitization, silicification and pyritization. Thin veining of siderite or ankerite may be locally developed adjacent to veins. In the Coeur d'Alene camp a broader zone of bleached sediments is common. In volcanic and intrusive hostrocks the alteration is argillic, sericitic or chloritic and may be quite extensive.

WEATHERING: Black manganese oxide stains, sometimes with whitish melanterite, are common weathering products of some veins. The supergene weathering zone associated with these veins has produced major quantities of manganese. Galena and sphalerite weather to secondary Pb and Zn carbonates and Pb sulphate. In some deposits supergene enrichment has produced native and horn silver.

ORE CONTROLS: Regional faults, fault sets and fractures are an important ore control; however, veins are typically associated with second order structures. In igneous rocks the faults may relate to volcanic centers. Significant deposits restricted to competent lithologies. Dikes are often emplaced along the same faults and in some camps are believed to be roughly contemporaneous with mineralization. Some polymetallic veins are found surrounding intrusions with porphyry deposits or prospects.

GENETIC MODELS: Historically these veins have been considered to result from differentiation of magma with the development of a volatile fluid phase that escaped along faults to form the veins. More recently researchers have preferred to invoke mixing of cooler, upper crustal hydrothermal or meteoric waters with rising fluids that could be metamorphic, groundwater heated by an intrusion or expelled directly from a differentiating magma. Any development of genetic models is complicated by the presence of other types of veins in many districts. For example, the Freiberg district has veins carrying F-Ba, Ni-As-Co-Bi-Ag and U.

COMMENTS: Ag-tetrahedrite veins, such as the Sunshine and Galena mines in Idaho, contain very little sphalerite or galena. These may belong to this class of deposits or possibly the five-element veins. The styles of alteration, mineralogy, grades and different geometries can usually be used to distinguish the polymetallic veins from stringer zones found below syngenetic massive sulphide deposits.

ASSOCIATED DEPOSIT TYPES:

- Metasediment host: Polymetallic mantos (M01).
- Igneous host: May occur peripheral to virtually all types of porphyry mineralization (L01, L03, L04, L05, L06, L07, L08) and some skarns (K02, K03).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values of Zn, Pb, Ag, Mn, Cu, Ba and As. Veins may be within arsenic, copper, silver, mercury aureoles caused by the primary dispersion of elements into wallrocks or broader alteration zones associated with porphyry deposit or prospects.

GEOPHYSICAL SIGNATURE: May have elongate zones of low magnetic response and/or electromagnetic, self potential or induced polarization anomalies related to ore zones.

OTHER EXPLORATION GUIDES: Strong structural control on veins and common occurrence of deposits in clusters can be used to locate new veins.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE : Individual vein systems range from several hundred to several million tonnes grading from 5 to 1500 g/t Ag, 0.5 to 20% Pb and 0.5 to 8% Zn. Average grades are strongly influenced by the minimum size of deposit included in the population. For B.C. deposits larger than 20 000 t the average size is 161 000 t with grades of 304 g/t Ag, 3.47 % Pb and 2.66 % Zn. Copper and gold are reported in less than half the occurrences, with average grades of 0.09 % Cu and 4 g/t Au.

ECONOMIC LIMITATIONS: These veins usually support small to medium-size underground mines. The mineralization may contain arsenic which typically reduces smelting credits.

IMPORTANCE: The most common deposit type in British Columbia with over 2 000 occurrences; these veins were a significant source of Ag, Pb and Zn until the 1960s. They have declined in importance as industry focused more on syngenetic massive sulphide deposits. Larger polymetallic vein deposits are still attractive because of their high grades and relatively easy benefication. They are potential sources of cadmium and germanium.

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POLYMETALLIC VEINS Ag-Pb-Zn±Au   I05

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Cu±Ag QUARTZ VEINS

I06

by David V. Lefebure

IDENTIFICATION

SYNONYMS: Churchill-type vein copper, vein copper

COMMODITY (*BYPRODUCTS*): Cu (Ag, rarely Au).

EXAMPLES (British Columbia (MINFILE #) - *Canada/International*): Davis-Keays (094K012, 050), Churchill Copper (Magnum, 094K003), Bull River (082GNW002), Copper Road (092K060), Copper Star (092HNE036), Copper Standard (092HNE079), Rainbow (093L044); *Bruce Mines and Crownbridge (Ontario, Canada), Blue Wing and Seaboard (North Carolina, USA), Matahambre (Cuba), Inyati (Zimbabwe), Copper Hills (Western Australia), Tocopilla area (Chile), Burgas district (Bulgaria), Butte (Montana, USA), Rosario (Chile).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Quartz-carbonate veins containing patches and disseminations of chalcopyrite with bornite, tetrahedrite, covellite and pyrite. These veins typically crosscut clastic sedimentary or volcanic sequences, however, there are also Cu quartz veins related to porphyry Cu systems and associated with felsic to intermediate intrusions.

TECTONIC SETTINGS: A diversity of tectonic settings reflecting the wide variety of hostrocks including extensional sedimentary basins (often Proterozoic) and volcanic sequences associated with rifting or subduction-related continental and island arc settings.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins emplaced along faults; they commonly postdate major deformation and metamorphism. The veins related to felsic intrusions form adjacent to, and are contemporaneous with, mesozonal stocks.

AGE OF MINERALIZATION: Any age; can be much younger than hostrocks.

HOST/ASSOCIATED ROCK TYPES: Cu±Ag quartz veins occur in virtually any rocks although the most common hosts are clastic metasediments and mafic volcanic sequences. Mafic dikes and sills are often spatially associated with metasediment-hosted veins. These veins are also found within and adjacent to felsic to intermediate intrusions.

DEPOSIT FORM: The deposits form simple to complicated veins and vein sets which typically follow high-angle faults which may be associated with major fold sets. Single veins vary in thickness from centimetres up to tens of metres. Major vein systems extend hundreds of metres along strike and down dip. In some exceptional cases the veins extend more than a kilometre along the maximum dimension.

TEXTURE/STRUCTURE: Sulphides are irregularly distributed as patches and disseminations. Vein breccias and stockworks are associated with some deposits.

ORE MINERALOGY (Principal and *subordinate*):

- Metasediment and volcanic-hosted: Chalcopyrite, pyrite, chalcocite; *bornite, tetrahedrite, argentite, pyrrhotite, covellite, galena.*
- Intrusion-related: Chalcopyrite, bornite, chalcocite, pyrite, pyrrhotite; *enargite, tetrahedrite-tennantite, bismuthinite, molybdenite, sphalerite, native gold and electrum.*

GANGUE MINERALOGY (Principal and *subordinate*): Quartz and carbonate (calcite, dolomite, ankerite or siderite); *hematite, specularite, barite.*

Cu±Ag QUARTZ VEINS **I06**

ALTERATION MINERALOGY: Wallrocks are typically altered for distances of centimetres to tens of metres outwards from the veins.

- Metasediment and volcanic-hosted: The metasediments display carbonatization and silicification. At the Churchill and Davis-Keays deposits, decalcification of limy rocks and zones of disseminated pyrite in roughly stratabound zones are reported. The volcanic hostrocks exhibit abundant epidote with associated calcite and chlorite.
- Intrusion-related: Sericitization, in places with clay alteration and chloritization.

WEATHERING: Malachite or azurite staining; silicified linear "ridges".

ORE CONTROLS: Veins and associated dikes follow faults. Ore shoots commonly localized along dilational bends within veins. Sulphides may occur preferentially in parts of veins which crosscut carbonate or other favourable lithologies. Intersections of veins are an important locus for ore.

GENETIC MODEL: The metasediment and volcanic-hosted veins are associated with major faults related to crustal extension which control the ascent of hydrothermal fluids to suitable sites for deposition of metals. The fluids are believed to be derived from mafic intrusions which are also the source for compositionally similar dikes and sills associated with the veins. Intrusion-related veins, like Butte in Montana and Rosario in Chile, are clearly associated with high-level felsic to intermediate intrusions hosting porphyry Cu deposits or prospects.

ASSOCIATED DEPOSIT TYPES:

- Metasediment and volcanic-hosted: Possibly related to sediment-hosted Cu (E04) and basaltic Cu (D03).
- Intrusion-related: High sulphidation (H04), copper skarns (K01), porphyries (L01?, L03, L04) and polymetallic veins (I05).

COMMENTS: Cu±Ag quartz veins are common in copper metallogenetic provinces; they often are more important as indicators of the presence of other types of copper deposits.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: High Cu and Ag in regional silt samples. The Churchill-type deposits appear to have very limited wallrock dispersion of pathfinder elements; however, alteration halos of silica and carbonate addition or depletion might prove useful. Porpyhyry-related veins exhibit many of the geochemical signatures of porphyry copper systems.

GEOPHYSICAL SIGNATURE: Large veins with conductive massive sulphides may show up as electromagnetic conductors, particularly on ground surveys. Associated structures may be defined by ground magnetic, very low frequency or electromagnetic surveys. Airborne surveys may identify prospective major structures.

OTHER EXPLORATION GUIDES: Commonly camp-scale or regional structural controls define a dominant orientation for veins.

ECONOMIC FACTORS

GRADE AND TONNAGE: Typically range from 10 000 to 100 0000 t with grades of 1 to 4% Cu, nil to 300 g/t Ag. The Churchill deposit has reserves of 90 000 t of 3 % Cu and produced 501 019 t grading 3% Cu and the Davis-Keays deposit has reserves of 1 119 089 t grading 3.43 % Cu. The Big Bull deposit has reserves of 732 000 t grading 1.94% Cu. The intrusion-related veins range up to millions of tonnes with grades of up to 6% Cu. The Butte veins in Montana have produced several hundred million tonnes of ore with much of this production from open-pit operations.

ECONOMIC LIMITATIONS: Currently only the large and/or high-grade veins (usually associated with porphyry deposits) are economically attractive.

Cu±Ag QUARTZ VEINS 106

IMPORTANCE: From pre-historic times until the early 1900s, high-grade copper veins were an important source of this metal. With hand sorting and labour-intensive mining they represented very attractive deposits.

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ACKNOWLEDGEMENTS: This deposit profile represents the results of a literature review. It benefited from comments by David Sinclair and Vic Preto.

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EPITHERMAL Au-Ag-Cu: HIGH SULPHIDATION H04

by Andre Panteleyev

IDENTIFICATION

SYNONYMS: (Epithermal) acid-sulphate, quartz-alunite Au, alunite-kaolinite ● pyrophyllite, advanced argillic, Nansatsu-type, enargite gold. The deposits are commonly referred to as *acid-sulphate* type after the chemistry of the hydrothermal fluids, *quartz-alunite* or *kaolinite-alunite* type after their alteration mineralogy, or *high-sulphidation* type in reference to the oxidation state of the acid fluids responsible for alteration and mineralization.

COMMODITIES (*BYPRODUCTS*): Au, Ag, Cu (*As, Sb*).

EXAMPLES (British Columbia (MINFILE #) - *International*): Mt. McIntosh/Hushamu (EXPO, 92L240), Taseko River deposits - Westpine (Empress) (92O033), Taylor-Windfall (92O028) and Battlement Creek (92O005); *Goldfield and Paradise Peak (Nevada, USA), Summitville (Colorado, USA); Nansatsu (Japan), El Indio (Chile); Temora (New South Wales, Australia), Pueblo Viejo (Dominica), Chinkuashih (Taiwan), Rodalquilar (Spain), Lepanto and Nalesbitan (Philippines).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Veins, vuggy breccias and sulphide replacements ranging from pods to massive lenses occur in volcanic sequences associated with high level hydrothermal systems marked by acid-leached, advanced argillic, siliceous alteration.

TECTONIC SETTING: Extensional and transtensional settings, commonly in volcano-plutonic continent-margin and oceanic arcs and back-arcs. In zones with high-level magmatic emplacements where stratovolcanoes and other volcanic edifices are constructed above plutons.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Subvolcanic to volcanic in calderas, flow-dome complexes, rarely maars and other volcanic structures; often associated with subvolcanic stocks and dikes, breccias. Postulated to overlie, and be genetically related to, porphyry copper systems in deeper mineralized intrusions that undelie the stratovolcanoes.

AGE OF MINERALIZATION: Tertiary to Quaternary; less commonly Mesozoic and rarely Paleozoic volcanic belts. The rare preservation of older deposits reflects rapid rates of erosion before burial of subaerial volcanoes in tectonically active arcs.

HOST/ASSOCIATED ROCK TYPES: Volcanic pyroclastic and flow rocks, commonly subaerial andesite to dacite and rhyodacite, and their subvolcanic intrusive equivalents. Permeable sedimentary intervolcanic units can be sites of mineralization.

DEPOSIT FORM: Veins and massive sulphide replacement pods and lenses, stockworks and breccias. Commonly irregular deposit shapes are determined by hostrock permeability and the geometry of ore-controlling structures. Multiple, crosscutting composite veins are common.

TEXTURE/STRUCTURE: Vuggy 'slaggy' silica derived as a residual product of acid leaching is characteristic. Drusy cavities, banded veins, hydrothermal breccias, massive wallrock replacements with fine-grained quartz.

ORE MINERALOGY (Principal and *subordinate*): pyrite, enargite/luzonite, chalcocite, covellite, bornite, gold, electrum; *chalcopyrite, sphalerite, tetrahedrite/tennantite, galena, marcasite, arsenopyrite, silver sulphosalts, tellurides including goldfieldite*. Two types of ore are commonly present: massive enargite-pyrite and/or quartz-alunite-gold.

GANGUE MINERALOGY (Principal and *subordinate*): Pyrite and quartz predominate. Barite may also occur; carbonate minerals are absent.

EPITHERMAL Au-Ag-Cu: HIGH SULPHIDATION H04

ALTERATION MINERALOGY (Principal and *subordinate*): Quartz, kaolinite/dickite, alunite, barite, hematite; sericite/illite, amorphous clays and silica, pyrophyllite, andalusite, diaspore, corundum, tourmaline, *dumortierite, topaz, zunyite, jarosite, Al-P sulphates (hinsdalite, woodhouseite, crandalite, etc.*) and native sulphur. Advanced argillic alteration is characteristic and can be areally extensive and visually prominent. Quartz occurs as fine-grained replacements and, characteristically, as vuggy, residual silica in acid-leached rocks.

WEATHERING: Weathered rocks may contain abundant limonite (jarosite-goethite-hematite), generally in a groundmass of kaolinite and quartz. Fine-grained supergene alunite veins and nodules are common.

ORE CONTROLS: In volcanic edifices - caldera ring and radial fractures; fracture sets in resurgent domes and flow-dome complexes, hydrothermal breccia pipes and diatremes. Faults and breccias in and around intrusive centres. Permeable lithologies, in some cases with less permeable cappings of hydrothermally altered or other cap rocks. The deposits occur over considerable depths, ranging from high-temperature solfataras at paleosurface down into cupolas of intrusive bodies at depth.

GENETIC MODEL: Recent research, mainly in the southwest Pacific and Andes, has shown that these deposits form in subaerial volcanic complexes or composite island arc volcanoes above degassing magma chambers. The deposits can commonly be genetically related to high-level intrusions. Multiple stages of mineralization are common, presumably related to periodic tectonism with associated intrusive activity and magmatic hydrothermal fluid generation.

ASSOCIATED DEPOSIT TYPES: Porphyry Cu±Mo±Au deposits (L04), subvolcanic Cu-Ag-Au (As-Sb) (L01), epithermal Au-Ag deposits: low sulphidation type (H05), silica-clay-pyrophyllite deposits (Roseki deposits) (H09), hotspring Au-Ag (H03), placer Au deposits (C01,C02).

COMMENTS: High-sulphidation epithermal Au-Ag deposits are much less common in the Canadian Cordillera than low-sulphidation epithermal veins. However, they are the dominant type of epithermal deposit in the Andes.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Au, Cu, As dominate; also Ag, Zn, Pb, Sb, Mo, Bi, Sn, Te, W, B and Hg.

GEOPHYSICAL SIGNATURE: Magnetic lows in hydrothermally altered (acid-leached) rocks; gravity contrasts may mark boundaries of structural blocks.

OTHER EXPLORATION GUIDES: These deposits are found in second order structures adjacent to crustal-scale fault zones, both normal and strike-slip, as well as local structures associated with subvolcanic intrusions. The deposits tend to overlie and flank porphyry copper-gold deposits and underlie acid-leached siliceous, clay and alunite-bearing 'lithocaps'.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: There is wide variation in deposit types ranging from bulk-mineable, low-grade to selectively mined, high-grade deposits. Underground mines range in size from 2 to 25 Mt with grades from 178 g/t Au, 109 g/t Ag and 3.87% Cu in direct smelting ores (El Indio) to 2.8 g/t Au and 11.3 g/t Ag and 1.8% Cu (Lepanto). Open pit mines with reserves of <100 Mt to >200 Mt range from Au-Ag mines with 3.8 g/t Au and 20 g/t Ag (Pueblo Viejo, Dominica) to orebodies such as the Nansatsu deposits, Japan that contain a few million tonnes ore grading between 3 and 6 g/t Au. Porphyry Au (Cu) deposits can be overprinted with late-stage acid sulphate alteration zones which can contain in the order of ~1.5 g/t Au with 0.05 to 0.1% Cu in stockworks (Marte and Lobo) or high-grade Cu-Ag-Au veins (La Grande veins, Collahausi). More typically these late stage alteration zones carry <0.4 to 0.9 g/t Au and >0.4 to 2% Cu (Butte, Montana; Dizon, Philippines).

EPITHERMAL Au-Ag-Cu: HIGH SULPHIDATION H04

ECONOMIC LIMITATIONS: Oxidation of primary ores is commonly neccessary for desireable metallurgy; primary ores may be refractory and can render low-grade mineralization noneconomic.

IMPORTANCE: This class of deposits has recently become a focus for exploration throughout the circum-Pacific region because of the very attractive Au and Cu grades in some deposits. Silica-rich gold ores (3-4 g/t Au) from the Nansatsu deposits in Japan are used as flux in copper smelters.

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EPITHERMAL Au-Ag: LOW SULPHIDATION H05

by Andre Panteleyev

IDENTIFICATION

SYNONYMS: (Epithermal) adularia-sericite; quartz-adularia, Comstock, Sado-type; bonanza Au-Ag; alkali chloride (hydrothermal).

COMMODITIES (*BYPRODUCTS*): Au, Ag (*Pb, Zn, Cu*).

EXAMPLES (British Columbia (MINFILE #) - *International*): Toodoggone district deposits - Lawyers (94E066), Baker (94E026), Shas (94E050); Blackdome (92O050-053); Premier Gold (Silbak Premier), (104B054); Cinola (103F034); *Comstock, Aurora (Nevada, USA), Bodie (California, USA), Creede (Colorado, USA), Republic (Washington, USA), El Bronce (Chile), Guanajuato (Mexico), Sado, Hishikari (Japan), Colqui (Peru), Baguio (Philippines) Ladolam (Lihir, Papua-New Guinea).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Quartz veins, stockworks and breccias carrying gold, silver, electrum, argentite and pyrite with lesser and variable amounts of sphalerite, chalcopyrite, galena, rare tetrahedrite and sulphosalt minerals form in high-level (epizonal) to near-surface environments. The ore commonly exhibits open-space filling textures and is associated with volcanic-related hydrothermal to geothermal systems.

TECTONIC SETTING: Volcanic island and continent-margin magmatic arcs and continental volcanic fields with extensional structures.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level hydrothermal systems from depths of ~1 km to surficial hotspring settings. Regional-scale fracture systems related to grabens, (resurgent) calderas, flow-dome complexes and rarely, maar diatremes. Extensional structures in volcanic fields (normal faults, fault splays, ladder veins and cymoid loops, etc.) are common; locally graben or caldera-fill clastic rocks are present. High-level (subvolcanic) stocks and/or dikes and pebble breccia diatremes occur in some areas. Locally resurgent or domal structures are related to underlying intrusive bodies.

AGE OF MINERALIZATION: Any age. Tertiary deposits are most abundant; in B.C. Jurassic deposits are important. Deposits of Paleozoic age are described in Australia. Closely related to the host volcanic rocks but invariably slightly younger in age (0.5 to 1 Ma, more or less).

HOST/ASSOCIATED ROCK TYPES: Most types of volcanic rocks; calcalkaline andesitic compositions predominate. Some deposits occur in areas with bimodal volcanism and extensive subaerial ashflow deposits. A less common association is with alkalic intrusive rocks and shoshonitic volcanics. Clastic and epiclastic sediments in intra-volcanic basins and structural depressions.

DEPOSIT FORM: Ore zones are typically localized in structures, but may occur in permeable lithologies. Upward-flaring ore zones centred on structurally controlled hydrothermal conduits are typical. Large (> 1 m wide and hundreds of metres in strike length) to small veins and stockworks are common with lesser disseminations and replacements. Vein systems can be laterally extensive but ore shoots have relatively restricted vertical extent. High-grade ores are commonly found in dilational zones in faults at flexures, splays and in cymoid loops.

TEXTURE/STRUCTURE: Open-space filling, symmetrical and other layering, crustification, comb structure, colloform banding and multiple brecciation.

EPITHERMAL Au-Ag: LOW SULPHIDATION H05

ORE MINERALOGY (Principal and *subordinate*): Pyrite, electrum, gold, silver, argentite; *chalcopyrite, sphalerite, galena, tetrahedrite, silver sulphosalt and/or selenide minerals.* Deposits can be strongly zoned along strike and vertically. Deposits are commonly zoned vertically over 250 to 350 m from a base metal poor, Au-Ag-rich top to a relatively Ag-rich base metal zone and an underlying base metal rich zone grading at depth into a sparse base metal, pyritic zone. From surface to depth, metal zones contain: Au-Ag-As-Sb-Hg, Au-Ag-Pb-Zn-Cu, Ag-Pb-Zn. In alkalic hostrocks tellurides, V mica (roscoelite) and fluorite may be abundant, with lesser *molybdenite.*

GANGUE MINERALOGY (Principal and *subordinate*): Quartz, amethyst, chalcedony, quartz pseudomorphs after calcite, calcite; *adularia, sericite, barite, fluorite, Ca-Mg-Mn-Fe carbonate minerals such as rhodochrosite, hematite and chlorite.*

ALTERATION MINERALOGY: Silicification is extensive in ores as multiple generations of quartz and chalcedony are commonly accompanied by adularia and calcite. Pervasive silicification in vein envelopes is flanked by sericite-illite-kaolinite assemblages. Intermediate argillic alteration [kaolinite-illite-montmorillonite (smectite)] formed adjacent to some veins; advanced argillic alteration (kaolinite-alunite) may form along the tops of mineralized zones. Propylitic alteration dominates at depth and peripherally,.

WEATHERING: Weathered outcrops are often characterized by resistant quartz ± alunite 'ledges' and extensive flanking bleached, clay-altered zones with supergene alunite, jarosite and other limonite minerals.

ORE CONTROLS: In some districts the epithermal mineralization is tied to a specific metallogenetic event, either structural, magmatic, or both. The veins are emplaced within a restricted stratigraphic interval generally within 1 km of the paleosurface. Mineralization near surface takes place in hotspring systems, or the deeper underlying hydrothermal conduits. At greater depth it can be postulated to occur above, or peripheral to, porphyry and possibly skarn mineralization. Normal faults, margins of grabens, coarse clastic caldera moat-fill units, radial and ring dike fracture sets and both hydrothermal and tectonic breccias are all ore fluid channeling structures. Through-going, branching, bifurcating, anastamosing and intersecting fracture systems are commonly mineralized. Ore shoots form where dilational openings and cymoid loops develop, typically where the strike or dip of veins change. Hangingwall fractures in mineralized structures are particularly favourable for high-grade ore.

GENETIC MODEL: These deposits form in both subaerial, predominantly felsic, volcanic fields in extensional and strike-slip structural regimes and island arc or continental andesitic stratovolcanoes above active subduction zones. Near-surface hydrothermal systems, ranging from hotspring at surface to deeper, structurally and permeability focused fluid flow zones are the sites of mineralization. The ore fluids are relatively dilute and cool solutions that are mixtures of magmatic and meteoric fluids. Mineral deposition takes place as the solutions undergo cooling and degassing by fluid mixing, boiling and decompression.

ASSOCIATED DEPOSIT TYPES: Epithermal Au-Ag: high sulphidation (H04); hotspring Au-Ag (H03); porphyry Cu±Mo±Au (L04) and related polymetallic veins (I05); placer gold (C01, C02).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values in rocks of Au, Ag, Zn, Pb, Cu and As, Sb, Ba, F, Mn; locally Te, Se and Hg.

GEOPHYSICAL SIGNATURE: VLF has been used to trace structures; radiometric surveys may outline strong potassic alteration of wallrocks. Detailed gravity surveys may delineate boundaries of structural blocks with large density contrasts.

OTHER EXPLORATION GUIDES: Silver deposits generally have higher base metal contents than Au and Au-Ag deposits. Drilling feeder zones to hotsprings and siliceous sinters may lead to identification of buried deposits. Prospecting for mineralized siliceous and silica-carbonate float or vein material with diagnostic open-space textures is effective.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The following data describe the median deposits based on worldwide mines and U.S.A. models:

- Au-Ag deposits (41 Comstock-type 'bonanza' deposits) - 0.77 Mt with 7.5 g/t Au, 110 g/t Ag and minor Cu, Zn and Pb. The highest base metal contents in the top decile of deposits all contain <0.1% Cu, Zn and 0.1% Pb
- Au-Cu deposits (20 Sado-type deposits) - 0.3 Mt with 1.3% g/t Au, 38 g/t Ag and >0.3% Cu; 10 % of the deposits contain, on average, about 0.75% Cu with one having >3.2% Cu.

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Cu SKARNS

K01

by Gerald E. Ray

IDENTIFICATION

SYNONYMS: Pyrometasomatic and contact metasomatic copper deposits.

COMMODITIES (*BYPRODUCTS*): Cu (*Au, Ag, Mo, W, magnetite*)

EXAMPLES (British Columbia - *Canada/International*): Craigmont (092ISE 035), Phoenix (082ESE 020), Old Sport (092L 035), Queen Victoria (082FSW 082); *Mines Gaspé deposits (Québec, Canada), Ruth, Mason Valley and Copper Canyon (Nevada, USA), Carr Fork (Utah, USA), Ok Tedi (Papua New Guinea), Rosita (Nicaragua).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Cu-dominant mineralization (generally chalcopyrite) genetically associated with a skarn gangue (includes calcic and magnesian Cu skarns).

TECTONIC SETTING: They are most common where Andean-type plutons intrude older continental-margin carbonate sequences. To a lesser extent (but important in British Columbia), they are associated with oceanic island arc plutonism.

AGE OF MINERALIZATION: Mainly Mesozoic, but may be any age. In British Columbia they are mostly Early to mid-Jurassic.

HOST/ASSOCIATED ROCK TYPES: Porphyritic stocks, dikes and breccia pipes of quartz diorite, granodiorite, monzogranite and tonalite composition, intruding carbonate rocks, calcareous volcanics or tuffs. Cu skarns in oceanic island arcs tend to be associated with more mafic intrusions (quartz diorite to granodiorite), while those formed in continental margin environments are associated with more felsic material.

DEPOSIT FORM: Highly varied; includes stratiform and tabular orebodies, vertical pipes, narrow lenses, and irregular ore zones that are controlled by intrusive contacts.

TEXTURES: Igneous textures in endoskarn. Coarse to fine-grained, massive granoblastic to mineralogically layered textures in exoskarn. Some hornfelsic textures.

ORE MINERALOGY (Principal and *subordinate*): Moderate to high sulphide content. Chalcopyrite ± pyrite ± magnetite in inner garnet-pyroxene zone. Bornite ± chalcopyrite ± sphalerite ± tennantite in outer wollastonite zone. Either hematite, pyrrhotite or magnetite may predominate (depending on oxidation state). Scheelite and traces of *molybdenite, bismuthinite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite and tetrahedrite* may be present.

ALTERATION MINERALOGY: Exoskarn alteration: high garnet:pyroxene ratios. High Fe, low Al, Mn andradite garnet (Ad35-100), and diopsidic clinopyroxene (Hd2-50). The mineral zoning from stock out to marble is commonly: diopside + andradite (proximal); wollastonite ± tremolite ± garnet ± diopside ± vesuvianite (distal). Retrograde alteration to actinolite, chlorite and montmorillonite is common. In British Columbia, skarn alteration associated with some of the alkalic porphyry Cu-Au deposits contains late scapolite veining. Magnesian Cu skarns also contain olivine, serpentine, monticellite and brucite.
Endoskarn alteration: Potassic alteration with K-feldspar, epidote, sericite ± pyroxene ± garnet. Retrograde phyllic alteration generates actinolite, chlorite and clay minerals.

ORE CONTROLS: Irregular or tabular orebodies tend to form in carbonate rocks and/or calcareous volcanics or tuffs near igneous contacts. Pendants within igneous stocks can be important. Cu mineralization is present as stockwork veining and disseminations in both endo and exoskarn; it commonly accompanies retrograde alteration.

Cu SKARNS K01

COMMENTS: Calcic Cu skarns are more economically important than magnesian Cu skarns. Cu skarns are broadly separable into those associated with strongly altered Cu-porphyry systems, and those associated with barren, generally unaltered stocks; a continuum probably exists between these two types (Einaudi *et al.*, 1981). Copper skarn deposits related to mineralized Cu porphyry intrusions tend to be larger, lower grade, and emplaced at higher structural levels than those associated with barren stocks. Most Cu skarns contain oxidized mineral assemblages, and mineral zoning is common in the skarn envelope. Those with reduced assemblages can be enriched in W, Mo, Bi, Zn, As and Au. Over half of the 340 Cu skarn occurrences in British Columbia lie in the Wrangellia Terrane of the Insular Belt, while another third are associated with intraoceanic island arc plutonism in the Quesnellia and Stikinia terranes. Some alkalic and calcalkalic Cu and Cu-Mo porphyry systems in the province (e.g. Copper Mountain, Mount Polley) are associated with variable amounts of Cu-bearing skarn alteration.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Rock analyses may show Cu-Au-Ag-rich inner zones grading outward through Au-Ag zones with high Au:Ag ratios to an outer Pb-Zn-Ag zone. Co-As-Sb-Bi-Mo-W geochemical anomalies are present in the more reduced Cu skarn deposits.

GEOPHYSICAL SIGNATURE: Magnetic, electromagnetic and induced polarization anomalies.

ASSOCIATED DEPOSIT TYPES: Porphyry Cu deposits (L04), Au (K04), Fe (K03) and Pb-Zn (K02) skarns, and replacement Pb-Zn-Ag deposits (M01).

ECONOMIC FACTORS

GRADE AND TONNAGE: Average 1 to 2 % copper. Worldwide, they generally range from 1 to 100 Mt, although some exceptional deposits exceed 300 Mt. Craigmont, British Columbia's largest Cu skarn, contained approximately 34 Mt grading 1.3 % Cu.

IMPORTANCE: Historically, these deposits were a major source of copper, although porphyry deposits have become much more important during the last 30 years . However, major Cu skarns are still worked throughout the world, including in China and the U.S.

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PORPHYRY Mo (LOW-F-TYPE)[1] L05

by: W. David Sinclair[2]

IDENTIFICATION

SYNONYMS: Calcalkaline Mo stockwork; Granite-related Mo; Quartz-monzonite Mo.

COMMODITIES (*BYPRODUCTS*): Mo (*Cu, W*)

EXAMPLES (British Columbia - *Canada/International*): Endako (093K006), Boss Mountain (093A001), Kitsault (103P120), Adanac (104N052), Carmi (082ESW029), Bell Moly (103P234), Red Bird (093E026), Storie Moly (104P069), Trout Lake (082KNW087); *Red Mountain (Yukon, Canada), Quartz Hill (Alaska, USA), Cannivan (Montana, USA), Thompson Creek (Idaho, USA), Compaccha (Peru), East Kounrad (Russia), Jinduicheng (China).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stockwork of molybdenite-bearing quartz veinlets and fractures in intermediate to felsic intrusive rocks and associated country rocks. Deposits are low grade but large and amenable to bulk mining methods.

TECTONIC SETTING(S): Subduction zones related to arc-continent or continent-continent collision.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level to subvolcanic felsic intrusive centres; multiple stages of intrusion are common.

AGE OF MINERALIZATION: Archean (e.g. Setting Net Lake, Ontario) to Tertiary; Mesozoic and Tertiary examples are more common.

HOST/ASSOCIATED ROCK TYPES: All kinds of rocks may be hostrocks. Tuffs or other extrusive volcanic rocks may be associated with deposits related to subvolcanic intrusive rocks. Genetically related intrusive rocks range from granodiorite to granite and their fine-grained equivalents, with quartz monzonite most common: they are commonly porphyritic. The intrusive rocks are characterized by low F contents (generally <0.1 % F) compared to intrusive rocks associated with Climax-type porphyry Mo deposits.

DEPOSIT FORM: Deposits vary in shape from an inverted cup, to roughly cylindrical, to highly irregular. They are typically hundreds of metres across and range from tens to hundreds of metres in vertical extent.

TEXTURE/STRUCTURE: Ore is predominantly structurally controlled; mainly stockworks of crosscutting fractures and quartz veinlets, also veins, vein sets and breccias.

ORE MINERALOGY (Principal and *subordinate*): Molybdenite is the principal ore mineral; *chalcopyrite, scheelite, and galena are generally subordinate.*

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[1] Geological Survey of Canada contribution number 61494
[2] Geological Survey of Canada, Ottawa

PORPHYRY Mo (LOW-F-TYPE) L05

GANGUE MINERALOGY: Quartz, pyrite, K-feldspar, biotite, sericite, clays, calcite and anhydrite.

ALTERATION MINERALOGY: Alteration mineralogy is similar to that of porphyry Cu deposits. A core zone of potassic and silicic alteration is characterized by hydrothermal K-feldspar, biotite, quartz and, in some cases, anhydrite. K-feldspar and biotite commonly occur as alteration selvages on mineralized quartz veinlets and fractures but may be pervasive in areas of intense fracturing and mineralization. Phyllic alteration typically surrounds and may be superimposed to various degrees on the potassic-silicic core; it consists mainly of quartz, sericite and carbonate. Phyllic alteration is commonly pervasive and may be extensive. Propylitic alteration consisting mainly of chlorite and epidote may extend for hundreds of metres beyond the zones of potassic-silicic and phyllic alteration. Zones of argillic alteration, where present, are characterized by clay minerals such as kaolinite and are typically overprinted on the other types of alteration; distribution of argillic alteration is typically irregular.

WEATHERING: Oxidation of pyrite produces limonitic gossans; oxidation of molybdenite produces yellow ferrimolybdite.

ORE CONTROLS: Quartz veinlet and fracture stockwork zones superimposed on intermediate to felsic intrusive rocks and surrounding country rocks; multiple stages of mineralization commonly present.

GENETIC MODEL: Magmatic-hydrothermal. Large volumes of magmatic, highly saline aqueous fluids under pressure strip Mo and other ore metals from temporally and genetically related magma. Multiple stages of brecciation related to explosive fluid pressure release from the upper parts of small intrusions result in deposition of ore and gangue minerals in crosscutting fractures, veinlets and breccias in the outer carapace of the intrusions and in associated country rocks. Incursion of meteoric water during waning stages of the magmatic-hydrothermal system may result in late alteration of the hostrocks, but does not play a significant role in the ore-forming process.

ASSOCIATED DEPOSIT TYPES: Ag-Pb-Zn veins (I05), Mo-bearing skarns (K07) may be present.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Mo, Cu, W and F may be anomalously high in hostrocks close to and overlying mineralized zones; anomalously high levels of Pb, Zn and Ag occur in peripheral zones as much as several kilometres distant. Mo, W, F, Cu, Pb, Zn and Ag may be anomalously high in stream sediments. Mo, W and Pb may be present in heavy mineral concentrates.

GEOPHYSICAL SIGNATURE: Magnetic anomalies may reflect presence of pyrrhotite or magnetite in hornfels zones. Radiometric surveys may be used to outline anomalous K in altered and mineralized zones. Induced polarization and resistivity surveys may be used to outline high-pyrite alteration zones.

OTHER EXPLORATION GUIDES: Limonitic alteration of pyrite can result in widespread gossan zones. Yellow ferrimolybdite may be present in oxidized zones. Ag-Pb-Zn veins may be present in peripheral zones.

PORPHYRY Mo (LOW-F-TYPE) L05

ECONOMIC FACTORS

GRADE AND TONNAGE: Typical size is 100 Mt at 0.1 to 0.2 % Mo. The following figures are for production plus reserves.

Endako (B.C.): 336 Mt at 0.087 % Mo; Boss Mountain (B.C.): 63 Mt. at 0.074 % Mo; Kitsault (B.C.): 108 Mt at 0.115 % Mo; Lucky Ship (B.C.): 14 Mt at 0.090 % Mo; Adanac (B.C.): 94 Mt at 0.094 % Mo; Carmi (B.C.): 34 Mt at 0.091 % Mo; Mount Haskin (B.C.): 12 Mt at 0.090 % Mo; Bell Moly (B.C.): 32 Mt at 0.066 % Mo; Red Bird (B.C.): 34 Mt at 0.108 % Mo; Storie Moly (B.C.): 101 Mt at 0.078 % Mo; Trout Lake (B.C.): 50 Mt at 0.138 % Mo; Glacier Gulch (B.C.): 125 Mt at 0.151 % Mo; Red Mountain (Yukon): 187 Mt at 0.100 % Mo; Quartz Hill (Alaska): 793 Mt at 0.091 % Mo; Thompson Creek (Idaho): 181 Mt at 0.110 % Mo; Compaccha (Peru): 100 Mt at 0.072 % Mo; East Kounrad (Russia): 30 Mt at 0.150 % Mo.

IMPORTANCE: Porphyry Mo deposits associated with low-F felsic intrusive rocks have been an important source of world molybdenum production. Virtually all of Canada's Mo production comes from these deposits and from porphyry Cu-Mo deposits.

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