Drill Core Evaluation of Vermilion Greenstone Belt Gold Mineralization, Northeastern Minnesota

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Report 373

ABSTRACT

Vermilion Greenstone Area
The Minnesota DNR Drill Core library contains samples from 134 drill holes from the Vermilion Greenstone Area of Projects 372 and 373 in northern St. Louis County. From the early 1900's through 1999, sixteen companies drilled exploration drill holes looking for iron ore, base metals and gold. Our new data is centered on five smaller prospect areas within the Vermilion Greenstone Belt. Companies with publicly available exploration data for these five prospects are listed in Appendix 1.

The purpose of Project 373 is to generate new digital data from drill hole samples within the project area, with an emphasis on gold. Work and products include descriptive logs; real-time, semi-quantitative X-Ray Fluorescence spectrometry (XRF) values; microprobe work; and quantitative laboratory sample analyses. Project digital formats include image formats, Excel spreadsheets, Geographic Information Systems (GIS) files, and a previously open-filed Power Point summary (files listed in Appendix 2). Samples from 24 drill holes associated with the five prospects were logged and sampled, along with another six examined before the project boundary was finalized. Most materials were drill cores, but three drill holes had cuttings. See PowerPoint "**P373VermilionAu5.ppt**" for a summary of key information.

Previous assays on interval footages in the Vermilion Greenstone project area had gold values as high as 35.6 parts per million (ppm). Existing exploration data for the Vermilion Greenstone Project area has been summarized in MnDNR Project 372. Known gold mineralization has been verified and better elucidated in this report. The project also found previously unrecognized gold occurrences in drill samples, and these are listed in Table 1. Semi-quantitative XRF values have provided added chemistry data to better characterize the mineralization occurrences, and to help guide other sampling. Several different types of gold mineralization are represented in the Vermilion Project area. No current gold mines are found in this area, but the regional existence of anomalous gold has been verified.

INTRODUCTION

The Project 373 area comprises several townships in northern St. Louis County, Minnesota (see location maps in Fig. 1). The Archean rocks are part of the Wawa Subprovince of the Superior Province of the Canadian Shield. Rocks consist of

volcanic-sedimentary sequences and intrusions. Most rocks have been subjected to greenschist facies metamorphism. Outcrop exposure is variable, but good compared with most of Minnesota. Past sampling, maps, and reports have been produced by the Minnesota DNR, the Natural Resource Research Institute, and the Minnesota Geological Surveys.

A "gold rush" in 1865 lead to the discovery of iron ore, but little gold was found. About 100 million tons of direct shipping magnetite and hematite ore within Algoma type Banded Iron Formation(s) (BIF) came from this greenstone. The village of Soudan hosted the first iron mine in Minnesota, with the city of Ely hosting another five major mines. Numerous smaller mines also existed. The iron formation is responsible for one of the strongest magnetic anomalies in Minnesota (Fig. 2). Vermilion underground iron production ceased in Ely in 1965, but several episodes of gold and base metal exploration followed. Exploration activities found numerous gold and base metal showings.

The Project 373 work is meant to complement existing data. A large percentage of the old exploration data is available through the Internet at the Minnesota Department of Natural Resources website (http://www.dnr.state.mn.us/lands_minerals/index.html). Project 373 procedures and results are presented in this report, along with further explanation of other project data files.

Table 1. Previously Unrecognized Gold-Bearing Intervals in Archived Vermilion Drill Core – Semi-quantitative XRF Results

Prospect	Au Mineralization Type	Semi-quantitative XRF Value	Au Association
Raspberry	Intrusion hosted	To 101 ppm Au	Pb (galena), Quartz veins, Rutile; Fe, As, Mn, Cr, Se, Sn
Raspberry	Shear zone related (remobilization?)	To 67 ppm Au	Pb (galena), Quartz veins, Rutile?; Pb, Ag, Se
Foss Lake	Algoma BIF related Au	To 28 ppm Au	Fe oxide to Sulfide-graphite transition; As, Ba, Pb
Eagles Nest Shear	Shear zone related	To 4 ppm Au	Pyrite; Mn, Sr, Ba, Mo?, Cu?
Murray Shear	Volcanic Hosted Massive Sulfide?	To 148 ppm Au	Sphalerite, pyrrhotite?, Cr magnetite?; Cr, Zn, Sb, Cd, Hg

PROCEDURES

Existing data consists of a wide-range of geologic, geochemical, and geophysical data. Most drill holes had logs, with variable amounts of assaying and geochemical data available. Each prospect area had two or more drill holes with samples. Project 373 work consisted of reviewing existing chemistry data and logs, logging of samples, using the XRF for semi-quantitative values, documenting features with images, and choosing samples for quantitative laboratory analyses and microprobe work.

Review Existing data

Existing chemistry data used was predominantly from two compilation sources. The first is a large, early compilation of Bedrock Geochemistry of Archean Rocks in Northern Minnesota by the NRRI (Hauck, S. A., Englebert, J. A., 1991). The separated rock and core geochemistry file has about 5.400 entries, many with NAD27 UTM coordinates (file "NRRIvermCHEM91-12h.xls").

The second source is a chemistry file from Dean Peterson's PHD thesis, and includes *most* of the Project 373 area, and additional lands to the west. Data came from the above compilation, with additional samples. This included various rock, core, soil, till, water, seep, and other samples. A subset of about 16,300 records were separated out (file DPetVerchem.xls), and a GIS shapefile (dprockch.shp) was made for those samples with included NAD27 UTM coordinates.

Data using NAD27 as a datum and not NAD83, were converted to NAD83 using the MinCON program. It appears that the DNR does not have some of the cores and cuttings that have been analyzed in the data. Much of the compiled chemistry data came from the MnDNR Assessment Files, housed in Hibbing, MN. Assessment file data also includes data such as drill hole location maps, logs, and geophysics.

Historic drill hole chemistry data varied in the amount of footage coverage and the number of elements analyzed. Most recent drill holes were from gold exploration, so gold was a common assay element, even if other elements were lacking.

Existing company drill hole logs were created within the internal constraints of respective exploration programs, and are generally of a good quality. Their descriptions and interpretations should be examined as references, since lithologies and textures are often obscured by variable alteration.

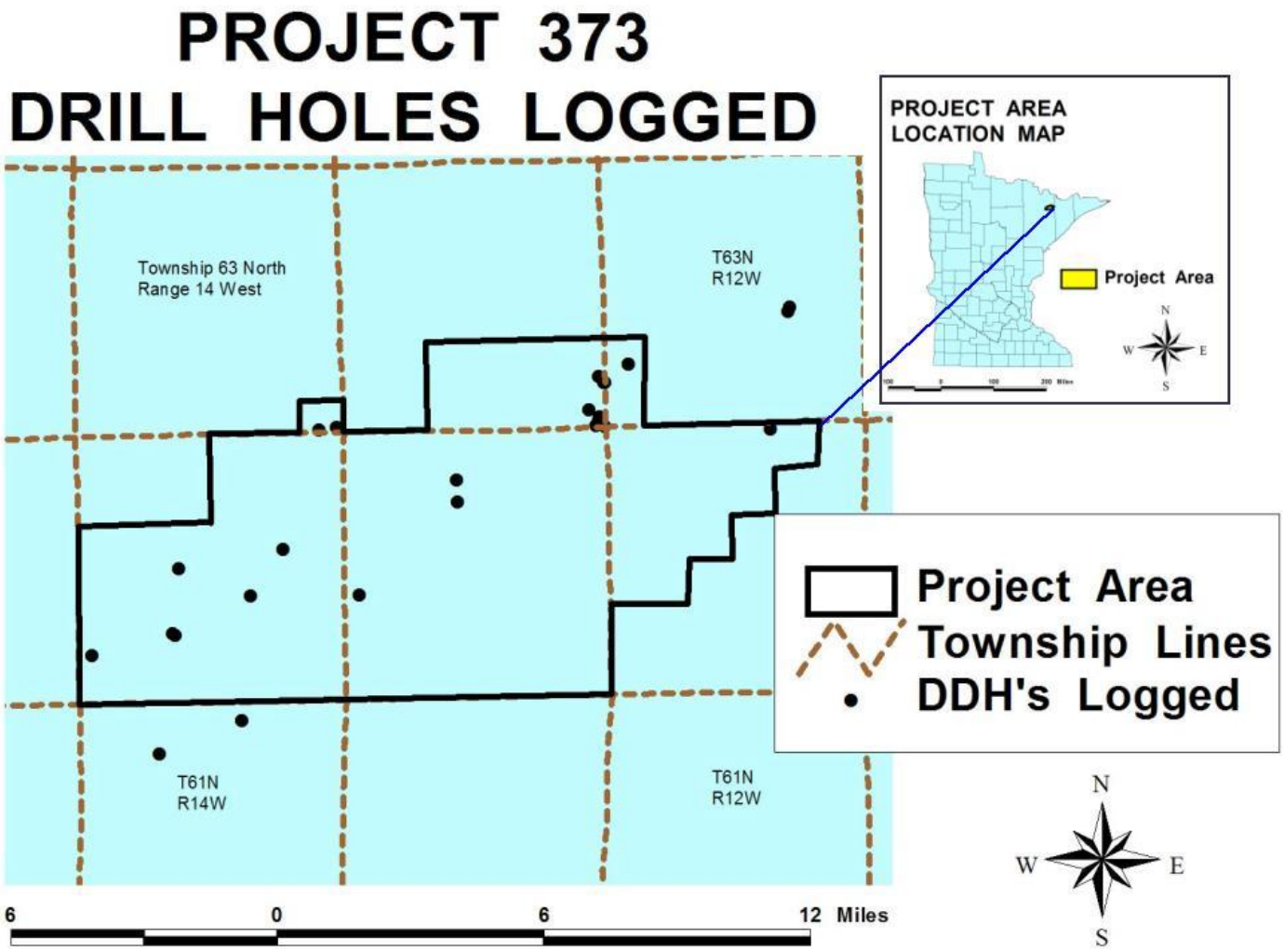


Fig. 1. Project 373 Location Maps

Sample Logging

Drill hole samples are maintained at the Minnesota DNR Drill Core Library in Hibbing, Minnesota. Paper records including logs, maps, geochemistry and geophysics, are available in the DNR Exploration Files. Most documents have been scanned, and are available via the DNR website.

Excel spreadsheet "P373DDHList.xls" contains a listing of the project drill holes logged for the project. Samples were examined and logged with the information placed into an Excel spreadsheet (spreadsheet file "P373LithLog.xls"). Each spreadsheet row describes a footage interval with drill hole identifiers and the footage interval. Each footage interval is given up to 5 lithologic codes (codes in spreadsheet file "P373LithCodes.xls") indicating decreasing lithologies within the given interval. A "Comments" field stores important additional information. Additional smaller scale information can be found in the XRF data files.

The Archean rocks logged are typical greenstone belt rocks, with many multiply deformed and, or metamorphosed. Targeted mineralization often has associated veining and alteration. These processes may impede original protolith determination, but protolith identification was attempted where possible. Original company logs provide additional information.

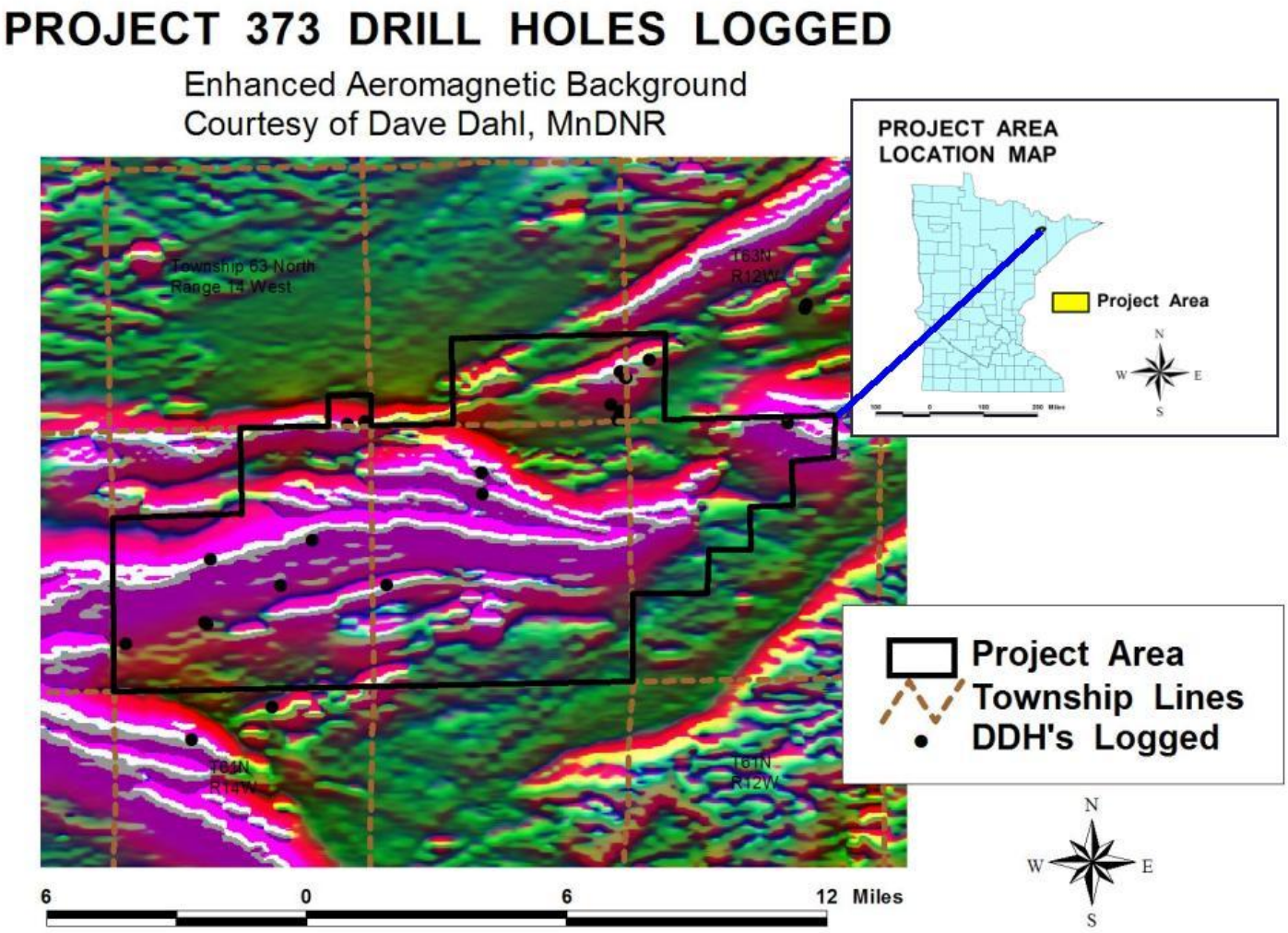


Fig. 2. Project 373 Location Maps with Aeromagnetic Background

Semi-quantitative XRF Reported Chemistry Values

The X-Ray Fluorescence Spectrometer (XRF) is a hand held semi-quantitative analytical instrument that provides real-time chemistry data on analyzed samples. The sampling window and X-Ray beam are roughly circular with a measured area of about .76 cm^2. The XRF results should be an average of all mineral grains within this window.

The XRF instrument was used while mounted in a sampling stand, upon which core/rock pieces were placed. For drill holes SH-1, SH-11 and SH-19, samples of cuttings were first placed in XRF sample cups.

Each XRF instrument construction has inherent elemental and detection limitations. These must be weighed when selecting an XRF. Our XRF instrument is designed to analyze for gold and a variety of transition metal elements. This is only possible by excluding other elements.

The XRF produces downloaded data in a Comma Separated Variable (CSV) format. Sampling information was maintained in a separate Excel spreadsheet, with the CSV file was later joined directly to the spreadsheet. Integrity was maintained by including one analyzed element (usually titanium) and its amount within the spreadsheet to insure eventual proper matching with the CSV file.

The XRF is capable of running in two different modes, "Soil" and "Alloy". With an emphasis on trace amounts, the "soil" mode was used for Project 373. Direct comparison between soil and alloy modes is not possible since a sample must be moved between modes in order to analyze the required standardization puck (see below). Higher elemental amounts are probably more accurate in the alloy mode.

The XRF sampling window size is the same order of magnitude of most rock mineral grains, with most mineral grain sizes being less than 10 mm. The XRF analyses performed have been locally extensive to evaluate optimum sampling scales and sampling density. A given analysis may or may not be representative of the rock, and is very grain-size dependent. Grain size or homogeneity sometime require multiple readings and averaging. Gold and other mineralization is often concentrated within specific small mineral grains. The XRF window size was used to advantage by doing traverses across mineralized grains, veins, and their selvages. As interesting gold or base metal values are traversed, associated elements trends can be delineated, at least for the elements the XRF can see. A number of traverses across different rock or alteration types have been done.

As with the Virginia Horn, the Raspberry Prospect demonstrated that the XRF is particularly useful for delineating other elements that are associated with Au (arsenopyrite in the Horn; galena in the Raspberry). Once these visual clues are determined, it forms a useful criterion for other core that should be assayed. XRF results should be reported as "Semi-quantitative XRF reported values".

XRF Traits and XRF Quality Control

The XRF does a fairly good job at reflecting anomalous Au, although due to the sampling size, the nugget effect has to be remembered. A lack of indicated measurable Au, does not preclude the sample from actually containing anomalous Au. A pulverized rock chemistry standard from the U.S. Geological Survey (USGS), DGPM-1 contains .7 ppm gold (assayed). The XRF instrument, when analyzing this sample, produced semi-quantitative XRF reported values from below the "Level of Detection" (LOD) to 8 ppm. This implies that assayed values less than 1 ppm can be ascertained, although the amounts determined may be overvalued.

XRF analytical results produce a Level of Detection (LOD) value for each element analyzed. The LOD varies for each element, and also varies for each sample with overall sample composition changes (in other words, the total chemical matrix of the sample). Regarding XRF analytical values, with other things being equal, samples producing XRF values for Au (for example) to the ppm level, had LOD values varying from +/- 1 ppm to +/- 6 ppm (or more?).

The XRF software generally does not detect elements unless they are about 3x the LOD or +/- amount. Cognizance of this is important when examining and directly comparing data. XRF chemistry values below the LOD value may not preclude the existence of values of interest.

In order to lower the +/- amount and to better differentiate between elements, the analysis time must be raised. Very large XRF values (such as >10 ppm Au) may be indicated in 60 second analyses, but to determine lesser amounts, 200 or more seconds are needed. Samples take about 3.5 to 5 minutes each to run, which is necessary to produce Au values with lower detection limits Greater times could be used, but 200 seconds is a compromise since increased sample times does mean the analysis of fewer samples. If base metals were targeted, shorter times probably would be acceptable. For first time samples, at least a few scattered long duration analyses should be done to check for surprises (especially for precious metals), especially if LOD values are high.

The XRF instrument must also be used in a manner cognizant of the sampling size and the nature of what is sampled. When examining data and comparing, ratios may provide the best indications of unknown mineral identification or observed alteration changes. In the Raspberry Prospect, adjacent analyses with variable amounts of unknown small mineral needles (in quartz veins), indicated a variable Ti content, providing evidence that the needles were rutile and not tourmaline (needles of tourmaline also often tend to also have crisper crystal margins). Traverses across veins, selvages, or sulfides can provide information on elemental and mineralization associations.

If an XRF project analyzes a limited suite of rock compositions (matrix), analysis for each specific element can be tweaked to maximize analytical accuracy and precision for this matrix. Because of the wide-spectrum of rock compositions in greenstone belts, this was not attempted in Project 373.

Quality control samples consist of several types. Internal machine calibration is maintained by analyzing a metal puck "standard" supplied by the XRF

manufacturer, Innov-X. Upon starting the XRF, this is the first sample analyzed (requested by the XRF), and is requested every 10 to 30 samples, depending on the time between analyses.

Beside the calibration puck, the use of standards was modified and modeled after the USEPA 6200 method for XRF instruments. At startup and shutdown, the standard puck is analyzed, as is a silica sand "blank", and a known pulverized standard. Once a week, precision is tested by analyzing a known standard seven times without moving the sample.

In total, about 20% of all analyses were quality control related. The quality control samples can be viewed in Excel file "XRFMasterP373.xls", along with the other analyses.

Documenting Features With Images

Digital images were taken with a digital camera and a Proscope digital microscope. The digital microscope had built in Light Emitting Diode (LED) illuminations, and included lenses to magnify 10, 30, 100, 200, and 400 times (x). Due to typical rock grain sizes, the 30x and 100x lenses were used primarily. Higher magnifications have narrower range of views and depths, and surficial blemishes such as saw marks become overly prominent unless extra sample preparation is done

Except for 10x magnification, a scale can be added easily along with annotations. For use, the images must be exported from the proprietary software.

Laboratory Chemistry

Sixty five samples have been sent in for analyses, with another 285 samples tentatively planned.

Most gold exploration drill holes had extensive gold analyses. Gold is our emphasis, and one aspect of our work will be to complement existing analyses with additional elements to characterize Au related alteration. By contrasting altered vs unaltered intervals, more favorable land parcels may be indicated.

Chemical analyses, which included a wide spectrum of elements, are chosen to complement and extend the previous work so as to allow for improved understanding of the known irregular, unpredictable gold distribution.

Note that for statistic files with chemistry, chemistry values below the detection limit (<detection limit) were replaced with 3/5 of the detection limit value (= 3/5 x detection limit number).

PROJECT RESULTS

Data was compiled in digital files and a file listing is given in Appendix A. The summarized result data in the next subsection is organized by prospect, and the drill hole core and cuttings examined within each.

The X-Ray Fluorescence (XRF) Spectrometer has provided limited ***real-time***, semi-quantitative chemistry data. This data has aided logging information, and provided assistance in choosing samples for other analyses. Most mineralization alteration provides visible clues, but grain size and mineral similarities may mask more, or less, subtle chemistry changes. XRF data provides real time data to help elucidate alteration and mineralization. As with the Virginia Horn, the Raspberry Prospect demonstrated that the XRF is particularly useful for delineating other elements that are associated with Au (arsenopyrite in the Horn; galena in the Raspberry). Once these visual clues are determined, they form useful criteria for determining other core intervals needing additional examination or assay work.

Mineralization Summary

Archean greenstone gold mineralization can be categorized into a number of classifications and types. Past gold mineralization models pursued by companies in the Project 373 area include Algoma Banded Iron Formation (BIF) related Au, intrusion related Au, Volcanic Hosted Massive Sulfide (VHMS) related Au, and shear zone related Au. The latter tends to overlap with the three others. Limited earlier drilling in the project area was locally also done for VHMS base metals and BIF related iron ore.

Greenstone alteration, deformation, recrystallization, metamorphism, and multiple processes have all contributed to masking the mineralization types in some cases, such as the Murray Shear. Part of the reason for included images is to complement any incomplete verbal descriptions, and to provide the end user with additional information, including textures, to be combined with their own experience.

XRF data in the summaries below help to indicate the predominance and importance of one gold mineralization model locally over others within the respective prospect areas. The existence of regionally anomalous gold, representing a number of mineralization types, bodes well for the eventual finding of an ore body.

Prospect and Drill Sample Summaries

Raspberry Prospect Summary

Raspberry Au mineralization appears to be intrusion hosted, with local fault remobilization. The gold is associated with small amounts of base metals and other trace elements. Molybdenum (as molybdenite?) has also been found, but the best Au association appears to be with lead (as galena?) and rutile in quartz veins (see

TABLE 2. RASPBERRY PROSPECT SUMMARY with NEW INFORMATION			
			New data consists of some previously unknown XRF gold intervals, **but most concerns gold mineralization associated elements.**
DDH	**DNR Inven. Number**	**Footage**	**New Information**
R-11	**14131**	**80.4 - 81.3**	Original galena observation verified; molybdenite, fuchsite, rutile observed; Au mineralization associated with more proximal Pb,Mo,Sr,Zn,Ag, Cu,Sb, and less proximal (zoned?) Pb,Mo,Cd,Sb, As,Ag,Sn,Se,Cu, Zn,Sr,Ba?; **Maximum 116 ppm XRF Au anomaly. See Figures 3 and 4.**
R-11	**14131**	**148.3 - 149.5**	Molybdenite, galena, other sulfides observed; Au mineralization associated with more proximal Sb,Pb,Cu,As,Ag,Cd,Zn,Mo and less proximal (zoned?) As,Cr,Mn, Ag,Cd,Se,Sr,Cd; **Maximum 33 ppm XRF Au anomaly**
R-11	**14131**	**162.4 - 163.0**	Cu-Pb sulfides and fuchsite observed; Au mineralization associated with more proximal Pb and Mo, and less proximal (zoned?) Pb,Sb,Cu,Zn,As,Se,Ba?,Hg?,Cd, Ti; **13 ppm XRF Au anomaly**
R-11	**14131**	**234.9 - 249**	Polymetallic sulfides and fuchsite sporadically observed; Au mineralization associated with Mo,Pb,Ba?,Cd?,Se?; **sporadic NEW XRF Au anomalies* to 5 ppm**
R-11	**14131**	**255.4 - 261.4**	Polymetallic sulfides and fuchsite sporadically observed; Au mineralization associated with Pb,Hg,Ni?,Co?,Cu?, Zn?,As?,Sr?,Sn?, and Ba?**; one XRF Au anomaly* to 9 ppm**
R-11	**14131**	**355 - 361.7**	Polymetallic sulfides and fuchsite sporadically observed; Au mineralization complexly associated with Pb,Mo,Cr?, Co?,Ni?,Cu?, Zn?,As?,Cd?,Sn?,Ba?,Hg?; **XRF Au anomalies to maximum 36 ppm**
R-11	**14131**	**419.2 - 422.1**	Polymetallic sulfides, high chrome specular hematite, quartz barite veins w/ fluorescent calcite sporadically observed; Au mineralization complexly associated with Pb (proximal), Mo (distal), and Hg,Sr,Ag,Ba,Se,As,Cu,Co,Fe, Cr,Ti; **one 7 ppm XRF Au anomaly**
R-11	**14131**	**573 - 578.6**	Polymetallic sulfides, quartz veins with Ba-Sr, rutile in veins w/ fluorescent calcite sporadically observed; Au mineralization complexly associated with more proximal Ba,Sr,Pb,Mo,Ti,As,Sn,Hg,Se,Cr,Zr,Sn; and less proximal (to Au) As,Zr, Se,Sn,Hg,Zn,Co,Ba,Pb,Sr; **maximum XRF Au anomaly* is 62 ppm**
R-11	**14131**	**613.5 - 613.55**	Felsic and qz veins in mafic country rock; with polymetallic sulfides; two element associations with Au mineralization associated with more proximal Pb,Ag,Se; and less proximal (to Au) for Sn,Hg?,Mo,As,Se,Pb?,Cu,Co,Ti?; **NEW XRF Au anomaly to 67 ppm**
R-9	**14136**	**34.4 - 34.5**	Minor galena, pyrite, crystalline hematite with chrome locally; Au mineralization more directly associated with Pb, Hg,As; **NEW XRF Au anomaly to 3 ppm**
R-9	**14136**	**141.7 - 141.8**	Minor galena, pyrite, crystalline hematite with chrome locally; Au mineralization most directly associated with Pb; less spatially with As,Cu,Se,Ag,Mo,Cd,Sn,Ba, and Hg; **NEW XRF Au anomaly to 101 ppm**
SH-01	**18398**	**10 - 12**	Vein quartz and minor pyrite observed in cuttings; Au mineralization most directly associated with Pb,Ag,Cu, and Co**; XRF Au anomaly up to 6 ppm, agrees well with original assay**
SH-11	**18408**	**62 - 64**	Minor pyrite and vein quartz observed in cuttings; Au mineralization most directly associated with Zn,Cu,Pb,Co,As,Mo and Ag; **XRF Au anomaly up to 4 ppm, agrees well with original assay**
SH-19	**18416**	**112 - 114**	Minor pyrite, galena, molybdebite(?) observed in cuttings; Au mineralization most directly associated with Cu,Mo,Ag, and Pb; and lesser spatially(?) with Sn and Hg; **XRF Au anomaly up to 22 ppm, about 2/3 value of original assay**
*Previous assays below 67 ppb detection			

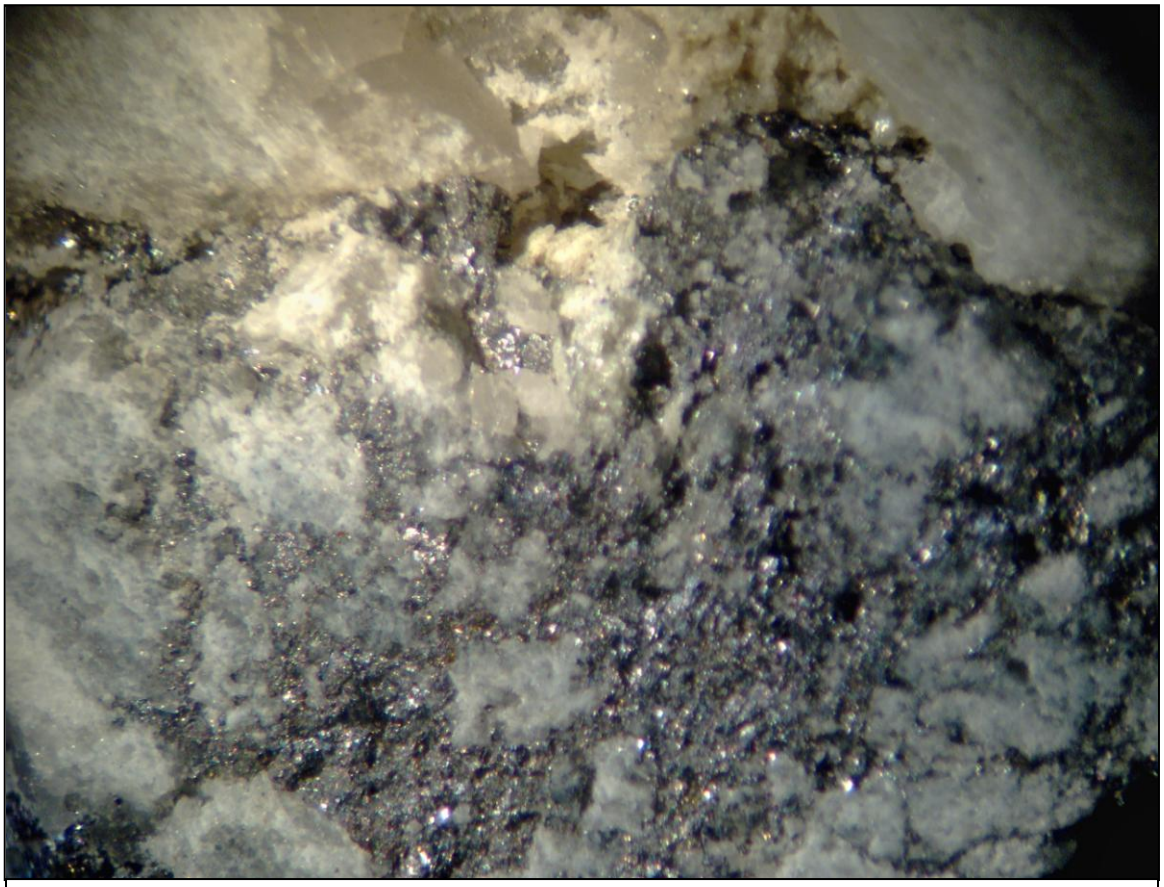


Figure 3. Gold-bearing, fine-grained galena in vuggy quartz vein with minor calcite. DDH R-11 at 80.4'. Horizontal field of view is 12.6 mm.

Figs. 3 and 4, from DDH R-11). One semi-quantitative XRF analysis had up to 116 ppm Au associated with this galena (Fig. 3).

The intrusion itself is a syntectonic (Peterson, 2001), slightly magnetic granodiorite with medium-grained K-spar/plagioclase and minor quartz, with finer interstitial Fe-Mg silicates. Variable calcite is fairly ubiquitous. Fe-Mg silicates are predominatly chlorite with variable euhedral biotite, and perhaps amphibole. The syntectonic intrusion has associated sills, and,or dykes. Chilling near country rock occurs. Experienced country rock is mafic, probably volcanic(?). Gold locally occurs in some quartz veins near contact.

There appears to be several sets of syntectonic veins within the granodiorite, with Au associated with minor base metals and rutile in some veins. This galena (and molybdenite?) and gold may be more intimately associated with hairline (late) fractures-veins within, and possibly crossing, the quartz veins locally. Other combinations of base metals are less commonly associated with gold. Carbonate is often on quartz vein margins. Quartz (+- carbonate) veins are variable in distribution and typically have alteration selvages whereby interstitial mafics are replaced by sericite, pyrite, and quartz (DDH R-11, 181.1-181.4', Figs. 5,6,7,8,9).

Silicification and alteration occur in intervals where quartz vein footages are

Figure 4. From DDH R-11 at 80.9'; shows typical rutile needles. Horizontal field of view is about 3 mm.

maximized. Iron sulfides are relatively barren. White, opaque Mn bearing fluorescent red-orange calcite (and barium minerals?) occur in many quartz veins and may also be Au associated (Fig. 10).

The system appears to be low in arsenic, although mercury can be high with fractures, slip surfaces and veins.

Of the gold fire assays on the first samples sent in, only one sample came back with >1 ppm Au (1.72 ppm). Several other values were over 100 ppb Au. At the sampling interval scale, the associations of gold with other elements is unclear, although a Pb association apparent in some.

Microprobe Work

Two days were spent doing microprobe work with Peter McSwiggen and Associates. A week previous to this was spent delineated the best targets for the probe work, to maximize the actual probe time.

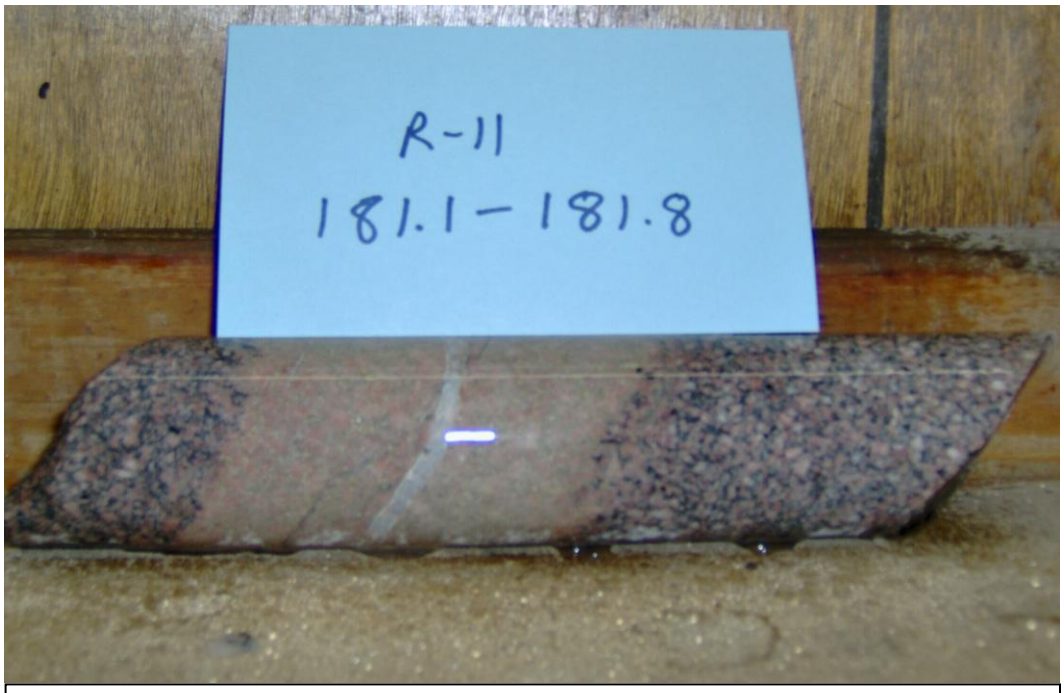


Figure 5. Quartz vein with alteration selvage in granodiorite. Drill core diameter is 4.8 cm for scale.

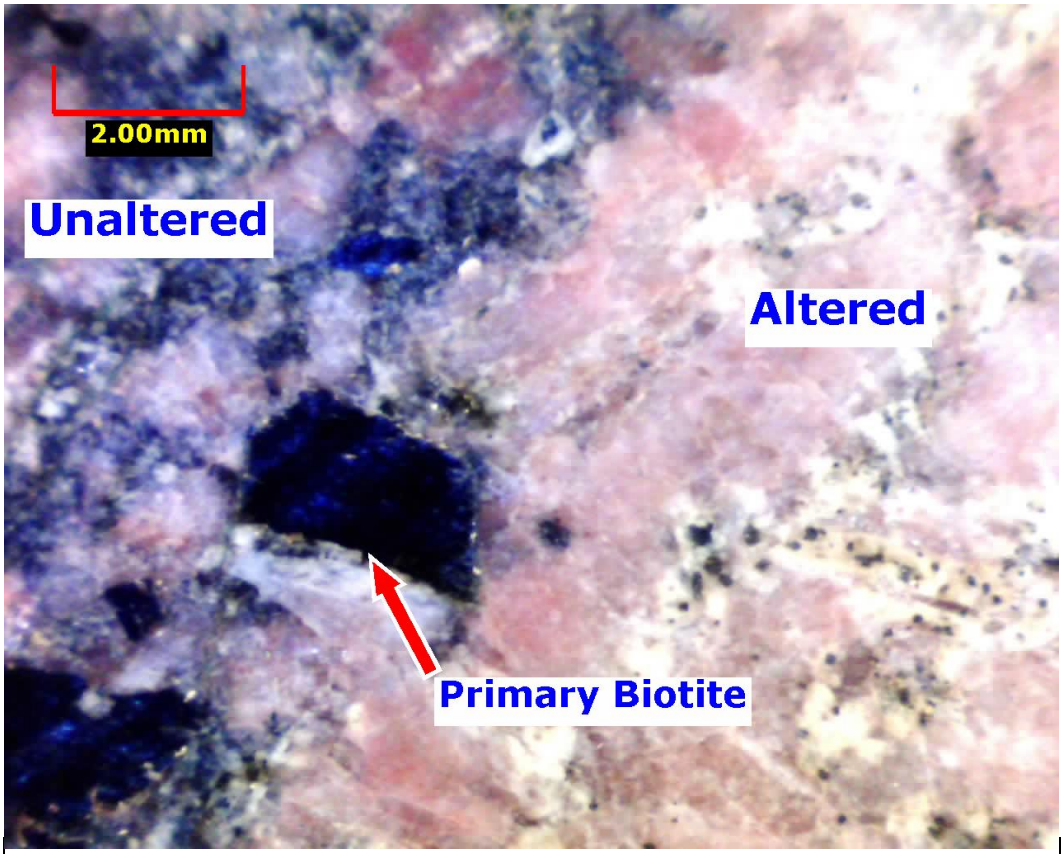


Figure 6. Quartz vein alteration selvage contact.

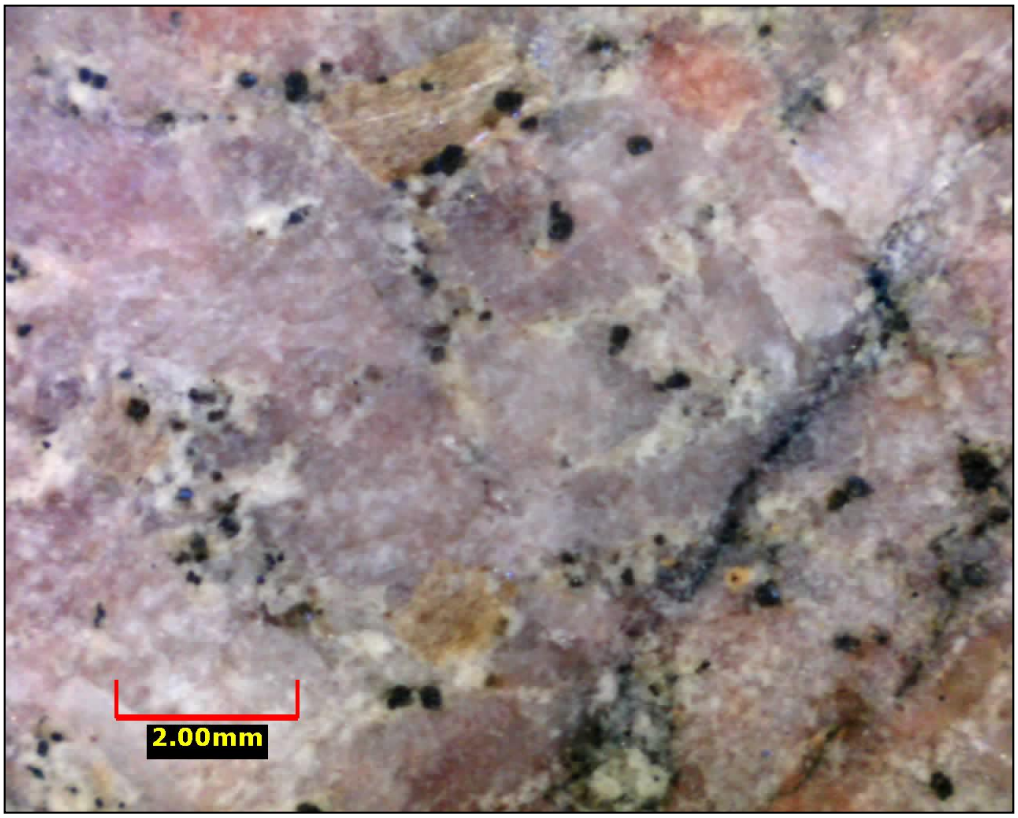


Figure 7. Altered granodiorite in quartz vein selvage.

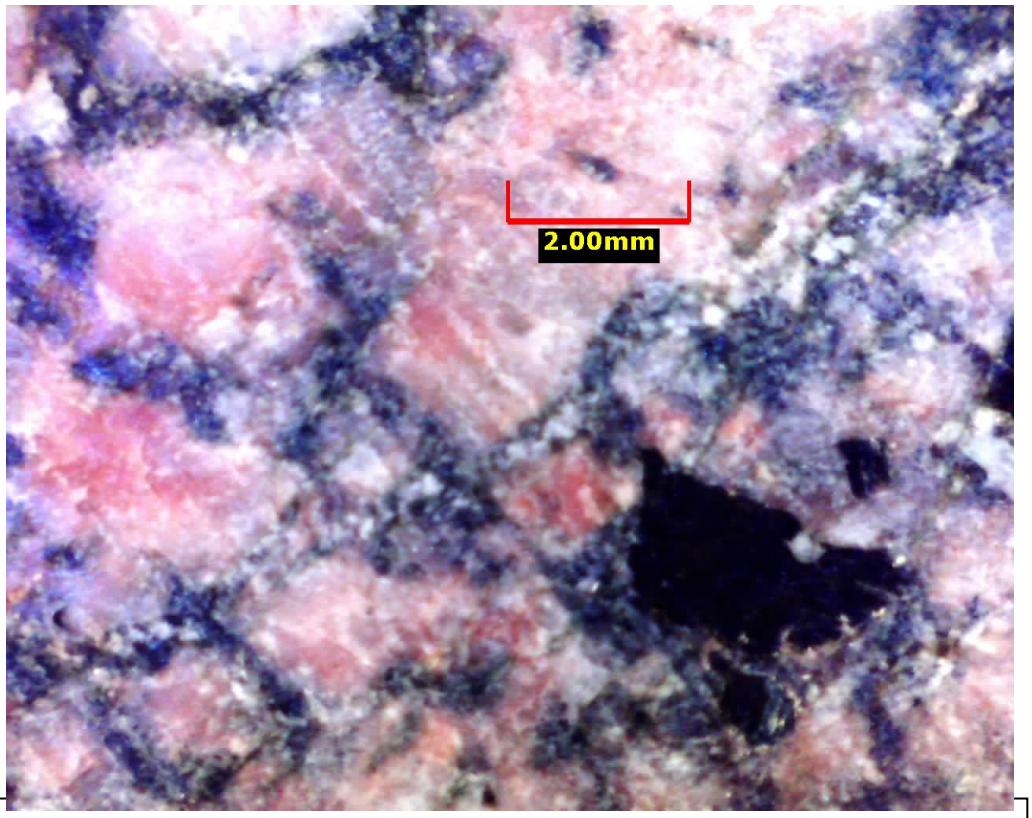


Figure 8. Unaltered granodiorite with primary biotite.

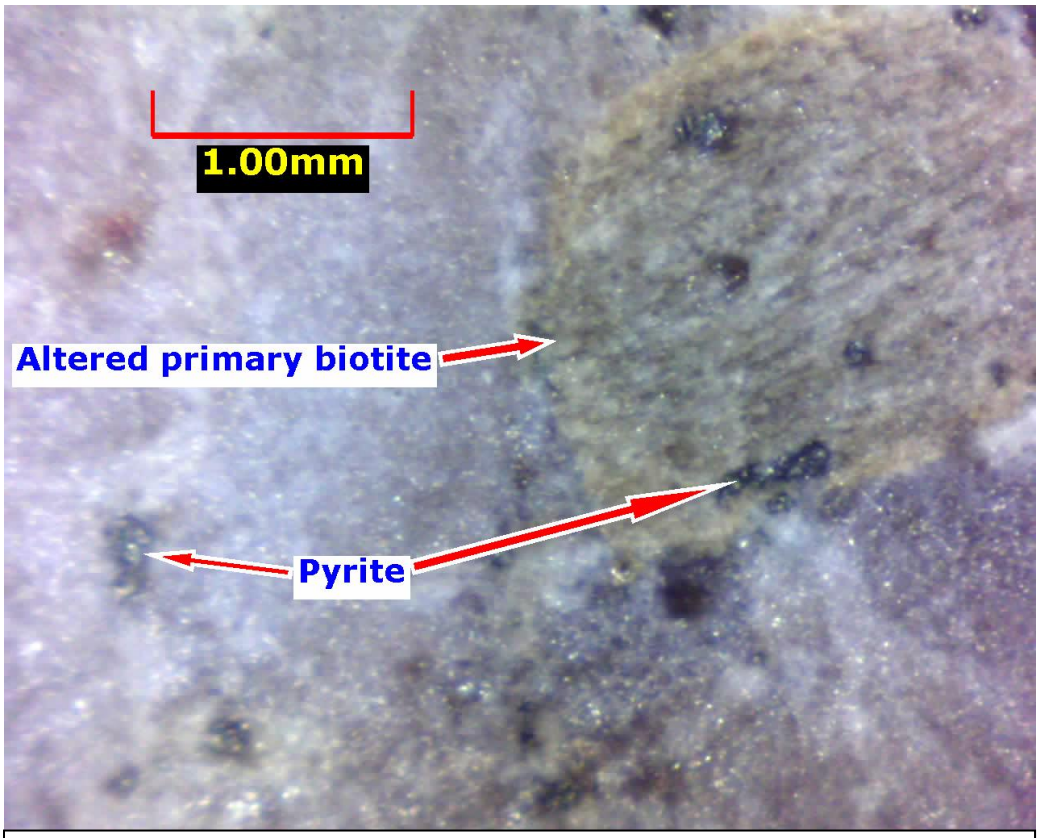


Figure 9. Altered granodiorite in quartz vein selvage showing quartz, pyrite and altered primary biotite.

Figure 10. Fluorescent, Mn bearing calcite in quartz vein in DDH R-11 at 292.4-294.6'. Long wave ultraviolet light. Horizontal dimension of core is 4.8 cm.

Two main aspects were examined with the probe work. One was the elucidation of the Au bearing phase associated with the galena and/or rutile in the Raspberry. Grain analyses did not turn up any Au, which may be due to a gold solid solution in the galena. Gold is relatively difficult to discern on Back Scattered Images (BSI) when dense phases such as galena are involved. Mapping for Au would probably determine more precisely where it is. The other aspect was to follow up on the Scott and Radford (2007) journal article on rutile trace elements related to strong gold mineralization. The element suite indicated high amounts of vanadium, and BSI's indicate some zoning in rutile. The analyses are included in file P373ProbeAnalyses.xls. See Table 2 for a summary of new information produced.

Drill Hole Summaries

Drill Hole R-9 **Mn DNR Inventory Number 14136**

See files P373LithLog.xls, and the XRF files P373_Raspberry_XRF.xls and P373_R-9_XRF.xls. DDH R-9 (Amoco) is located on an outlying dike or sill extending from the main Raspberry intrusion. Besides granodiorite, a three foot interval is brecciated, and the core ends in mafic fragmental country rock. Pyrite and copper bearing pyrite is ubiquitously disseminated. Local arsenic and lead-arsenic(?) sulfides also occur. A quartz vein with a metallic grey mineral(s) had elevated semi-quantitative XRF results for (in decreasing amounts) Pb (269529 ppm), Fe, As, Mn, Cr, Cu, Se, Cd, and Sn (611 ppm).

Feldspar and quartz grains tend to have finer interstitial mafic minerals in variable proportions, and may represent footwall contamination (hornfelsed basalt?). Similar material is also found along fractures-veins. XRF also indicates that titanium, manganese, and barium also are elevated (no Au found). Whether Ba sulphate or carbonate is present is not known. The "granodiorite" intrusion has moderate amounts of quartz veins and fairly ubiquitous calcite (elevated Sr?). Two phases appear to be fluorescent. Mn probably is the long-wave fluorescent activator (.1-.2% Mn), although similar amounts of Fe are also present (different phase?) which normally absorbs mercury vapour short-wave UV light.

Entire core was split and presumably sampled by Amoco, but only pre-existing gold data found was for three samples.

The mafic footwall (hornfelsed) of the granodiorite contains semi-quantitative XRF results of 1-2% Ti, .1-.4% Mn, Fe to 19%, and Co to .2%. Cobalt and/or titanium may also be good indicators of mafic contamination in the more felsic granodiorite melt this felsic melt, as in the mafic groundmass of the quartz and feldspar, and mafic fractures.

The footwall could be mafic volcanics (fragmental locally) or BIF, with the elevated Ti tending to indicate mafic volcanics.

Drill Hole R-11 Mn DNR Inventory Number 14131

See files P373LithLog.xls and the XRF file P373_R-11.xls. This drill hole is located in the main portion of the intrusion (Peterson, 2001). Core passes into mafic volcanic country rock, which also has semi-quantitative XRF gold results in quartz veins. Aplite veins exist in both granodiorite and country rock.

Adjacent semi-quantitative XRF results on variable amounts of unknown small mineral needles in quartz veins, indicates a variable Ti content, providing evidence that the needles were rutile and not tourmaline (needles of tourmaline also tend to have crisper margins. Rutile needles have been found in quartz veins. White, opaque Mn bearing fluorescent red-orange calcite (and barium minerals?) may also be Au associated.

Predominant quartz vein alteration appears to alter mafic minerals (chlorite, biotite and hornblende?) to sericite; with silicification in intervals where quartz vein footages are maximized. There appears to be several sets of syntectonic veins, with Au associated with minor base metals with some veins. This galena (and moly?) and gold may be more intimately associated with hairline (late) fractures-veins within, and possibly crossing the quartz veins locally. The system appears to be low in arsenic, although mercury can be high with fractures, slip surfaces and veins. Some fractures-veins in R-11 with specular hematite, also had elevated Hg, Pb, Co, Cr, Sn, and Sb. Some gold bearing veins also had minor green minerals. Semi-quantitative XRF results did not show associated chromium, however it may be roscoelite instead of fuchsite. Vanadium could not be measured in soil mode.

Drill Hole SH-01 Mn DNR Inventory Number 18398

See files P373LithLog.xls and the XRF file P373_SH-01.xls. Cutting samples washed and described. Unwashed samples placed in XRF cups for semi-quantitative analyses. Rock is variably calcareous granodiorite with variable amounts of quartz veins and pyrite. Mafics variably sericite-pyrite altered. Drill hole is located in the main granodiorite intrusion.

Samples contained one footage interval with measurable semi-quantitative XRF results for gold. Semi-quantitative XRF results indicate elevated Pb, Ag, Cu, and Co besides the gold.

Drill Hole SH-19 Mn DNR Inventory Number 18416

See files P373LithLog.xls and the XRF file P373_SH-19.xls. Cutting samples washed and described. Unwashed samples placed in XRF cups for semi-quantitative analyses. Rock is variably calcareous granodiorite with variable amounts of quartz

veins and pyrite. Mafics variably sericite-pyrite altered. Drill hole is located in the main granodiorite intrusion.

Samples contained one footage interval with measurable semi-quantitative XRF results for gold. Semi-quantitative XRF results indicate elevated Mo, Ag, Cu, Pb, and Sn along with the gold.

Drill Hole SH-11 Mn DNR Inventory Number 18408

See files P373LithLog.xls and the XRF file P373_SH-11.xls. Cutting samples washed and described. Unwashed samples placed in XRF cups for semi-quantitative analyses. Rock is variably calcareous granodiorite with variable amounts of quartz veins and pyrite. Mafics variably sericite-pyrite altered. Drill hole is located in the main granodiorite intrusion.

Samples contained one footage interval with measurable semi-quantitative XRF results for gold. Semi-quantitative XRF results indicate elevated Mo, Ag, Cu, Zn, Pb, and Co along with the gold.

Drill Hole 9 Mn DNR Inventory Number 39767

See files P373LithLog.xls and the XRF file XRFMasterP373.xls. Old core contained medium-grained granite/granodiorite, sericitic tuffaceous phyllite, and minor volcanic or tectonic breccia. Some granodiorite contaminated by banded iron formation(?).

No measurable semi-quantitative XRF results for gold, but granodiorite was anomalous in lead. Semi-quantitative XRF results for sericitic tuffaceous phyllite had elevated arsenic.

Foss Lake Prospect Summary

The two drill holes of this prospect are about 2000 feet apart, with considerably different rock types, and probable gold mineralization types. DDH 6314-36-1 contains mafic volcanics and variable iron formation. Semi-quantitative XRF results indicating previously unknown gold mineralization at the transition between magnetite-carbonate-chert-silicate banded iron formation (BIF) and sulfide-graphite BIF. The transition zone contains chert and iron silicates, carbonate, and sulfide with variable graphite. Very fine acicular fibers were noted, and the chert locally had an unusual bluish cast. Microscopic examination indicates the presence of respectively probable grunerite, and glaucophane(?) or crossite(?), see Figs. 11-15.

These minerals have not been verified by microprobe work.

DDH 6314-36-2 has sheared chlorite-sericite-ankerite-quartz-pyrite schist. The probable protolith is felsic(?) tuff and perhaps local agglomerate.

See Table 3 below for a summary of new information produced from the Foss Lake drill holes.

TABLE 3. FOSS LAKE PROSPECT SUMMARY with NEW INFORMATION

			New XRF gold values and association (BIF transition) found in DDH 6314-36-1 with known anomalous assays (shear related) verified in DDH 6314-36-2, with new XRF gold mineralization associated element data.
DDH	**DNR Inven. Number**	**Footage**	**New Information**
6314-36-1	**14347**	**92.4 - 92.6**	**New anomalous XRF Cu values (to 15683 ppm) and Zn values (14433 ppm) of sulfides near basalt(?) BIF transition**
6314-36-1	**14347**	**205 - 258**	Magnetite-chert BIF with possibly **anomalous XRF cobalt** to 9649 ppm (may be XRF analytical interference?); and **pale blue-grey chert colouration** noted**, with observed glaucophane/crossite**, possibly related to Na metasomatism? or unusual P-T conditions?; **odd textures; grunerite needles locally; see Figures 11 through 15.**
6314-36-1	**14347**	**312-314.1**	**Disturbed chert, Fe silicates/carbonate, with graphite with pyrite, near oxide-sulphide BIF transition; with new anomalous XRF Au values to 28 ppm, and 2119 ppm As**
6314-36-1	**14347**	**493.5**	Dacite bomb(?) with **new anomalous XRF Au (2 ppm)**; primary fragment chemistry?, or alteration?
6314-36-1	**14347**	**495.5**	**Ultramafic(?) fragment or intrusive; elevated XRF Cr to 2090 ppm, XRF Co to 682 ppm, but Ni not impressive**
6314-36-2	**14348**	**95.4**	**Previously anomalous assayed gold (to 3010 ppb) verified, with associated elevated XRF Cu,Co,Cr,As,Mo,Ag,Hg,Pb values; sheared, altered felsic tuffs**

Drill Hole Summaries

Drill Hole 6314-36-1 Mn DNR Inventory Number 14347

See files P373LithLog.xls and the XRF file P373_6314-36-1.xls. Drill hole 6314-36-1 cut through a magnetite-chert-silicate-carbonate-sulfide Algoma BIF with footages of basalt on either side. The sulfide and graphite portion of the BIF was previously heavily sampled, with base metals, Au, and some trace elements analyzed, with minimal positive results for gold. The chert-graphite-sulfide BIF closer to the broad transition from the oxide-chert BIF was relatively unsampled. The laminated chert and graphite produced semi-quantitative XRF results gold values of 12, 18, and 28 ppm in 3 different locations. Chert is also leached and goethitic locally (altered).

In the oxide BIF, observed BIF chert exhibited a slight blue cast. Fibrous needles were also locally observed with a hand lens, including pale blue-white needles. Microscopic examination indicated the presence of respectively probable grunerite, and glaucophane(?) or crossite(?). The bluish cast appears to result from the bluish amphiboles, based on bluish and lavender pleochroism. Figures 11, 12, 13, and 14 show the amphiboles in DDH 6314-36-1 at 247.9’. Images and microscopic examination were done in plane polarized light.

The blue amphiboles are both *more normally* associated with younger rocks and high pressure-low temperature metamorphism (as in "rapid" subduction, thicker crust, and lower crustal heat flows), and, or sodium metasomatism. Figure 11 shows some of the coarser crystalline blue glaucophane/crossite associated with a broken-disrupted chert lamina or quartz vein, with the quartz fragments rotated. The horizontal field of view (FOV) for the image is about 1.55 mm. The amphibole may reflect built up pressure when this quartz vein/chert lamina brittlely deformed (relatively lower pressure), but genesis connotations are speculative.

Figure 12 also shows the amphibole textures at a larger scale. The horizontal FOV is about 1.71 mm. Figures 13 and 14 both show some grains with different orientations, and show the more purple shade of pleochroism. The horizontal FOV for each is about .44 mm.

The opaques shown are predominantly coarser, more euhedral magnetite, with lesser, finer, scattered hematite grains. Rare pyrite also occurs. The brownish, finer amphibole needles are probably grunerite. Figure 15 (247.9’) shows the interface between a magnetite-hematite rich band and a cherty lamina. Fine amphibole needles can be observed. The chert contains domains (.07 mm or smaller) denoted by dustings of presumably very fine oxides. This was photographed in plane-polarized light. Quartz is recrystallized. Minor late calcite veinlets occur.

With respect to mineralization, the above chert-oxide BIF is close to a 1000 ppm Zn bump and about 60' from the oxide-sulfide BIF transition with measurable gold.

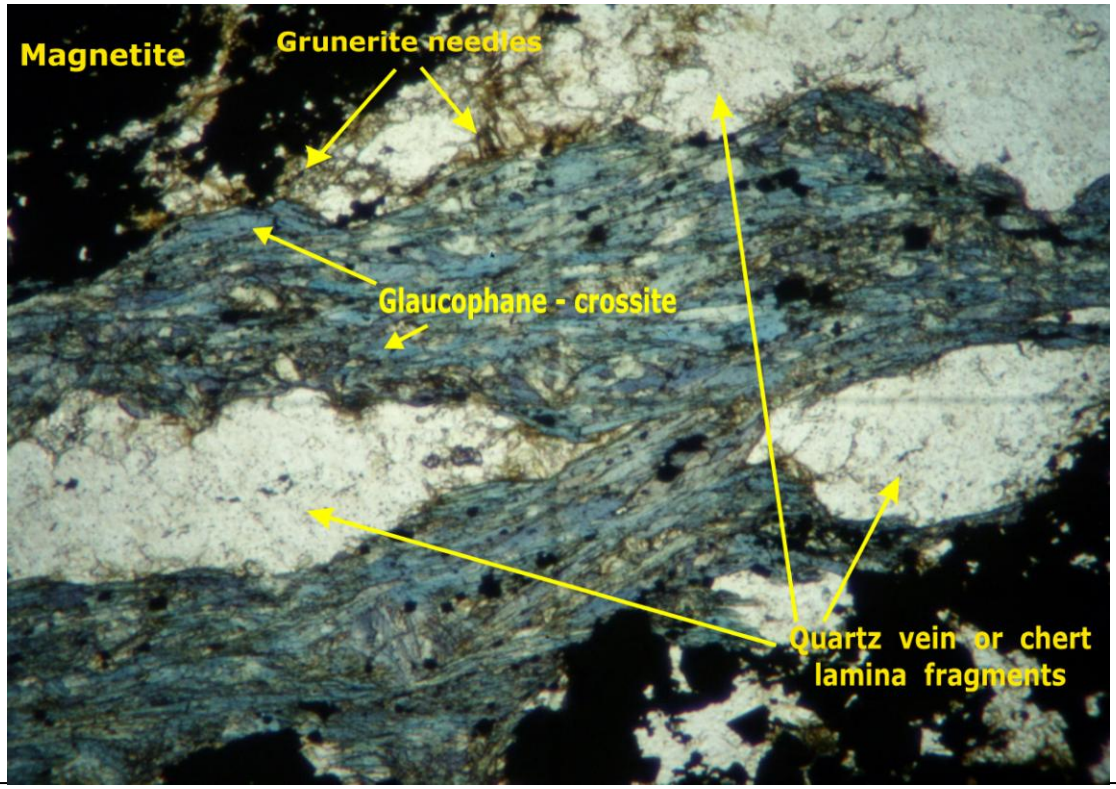


Figure 11. Blue amphiboles infilling between quartz vein or chert lamina fragments. Horizontal field of view is 1.55 mm.

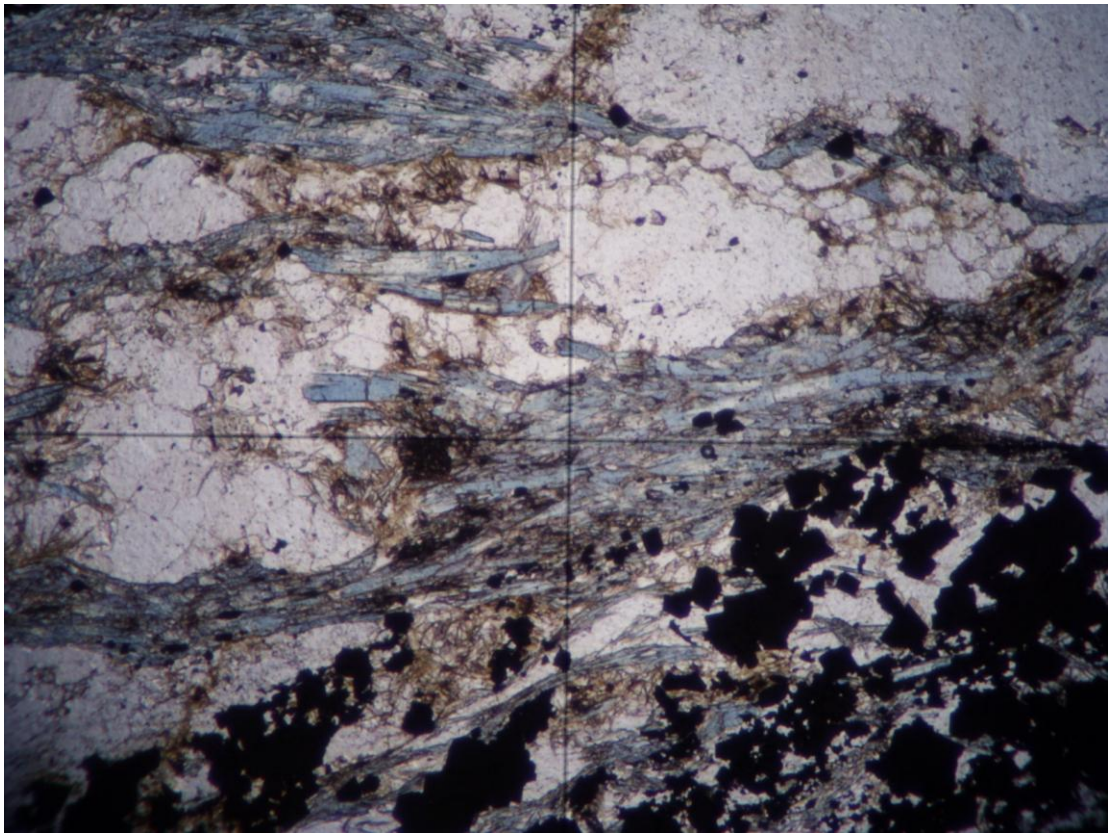


Figure 12. Blue amphiboles infilling disrupted quartz vein or chert lamina. Horizontal field of view is 1.71 mm.

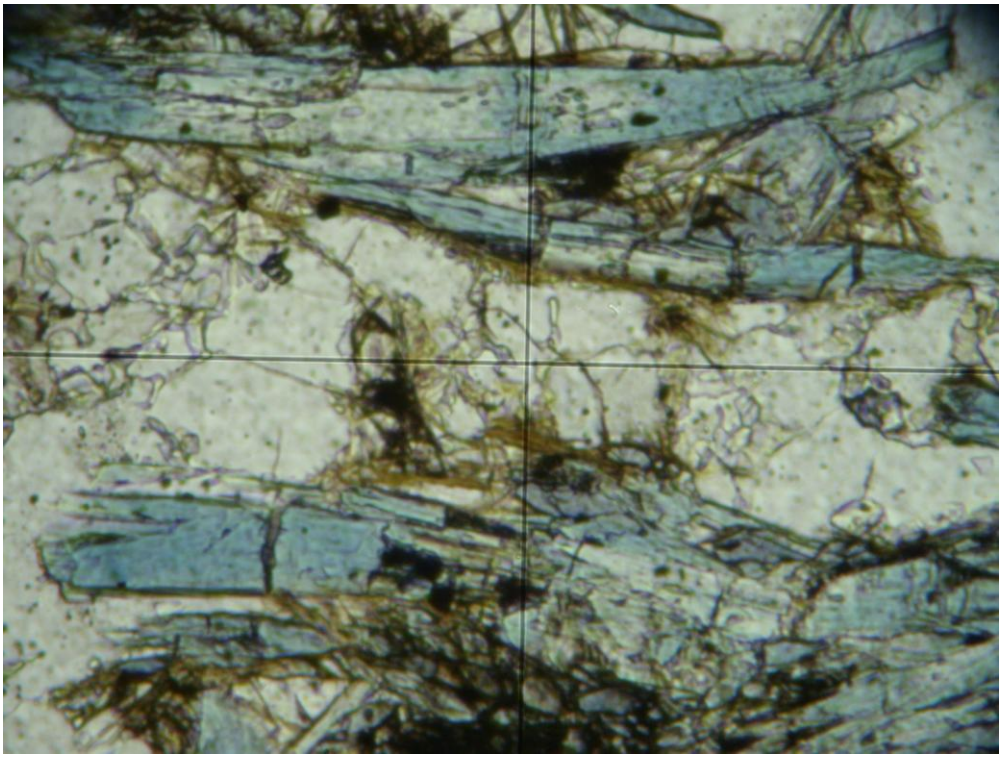


Figure 13. Blue amphiboles with different orientations showing blue and purple pleochroism. Horizontal field of view is .44 mm.

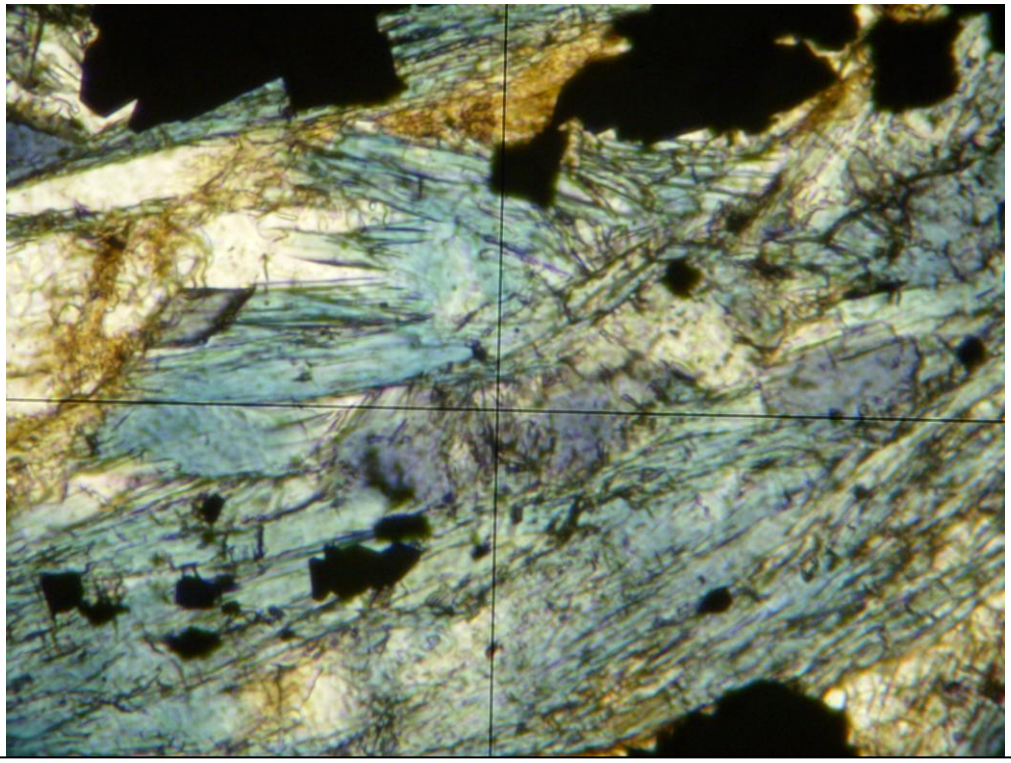


Figure 14. Blue amphiboles with different orientations showing blue and purple pleochroism. Horizontal field of view is .44 mm.

A short dolostone occurs below the graphite-sulfide BIF, along with felsic volcaniclasts (to 10 cm) adjacent to the sulfide-graphite BIF. A major shear in mafic (ultramafic?) volcanics toward the drill core bottom occurs with a massive sulfide breccia matrix.

Semi-quantitative XRF results indicate the gold is associated with elevated As, Cu, Co, Pb, and Mo.

Drill Hole 6314-36-2 Mn DNR Inventory Number 14348

See files P373LithLog.xls and the XRF file P373_6314-36-2.xls. Foss Lake drill hole 6314-36-2 appears to contain semi-quantitative XRF gold results related to major shearing, associated with iron carbonate, sericite, minor sulfides and silica. The gold distribution appears to be sporadic. Regionally, fractures within logged drill cores typically have anomalous associated mercury, and if the mapping of shears is necessary to understand this mineralization, then this may be a possible future tool.

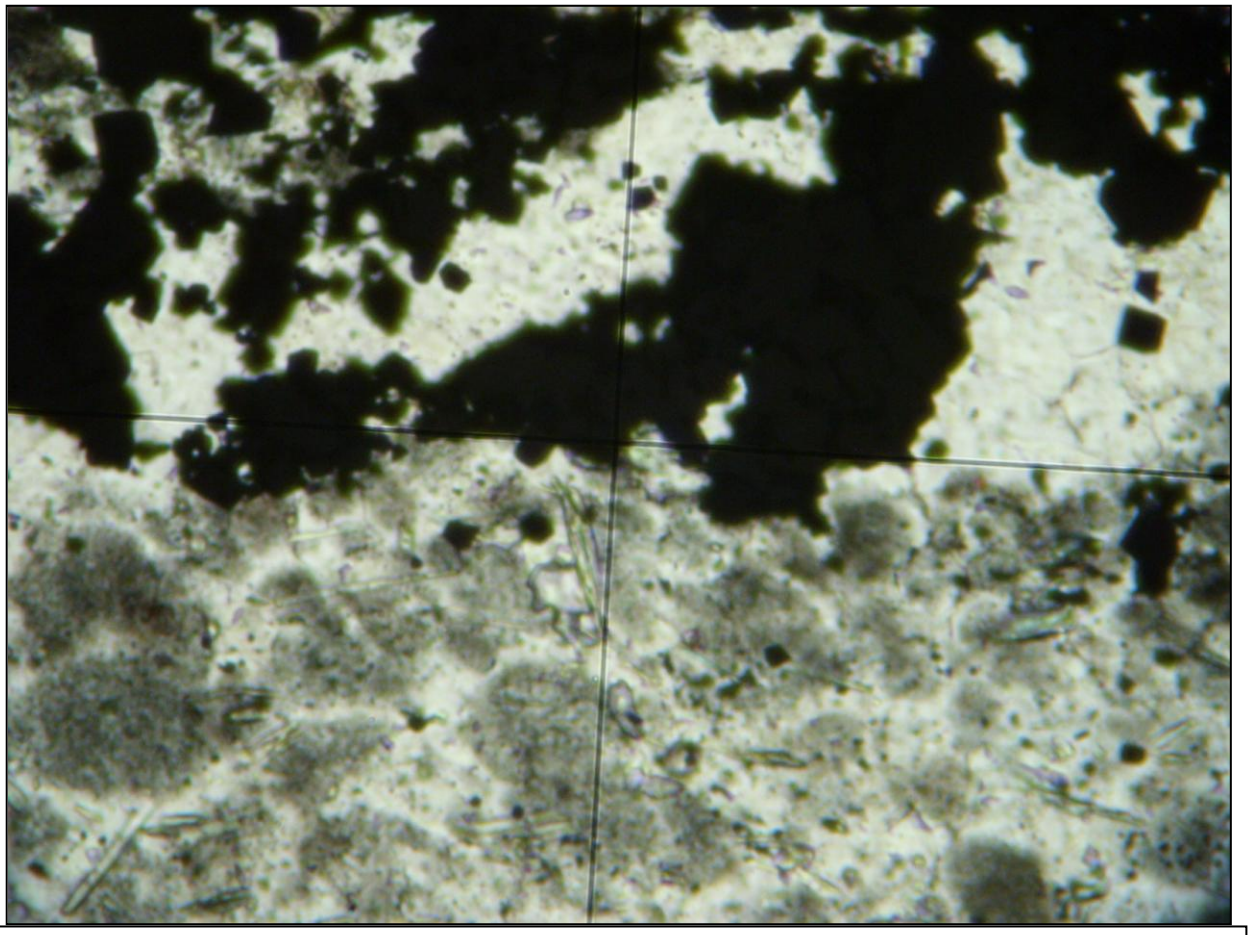


Figure 15. Contact between magnetite and chert rich laminae. Horizontal field of view is .44 mm. Note fine amphibole needles.

Semi-quantitative XRF anomalous gold results indicate corresponding elevated Cr, As, Co, Cu, Mo, Hg, and local Ag. Beside local arsenopyrite and pyrite, minor fuchsite was observed.

Eagles Nest Shear Prospect Summary

Eagles Nest Shear drill holes appear to be associated with shear related gold mineralization with associated iron carbonate, sericite, minor sulfides and silica. In general, large footages are sheared and altered. The gold distribution appears to be sporadic (based on previous assays). Slightly different factors may be involved with each area, but alteration patterns can still be sought. Regionally, fractures within logged drill cores typically have anomalous associated mercury, and if the mapping of shears is necessary to understand this mineralization, then this may be a potential future tool. Only one XRF reading indicated measurable gold. See Table 4 below for a Summary of Eagles Nest results.

Drill Hole Summaries

Drill Hole EN-6 Mn DNR Inventory Number 14467

See files P373LithLog.xls and the XRF file P373_EN-6.xls. DDH EN-6 (Eagle Nest) contains locally sheared and breciated volcanics (metabasalt and variable tuffs) and BIF; and is quite calcareous with local limestone-dolostone. One thicker carbonate vein(?) had stylolites.

Semi-quantitative XRF anomalous results include Fe and MN (BIF), and Se, Hg, Cu, and Sn locally. No anomalous semi-quantitative XRF gold analyses were determined.

Drill Hole M-5 Mn DNR Inventory Number 40962

Evidently old McComber Mine samples without drill core surfaces, type uncertain, consisting of metamorphosed magnetic BIF (ore?); with trace disseminated pyrite; slight oxidation.

No semi-quantitative XRF analyses were run due to software upgrade hiatus.

Drill Hole P1382/2487 Mn DNR Inventory Number –not assigned

Metamorphosed magnetic BIF; with trace disseminated pyrite.

No semi-quantitative XRF analyses were run due to software upgrade hiatus

Drill Hole EN-5 **Mn DNR Inventory Number 14286**

See files P373LithLog.xls and the XRF file P373_EN-5.xls. DDH EN-5 contains classically, but variably sheared felsic to mafic volcanics and dacitic(?) porphyry. Core is variably pyritic and locally mylonitic, with shearing favouring the porphyry-volcanic contacts. Shearing associated with sericite, Fe carbonate, quartz, sulfides, and local minor fuchsite.

TABLE 4. EAGLES NEST PROSPECT SUMMARY with NEW INFORMATION			
			Previous chemical analyses of these logged drill cores were for gold assays only, so new information consists of XRF element data associated with gold mineralization. Only one reading with XRF measurable Au occured. Drill core contains local elevated Co,Hg,Cu,Sn,Ni,Sn,As,Zn.
DDH	**DNR Inven. Number**	**Footage**	**New Information**
EN-5	**14286**	**254.6 - 257.4**	**Magnetite-chert-sulfide BIF with altered tuff, with local elevated XRF Hg (to 72 ppm) and Ni (to 2509 ppm)**
EN-5	**14286**	**267.05**	**Altered volcanics with 4 ppm XRF measurable Au and 100 ppm Ag**
EN-5	**14286**	**464.8**	**Veinlet in metabasalt with XRF values of 3046 Ba, 81 ppm Sn, and 46 ppm Hg**
EN-6	**14467**	**361 - 368.5**	**Local veinlet sulfides in BIF with XRF Cu to 48662 ppm**
EN-6	**14467**	**417 - 438**	**Limestone/dolostone within BIF; with XRF values to 3355 ppm Co and 70 ppm Hg**

System may have lacked volatiles during shearing.

Semi-quantitative XRF anomalous results include Ni and Ag associated with the minor gold. Hg and Rb were also elevated. Potassium is not visible with the XRF, but rubidium may parallel potassium (addition of sericite?). Chromium values may reflect local fuchsite.

Murray Shear Prospect Summary

Previous analyses of the Murray Shear drill cores examined were centered on zinc, copper, silver and gold. The SXL drill holes, generally, also had additional trace and whole rock analyses. Previous data could establish a link between zinc and gold, with the current work adding additional apparent relationships. The more complete previous data allows for better comparison with the new semi-quantitative XRF results. New work results are summarized also in Table 5 below.

The SXL drill cores contain a sequence of altered volcanics, minor chemical sulfide sediments, and minor intrusions. Volcanics consist predominantly of tuffs, with locally visible pumice or glass fragments (altered). These contain ash to agglomeratic sized fragments. Fragments and finer matrix are similar in appearance, making volcaniclast sizes difficult to discern. Rocks appear to be predominantly intermediate in nature with lesser felsic and perhaps mafic material. Coarser volcaniclasts tend to be more felsic (or at least these are easier to differentiate from the matrix). Bedding tends to be rather nebulous, but appears to parallel a general flattening fabric. Grading is not reliably discernible. Mafic flows are probable, along with intermediate to mafic intrusives.

Sulfides, beside disseminated pyrite and locally disseminated sphalerite, occur prominently as fabric/bedding-parallel laminae or shears, and similar stringers/veins that are oblique to the bedding/fabric. Both may be sphalerite (notably), magnetite, and pyrite rich; although the oblique ones tend to exhibit higher copper amounts (and more? pyrite), based on semi-quantitative XRF results. Anomalous gold values are associated with SOME, but not all, sphalerite laminae/stringers according to semi-quantitative XRF results. Laminae siliceous fragments may result from brecciation, and the sphalerite may act as a gold trap. Altered intervals with more disseminated sphalerite may lack gold.

Semi-quantitative XRF anomalous gold values in the SXL drill holes have two apparent element associations. **The highest gold values were associated with the sphalerite laminae/veins, and had associated Zn, Sb, Cd, Cr, Co, and Cu.** Sphalerite veins/laminae without gold had less Cr and Sb notably. Zn and Cd were also less, although as elements they chemically tend to be paired and may just reflect lesser sphalerite. The lesser sphalerite in the lamina *without* gold, may not represent a direct relation with gold (it's unknown). **Lesser gold values were also associated with the second association, the probable remobilization along veins/shears. These tended to have elevated arsenic, Co, and Pb;** with the high Zn, Cd, Cr, Sb values eliminated or reduced substantially. These generalizations may have exceptions, and the end-user should examine the raw data.

DDH FM-5 contains two footages with semi-quantitative XRF gold values. The rock is mylonitic to schistose tuffs with quartz veins, pyrite and iron carbonate. Semi-quantitative XRF have results variably elevated Ag, Co, Cr, Hg, Pb, Mo, and Se.

TABLE 5. MURRAY SHEAR PROSPECT SUMMARY with NEW INFORMATION			
			More complete previous analyses allows for better comparisons with new XRF data, including any XRF nugget effects. The established Zn-Au connection from previous data has been expanded upon. All SXL-1 XRF Au bumps were previously assayed, but several previously unknown ones in SXL-4 and FM-5 were discovered. The general, but variable, additional associations of Cr,Cd,Sb, and Hg with the Zn and Au has been established. XRF "ppm" values shown are direct results from the XRF and are not an indication of actual precision.
DDH	**DNR Inven. Number**	**Footage**	**New Information**
FM-5	**14469**	**94.10**	**New XRF anomalous Au to 3 ppm in a calcareous mafic flow (top?) breccia**; associated with minor Sr (286 ppm), Mo (69 ppm), Mn (1341 ppm), Cu (246 ppm), and Ba (344 ppm).
SXL-4	**18680**	**209.7 - 209.95**	Previous assay value <5 ppb Au. **New semiquantitative XRF values to 25 ppm, with associated XRF Zn (256109 ppm), Cr (2282 ppm), Fe (124531 ppm), Cd (644 ppm), Co (1102 ppm), and Cu (463 ppm). Cr within moderately magnetic Fe spinel associated with sphalerite(?).**
SXL-4	**18680**	**222 - 222.05**	**No previous assay. New semiquantitative XRF values to 32 ppm, with associated XRF Zn (405674 ppm), Cr (3653 ppm), Fe (142579 ppm), Cd (803 ppm), Co (1219 ppm), and Sb (195 ppm). Cr within moderately magnetic Fe spinel associated with sphalerite(?).**
SXL-4	**18680**	**430.2 - 436.2**	Previous assay value 48 ppb Au. **New semiquantitative XRF values to 114 ppm in stringer, with associated XRF Zn (935882 ppm), Cr (8383 ppm), Fe (327461 ppm), Cd (1716 ppm), Co (4118 ppm), Sb (318 ppm), and Cu (227 ppm). Cr within moderately magnetic Fe spinel associated with sphalerite(?).**
SXL-4	**18680**	**446.13 - 452.75**	Previous assay value <5 ppb Au. **New semiquantitative XRF values to 40 ppm, with associated XRF Zn (364655 ppm), Cr (3279 ppm), Fe (103241 ppm), Cd (797 ppm), Co (1266 ppm), Sb (132 ppm), and Cu (944 ppm). Cr within moderately magnetic Fe spinel associated with sphalerite(?).**

Drill Hole Summaries

Drill Hole SXL-1 Mn DNR Inventory Number 18682

DDH SXL-1 (Murray Shear) traverses a largely volcanic sequence, of largely intermediate to felsic tuffs. Beside the altered volcanics, SXL-1 contains minor chemical sulfide sediments, and minor intrusions. Volcanics consist predominantly of tuffs, with locally visible pumice or glass fragments (altered). These contain ash to agglomeratic/debris flow sized fragments. Fragments and finer matrix are similar in appearance, making volcaniclast sizes difficult to discern. Rocks appear to be predominantly intermediate to felsic in nature, with increasing mafic material toward the base. Coarser volcaniclasts tend to be more felsic (or at least these are easier to differentiate from the matrix). Bedding tends to be rather nebulous, but appears to parallel a general fabric flattening. Grading is not reliably discernible.

Entire drill core shows alteration, with the fairly ubiquitous Fe-Mg minerals (chlorite and local amphibole). These minerals may possibly reflect a fairly ubiquitous alteration, and, or, an intermediate nature (andesitic??) of the original volcanics. Coloration is predominantly shades of grey with lesser green-grey; indicating a somewhat more magnesic (relative to iron) general character compared with that of normal metabasalt greenstone. Limited previous whole rock analyses verify this (to 10% MgO), and rocks may be magnesian andesite(?) or boninite(?). The entire sequence may also be more felsic than indicated, however, with the alteration giving the appearance of a more Fe-Mg rich rock. Volcanic fragment/clast coarseness may also be greater than described. Appearance similarities of fragments and matrix (except for coarser fragments of more felsic parentage) may hinder accurate descriptions. Weathered outcrops may well display textures better.

Previous analyses extended some beyond gold, with other metals, trace elements, and whole rock analyses sporadically. Only areas with greater sphalerite were more thoroughly sampled originally, and this included all XRF gold anomalous areas.

Sulfides consist of pyrite-chalcopyrite-sphalerite stringers (with magnetite?) and more typically stratiform laminae(?) with less copper. Local black chlorite ("black schist" appearing) alteration occurs, with mantling of sulfides by dark chlorite, possibly indicating a VHMS (distal or marginal?) type alteration. This DDH lacked oxide-chert BIF, as at Foss Lake, but minor, often disrupted, "chert" laminae (Figs. 25, 26, 27. 28, and 29) occur in the volcanics in proximity to the stratiform sphalerite laminae. "Chert" generally is recrystallized, and could also possibly be disrupted quartz veins or siliceous tuffs. Such "stratiform" laminae could also reflect alteration occurring below the seafloor. There does appear to be a fabric related connotation, but whether this is volcanic-sedimentary or schistosity-tectonic related is unclear.

Semi-quantitative XRF analyses of the various sulfide laminae, stringers, and clasts did not show measurable gold until about 231.05'. A single, 1 cm sphalerite lamina with volcaniclasts/fragments indicated anomalous Au, so a series of analyses were done. Adjacent sphalerite laminae were not Au bearing. The gold bearing interval correlated well with anomalous chromium, zinc, antimony, cadmium, and mercury. Spot semi-quantitative XRF gold values were as high as 148 ppm; along with chromium to 10618 ppm; zinc to "100%"; antimony to 607 ppm; and cadmium to 2983 ppm. Mercury was generally elevated in the drill core, but not as specifically to the anomalous gold. Elevated tin also occurred sporadically. The high Au interval had not been previously sampled, so it will be interesting to compare with eventual assay values with the semi-quantitative XRF values. The highest previous assay for Au was 294 ppb over 3 feet. Whether gold was depositional with the sphalerite, or later introduced, is uncertain. Other occurrences of anomalous gold and sphalerite were found downhole.

Extensive semi-quantitative XRF analyses were carried out to try to discriminate mineralization, and also to test the instrument regarding this scale of mineralization. The digital logs currently being created are fairly general, with more specific descriptions being maintained with the XRF records, making the comparison with real-time chemistry easier for the data consumer. Differences between my descriptions and the original company logs should induce geologists to examine the core themselves. The semi-quantitative XRF analyses typically center on specific features, although background (especially matrix) chemistry were also sought. Individual background values *may* represent difficult-to-distinguish individual lapilli, however, and should be viewed in this context.

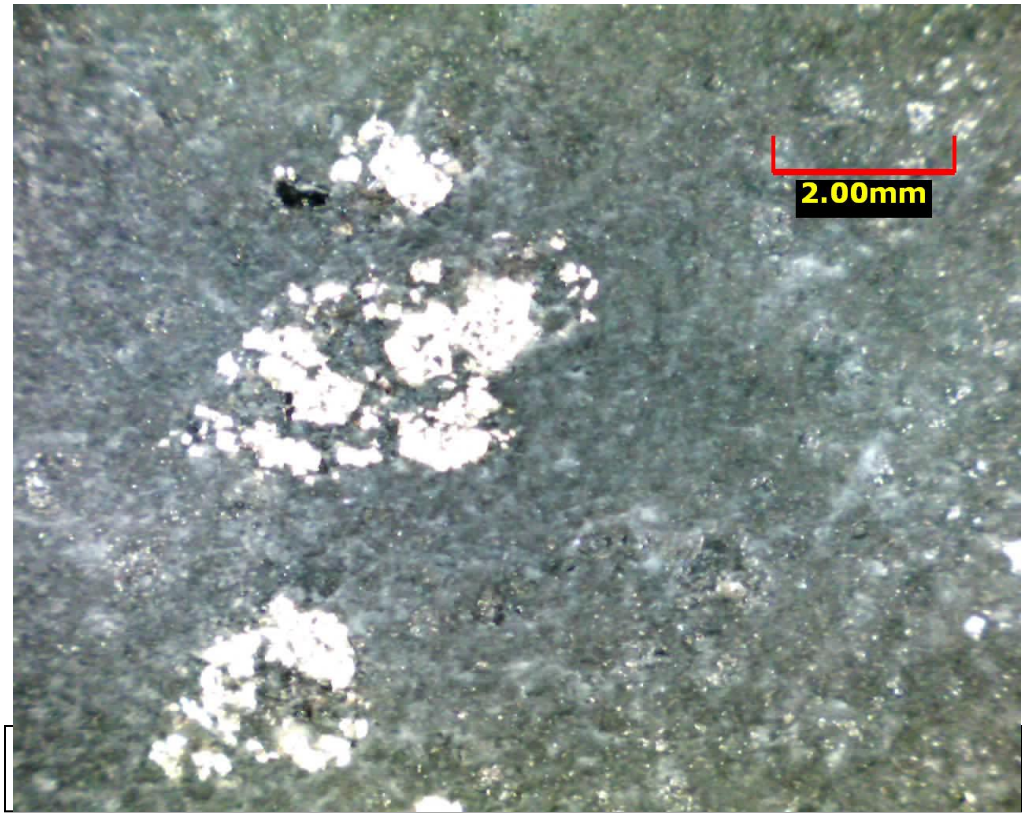
Sulfides in SXL-1 are fairly abundant, but generally <10% within the tuffs. Massive sulfides more than a cm are rare. All sulfides can occur together, but in general, the sulfides occur as the following different modes:

1) **Stratiform laminae**, typically of sphalerite (often siliceous) and, or disseminated magnetite or pyrrhotite. These may be chemical sediment laminae formed on the seafloor, sub-seafloor alteration, or shear related. Some sphalerite laminae are gold bearing (elevated Cr, Sb, Cd); others are not (also less Cr, Sb, Cd, Zn?). The highest XRF Zn and Au values are associated with sphalerite lamina with disrupted to fragmental quartz. This may be vein quartz or recrystallized chert, and fragments may represent primary, tectonic, or hydrothermal brecciation (Fig. 25). The laminae are somewhat magnetic, probably from magnetite(?) or pyrrhotite(?). Core is moderately magnetic locally. Sphalerite may be zoned. Disseminated sphalerite-bearing portions may be footwall alteration below the ocean-volcanic interface (with chloritic alteration); or more syngenetic with volcanic deposition. Au bearing sphalerite associated with chlorite alteration has associated pyrite. Cu may be present with the sphalerite, but the amount is reduced(?) locally in the gold-bearing laminae. Sphalerite could be a trap for gold, brought in through shears.
2) **Generally irregular masses to cross-cutting, often discontinuous, stringers** of mixed sulfide (with pyrite and chalcopyrite predominating). These sulfides often appear to be interstitial (discontinuous stringers?) between volcaniclasts, and formed during (syndepositional) and/or shortly after (alteration) sedimentation. Larger blebs are often adjacent to coarser

volcaniclasts (void filling? by alteration). The highest XRF copper values tend to be with these stringers.

3) **Siliceous sulfide and sulfide "clasts**" (Figs. 16 and 17). Generally less than several cm, often flattened, (otherwise with rounded margins) grains or clasts of pyrite; aligned roughly with texture variations (bedding). Larger (+ 1 cm sized) sulfide clasts tend to be more pyritic and recrystallized. Some "clasts" may be alteration of amygdales(?).
4) **Sulfide bearing quartz eyes(?), amygdales, siliceous grains, or melt inclusions(?)**; typically less than 2 mm in size (Fig. 18); typically sulfide is pyrite, sphalerite, or pyrrhotite(?). May be smaller versions of 3) above. Sulfide, when present, tends to be in grain centers, but also may radiate outward toward the grain margins. Grains could also be possible siliceous melt droplets with immiscible sulfides. Sulfide compositions tend to reflect tend to echo compositions of proximal sulfides occurring as other forms; generally zinc rich or zinc poor; perhaps related to the same genesis.
5) **Remobilized veinlets**, small scale and small in importance(?).

Figure 16. Siliceous sulfide "clasts"(?) in SXL-1 @ 300.35'.



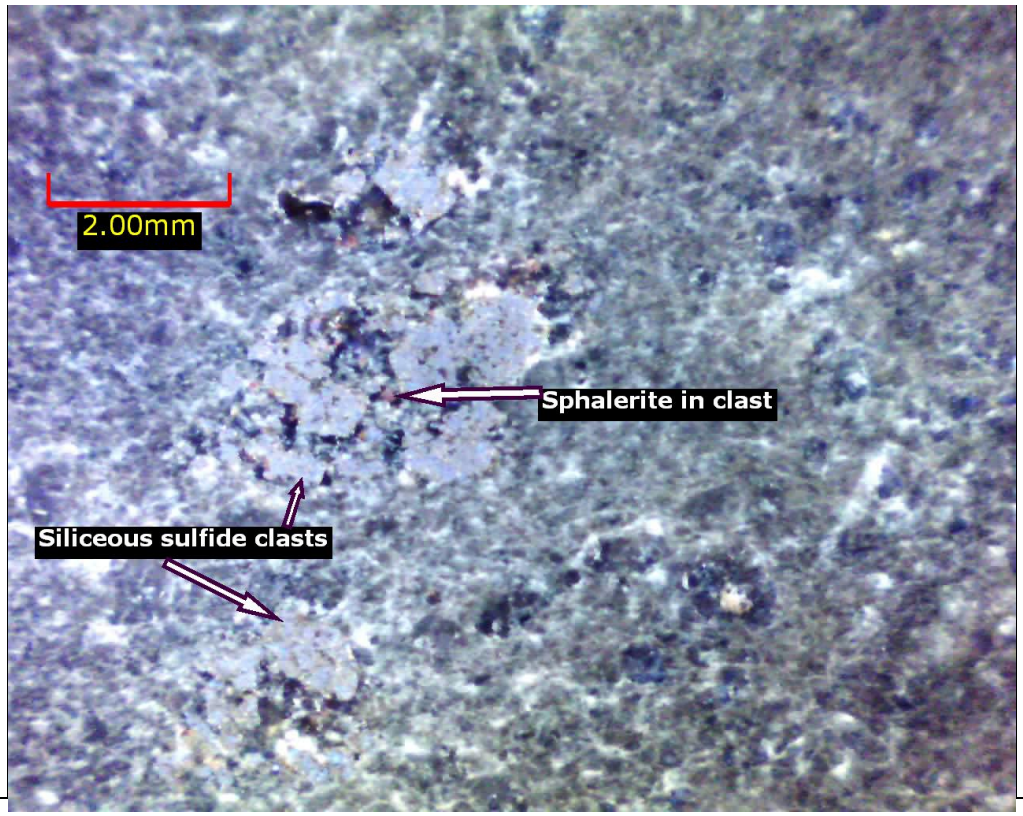


Figure 17. Same siliceous-pyritic "clasts" w/ different lighting.

DDH SXL-1 Alteration

The volcanics are calcareous above about 230' (decrease downward?). Below this, rock appears to have local (increasing down?) sericitic alteration as indicated also by lesser chlorite; although this may also reflect an increase of more felsic primary material. The chloritic alteration mentioned earlier may be ubiquitous in distribution, but generally minor in amount. Some exceptions occur where the alteration is more intense and forms a local "black schist" (Figs. 19 and 20). These places are minor and typically are .1' or less. Sulfides, especially cross-cutting stringer sulfide (higher copper, Fig. 24) may be associated with the black schist. This can be cross-cutting, but in some cases, chloritic areas are more stratiform in orientation. It also occurs as small grains/fragments. These appear to be either sedimentary or reworked grains, or (more likely?) more readily altered (glassy?) fragments (Figs. 21, 22, and 23). Mg cannot be analyzed by the XRF, however the XRF indicates that this chlorite alteration is enriched in titanium, manganese, and chromium (with iron also, of course). Base metal values may also be elevated within the chlorite on the order of several hundred ppm.

Our XRF work has found several sphalerite laminae/shears/veins in SXL-1 with elevated gold, including some not previously analyzed. Attention was paid to associated features with the hopes of providing clues to potentially greater mineralization, such as distally along strike or stratigraphically higher or lower.

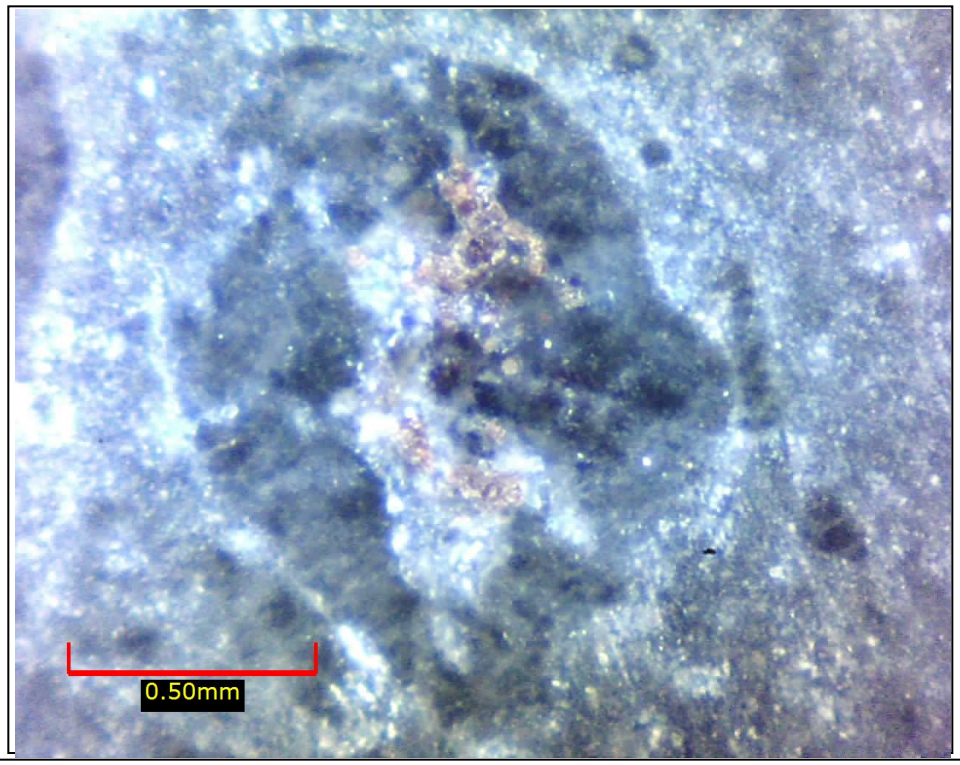


Figure 18. Sphalerite in quartz eye(?) in quartz eye in tuff: DDH SXL-1 @ 231.08'; between the sphalerite lamina with gold and sphalerite lamina without gold.

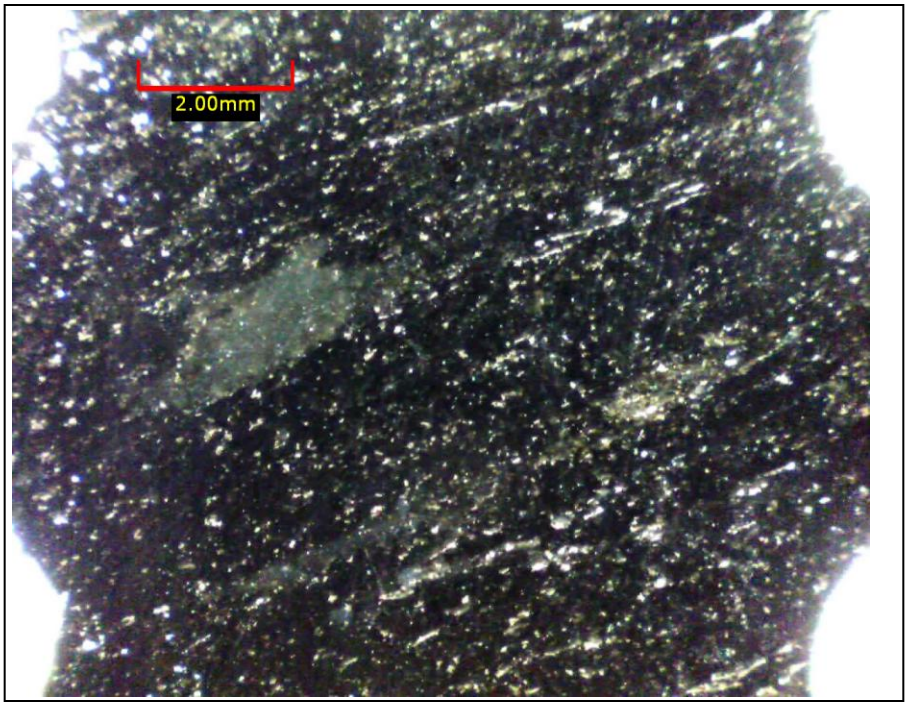


Figure 19. Black chlorite schist alteration/layer in DDH SXL-1 @ 264.4'.

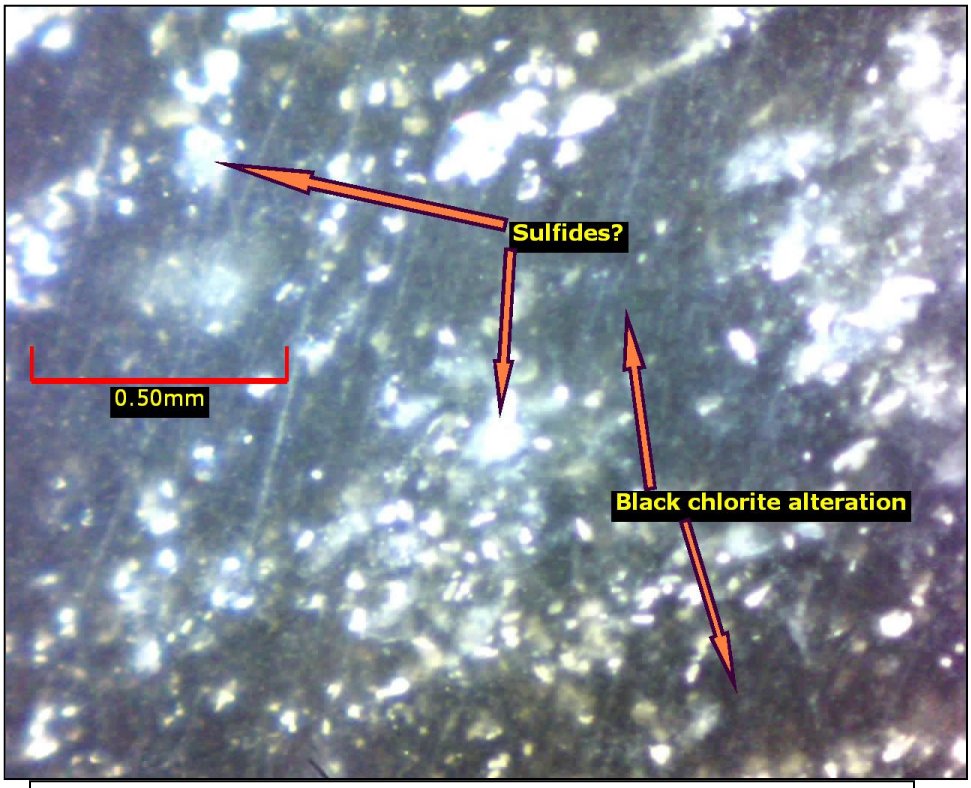


Figure 20. Enlarged view of "black schist" in Figure 19.

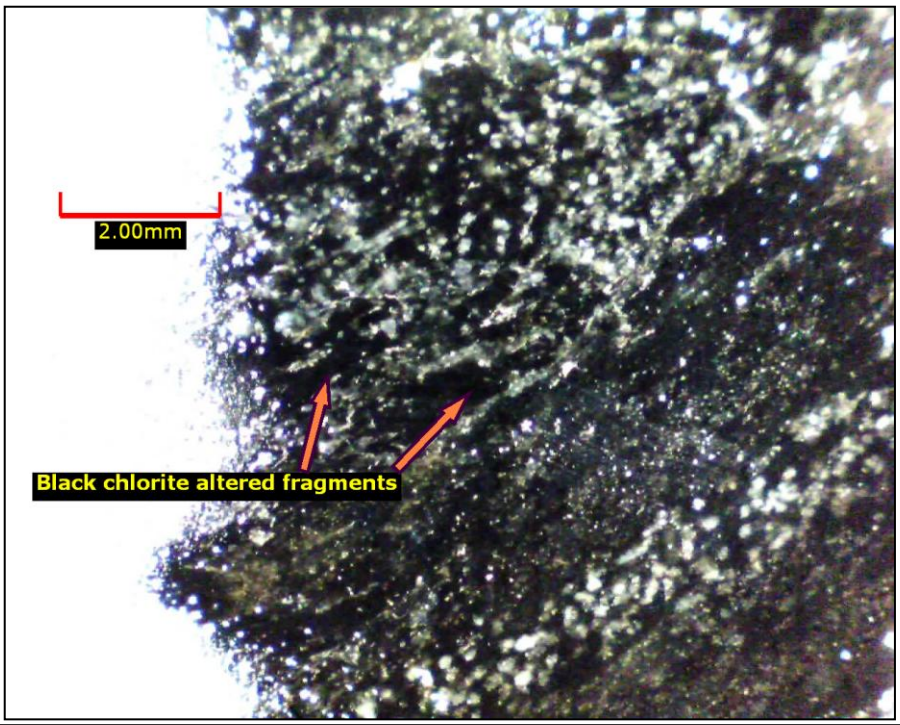


Figure 21. Chlorite altered fragments in DDH SXL-1 at 264.4'.

The differentiation of sulfide rich (Fe sulfide vs sphalerite) quartz eyes or altered amygdales(?); and disseminated (alteration?) sulfide changes, may be useful.

Finished XRF data for this drill hole (see files XRFMasterP373.xls and XRFAnomalousP373.xls) may allow for the creation of smaller subpopulations of data for analysis and comparison. Features may include lithology, alteration, sulfide type, veins, and selvages. Minor elements, particularly chromium and antimony, from the semi-quantitative XRF may allow for better differentiation of Au bearing sphalerite from other sphalerite. These chemistry generalizations should be used cautiously, and the end-user is encouraged to view the data in the context of their own priorities.

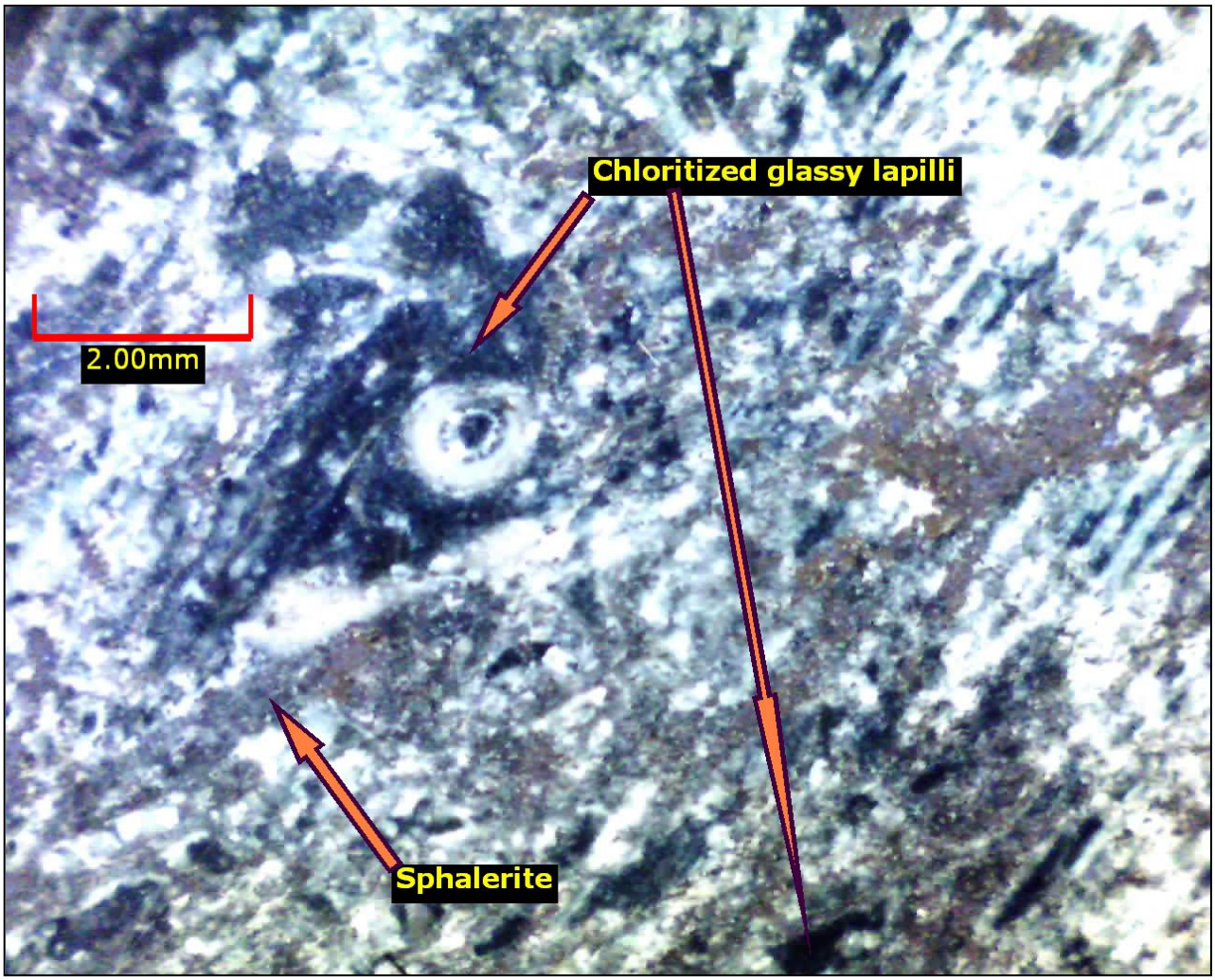


Figure 22. Chlorite altered glassy tuff fragments in DDH SXL-1 at 264.4'.

Other XRF analyses in SXL-1 with high zinc (to 67982 ppm), but non-detectable Au; lacked the Sb and Hg. The Cr and Cd was reduced, but proportionately present.

The highest XRF copper to date in SXL-1 is 26192 ppm in stringer sulfides w/ pyrrhotite(?), magnetite(?), and pyrite. This stringer sulfide also has variable Zn, generally lower than the copper.

The sphalerite in SXL-1 is typically reddish, although it may be zoned with darker centers (more Fe (?) rich).

Figure 23. Same as Figure 22 but different illumination.

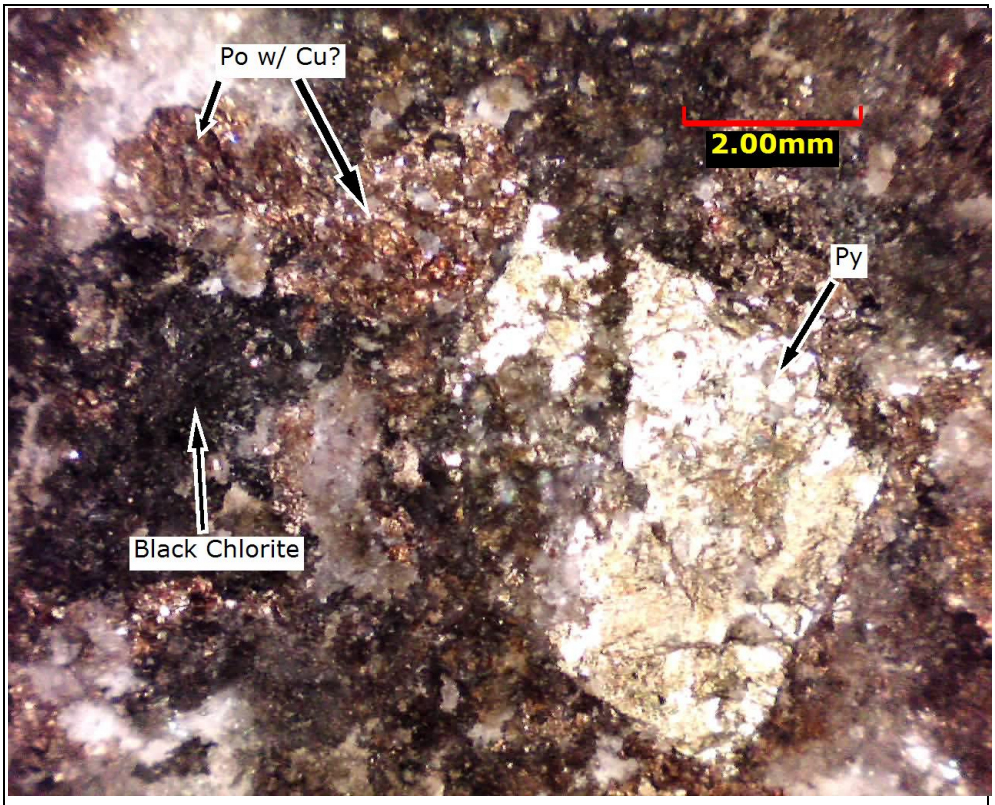


Figure 24. Black schist alteration in tuff; DDH SXL-1 @ 99.3'.

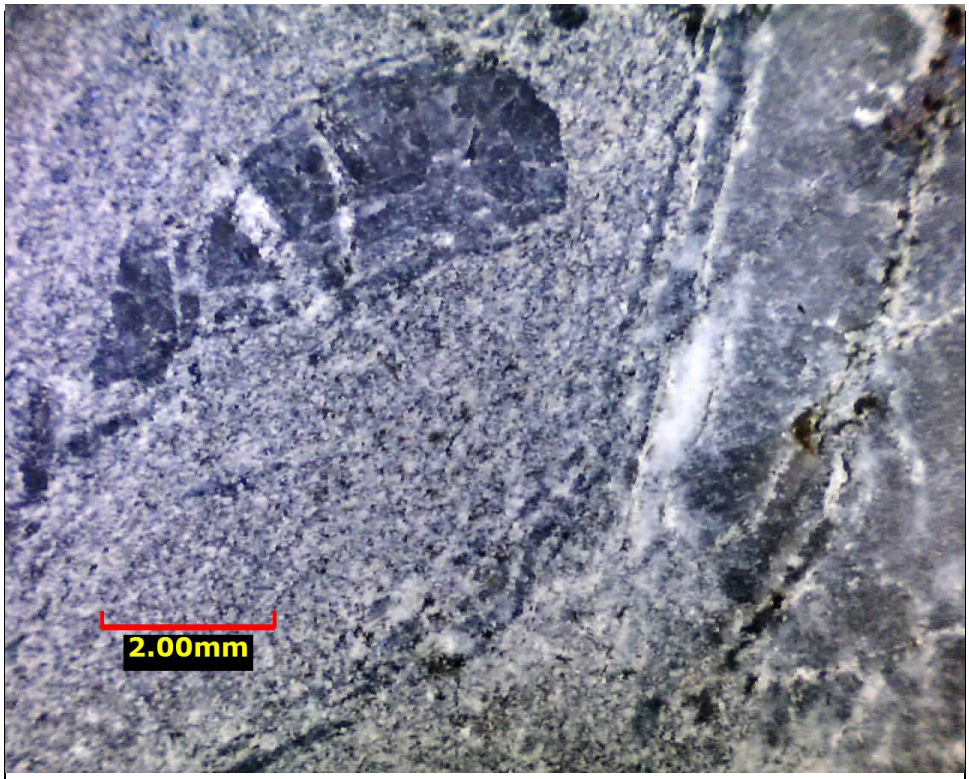


Figure 25. DDH SXL-1 @ 172.6' showing disrupted chert lamina in tuff.

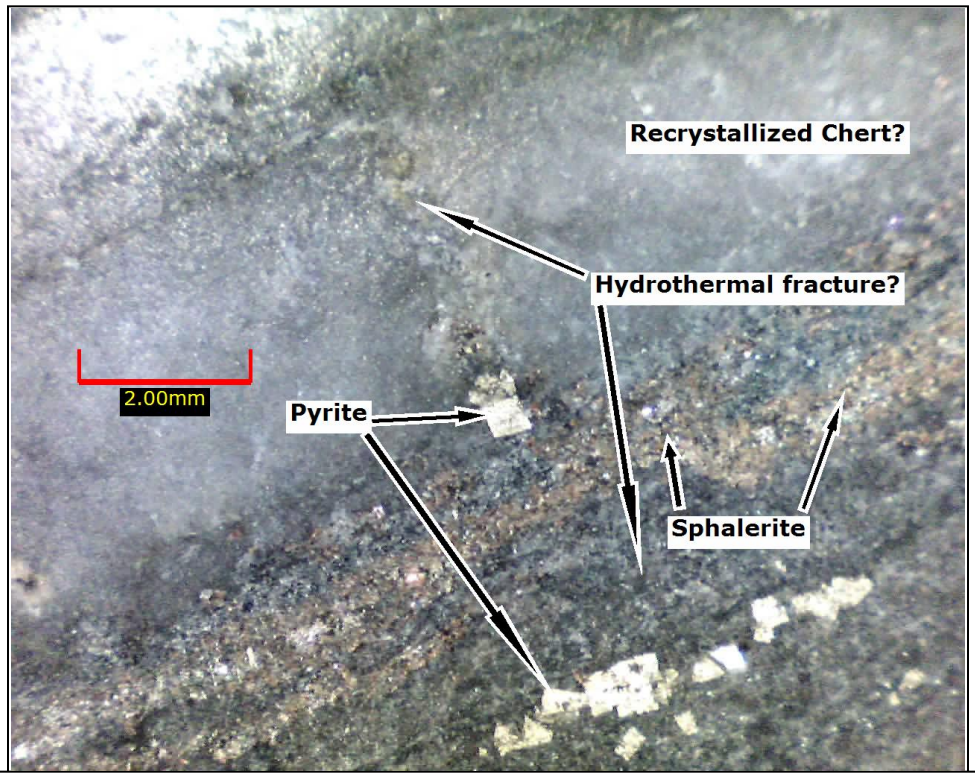


Figure 26. DDH SXL-1 @ 174' showing recrystallized chert layer and sphalerite lamina.

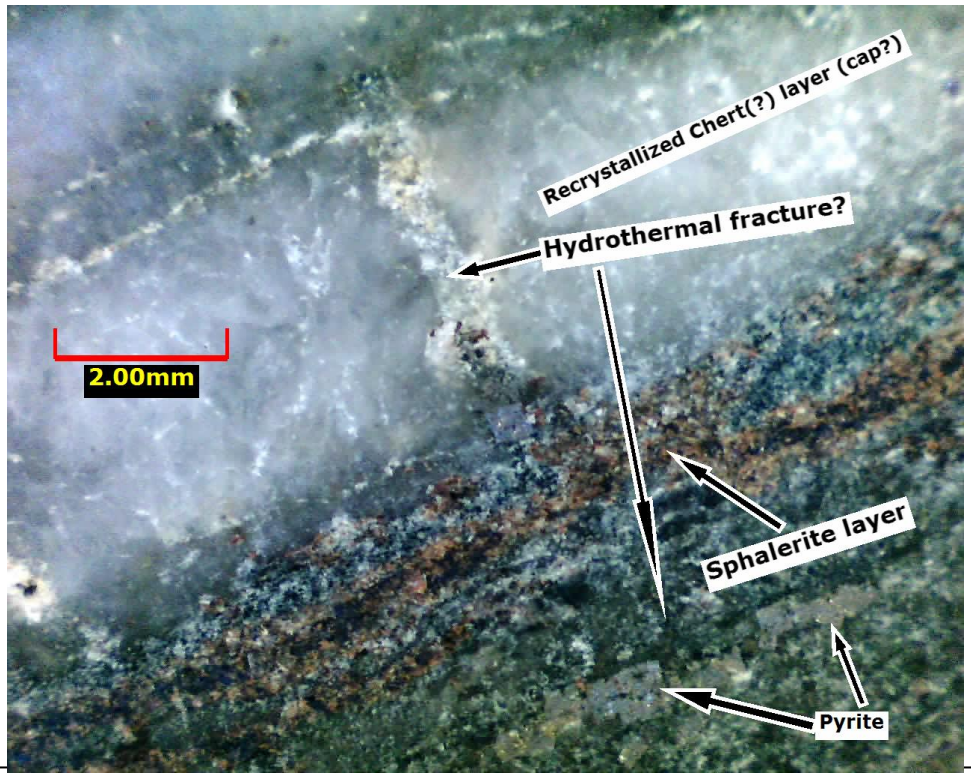


Figure 27. DDH SXL-1 @ 174' ; same view as Figure 26 except using a different illumination

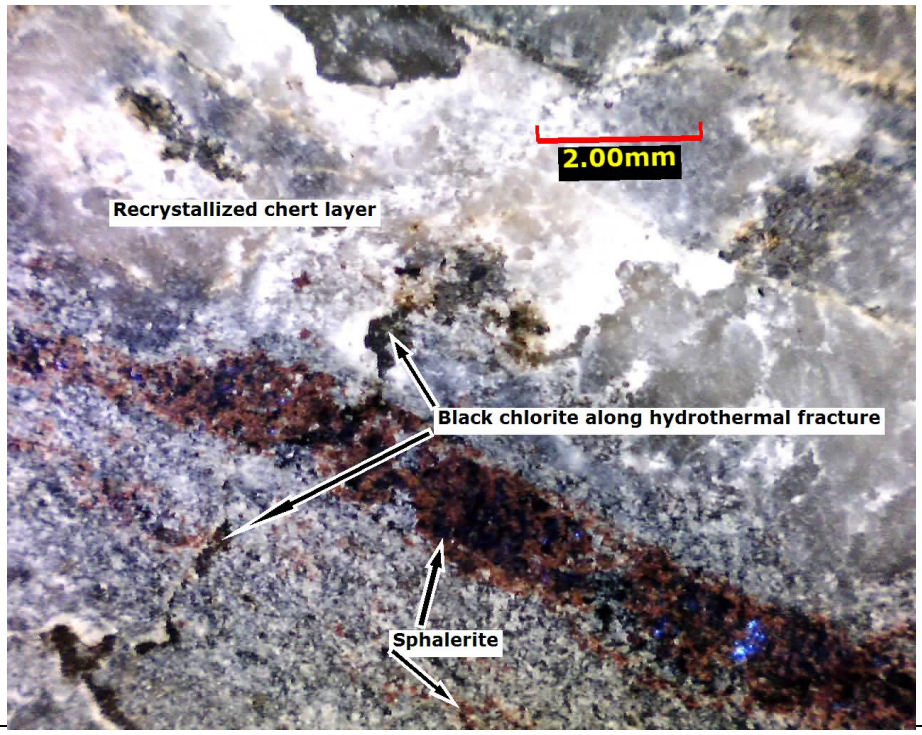


Figure 28. DDH SXL-1 @ 174'; Chlorite stringer cross-cutting sphalerite and chert lamina.

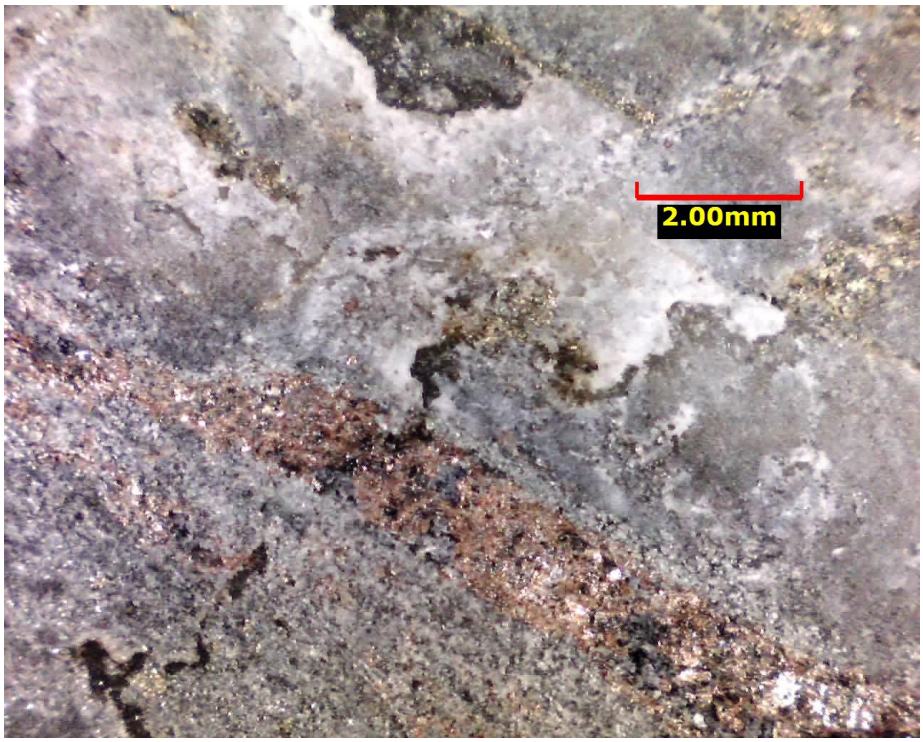


Figure 29. Same view as Figure 28, but different illumination.

Figures 30 and 31 show two siliceous sphalerite laminae/veins with brecciated(?) quartz. Quartz may be recrystallized cherts, or siliceous tuff . The lower (wider) sphalerite is gold-bearing, and the upper (narrower) one is not gold bearing. The sample vertical dimension is 3.6 cm.

Figure 30. Comparison of gold-bearing and non-gold-bearing sphalerite and brecciated chert, felsic volcanics, or quartz vein(?). Rock is dry.

Quartz fragments are recrystallized and relatively transparent. A thin section may help with residual textures. I think a chert or silicified tuff are the most likely protoliths. Figure 31 is the same as Figure 30, except the rock has been wetted.

Drill Hole SXL-4 **Mn DNR Inventory Number 18680**

This drill core was similar to SXL-1 with regard to the gold mineralization format. An empirical observation is that there are fewer(?), minimally disturbed sphalerite laminae. They also tend to be at a lesser angle to the core axis, and they tend to be more brecciated and fragmental than in SXL-1. There is also proportionately more stringer and irregular interstitial sphalerite.

Dark chlorite and calcite alteration may be more ubiquitous, and even semi-pervasive, but the amount of intensely focused black schist may be less than in

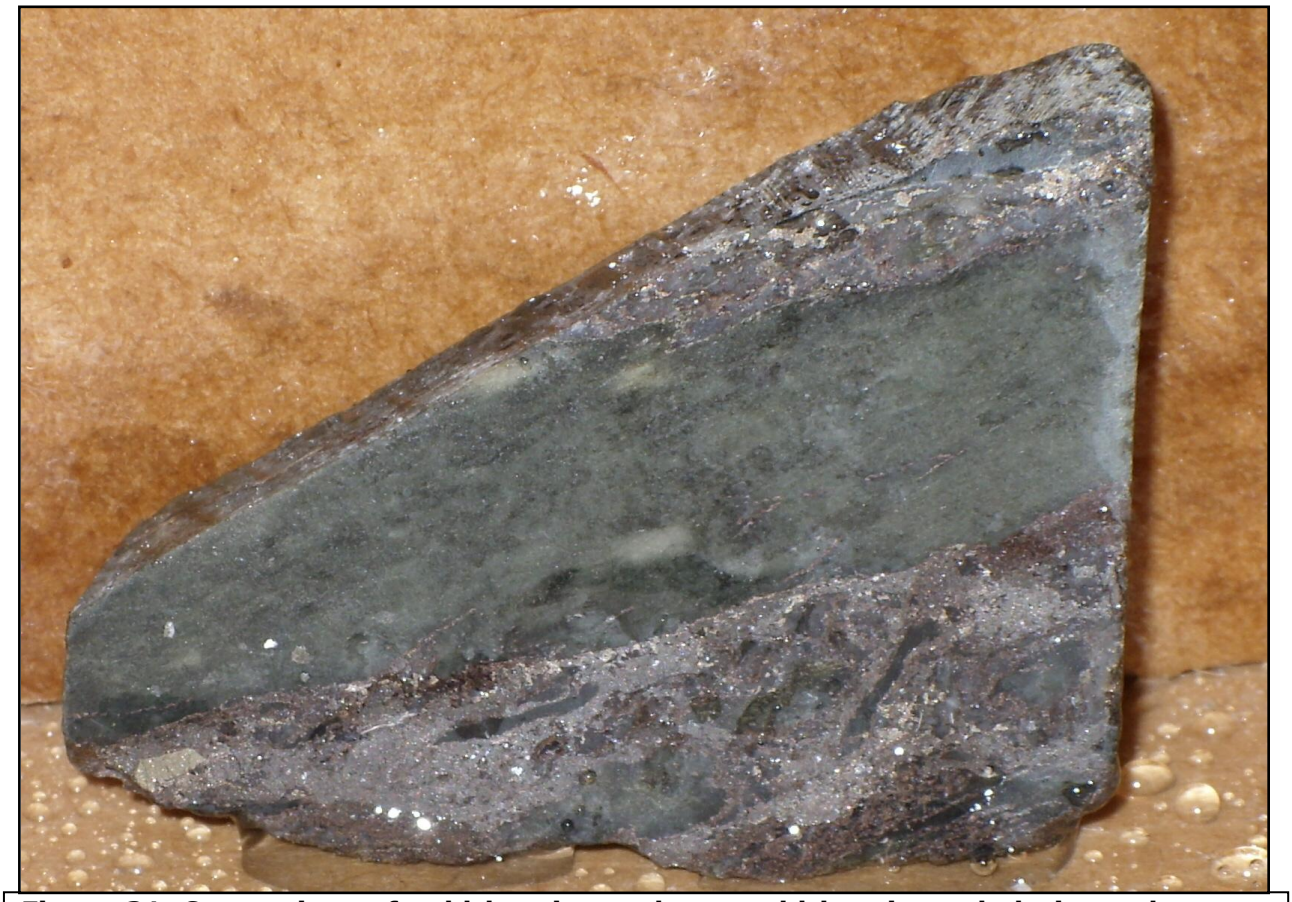


Figure 31. Comparison of gold-bearing and non-gold-bearing sphalerite and brecciated chert, felsic volcanics, or quartz vein(?). Rock is wet. Vertical sample dimension is 3.6 cm.

SXL-1. The total footage of coarser volcanics in SXL-4 may be greater, but the intersecting stratigraphic interval may be different.

Figs. 32, 33, 34, 35, and 36 show examples of sphalerite and gold mineralization in the SXL drill holes, as taken from DDH SXL-4. Semi-quantitative XRF analyses of the two sphalerite-magnetite laminae in Fig. 32 were respectively 63 and 76 ppm gold. In Fig. 33, the more brecciated quartz-sphalerite vein(?) had sphalerite values with 61 and 21 ppm. In Fig. 34, the sphalerite quartz lamina/vein returned semi-quantitative XRF analyses between of 8 and 109 ppm. In Figure 35, a larger (about 1x1.5 cm) void filling of sphalerite with a chalcopyrite-pyrite center returned semi-quantitative XRF analyses of 28 ppm gold. Close-by analysis of the chlorite-sphalerite altered country rock had a reduced zinc value and no measurable gold. In Figure 36, the disturbed-brecciated quartz and sphalerite returned semi-quantitative XRF analyses of 60 ppm.

The gold mineralization may have a more primary component whereby the gold is deposited with *some* sphalerite. The "laminae" sphalerite and gold appears to have a fabric relationship. If not related to bedding, then perhaps the first schistosity that generally parallels bedding. The sphalerite could be acting as a trap for gold during later deformation/faulting and hydrothermal movement.

Figs. 37 and 38 show the close up texture of the sphalerite-magnetite-quartz laminae. Note that semi-quantitative XRF values for chromium may be magnetite hosted. Magnetite and pyrrhotite appear to be very fine-grained.

Figure 32. Sphalerite laminae in DDH SXL-4 @ 143.1', associated with shear (or ashy tuff(?) laminae) and brecciated quartz veins(?). Vertical sample dimension 3.6 cm.

Figure 33. DDH SXL-4 @143.45' showing brecciated chloritic volcanics, sphalerite, and quartz. Sphalerite filling voids(?).

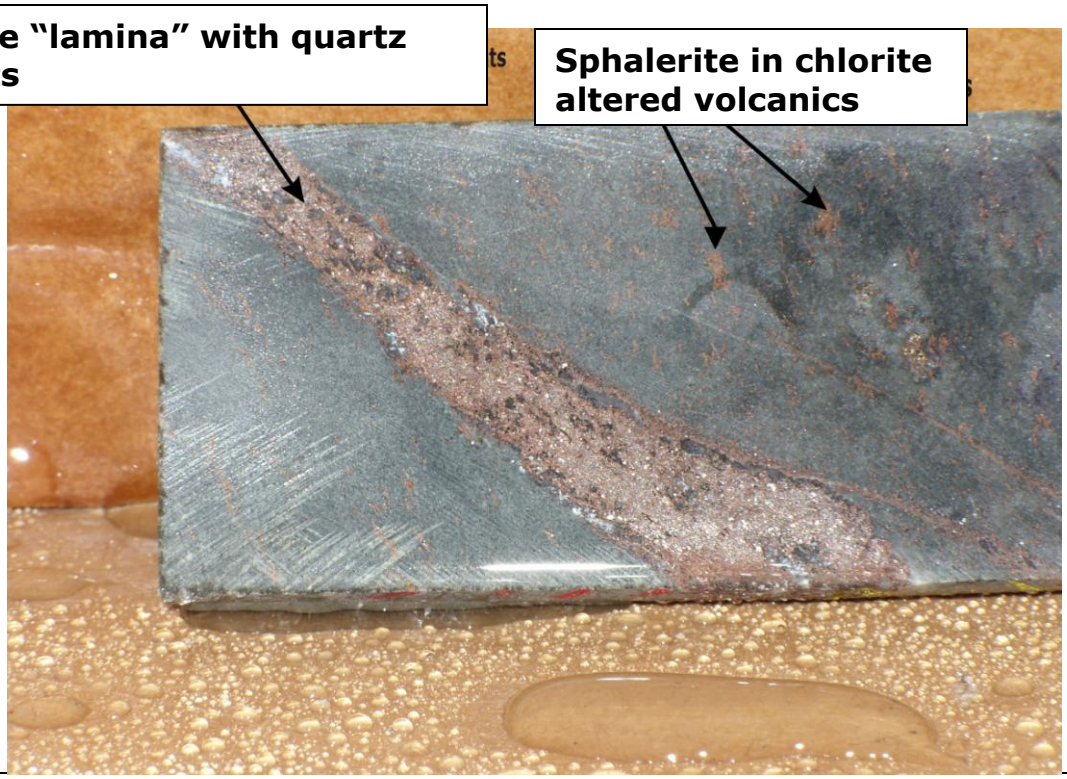


Figure 34. DDH SXL-4 @ 297.0'. Showing sphalerite "lamina" with brecciated quartz pieces, and sphalerite and chlorite alteration of country rock volcanics. Sphalerite associated with magnetite/pyrrhotite, and is somewhat magnetic.

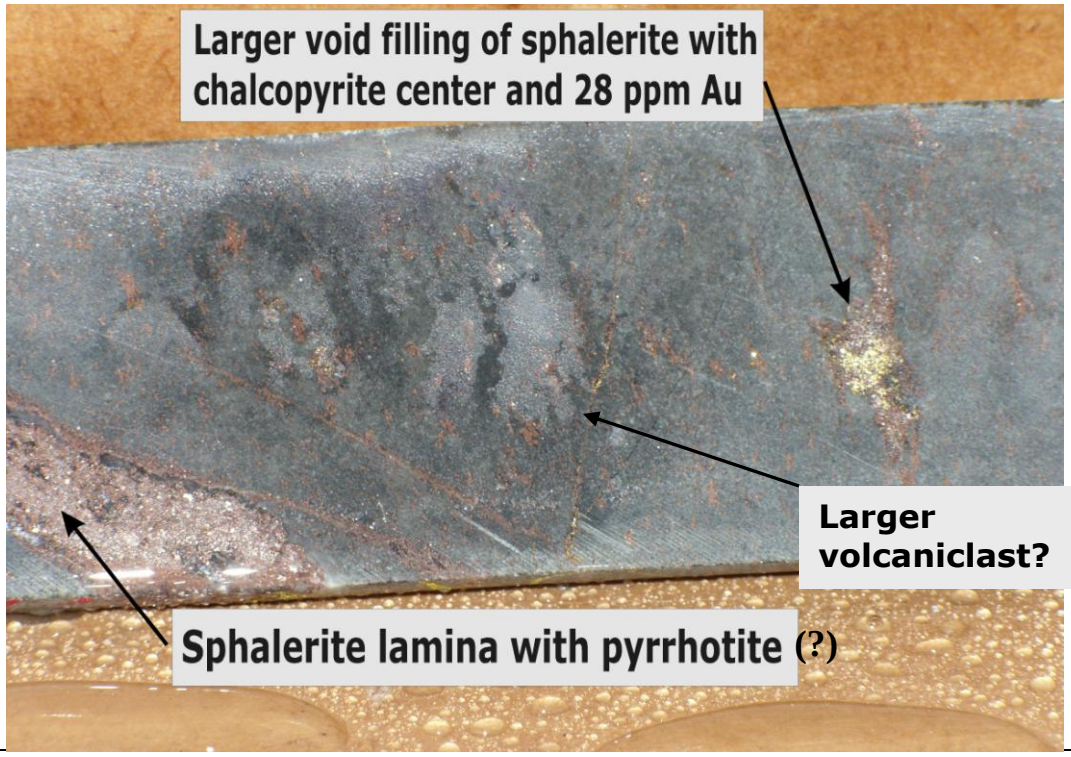


Figure 35. DDH SXL-4 @ 296.65' showing sphalerite "lamina" with brecciated quartz pieces, and larger sphalerite void filling with chalcopyrite and pyrite center. Vertical sample dimension 3.6 cm. Same sphalerite lamina as in Figure 34.

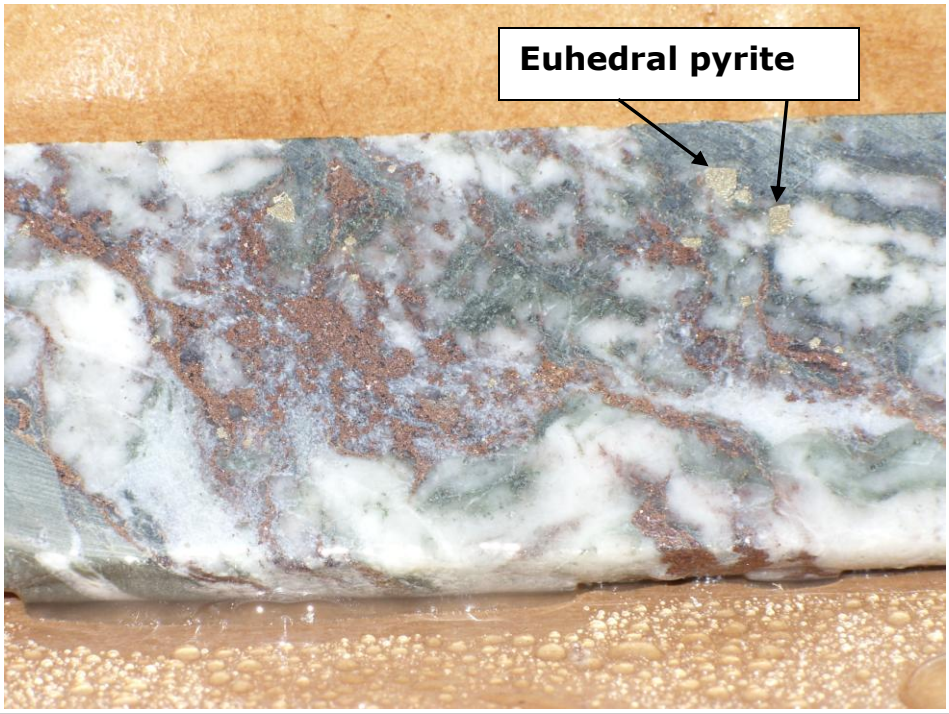


Figure 36. DDH SXL-4 @ 414.8' showing disturbed to brecciated reddish sphalerite, quartz, pyrite (some euhedral faces), minor calcite, and chloritic country rock. Vertical dimension of core is 3.6 cm.

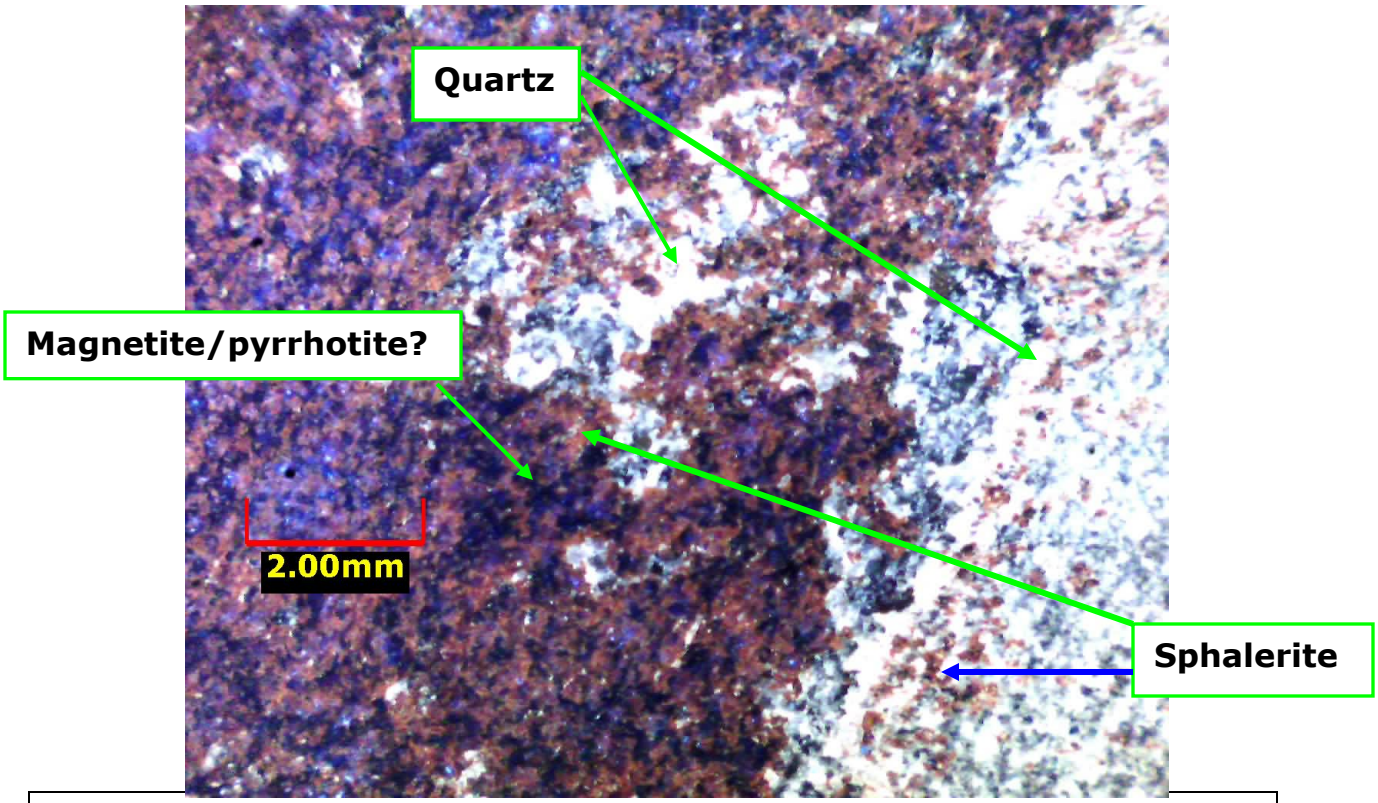


Figure 37. DDH SXL-4 @ 297.0' showing internal structure of reddish sphalerite "lamina" with brecciated(?) quartz pieces.

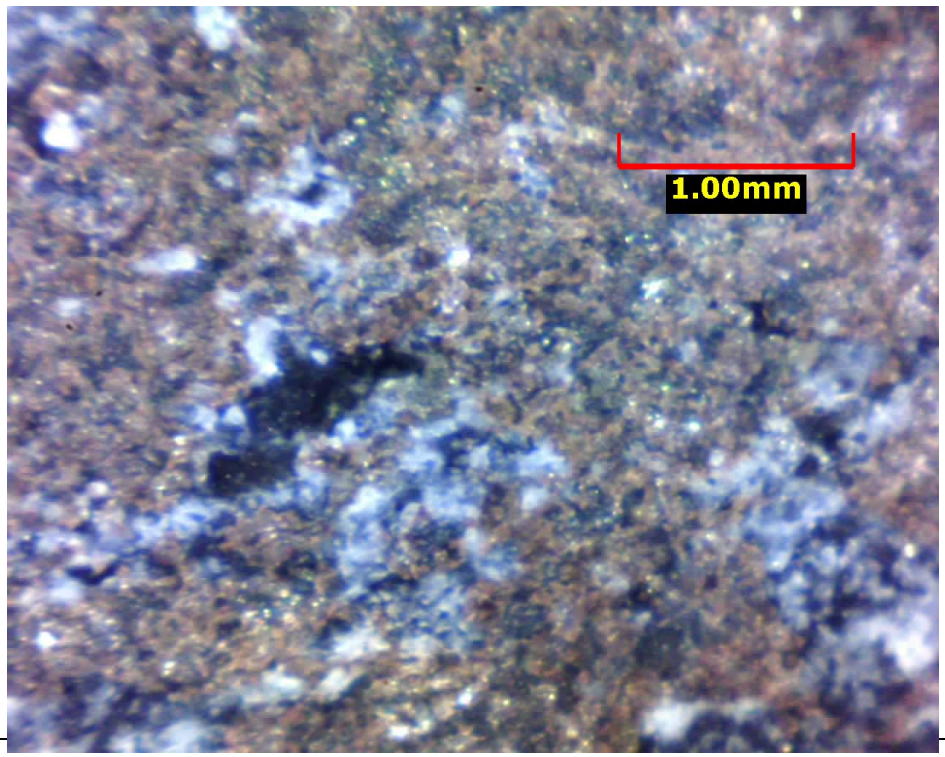


Figure 38. DDH SXL-4 @ 297.0'. Showing internal structure of reddish sphalerite "lamina" with brecciated(?) quartz pieces. Pyrrhotite is very fine-grained.

Drill Hole FM-5 **Mn DNR Inventory Number 14469**

Rocks consist of altered, probable felsic tuff, metabasaltic rocks, and multiple dacitic porphyry intrusions. These have been sheared and are locally mylonitic, especially at the porphyry and volcanic schist contacts. Porphyries are variably sheared and altered. Tuff is typically schist of chlorite, sericite, iron carbonate, green mica, goethite, pyrite, and quartz. Some tuff fragments look glassy and perlitic. A previous elevated gold assay was centered on a quartz, iron carbonate, goethite, pyrite vein. Chlorite is often replaced by sericite near quartz veins, and Fe carbonate is altered to hematite. Pyrite tends to increase near veins, and rutile was found locally in the veins. Beside sericitic alteration, fuchsite was also locally present.

Semi-quantitative XRF results indicated three zones with measurable gold (<10 ppm). One was within metabasalt; one in the sheared tuffs; and one in the deformed dacite porphyry. Gold associations varied, but generally gold was associated with elevated mercury, molybdenum, silver, and modest chromium (fuchsite).

Figs. 39, 40, 41, and 42 show some alteration types in the felsic lapilli tuffs. Figs. 43, 44, and 45 show deformation and alteration of dacite porphyry as shearing and alteration increase respectively. The more intense the shearing and alteration, the more the tuffs and porphyries tend to look like each other. Figure 46

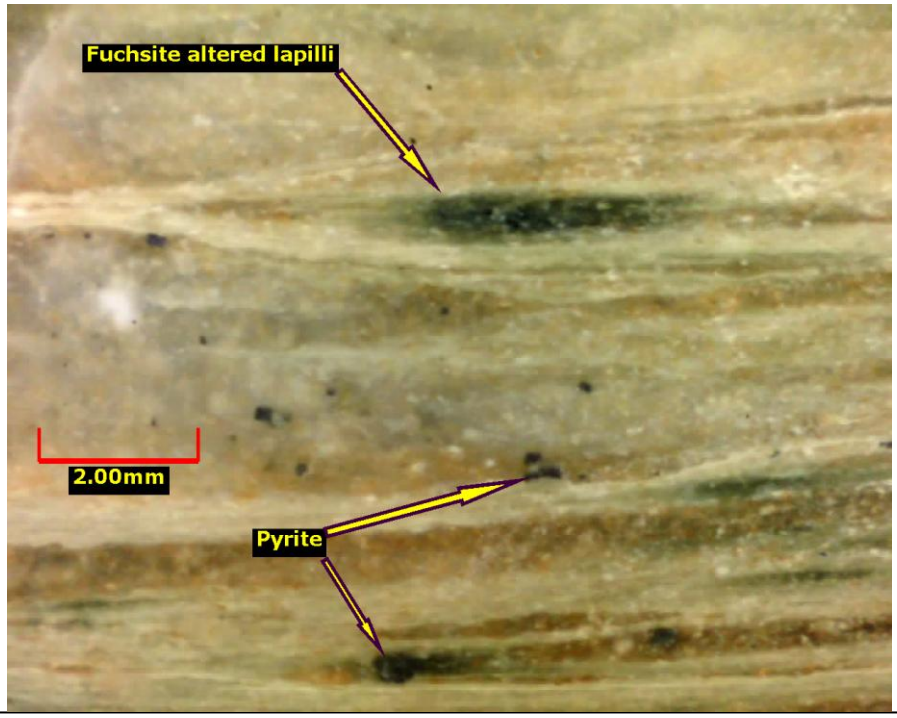


Figure 39. DDH FM-5 @ 247.1’ showing fuchsite altered lapilli in sericite-pyrite altered felsic tuff

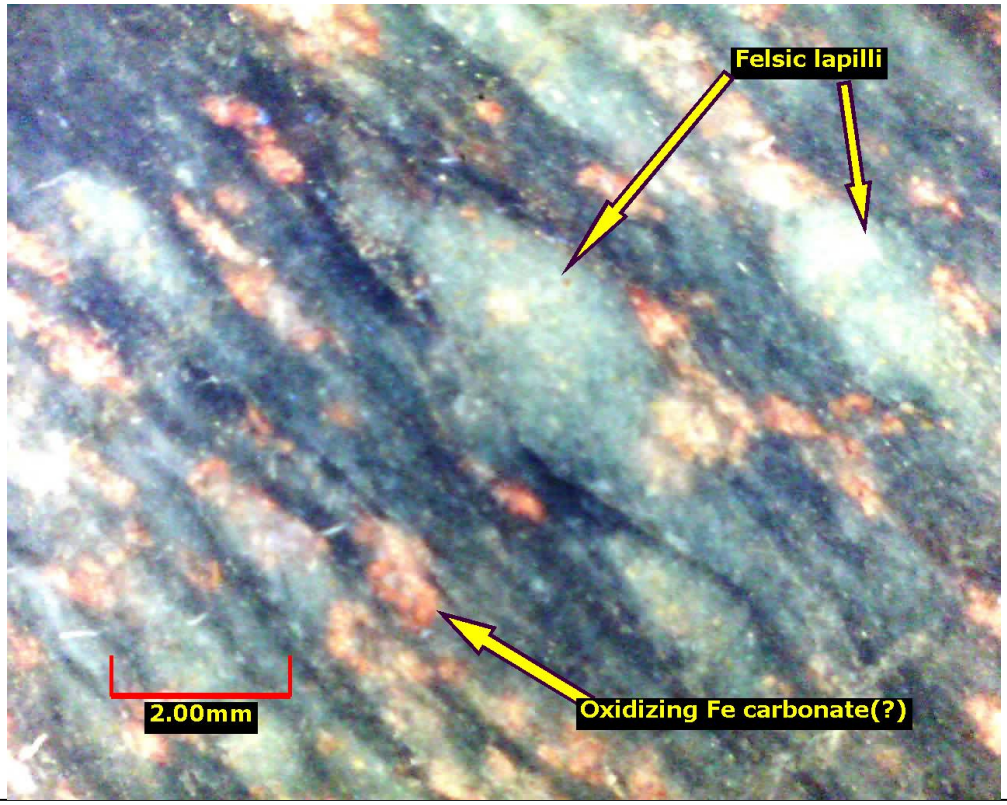


Figure 40. DDH FM-5 @ 172.9’ showing iron carbonate (oxidized) altered felsic lapilli tuff.

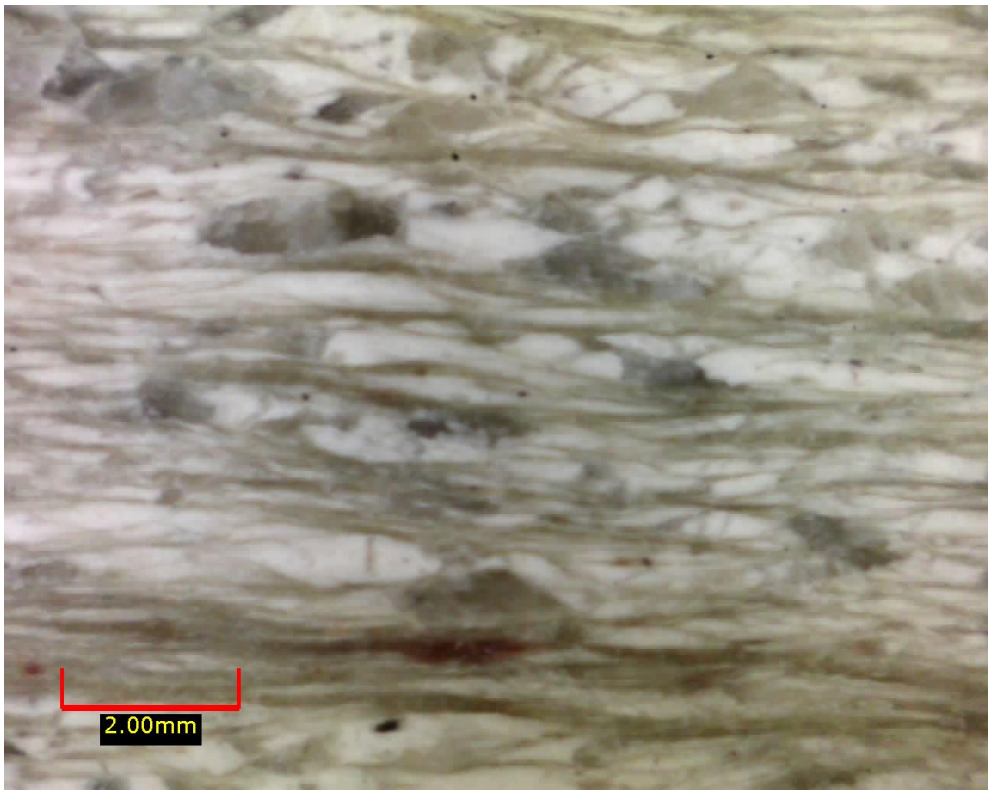


Figure 41. DDH FM-5 @ 181.4’ showing sericite altered, sheared felsic tuff.

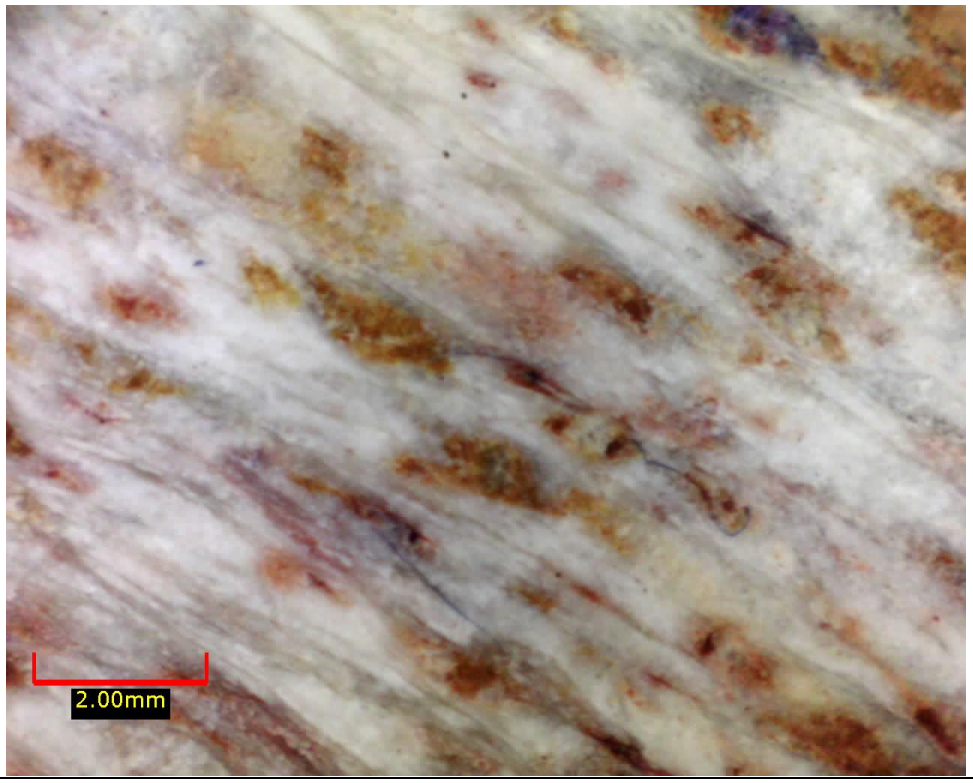


Figure 42. DDH FM-5 @ 182.3’ showing sericite and Fe carbonate altered, sheared felsic tuff.

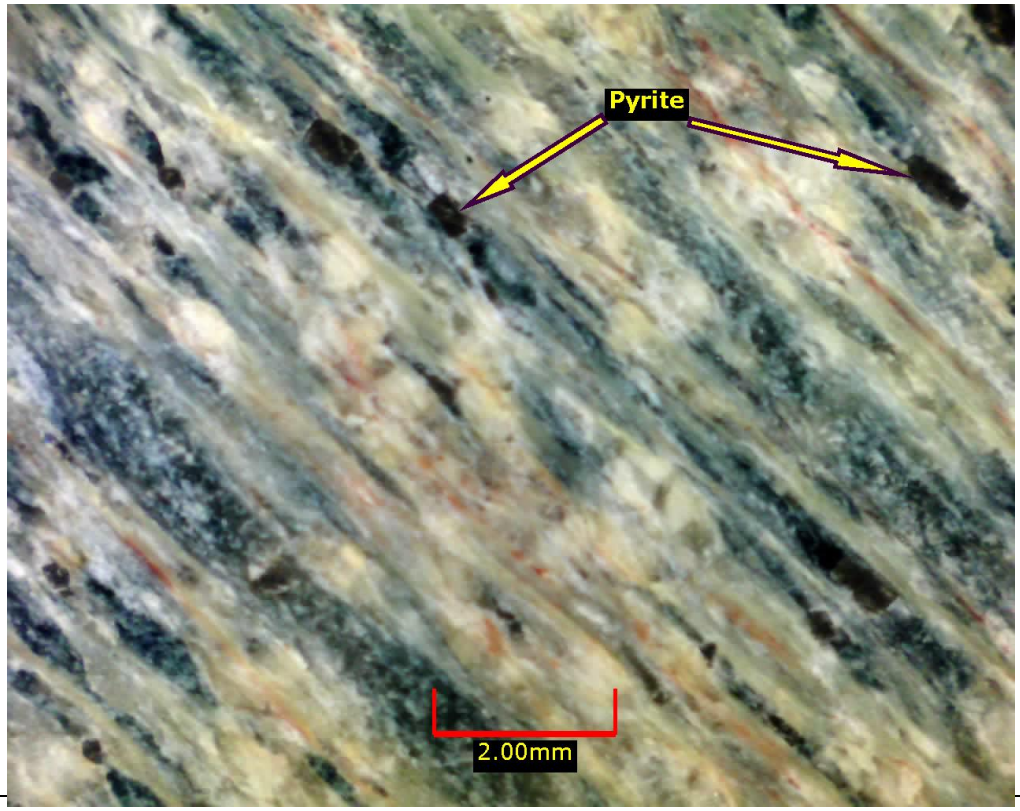


Figure 43. DDH FM-5 @ 187.1' showing deformed dacitic porphyry with sericite and pyrite being added. Mafics being chloritized.

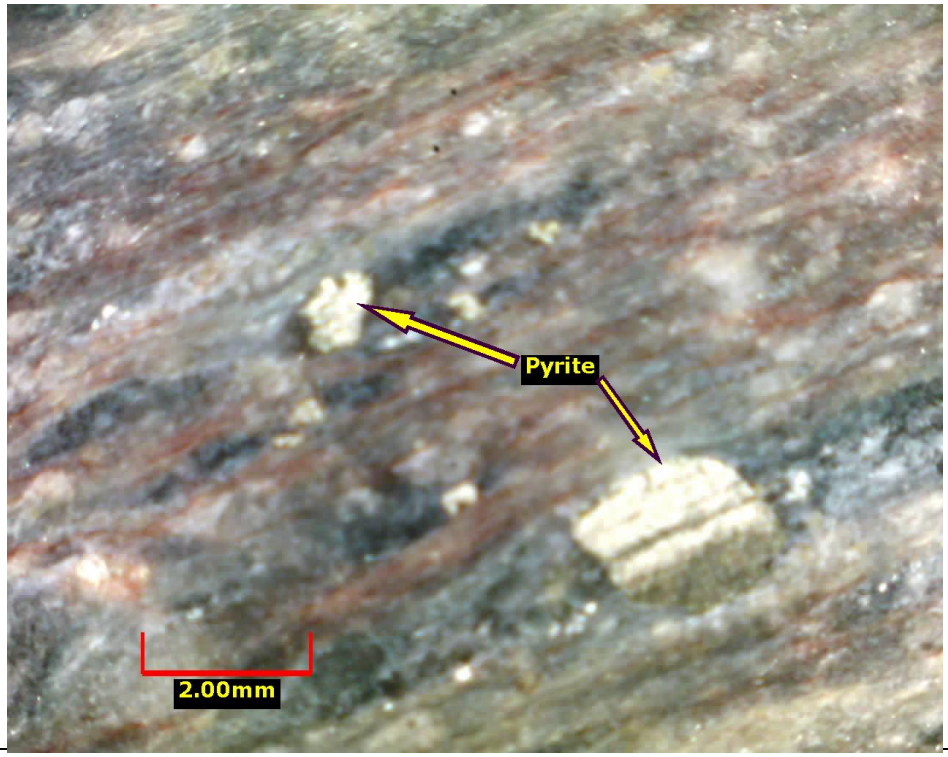


Figure 44. DDH FM-5 @ 195.2' showing deformed dacitic porphyry with sericite and pyrite being added. Mafics being chloritized. More sheared than Figure 43.

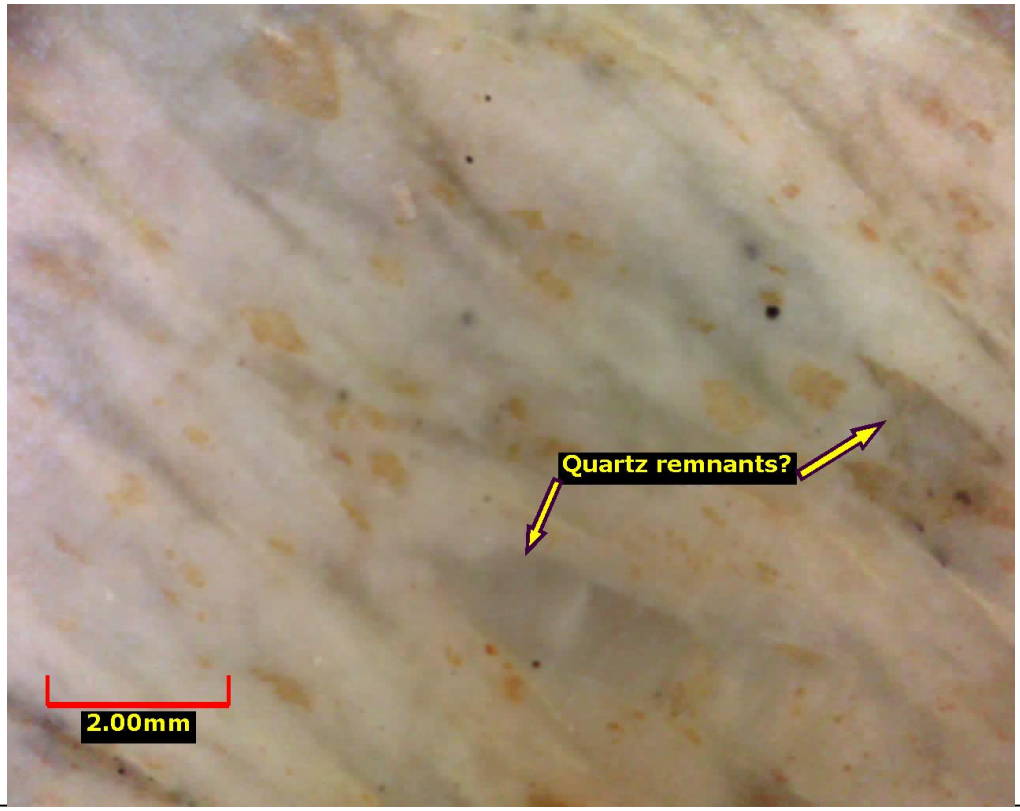


Figure 45. DDH FM-5 @ 191.5' showing deformed dacitic porphyry with extensive sericite alteration. Quartz grains and coarser texture remain.

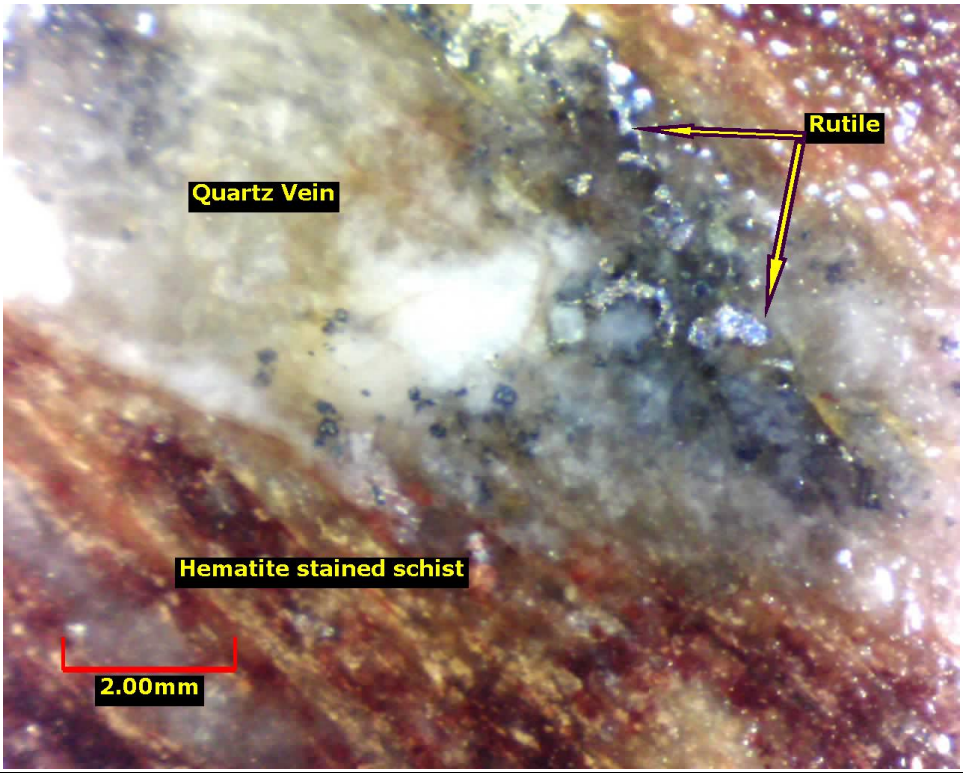


Figure 46. DDH FM-5 @ 174.45' showing quartz vein with rutile in hematite oxidized iron carbonate- sericite schist.

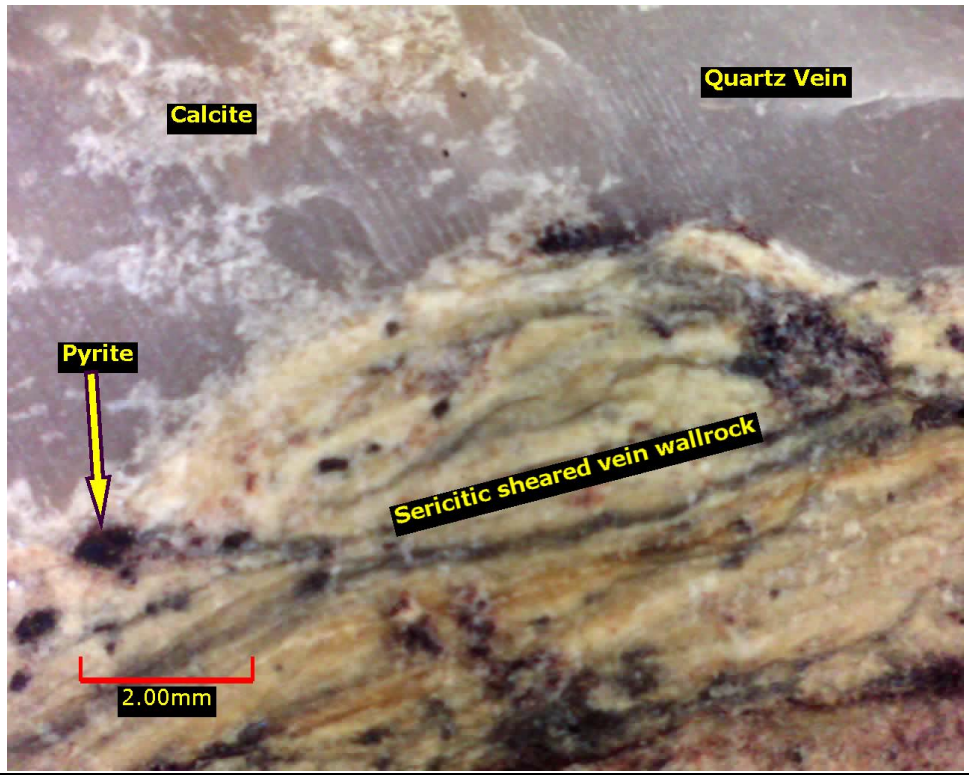


Figure 47. DDH FM-5 @ 174.8' showing sheared margin of quartz vein. Quartz vein is crackled with late calcite filling voids.

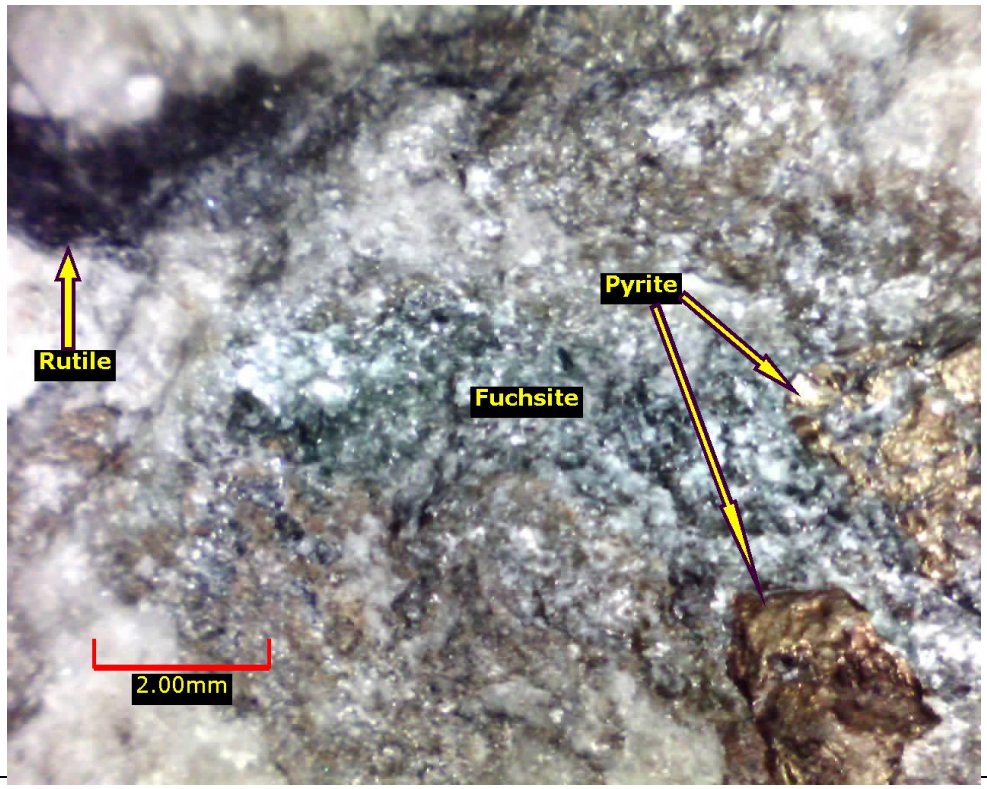


Figure 48. DDH FM-5 @ 253.4' showing rutile, fuchsite, and pyrite grains in quartz vein (see XRF results).

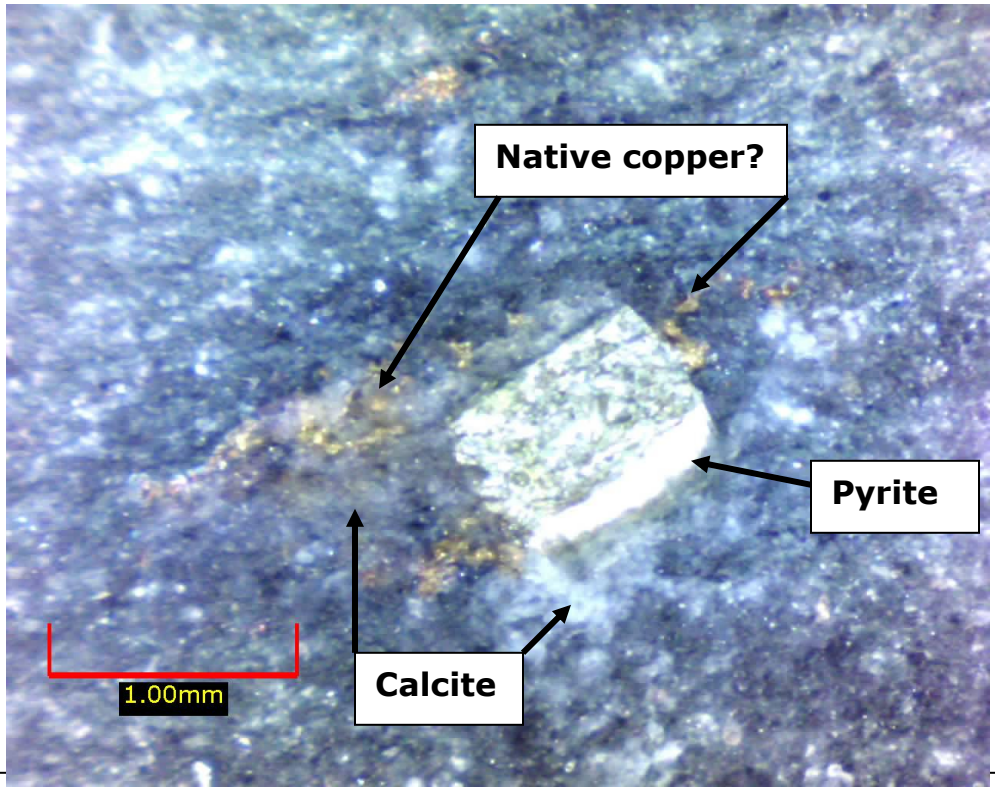


Figure 49. DDH FM-5 @ 144.5' small native copper(?) grains in calcite pressure shadow(?) of euhedral pyrite grain.

shows the irregular form of rutile in a quartz vein. Figure 47 shows the sheared margin of a quartz vein. Figure 48 shows a fuchsite mass with rutile and pyrite in a quartz-calcite-other carbonate vein. XRF data verified the chromium in the fuchsite, and the titanium in the rutile, and illustrates the scale at which the XRF can provide useful data. Figure 49 shows fine-grained native copper grains within the calcite pressure shadow of a euhedral pyrite crystal.

The rock left the impression of lacking volatiles during shearing, and perhaps the measurable but low gold values reflect this.

Spaulding Prospect Summary

Foss Lake Drill hole 6314-36-2, the Spaulding Prospect, the Eagles Nest Shear, and perhaps the Murray Shear drill holes appear to be shear related Au with associated iron carbonate, sericite, minor sulfides and silica. In general, large footages are sheared and altered. The gold distribution appears to be sporadic.

Two drill holes were logged from this prospect, however this area was not included in the proposed current future lease area. Both drill cores contained quartz, sericite, iron carbonate, pyrite schists, probably derived from felsic volcanics. Local sulfide BIF or alteration also occurred. Semi-quantitative XRF gold analyses had values as

high as 378 ppm. Anomalous gold was associated with arsenic and lead with smaller irregular amounts of other metals.

Drill Hole Summaries

Drill Hole 23-9A **Mn DNR Inventory Number 15586**

Rock is sheared altered felsic metavolcanics and sulfide iron formation, with local chert. Rock is now ankerite, quartz, pyrite, sericite schist. Sulfide may be alteration, or shear introduced. Sulfide is mostly pyrite with local arsenopyrite. With depth, proportions change with more sericite and quartz, graphite and chlorite(?); and less ankerite and pyrite.

Semi-quantitative XRF analyses indicate gold (to 489 ppm) increases downhole with the chlorite(?) and graphite, along with greatly elevated arsenic (to 36055 ppm) and base metals (zinc to 13918 ppm, copper to 4817 ppm). Somewhat elevated chromium (to 592 ppm) may indicate that greenish mica may be fuchsite and not chlorite. Mercury is typically elevated (to 16 ppm) except where gold is anomalous.

Drill Hole 23-2 **Mn DNR Inventory Number 15598**

Protolith rock appears to be sheared, interlayered altered felsic, intermediate, and mafic metavolcanics. Rock is now ankerite, sericite, quartz schist with quartz-calcite veins and local pyrite; grading into chloritic to sericitic schist with quartz-calcite veins and local pyrite, and becoming more brecciated and folded with depth.

Semi-quantitative XRF analyses had only one measurable gold sample (to 6 ppm), in a quartz-calcite vein with minor sulfide. This analyses had minor elevated arsenic (to 240 ppm) and lacked base metals except for associated minor elevated molybdenum (to 61 ppm) and manganese (to 6990 ppm).

Miscellaneous Samples

Early sample sets and drill hole materials have been logged, mostly from old drilling associated with Algoma iron formation exploration. Beside iron formation, rocks include mafic and felsic volcanics, less recognizable phyllites and schists, and minor ultramafics (1970 ppm Cr, 2881 ppm Ni). Quartz, calcite veins, and disseminated sulfide are not unusual, as is a variable amounts of tectonism. No measurable Au in the XRF, but As ran as high as 742 ppm, and Cu as high as 1881 ppm. Cobalt amounts are often elevated, occasionally exceeding 5000 ppm. Cobalt appears to be regionally anomalous. Jim Sellner has found maps that have better locations for many of these.

Drill Hole P1256 Mn DNR Inventory Number –not assigned

Consists of three separate rock samples, and are probably outcrop samples. Rock is metagabbro and metabasalt with local felsite veins. The metabasalt sample with the felsite vein was very dark, and semi-quantitative XRF analyses indicated a *more* ultramafic parentage, with chromium values to 3578 ppm, nickel to 646 ppm, and cobalt to 992 ppm.

Drill Hole P1257 Mn DNR Inventory Number –not assigned

Consists of two separate rock samples, and are probably outcrop samples. Rock is metabasalt volcanics or fine-grained intrusive. The metabasalt semi-quantitative XRF analyses did not indicate measurable chromium or nickel. One cobalt value was 1368 ppm. One analysis indicated 2266 ppm barium. Possibly exhibits a distalchemical connection to the Raspberry Prospect.

Drill Hole P1258 Mn DNR Inventory Number –not assigned

Consists of four separate rock samples sets, and are probably outcrop samples. Rock varied from mafic contaminated granodiorite to amphibolite to oxide diorite. Semi-quantitative XRF analyses had variable results as the rock types varied. Results included chromium values to 732 ppm, zinc to 577 ppm, arsenic to 19 ppm, strontium to 1250 ppm, zirconium to 400 ppm, barium to 2859 ppm, molybdenum to 42 ppm, lead to 26 ppm, and cobalt to 1480 ppm. Possibly exhibits a distal chemical and lithologic connection to the Raspberry Prospect.

Drill Hole 2485 Mn DNR Inventory Number 34553

Rock is metamorphosed magnetic BIF; with minor disseminated pyrite. Semi-quantitative XRF analyses indicated a cobalt value of 7984 ppm, and 91 ppm molybdenum, although high iron contents may cause the cobalt contents to appear abnormally high.

Drill Hole 2516 Mn DNR Inventory Number 34623

Crushed rock sample, probably used in iron ore evaluation. Rock is metamorphosed magnetic BIF; with minor disseminated pyrite. Semi-quantitative XRF analyses indicated a manganese values to 9156 ppm, molybdenum to 71 ppm, and cobalt values to 4655 ppm. Whether the manganese is an indication of a more proximal distance to hydrothermal vents is problematic.

Drill Hole 4 Mn DNR Inventory Number 36296

Core exists only for intermittent intervals. Core contains magnetic iron formation with pyrite and chert; metabasalt, and variably magnetic granodiorite with magnetite and mafics.

Semi-quantitative XRF analyses for the iron formation produced elevated manganese (to 6064 ppm) and, or, cobalt (to 6605 ppm). The BIF also had elevated lead towards the base (to 217 ppm).

Semi-quantitative XRF analyses for the granodiorite (mafic contaminated?) and metabasalt varied in amounts and distribution. They included values for barium to 880 ppm; mercury to 29 ppm; molybdenum to 68 ppm; copper to 897 ppm; cobalt to 1959 ppm; manganese to 4531 ppm; and chromium to 1961 ppm. Sulfide in this same material had elevated copper (to 19057 ppm), cobalt (to 1468ppm), and selenium (to 17 ppm).

Drill Hole 3 Mn DNR Inventory Number 35004

Rock is altered, calcareous, schistose dacitic tuff, with disseminated pyrite, quartz veins and sulfides along microfractures.

Semi-quantitative XRF analysis for the tuff has elevated arsenic (to 57 ppm) and cobalt (to 630 ppm) values. The sulfide produced elevated arsenic (to 742 ppm), cobalt (to 1649 ppm), copper (to 196 ppm), zinc (to 162 ppm), and lead (to 89 ppm) values.

Drill Hole 5 Mn DNR Inventory Number 36950

Rock is altered, calcareous, tuffaceous phyllite. Probably is felsic(?) in composition with minor quartz veins.

Semi-quantitative XRF analysis for the tuff has elevated cobalt (to 660 ppm), and silver (to 100 ppm).

Drill Hole 6 Mn DNR Inventory Number 37669

Rock is altered, calcareous, tuffaceous phyllite. Composition probably intermediate, and is slightly chloritic(?). Also has minor quartz veins.

Semi-quantitative XRF analysis for the tuff has elevated cobalt (to 733 ppm), strontium (to 1819 ppm), molybdenum (to 32 ppm), tin (to 162 ppm), barium (to 3988 ppm), and arsenic (to 22 ppm).

Drill Hole 7 Mn DNR Inventory Number 38715

Rock is folded to sheared, dacitic volcanics, chloritic or brecciated mafics(?), and laminated iron carbonate BIF (altered?) or oxidized Fe carbonate altered metabasaltic(?) sediment?, quartz veins, and oxidized goethitic pyrite(?). Rock is chloritic(?) locally.

Semi-quantitative XRF analysis for the tuff has elevated arsenic (to 95 ppm), and strontium (to 300 ppm). Mafics had local elevated values of chromium (707 ppm), cobalt (to 1381 ppm), and molybdenum (to 72 ppm). The Fe carbonate altered metabasaltic(?) sediment had elevated cobalt (575 ppm), copper (to 178 ppm), and arsenic (to 27 ppm). The goethite altered pyrite and quartz veins had elevated manganese to (18657 ppm), cobalt (to 621 ppm), arsenic (to 30 ppm), molybdenum (to 67 ppm), and lead (to 82 ppm).

Drill Hole 8 Mn DNR Inventory Number 39183

Rock is locally veined metabasalt, including fragmentals, with minor disseminated sulfide and perhaps ultramafics.

Semi-quantitative XRF analysis indicated elevated chromium (to 3026 ppm), cobalt (to 1963 ppm), nickel (2881 ppm), copper (to 1881 ppm), and molybdenum (to 60 ppm)**.**

Drill Hole W-1 Mn DNR Inventory Number 41546

Rock is grey phyllite with minor graphite, minor disseminated pyrite, minor quartz-calcite veinlets and minor tuffaceous laminae.

Semi-quantitative XRF analysis included elevated cobalt values (to 842 ppm), arsenic (to 22 ppm), and lead (to 25 ppm).

Drill Hole 2 Mn DNR Inventory Number 33114

Rock is phyllitic, schistose dacitic tuff and argillite with minor quartz veins.

Semi-quantitative XRF analyses included elevated chromium (458 ppm), cobalt (391 ppm), nickel (100 ppm), copper (245 ppm), arsenic (268 ppm), strontium (453 ppm), and mercury (19 ppm).

CONCLUSIONS

The Vermilion Greenstone Belt has long been associated with gold. In 1865, a "gold rush" occurred in the area around Lake Vermilion. Appreciable gold was not found at the time, but it did lead to the discovery of direct shipping iron ore at Soudan, Minnesota and eventually Ely, Minnesota. The Soudan Mine and the five major mines in Ely produced about 100 million tons or ore. Exploration developed numerous smaller mines in the greenstone. Many of these did not even warrant a rail spur, but the ensuing exploration activities and relatively good outcrop exposure encouraged future work for other metals, including gold.

Exploration by at least fifteen exploration companies has produced drill hole samples, geochemistry, geophysical work and other data. Some companies, such as Whiteside and U.S. Steel, even made the transitions from iron exploration to base-metal exploration to gold exploration.

Previous iron and base-metal exploration have produced valuable products used in more recent gold work. Gold exploration in the Vermilion has also produced positive results in showing the widespread presence of anomalous gold.

Our work has built upon this, and provided data to better differentiate or lump together the varied gold occurrences. Our XRF work has provided more detailed element associations with each prospect and each gold mineralization type encountered. The XRF has also allowed for better physical placement of any gold mineralization found. This includes visible clues since gold mineralization may be otherwise hidden. Element associations have been found, such as gold with arsenic (many fault related prospects), zinc (Murray Shear Prospect), titanium (Raspberry Prospect), or lead (Raspberry Prospect). Macroscopically visible grains with these elements may then be used as different visual guides in future work in these respective prospects. Table 6 has taken together some of the greater correlation coefficients for XRF gold and different elements for each prospect area. It is evident that several gold mineralization types occur. Note, however, that the values for Foss Lake and Eagles Nest Prospects are based on a smaller number of semi-quantitative XRF readings with anomalous measurable gold. All the prospects probably have several geochemical processes are involved in determining the final gold locations and associations.

The XRF has shown to be a valuable tool, however it must be used judiciously and its small sampling size taken into account. This is an advantage in determining chemical trends exhibited by different mineral grains and groups of grains associated with an element of interest such as gold.

Shear-Related Gold Mineralization

Foss Lake Drill hole 6314-36-2, the Spaulding Prospect, the Eagles Nest Shear, and perhaps the Murray Shear drill holes appear to be major shear related Au with associated iron carbonate, sericite, minor sulfides and silica. In general, large footages are sheared and altered. Felsic tuffs were the most common country rock. The gold distribution appears to be variably sporadic where the drill holes encountered mineralization. Slightly different factors may be involved with each area, but alteration patterns can still be sought. Element associations with gold

include Cr (fuchsite related), As (arsenopyrite), and locally Cu, Mo, Hg, Pb, Ag, and Ni. With gold, fractures within logged drill cores typically have anomalous associated mercury, and if the mapping of shears is necessary to understand this mineralization, then mercury mapping may be a possible future tool.

Intrusion Hosted Gold

The Raspberry Prospect had a large volume of previous work done. This syntectonic intrusion hosted gold mineralization was directly associated with galena and rutile associated in quartz and carbonate veins. Veins also locally contain fluorescent calcite and elevated strontium and barium. The quartz vein system and alteration also produced sericitiztion of mafics in the granodiorite intrusion and the introduction of pyrite. The gold was apparently focused with the galena and rutile, however.

Table 6 Comparison of Correlation Coefficients between Prospects

Numbers are correlation coefficients of shown respective element and gold, to show possible differences in mineralization.

A value of +1 indicates a perfect linear correlation.

Raspberry Prospect	Foss Lake Prospect	Eagles Nest Prospect	Murray Shear Prospect	Spaulding Prospect
			Zn .96	
			Cr .95	
		Sb .91	Cd .91	As .91
			Sb .88	
Pb .86		Fe .85		
Se .85				
Hg .81		Se .79		Zn .79
		Hg .78	Hg .78	Pb .78
As .73		Cd .73		
		Sn .73		
Cd .71	As .70			
		Co .68		
Sn .64		Ag .62		
		Pb .62	Sn .54	Hg .57
Ag .48	Ag .47		Ag .49	Se .47
				Cu .47
	Pb .45			Sb .46
Mo .39				

VHMS Related Gold

The Murray Shear Prospect had elevated gold directly associated with (some, not all) fabric parallel and cross-cutting reddish sphalerite-quartz breccias/laminae. Rocks are felsic volcaniclastics, mafic volcanics, and local intrusions. The sphalerite

is variably magnetic due to magnetic spinel (magnetite?) and, or, pyrrhotite. The protolith of siliceous fragments and proximal laminae is problematic. Sphalerite laminae with gold is associated with Zn, Sb, Cd, Cr, Co, and Cu. Cross-cutting (stringer?) sulfides tend to have more copper than the fabric parallel laminae. Stringer sulfides grade into irregular interstitial sulfides. Semi-pervasive and locally more concentrated chlorite alteration occurs, often with disseminated pyrite or sphalerite (part of alteration). If the sphalerite-gold mineralization is related to exhalative deposition or sub-seafloor alteration, volcanic stratigraphy or synvolcanic structures may promote thicker mineralization. Beside the zinc related mineralization, local, later shear remobilized gold is associated with As, Co, and Pb. The chromium is believed to be associated with the magnetic spinel, however a more complex mineralogy with those elements appearing to cluster together, may be involved with the gold.

BIF Related Gold

The first Foss Lake Prospect drill core examined (6314-36-1) contained a sequence of iron formation within basalts. Previously unknown gold was found within disturbed chert and graphite interlaminations at the broad transition from oxide-silicate-carbonate BIF to sulfide-graphite BIF. The elevated XRF gold was associated with elevated As, Cu, Co, Pb, and Mo.

Chert layers within the sequence were locally noticeable because of a slight bluish tinge in their colors. Hand lens examination showed the presence of pale acicular fibers in and on the margins chert. Brownish needles were also present on the margins, especially near iron oxides. Microscope examination indicated the minerals were amphiboles. The bluish minerals were glaucophane and crossite, and indicate probable sodic metasomatism. The brownish needles were probably grunerite.

The Vermilion Greenstone has demonstrated to be an area with anomalous gold, encompassing a number of different types of gold mineralization. No economic gold to date has been found in the Vermilion. Since 1865, gold exploration has occasionally emerged, but to no avail. Hopefully this work will add a few more puzzle pieces to bring the dream of 1865 to fruition.

APPENDICES

APPENDIX 1

The Minnesota Department of Natural Resources in Hibbing has publicly available exploration data for each of the five Vermilion Greenstone Prospects discussed. Much data is available digitally as scanned items at the MnDNR website http://minarchive.dnr.state.mn.us/. Data varies from regional airborne and grid geophysics; geochemistry; outcrop data, and drill hole data, and miscellaneous data of other types.

Each prospect area is listed below with companies for which publicly available data exists.

Raspberry Prospect (and Quartz Hill)

Previous companies working in prospect area

Whiteside
St. Joe America
New Jersey Zinc
Kerr McGee
Gold Fields Mining
Coca Mines
Bear Creek Mining
BHP-Utah
Amoco
American Shield
North Central Minerals Ventures
U.S. Steel

Foss Lake Prospect

Previous companies working in prospect area

Whiteside
Kerr McGee
U.S. Steel

Eagles Nest Shear Prospect

Previous companies working in prospect area

Whiteside
Newmont Mining
U.S. Steel

Murray Shear Prospect

Previous companies working in prospect area

Whiteside
Houston Oil & Minerals
Newmont Mining
American Shield
Teck Resources
U.S. Steel

Spaulding Prospect

Previous companies working in prospect area

Whiteside
New Jersey Zinc
Kerr McGee
BHP-Utah
U.S. Steel

APPENDIX 2

This is a listing of the digital computer files associated with this Open-File Report.

FILE DESCRIPTION	***FILE NAME***
This report	**P373OpenFileRpt.doc**
Part of Dean Peterson "Rock Chemistry" GIS shapefile - with both NAD27 and converted NAD83 UTM coordinates	**dprockch.dbf**
Part of Dean Peterson "Rock Chemistry" GIS shapefile	**dprockch.shp**
Part of Dean Peterson "Rock Chemistry" GIS shapefile	**dprockch.shx**
Part of Dean Peterson "Rock Chemistry" GIS shapefile	**dprockch.sbn**
Part of Dean Peterson "Rock Chemistry" GIS shapefile	**dprockch.sbx**
Dean Peterson Vermilion geochemistry -NAD27 UTM coordinates	**DPetVerchem.xls**
NRRI compiled Archean Chemistry subset	**NRRIvermCHEM91-12h.xls**
Dean Peterson thesis compiled chemistry subset - Above GIS shapefile made from this file	**DPetVerchem.xls**
Drill hole samples logged for this project	**P373DDHList.xls**
Digital lithologic logs for this project	**P373LithLog.xls**
Lithologic codes used in new lithologic logs	**P373LithCodes.xls**

Master XRF data table with all data results **XRFMasterP373.xls**
-separate sheets for data, standards,stats

XRF data results with only "anomalous" samples **XRFAnomalousP373.xls**

File to compare XRF and assay values **XRFAssayP373compare.xls**

File of logged DDH samples for project **P373 ddh logged.xls**
-with UTM coordinates used

File of anomalous XRF values **XRFAnomalousP373.xls**

Microprobe chemistry **P373ProbeAnalyses.xls**

Compares some correlation **P373CorCoefProspectCompare.xls**
coefficients between prospects

Series of XRF data files for a given **P373_"PROSPECT"_XRF.xls**
"PROSPECT"

Series of XRF data files for a given **P373_"DRILL HOLE"_XRF.xls**
"DRILL HOLE"

"Image" Folder contains macroscopic and microscopic images from the project.

"Probe" Folder contains microprobe images and microprobe chemistry data.

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