International Falls Drill Core Descriptions and Chemistry, Koochiching County, Minnesota Project 378

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International Falls Drill Core Descriptions and Chemistry

Executive Summary

The purpose of this work was to compile and build a framework for samples from thirteen historic drill cores in the Department of Natural Resources Drill Core Library of an under-examined area with complex geology. This report will be useful in the administration of State mineral ownership, and land use planning issues of this area.

Thirteen cores were logged and analyzed from the Wabigoon Greenstone Belt within the Superior Province of the Canadian Shield, in the area of International Falls, Minnesota. Core samples were drilled by exploration companies in the search for gold mineralization, and the Minnesota Department of Transportation. Besides the thirteen drill logs, 217 new laboratory geochemical analyses, and 2023 semi-quantitative XRF real-time analyses are presented in this report. The locations of drill cores and the regional geology is shown in Figure 1, along with the leasing status. This work fills in gaps of previous core analysis. Specifically, this work looked at pathfinder element association with gold, and other patterns to the gold mineralization in the belt.

This portion of the Wabigoon Greenstone belt is composed of generally schistose, greenschist to amphibolitic, mafic to felsic metavolcanics, metasediments, chemical exhalatives, and intrusives. New laboratory results include gold assays up to 799 ppb and zinc values to 2160 ppm. The previous exploration company work was in proximity to the Seine River-Rainy Lake fault system. This fault system is associated with the major tectonic boundary between the Wabigoon and Quetico subprovinces. This area hosts Minnesota's only known past producing gold mine on Little American Island. Gold and other mineralization occurs across the border in the Wabigoon subprovince in Canada.

A number of active mineral leases currently exist here, and as soon as they became active, no more work was done by MnDNR staff for this project on drill samples from those active mining units.

New core logging found new alteration and features favorable to gold mineralization. These include quartz-carbonate-sulfide veining; minor copper, zinc, lead sulfides; banded iron formation; quartz, sericite, carbonate, pyrite alteration; pyrite-pyrrhotite transitions; minor stratiform sphalerite; locally abundant vein and bedded tourmaline which may be exhalative; and anomalous gold assays. Weak gold mineralization has also been found in biotite schist for the first time in this district.

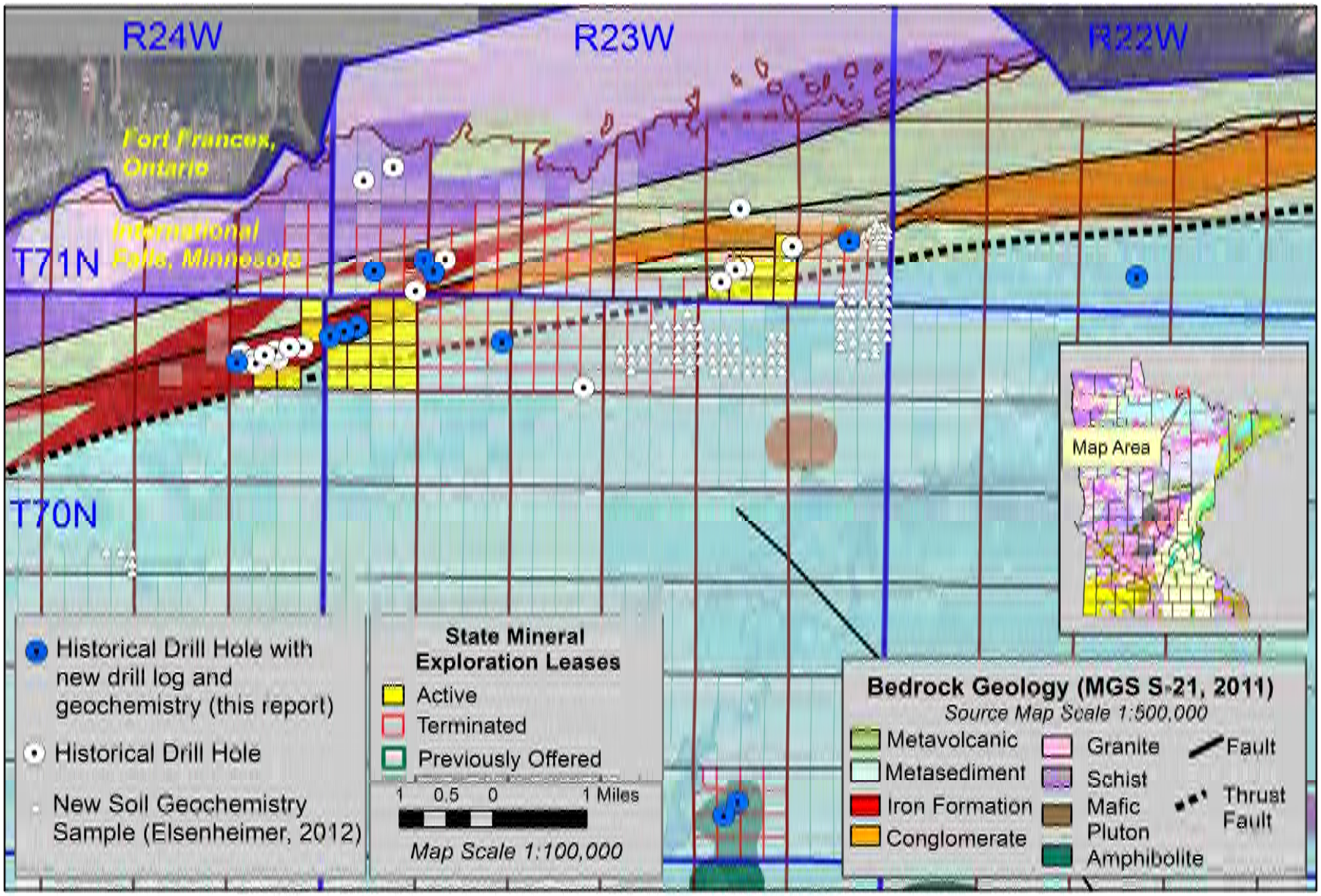

Figure 1: Drill Core Locations and Regional Geology of International Falls Area, Koochiching County, Minnesota (after Elsenheimer, 2012)

New laboratory assays have verified gold values to 799 ppb and zinc values to 2160 ppm. On a smaller scale, XRF analyses have established several different element associations with the gold mineralization. The gold bearing XRF semi-quantitative anomalies had combinations of associated anomalous Rb (Potassium analog), Mo, Ag, Pb, Zn, Cu, Ba, Sn, Cd, As, Sb, Mn, Ni, Fe, Cr, and possibly Sr and Co. The descriptive core logging was combined with XRF-identified trace element associations to classify the gold occurrences into five styles of gold mineralization.

1) A gold mineralization style related to possible Volcanic Hosted Massive Sulfide (VHMS) exhibited anomalous Zn, Cd, Pb, As, Sb, Sn, Fe and Cr.
2) A gold mineralization style related to iron-rich chemical sediment (and possible fuchsite-bearing) lode gold mineralization had associated anomalous Fe, Cr (fuchsite?), and elements with a more subtle contrast.
3) A gold mineralization style of ultramafic parentage of anomalous gold may be indicated by anomalous Fe, Cr, along with Ni.
4) A gold mineralization style related to possible porphyry systems exhibited anomalous Mo, and locally Ag, Cu, Mn, Sr, Ba, As, Sn, Hg, and Cd.
5) A lode gold vein mineralization style is associated with combinations of Fe, Mn, Ti, Co(?), Cu, Zn, Sr, Ag, Sn, Ba, and Pb; and may reflect scavenging of metals from the other, more primary types of gold mineralization.

This classification approach identifies what appear to be overlapping gold mineralization events. It further clarifies the connections between some drill cores with evidence for the same event, such as TC-36-1 and S-1. Within one drill core, such as ND-2, there can also be multiple styles.

This report is a product of the digital age, and as such, the information presented occurs in a number of formats to encourage more easy access by the user. Besides a searchable PDF format for this summary, the data occurs as separate spreadsheet files, Geographic Information System (GIS) shape files; and several Power Point slide presentations. The slide presentations each have a different emphasis to fill the needs of different audiences.

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Description of Work Done

The purpose of this work is to identify State mineral ownership with high mineral potential on a reconnaissance scale. While many types of economic mineralization are possible in rocks of this type, the focus of this work is on gold mineralization. The value of this work is only fully realized when it is made public.

The activities completed for this report consist of the following:

1) Find existing historical documents – some digital, some only in Mineral Exploration Archives;
2) Existing data was examined;
3) A list of available MnDNR Drill Core Library drill cores in the International Falls area was generated;
4) Core logging;
    a) Core was retrieved and laid out on tables
    b) Core was examined, described, logged
    c) XRF semi-quantitative analyses
    d) Prepping and microscopic examination of grains
    e) Taking selected photographs
5) Core sampling for chemical assay work;
    a) Look at previous work, new log, and XRF results
    b) Choose samples
    c) Sample – using rock saw
    d) Examine pieces going into sample bags, and remove any foreign material or coloration (paint?, saw varnish?)

All newly generated data for this project was digitally recorded. New State Mineral Leases that occurred during the middle of the project preempted the finishing of some logging and sampling.

Geologic data is cumulative, and geologic knowledge increases as more geologic data is available. Each company working in this area created independently their own unique packet of new information. Their new data, along with previously available information, combined as a guide for their work. The data in this report will add to the geologic information resources available for this area. Multiple episodes of work over many decades creates a larger foundation that often leads to positive results.

Regarding existing data, most DDH's in the study area near International Falls, MN were drilled by exploration companies in the quest of gold exploration during the mid- to late 1980's. Geophysics and geochemistry usually contributed greatly to the location of drill holes. Multiple holes were usually drilled on targets generated from geophysical grids. These grids have been compiled as maps for this area (Elsenheimer, 2012). There are high caliber drill logs available from the original explorers in the MnDNR Exploration Archive files offering additional useful geologic descriptions and interpretation of these complex rock types.

Core Logging

With alternating rock lithologies, logging is always a matter of lumping and splitting. Besides visual examination, the XRF analyses and previous Exploration Archive file information were used to aid in the logging procedure. Magnetism, carbonate testing, and Ultraviolet (UV) light were used to various degrees. All of the items listed under “4)” above were done at the same time, with variable amounts of “leapfrogging” for efficiency.

Where possible, identification of protolith was preferred. However metamorphism, deformation, and recrystallization made protolith identification more uncertain locally. Metamorphic rock names supplanted protolith names as identification became more uncertain. Rocks were generally metamorphosed or recrystallized to one degree or another, perhaps with the exception of the youngest intrusives. These intrusives may only exhibit contact disruption and minor veining from their intrusion.

The logging file contains lithologic information generalized, often over a longer interval. The XRF file contains lithologic information on a finer scale, to reflect the rock type within the small XRF analytical window. When possible with the XRF data, the differentiation between specific features and their background host rock types was made in the XRF rock descriptions. Specific feature’s for XRF testing included veins, alteration, spatial zoning, or mineral grains. Concerning the XRF assistance with logging, the window size needed extra care of placement because of the small area over which the semi-quantitative analysis did the averaging. Sometimes, very small features such as specific grains were meant to be targeted, and their placement over the window needed several attempts. The methodology made possible the added chemical contrasts necessary to elucidate gold and other grain chemistry associations.

Core Sampling

Core sampling was primarily done to provide supplemental information on gold mineralization. The past assay and analytical methodology varied with company and individual drill cores. Most companies assayed every foot of core because of the often hidden nature of gold mineralization. Most previous assays were only for gold, and our current sampling emphasized associated alteration chemistry. Previously unsampled portions included thicker, late (and unmetamorphosed?) intrusions; or biotite schist. These two lithologies apparently were considered to be lesser gold targets. Some prior analyses included limited base-metals and gold associated elements, and a small number of analyses included a wider suite of elements.

Previous assay results found most of the known gold mineralization. On a smaller scale, the XRF generated new information on how the gold is dispersed and some of the other gold associated elements. The XRF beam window analyzes between .5 and 1 gram of rock, compared to a 30 gram fire assay, or smaller samples for other laboratory analyses. The 30 gram fire assay samples were pulverized splits of core samples weighing between 100 to 5140 grams.

Our sampling procedure was to saw the existing rock samples in half lengthwise for assay. Flat sawn surfaces also provide for a better XRF analysis surface. One early XRF mapping of gold values on a half of core with a higher gold assay value, found numerous dispersed, elevated XRF gold values. In order to take a better picture without saw marks, this sample was sanded down with silicon carbide paper. Later XRF analyses on this piece, showed that some previous high gold values were missing. Further XRF analyses indicated fewer anomalous gold values with a more limited distribution. The very small gold grains are malleable. The implications are that gold grains tend to smear from diamond saw blades (and perhaps drill bits?) and that sanding removed the thinly smeared portions. This may present a larger ultrathin film gold surface to the XRF, resulting in displaced or modified gold XRF values. The minute nature of gold grains is reflected in XRF results. XRF results may have some resulting bias, but larger assay samples may average out this unnatural variation. There was no evidence for sawing gold contamination from a previously sawn sample.

Because of the time commitment, the sanding of core to eliminate smearing of gold was not routinely done per se. Sanding or cleaning was done when visible foreign material was present on any material being bagged for laboratory assay. This included any paint, saw varnish, and grease.

In determining elements associated with gold mineralization, the sample size difference between the semi-quantitative XRF values and laboratory chemistry/assay values, may be useful for the scale represented by the values. Since gold may exhibit a pronounced nugget effect, the small target XRF values may provide a more accurate picture of those elements associated with gold values concentrated as scattered discreet grains. By the same token, laboratory analysis of a five foot core interval, may provide a better representation of larger scale alteration associated with more localized gold mineralization.

It should also be noted that some previously assayed intervals with anomalous gold had new XRF data whereby no gold could be found. In other places, the new XRF data found gold, but the previous assays had minimal gold values. It appears that the gold mineralization is very sporadic, creating a rather severe nugget effect. The averaging effect of larger samples for assay may diminish this, but also diminish elevated amounts of alteration associated elements.

Geologic Processes Favorable to Gold Mineralization

High gold values from historic gold assays in this district have been identified over short intervals. Twenty historic values were greater than 1 ppm from drill core and surface collected rocks (Figure 2). Fifteen samples were from eight DDH’s, and five assays were from bedrock outcrop samples. Adjacent samples, however, exhibited quite variable gold amounts.

Gold mineralization is found worldwide in a variety of rock types of many geologic ages. Geologic features and processes affect gold transport, gold deposition, and the modes of occurrence. Archean gold mineralization is favorably created by a combination of regional and smaller-scale geologic processes and is manifested by their resulting products. Even if primary gold mineralization is syngenetic, ore deposits are usually a culmination of multiple concentrating processes including imposed epigenetic features and structural controls. Observed evidence of gold related processes in the project area include the following:

1) Creation and presence of large scale faulting with splays. Major structural discontinuities near major sedimentary and volcanic rock sequences are important. Large fault splays emanate from larger scale faults, notably the tectonic junction between the Quetico and Wabigoon Subprovinces.

Evidence from the Minnesota Aeromagnetic Survey and Minnesota Geological Survey mapping (Jirsa et al., 2011) indicate the close proximity to the large-scale Wabigoon-Quetico Subprovince faulted boundary. Offset stratigraphy indicates multiple splays that emanate from this major structural boundary. Specifically in drill cores, most rocks have a deformational schistosity, with local brecciation. Examples include DDH's ND-2, S-2, and TC-36-1. Long term temporal movement is shown by the variation in rock ages effected by the deformation(s), including, tectonized veins, and relatively undeformed intrusions and late brittle fractures with calcite. Non-linear fault segments promote motion irregularities creating breccia and fluid paths. Early quartz-carbonate veins result from deformation, with additional deformation boudinaging the same veins, along with deformed tourmaline crystals in quartz veins. Protolithologies indicate metavolcanic mafic to felsic rocks, and sequences of metasedimentary-volcaniclastic rocks with intervening chemical sediments.

2) Highly deformed steep shears with complex movements such as transpression movements along major faults. A vertical component of fault movement encourages upward movement of mineralizing fluids under pressure from below.

Evidence includes juxtaposed lithologic and metamorphic differences across major faults indicating combined vertical and horizontal motions along faults (Jirsa et al., 2011). Non-linear segments or bends in these large fault(s) also occur. These are areas where breccias and voids form to allow fluid pathways through different crustal levels. Depths with brittle-ductile rock transitions are important. More ductile folding (DDH's ND-2, ND-1, and TC-36-1) and more brittle brecciation (DDH's ND-2, ND-3, and TC-36-1) occur across the study area.

3) Highly deformed Archean host rocks.

Magnetic evidence implies that rocks of the study area are contiguous with the deformed rocks of the Archean Wabigoon Greenstone Belt in Canada. Most logged drill cores contains a pervasive deformational fabric, along with veins, folding, fractures, breccia, and other evidence of tectonism. The DDH's with minimal deformation are those farthest from the Subprovince boundary, notably DDH's 128/2R1 and 128/2R2.

4) Low- or medium-grade metamorphism. Metamorphism is associated with mineral dehydration and liberating of volatiles.

Evidence includes regional metamorphic mineralogy in drill cores, including chlorite, biotite, amphiboles, and local garnets (DDH's T-1, T-2, S-1, S-3, and SS-9). Liberated volatiles are available for transporting metals such as gold and other elements. Carbonates imply fluids containing carbon dioxide in the volatile mix.

5) Presence of iron-rich volcanics, related intrusives, or iron-rich chemical sediments. These form favored host rocks for gold mineralization around the world.

Evidence in core includes local strong magnetism and the visible presence of iron oxides. Iron-rich chemical exhalatives include DDH's ND-2 and ND-3. Mafic volcanics are found in DDH's ND-1, ND-2, S-3, S-2, S-1, and TC-36-1. Possible older mafic intrusives are found in DDH's TC-36-1, S-1, S-2, and ND-1.

6) Movement of hydrothermal fluids with gold associated pathfinder elements.

Evidence includes visible grains of chalcopyrite (Cu mineral notably in DDH’s T-1, T-2, and S-2), sphalerite (Zn mineral in DDH’s), pyrite, pyrrhotite, mixed carbonates, and tourmaline (B mineral). XRF semi-quantitative values with anomalous gold readings also showed combinations of elevated As, Sb, Hg, Pb, Cr, Ni, Rb, Mo, Ag, Cd, and Sn.

7) Silicic and (or) carbonate stockwork formation and replacement with native gold, auriferous pyrite, arsenopyrite, electrum, or gold telluride minerals.

Evidence includes gold associated deformed veining of quartz with calcite and mixed carbonates (XRF Mn, Fe, Sr), pyrite, pyrrhotite, minor base-metal sulfide, notably DDH’s ND-1 and ND-2. Intense silicification is lacking, and the extent of veining is variable and limited. Gold silicic veining locally contains elevated arsenic (up to 209 ppm in previous laboratory chemistry), tellurium (up to 2.38 ppm in previous laboratory chemistry), or silver (up to 54 ppm in new XRF data).

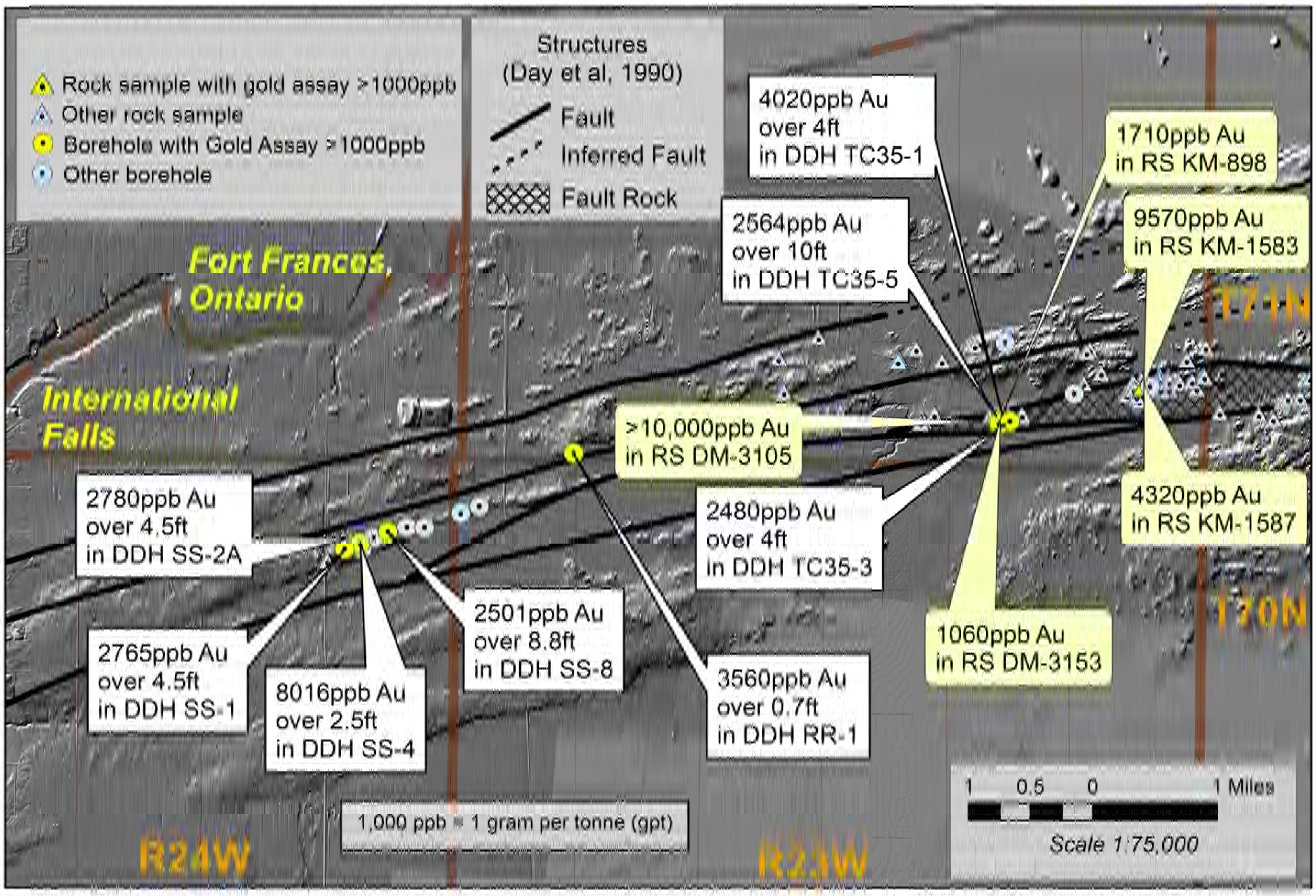

Figure 2: Location map of outcrop samples and borehole samples with anomalous gold assays >1000 ppb in the International Falls Area, Koochiching County, Minnesota (after Elsenheimer, 2012). For specific drill hole locations, see Figure 1, or Appendix 1.

8) Persistent sericite-carbonate alteration haloes and associated fuchsite.

Potassic metasomatism with associated sericite is not pervasive, although biotite and fuchsite may be related. Metamorphism of rocks and prevalence of biotite makes minor sericite difficult to discern. Evidence occurs with associated XRF gold and local elevated Rb associations (K analog). Gold locally is associated with fuchsite and chemically with associated chromium in the same DDH's, notably in DDH ND-2, ND-3, and S-2.

These processes are manifested in smaller-scale drill core observations noted in this project. Some of the smaller-scale features include the following:

1) Presence of volcanics and, or sediments with contrasting compositions
2) Presence of exhalatives and vent related chemical sediments
3) Presence of intrusions to provide heat, fluids, and differing chemistry
4) Alteration such as silicification, sericitization, carbonatization, sulfidation
5) Development (and filling) of voids and brecciation
6) Quartz-carbonate veining
7) Multi-cation carbonates
8) Presence of sulfides and transitions (such as pyrite-pyrrhotite transitions)
9) Presence of small amounts of base-metal sulfides
10) Presence of other trace elements such as antimony, arsenic, bismuth, mercury
11) Presence of trace minerals such as tourmaline and rutile

Gold Mineralization Models

Mineralization models have a common thread of being associated with the heat and fluids associated with different parts of volcanogenic sequences and metamorphism. The heat and fluids interact between new and existing volcanic rocks and seafloor and water. A regional longer-lived crustal tectonism produces a favorable environment for such volcanism, metamorphism, and gold mineralization models. The paragenetic sequence of observations concerning the favorable environment for gold mineralization is given in Figure 3.

1) Mesothermal lode gold. Gold is associated with quartz-carbonate veining with (usually) minor iron and base metal sulfides and trace elements such as As, Sb, Te, Hg, B. Veins often internally deformed and healed from emplacement during tectonism of the host rock such as metamorphosed iron-rich volcanics. Mineralization is typically associated with secondary fault splays with both vertical and horizontal motion components off of larger regional shear zones.
2) Volcanogenic Hosted Massive Sulfides. VHMS settings with exhalative chemical sediments and below seafloor stockworks associated with transitions associated with the felsic end of one volcanic cycle, and the mafic-ultramafic start of the next volcanic cycle. Caldera growth faults are often good foci of mineralization. Cu, Pb, Zn, Fe sulfides, and trace metals are usually involved.
3) Komatiite hosted gold, typically associated with ultramafic flows and related intrusions, with anomalous Fe, Mg, Ni, and Cr. Gold is typically alteration associated with quartz-carbonate-sericite-

fuchsite veining; or magmatic segregations typically with nickel sulfides and platinum group metals segregations.

4) BIF or Banded Iron Formation gold. Exhalative iron-rich chemical sediments associated with transitions associated with the felsic end of one volcanic cycle, and the mafic-ultramafic start of the next volcanic cycle. BIF often forms a pressure-building cap over hydrothermal systems. Gold is associated with sulfidation of BIF.
5) Porphyry gold association. Gold is associated with intruding porphyry igneous rocks, with associated fluids altering surrounding country rock and portions of the porphyry, and notably with disseminated copper and molybdenum sulfides , and (now metamorphosed) haloes of potassic alteration.
6) Intrusion hosted gold. Alteration of volatile-rich intrusions by deuteric fluids, after most silicates are crystallized, and volatile-rich fluids remain. Vugs and cavities are created with late veining and deposition of base-metal sulfides, sulfates, carbonates, and gold.

Figure 3. Observed Process Paragenesis

TIME **EARLY →==→ LATE**
Archean volcanism, sedimentation, exhalative chert, BIF, minor sulfides, tourmalinite(?), and penecontemporaneous intrusives **====================**
GOLD MINERALIZATION **? ============================**
Deformation, fabric formation **? = = = = = = ========= ductile-brittle ======= = = = = = = = = = == more brittle ===**
Regional Metamorphism (oriented amphiboles, sheet silicates, tourmaline?) **=============================**
Thermal recrystallization (garnet, non-oriented hornblende, grunerite, sheet silicates?, tourmaline) **============ ? == local w/ later dikes ==**
Formation of quartz veins with non-calcite carbonate, tourmaline, minor calcite and, minor sulfide **=================**
Formation of more brittle, calcite-bearing, fractures and veins (influencing placement of late unmetamorphosed mafic intrusions?) **? ============================**
Later mafic Intrusions **================**

Table of Mineral Potential Observations

The classification of gold mineralization styles is based upon observed criteria associated with gold mineralization with relevance to known gold mineralization models. These are here called Mineral Potential Observations and are tabulated in Appendix D. The observed criteria result from the interpreted protoliths, alteration, structure, and chemistry. The Mineral Potential Observation data is organized into the following evidence groupings:

- Anomalous Au Occurrences (Au > 300 ppb lab chemistry; Au >4 ppm XRF chemistry)
- Quartz carbonate sulfide veins/segregations
- Veins with tourmaline
- Base metal sulfides (stratiform and vein related)
- Gold associated trace elements (As, Bi, Te, Hg)
- Stratiform tourmaline
- Iron related chemical sediments
- Coarser siliceous rocks (agglomerates?)
- Mn garnets
- K-spar -muscovite -biotite - fluorite(?) veining/metasomatism
- Possible fuchsite
- Massive felsic flows(?)
- Unmetamorphosed(?) Mafic Dikes
- Tectonically emplaced coarse plagioclase phyric dikes
- All gabbros
- All mafic intrusives
- Elevated Ni and Cr
- VHMS? Related (Elevated Zn + - Cu + - Pb)

Observation occurrences may repeat in Appendix D as a given interval of drill core may contain numerous criteria. The Anomalous Au Occurrence grouping is included below in Table 1. The best indicator for possible gold mineralization is the occurrence of known anomalous gold.

Table 1. Table of Mineral Potential Observations for Anomalous Gold - Anomalous Au occurrences (Au > 300 ppb lab chemistry; Au > 4 ppm XRF chemistry)

Drill Hole (Inventory #) Location (T-R-S)	Anomalous Gold Content (somewhere within a stratigraphic unit designated by the footage interval)*	PROTO-LITHOLOGY	ALTERATION and METAMORPHISM	STRUCTURE	Geochemistry HLC	Geochemistry NLC	Geochemistry XRF
16266 71-23-32	Au to 21 ppm XRF 4 – 91 feet	Variably laminated finely fragmental dacitic(?) tuff with abundant chert beds	Quartz, calcite, chlorite?, sericite?, sulfide? Recrystallized, variably phyllitic to finely schistose; chlorite, mica, amphibole?	Hornfelsed(?) variably phyllitic to finely schistose; laminated and boudinaged; local chert laminae or quartz-calcite-pyrite veins/segregations w/ chlorite, biotite, sphalerite, fluorite(??); local sphalerite veinlets(?) with XRF Au	Zn to 852 ppm Pb to 23 ppm Au to 50 ppb	Zn to 790 ppm	FE 61% Co 4183 ppm Zn 22.7% As 209 ppm Rb 121 ppm Mo 177 ppm Ag 44 ppm Cd 407 ppm Sn 79 ppm Sb 149 ppm Au 21 ppm Hg 31 ppm
16266 71-23-32	Au 6 ppm XRF 171 – 186 feet	Bedded (tuffaceous?) chert with variable sulfide chemical sediment component (PO, PY, trace CPY)	Quartz, calcite?, sericite, Po, Py, Cpy Recrystallized, variably phyllitic to finely schistose	Hornfelsed(?) siliceous but variably phyllitic to finely schistose; local variable, complex brecciated veins w/ py, cpy, Fe carb, Fe-Mn oxide, mica, and local vugs, fluorite(??)?-chert??, to simple qtz-carb sulf veinlets (metasomatic??); some XRF Au	Zn to 1314 Cu 278 ppm	Zn to 2000 Cu 391 ppm, S > 4%	Mn 16499 ppm Fe 94.5% Co 22776 Cu 11.2% Zn 27964 ppm Se 63 ppm Rb 184 ppm 218 ppm Zr Mo 89 ppm Ag 38 ppm Sn 135 ppm Sb 83 ppm Ba 9832 ppm Au 6 ppm Hg 52 ppm

*See Appendix A for the digital file with details for the XRF sample footages (P378_XRF_I Falls.xlsx)

HLC = Historical lab chemistry based on reports DNR holds

NLC = New Lab Chemistry done for this project

XRF = XRF, hand-held, semi-quantitative, small spot analyzed, new data for this project

Table 1. Table of Mineral Potential Observations for Anomalous Gold - Anomalous Au occurrences (Au > 300 ppb lab chemistry; Au > 4 ppm XRF chemistry)

Drill Hole (Inventory #) Location (T-R-S)	Anomalous Gold Content (somewhere within a stratigraphic unit designated by the footage interval)*	PROTO-LITHOLOGY	ALTERATION and METAMORPHISM	STRUCTURE	Geochemistry HLC	Geochemistry NLC	Geochemistry XRF
16263 70-23-6	Au 34 ppm XRF 84 – 191 feet	Mafic metavolcanics and laminated tuffs with local laminated magnetite-chert BIF laminae	Quartz, calcite, chlorite?, amphibole, sulfide, tourmaline Recrystallized, schistose; amphibolitic	Hornfelsed(?), schistose; variably brecciated, locally folded, sheared; with qz veins (or chert?)	Cu to 534 ppm Au to 215 ppb	Cu to 525 ppm Au to 38 ppb	Ti 42487 ppm Mn 16975 ppm Fe>100% Co 2625 ppm Cu 11.36% Zn 31612 ppm Se 22 ppm Mo 64 ppm Cd 185 ppm Sn 108 ppm Sb 71 ppm Au 34 ppm Hg 40 ppm Pb 22740 ppm
16263 70-23-6	Au to 520 ppbHLC Au to 799 ppb NLC Au 53 ppm XRF 224-279 feet	Greywacke and/or Intermediate tuffs w/ minor chemical sediment (chert, sulfide)compnents	Quartz, calcite, biotite, amphibole, sulfide Recrystallized, schistose; biotitic, amphibolitic	Hornfelsed(?), schistose; brecciated, locally folded, brecciated; with generally disrupted qz veins or recrystallized(?) chert	Au to 520 ppb	Bi to 7 Te to 2.38 ppm Au to 799 ppb	Mn 21286 ppm Fe 64.8% Co 2047 ppm Ni 632 ppm Se 15 ppm Rb 196 ppm Zr 228 ppm Ag 36 ppm Sn 64 ppm Sb 47 ppm Au 53 ppm Hg 46 ppm

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Drill Hole (Inventory #) Location (T-R-S)	Anomalous Gold Content (somewhere within a stratigraphic unit designated by the footage interval)*	PROTO-LITHOLOGY	ALTERATION and METAMORPHISM	STRUCTURE	Geochemistry HLC	Geochemistry NLC	Geochemistry XRF
16263 70-23-6	Au 13 ppm XRF 311 – 653 feet	Greywacke and/or Intermediate tuffs w/ minor cherty BIF lamina with variable pyrite.	Quartz, calcite, biotite?, Py, XRF Au Recrystallized, schistose; biotitic	Hornfelsed(?), schistose, variably sheared, folded, and brecciated; local quartz (and biotite?, minor sulfide and carbonate) veins or segregations.	Au to 120 ppb	As to 53 ppm	Ti 37624 ppm Cr 3067 ppm Mn 10901 ppm Fe 86.8% Co 2178 ppm Ni 1459 ppm As 91 ppm As Se 23 ppm Rb 190 ppm Sr 1315 ppm Zr 312 ppm Mo 675 ppm Ag 54 ppm Sn 90 ppm Sb 72 ppm Ba 16595 ppm Au 13 ppm
16264 71-23-30	Au 15 ppm XRF 19 – 144.5 feet	Intermediate(?) tuffs and more massive flows with minor chemical sediment components; locally agglomeratic(?).	Quartz, muscovite, hornblende, calcite, biotite?, Po?, mag? Recrystallized, schistose; mica, amphibolitic	Hornfelsed(?), variably sheared and schistose; defomed qz carb vein/segregations with local sulfides and XRF Au		CO_2 to 9.3%	Ni 697 ppm Mo 75 ppm Ag 32 ppm Sn 67 ppm Au 15 ppm

*See Appendix A for the digital file with details for the XRF sample footages (P378_XRF_I Falls.xlsx)

HLC = Historical lab chemistry based on reports DNR holds

NLC = New Lab Chemistry done for this project

XRF = XRF, hand-held, semi-quantitative, small spot analyzed, new data for this project

Table 1. Table of Mineral Potential Observations for Anomalous Gold - Anomalous Au occurrences (Au > 300 ppb lab chemistry; Au > 4 ppm XRF chemistry)

Drill Hole (Inventory #) Location (T-R-S)	Anomalous Gold Content (somewhere within a stratigraphic unit designated by the footage interval)*	PROTO-LITHOLOGY	ALTERATION and METAMORPHISM	STRUCTURE	Geochemistry HLC	Geochemistry NLC	Geochemistry XRF
16264 71-23-30	Au 13 ppm XRF 161 – 409 feet	Laminated felsic-intermediate tuffaceous chert, magnetite, pyrite, and Fe carbonate exhalatives.	Quartz, calcite?, muscovite?, biotite?, magnetite?, pyrrhotite?,pyrite, Fe carbonate; local rutile needles; sphalerite laminae? or fabric parallel veinlets?? Recrystallized, schistose; mica	Hornfelsed(?), variably sheared and schistose; defomed qz carb(+- muscovite, pyrite) vein/segregations with local sulfides; local late fault breccia; porphyroblastic hornblende; local thin sphalerite/pyrite laminae or fabric parallel veinlets.	Zn to 810 ppm	Cr to 530 ppm Cu to 344 ppm Au to 15 ppb Hg to .733 ppb Ni 247 Se to 6.1 ppm Te to 1.14 ppm Sn to 4 ppm V to 473 ppm Zn to 2160 ppm	Ti 32390 ppm Mn 17928 ppm Fe 47.4% Cu 18862 ppm Zn 20.7% As 64 ppm Se 20 ppm Rb 116 ppm Zr 325 ppm Ag 42 ppm Cd 1179 ppm Sn 68 ppm Sb 294 ppm Ba 4709 ppm Au 13 ppm Hg 26 ppm
16262 70-23-6	Au 7 ppm XRF 92 – 603 feet	Protolith problematic from shearing; Mafic volcanics? with variable exhalative silicate magnetite chert sulfide carbonate? (with local tourmaline?) and possible medium-grained gabbro	Biotite?, carbonate, quartz, chlorite?, amphibole, magnetite?, sulfide?; carbonate and biotite(?) alteration generally decreasing downward. Recrystallized, schist; amphibolitic, biotite?	Hornfelsed(?) variably recrystallized, deformed, sheared and altered, schistose; variably deformed to folded to attenuated qtz-carb veins/segregations. Fracturing, shearing, and alteration generally decreasing downward.	Au 95 ppb Pb 65 ppm	B 320 ppm Au 61 ppb Pd 10ppb Pd	Ti 31305 ppm Cu 9573 ppm Rb 118 ppm Ag 30 ppm Sn 68 ppm Sb 59 ppm Ba 3404 ppm Au 7 ppm
16267 71-23-32	Au 5 ppm XRF 0-100 feet	Interrmediate to felsic tuff and felsic flows(?) with chert, magnetite, and silicate? exhaltive component??.	Amphibole,? biotite, muscovite?, calcite, K-spar, quartz, fluorite?, chlorite?, magnetite?, sulfide?, magnetite?, dolomite?; Metasomatized?. XRF Au Recrystallized, metasomatized?, variably phyllitic to finely schistose; mica, K-spar?, amphibolitic?	Hornfelsed(?) phyllitic to fine schist. Local veining and/or metasomatism w/ kspar, mica (biotite and musc?), calcite, fluorite(?); minor shears and brecciation. Fine fractures with calcite alteration. Qz segregations.veins more common toward base. Porphyroblastic dolomitic? carbonate @ 99'.	Pb 94 ppm Pb	B 150 ppm	Zr 260 ppm Mo 96 ppm Ag 33 ppm Au 5 ppm Hg 26 ppm

*See Appendix A for the digital file with details for the XRF sample footages (P378_XRF_I Falls.xlsx)

HLC = Historical lab chemistry based on reports DNR holds

NLC = New Lab Chemistry done for this project

XRF = XRF, hand-held, semi-quantitative, small spot analyzed, new data for this project

Table 1. Table of Mineral Potential Observations for Anomalous Gold - Anomalous Au occurrences (Au > 300 ppb lab chemistry; Au > 4 ppm XRF chemistry)

Drill Hole (Inventory #) Location (T-R-S)	Anomalous Gold Content (somewhere within a stratigraphic unit designated by the footage interval)*	PROTO-LITHOLOGY	ALTERATION and METAMORPHISM	STRUCTURE	Geochemistry HLC	Geochemistry NLC	Geochemistry XRF
16267 71-23-32	Au 6 ppm XRF 241 – 303 feet	Felsic to mafic? tuffs(?), with local minor exhalative oxide, sulfide, and chert(?) exhalative	Biotite?, muscovite, amphibole?, chlorite, quartz, calcite, carbonate, magnetite?, sulfide?, K-spar, fluorite?; Metasomatized? Recrystallized, metasomatized?, mylonitic phyllitic to schistose; chloritic, amphibolitic	Hornfelsed(?) metasomatized, generally mylonitic phyllitic to schistose; with quartz carbonate chlorite/hblende veins, bursts, or segregations, w/ minor sulfide.		CO_2 10.5%	Cu 7977 ppm As 152 ppm Se 13 ppm Ag 22 ppm Sn 54 ppm Au 6 ppm
14714 71-23-36	Au 5 ppm XRF 3 – 50.7 feet	Fragmental mafic(?) lapilli(?) volcanics, with minor exhalative chert, silicate, sulfide, magnetite BIF components	Quartz, calcite, chlorite, biotite?, magnetite?, sulfide?, amphibole? Recrystallized, schistose; chlorite	Hornfelsed(?) variably sheared, schistose; locally laminated, locally folded; some qz-carb segregations possible felsic fragments and not disrupted veins/segregations.	As 217 ppm Au 18 ppb Bi 3 ppm Mn 1962 ppm Hg 50 ppb Pb 11 ppm	V 1325 ppm	Ti 54252 ppm Rb 554 ppm Zr 395 ppm Mo 76 ppm Ag 39 ppm Ba 4088 ppm Au 5 ppm

*See Appendix A for the digital file with details for the XRF sample footages (P378_XRF_I Falls.xlsx)

HLC = Historical lab chemistry based on reports DNR holds

NLC = New Lab Chemistry done for this project

XRF = XRF, hand-held, semi-quantitative, small spot analyzed, new data for this project

Geologic Context of Drill Cores

This portion of the Wabigoon Greenstone belt is composed of generally schistose, greenschist to amphibolitic, mafic to felsic metavolcanics, metasediments, chemical exhalatives, and intrusives. The previous exploration company work was in proximity to the Seine River-Rainy Lake fault system, with fault splays cutting through this area. This fault system is associated with the major tectonic boundary between the Wabigoon and Quetico subprovinces.

This area hosts Minnesota's only known past producing gold mine on Little American Island. Gold and other mineralization occurs across the border in the Wabigoon subprovince in Canada. Currently, the Rainy River Gold Project is underway about 70 kilometers northwest of International Falls, and a Mineral Resiource Estimate was released in 2011 (SRK Consulting, 2011). Further delineation of the gold mineralization is underway. The past understanding of the geology has been hampered by rock textures, metamorphism and geologic structure. The Rainy River Gold Project area is currently being interpreted as a hybrid gold deposit originating with an earlier phase of permeability focused hydrothermal fluids within dacitic and basaltic volcanics. Post-volcanic structural deformation and hydrothermal activity appears to have locally upgraded the gold grades within shear zones (Wartman, 2011). A late zone of nickel-copper-precious metals sulfide mineralization hosted by a mafic-ultramafic intrusion has also been discovered.

The following sections summarize different observations and observed aspects of International Falls geology as logged in the drill core.

Rock Fabric (see Rock Mineralogy; see Veining)

In the International Falls area, the Archean greenstone metamorphic rock fabrics vary from being finely hornfelsic to recrystallized to a coarser more schistose fabric. Differences are apparently due to the relative timing and intensity of tectonic and heating events. The more schistose fabrics appear to be deformation and, at least locally, shear related. Strongly oriented mineral grains, however, often do not produce a strong schistose fabric. Recrystallization after the growth of oriented minerals (micas and amphiboles) is believed to be responsible for this. Whether this is due to heating from later dikes, or from another heating event, is uncertain. Faulting products include calcite veins and veinlets (generally relatively late), local clayey fault gouge (TC-36-1), breccia, and small offsets. The origin of some fragmental rocks is unclear due to later recrystallization and metamorphism. Wattman (2011) notes the existence of similar pseudo-textures due to alteration in the Rainy River Gold Project rocks, and such an origin cannot be ruled out. The deformational history appears to have been long and drawn out over the course of the formation of the International Falls rocks. In general, the sedimentary bedding and regional deformational fabric appear to be parallel or subparallel.

Later, mafic intrusive dikes (in DDH's SS-9 and TC-36-1) appear to lack a metamorphic fabric and appear to be post-Archean. Their contacts with Archean materials are often chaotic with country rock intermixing. Dike emplacement may have been associated with fault movements. Late veinlets of calcite and epidote, especially near contacts, may also indicate the involvement of prolonged shearing. One other generally massive rock without much deformation features, is a tan to pinkish siliceous, massive, aphanitic rock (in DDH's S-1, S-3, and TC-36-1). This is believed to be massive felsic volcanics, probably flows or possibly uniform recrystallized tuff(s). The siliceous, massive nature is believed to have directed stresses to preferentially deform more ductile surrounding greenstone belt materials, leaving these competent siliceous materials as coherent blocks.

Local folding is discernible, notably with laminated chemical sediments and tuffs. Siliceous rocks of these types appear to have had a lesser tendency to develop a schistose fabric, especially if the rocks form different domains or packages with different ductilities and internal fabrics.

Rock Protoliths (see Rock Mineralogy)

The Archean protoliths appear to be typical greenstone belt volcanics, sediments, local intrusives, and chemical sediments. Metamorphism and recrystallization have interfered with the preservation of original textures, but more primary textures are locally discernible. Many of the observed rocks were somewhat magnetic. Magnetite and lesser pyrrhotite occur in the more iron-rich rocks. Magnetite appears to be porphyroblastic in places.

More massive, siliceous felsic flows(?) and/or tuffs (some crystal tuffs) occur in DDH's S-1, S-3, and TC-36-1. The often aphanitic and/or local massive character and general lack of internal textures does not preclude an origin of massive recrystallized siliceous tuffs or cherty metasediment, however. These often have veinlets with K-feldspar, mica, calcite and perhaps minor fluorite(?).

Mafic metavolcanics vary from more massive chloritic to amphibolitic probable flows (DDH S-1) to fragmental rocks. Such fragmental rock textures may be more primary volcanic, or from relatively early brecciation with healing and fragment cementing. Deformed mafic dikes(?) with porphyroclastic plagioclase clots occur in DDH's ND-3, S-3, and perhaps S-1, although the dike origin is problematic. Fragmental, more siliceous tuffs (lapilli and coarser? fragments) are also discernible locally.

Finer laminated tuffs and cherty exhalites are difficult to differentiate in places. Oxide, magnetite, sulfide, silicate, and carbonate(?) chemical sediment components also tend to be mixed with these more siliceous contributions. Monomineralic chemical sediment laminae are thin and rare. Local lamina occur with scattered tourmaline (generally with chlorite or amphibole), and is believed to have an exhalitive origin. If so, metamorphism has recrystallized and coarsened the "tourmalinite" enough to allow for microscopic tourmaline identification. This material tends to be associated with other exhalite components. One lithotype with tourmaline consist of layers of massive chlorite (DDH SS-9) with porphyroblastic tourmaline and/or hornblende. Textures and mineralogy makes the origin somewhat problematic. Such material could also be altered sheared material. Some areas of greater iron-rich (and manganese) exhalatives have developed Mn-rich garnet porphyroblasts (DDH's SS-9, ND-3, S-3). Several DDH's (ND-3, S-2, S-3) had thin laminae of bedding-fabric parallel sphalerite. There is uncertainty about their nature as to whether they were stratiform or cross-cutting veinlets. If originally cross-cutting, then deformation and fabric has reoriented such laminae. It is unclear as to whether the nature of the exhalites represents more distal vent sources, or a more proximal hydrothermal component within the regional tectonic setting.

The late(r) mafic dikes have chilled aphanitic, jumbled contacts and are variably plagioclase and pyroxene(?) porphyritic. Center portions are medium-grained gabbro. More deformed and altered, possible Archean(?) metagabbros (DDH's ND-1, SS-9, 128/2R1, 128/2R2, 283-1/4R1) leave some doubt as to where they fit in this regional package of rocks. For ND-1 and SS-9, the recrystallization provides doubt whether they are indeed mafic intrusives; whereas the other three , (128/2R1, 128/2R2, 283-1/4R1) are more definitely mafic intrusives, but weathering and possible late shear alteration creates doubts that these may be younger and not Archean.

Rock Mineralogy (see Veining)

Besides quartz and minor feldspar, other major silicates locally include muscovite, biotite, chlorite, hornblende, other amphiboles, local garnet, and tourmaline. Amphibolite grade rocks were fairly common. Rocks often appeared to be more schistose, than the way that the rocks actually broke. This may reflect a more siliceous nature, or later hornfelsic recrystallization after the oriented silicates grew. Mafic volcanics tended to have significant chlorite or hornblende, although more grey, less iron-rich(?) amphiboles (light grey, actinolitic?, tremolitic??) may predominate over hornblende.

Sulfides were generally less than a few percent, with pyrrhotite, pyrite, chalcopyrite, and sphalerite being most common. Sulfide occurs as disseminations with local more concentrated layers as exhalites, within veinlets, or in (quartz) veins. Pyrrhotite and pyrite were locally found in close proximity, notably within deformed quartz veins. This appears to be one association with known XRF gold mineralization as evidenced by XRF mapping in DDH SS-7 within 173.5 to 173.8 feet (Figure 2). Chalcopyrite typically occurs as small disseminated grains, and produced XRF copper values to 11%. Sphalerite occurred as disseminated grains, but also as thin (stratiform?) laminae or fabric parallel veinlets (DDH's ND-3, ND-2, S-2, and S-3), with a notably association with more iron-rich exhalative portions (DDH's ND-3 and ND-2). The XRF zinc values, to 21% in DDH ND-3, had associated Cd, Au, and Sb.

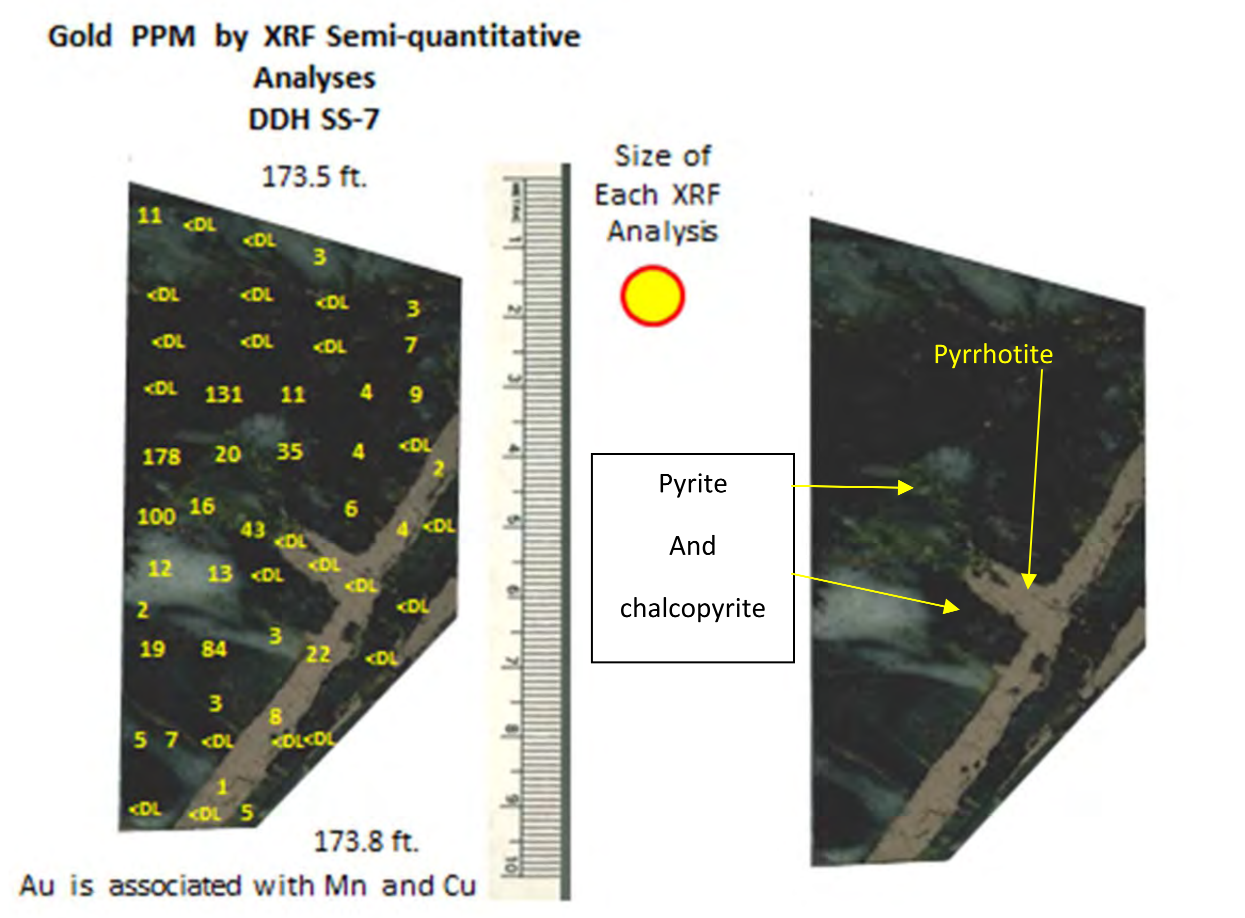

Figure 3: DDH SS-7 @ 173.5'. XRF mapping of gold value distribution in ppm.

Carbonate, generally calcite, was variably ubiquitous. Calcite, while possibly being introduced earlier, tended to fill late fractures and minor (deformational) voids. Calcite appears to postdate the quartz veins, or at least the earlier portion of quartz vein deformation. Semi-quantitative XRF analyses indicated elevated manganese in the non-iron-bearing calcite locally, producing pink to orange fluorescence (DDH TC-36-1). Some deformed quartz veins did have sporadic associated earlier carbonate that appeared to be more dolomitic, and also with some XRF iron.

Porphyroblastic minerals included garnets, hornblende, tourmaline, magnetite, and perhaps biotite or muscovite. These minerals, with the exception of garnet and perhaps hornblende, probably represent growth from the same finer-grained minerals in the matrix.

Porphyroblastic(?) magnetite grains to 1 mm occur in DDH's S-1, S-2, S-3, ND-1, ND-2, ND-3, and TC-36-1. These grains are in some mafic volcanics and not necessarily in just exhalite magnetic intervals. Porphyroblastic garnets tend to be associated with chemical sediments, notably DDH's T-1, T-2, S-3, SS-9, and ND-3. XRF analyses indicated elevated manganese along with iron. Some are euhedral, with some pressure shadows. DDH S-1 had possible garnets in an amphibolitic portion of possible felsic flows(?).

Porphyroblastic hornblende and tourmaline were often found intermixed together or perhaps growing in adjacent apparently planar, domains. These euhedral grains (1 to 5 mm) were most noticeable in areas of relatively massive, finer-grained chlorite or hornblende(?) schist of problematic protolith and origin. Both porphyroblasts were very dark colored. Hornblende porphyroblasts were more acicular and sharp pointed with a slight greenish color tinge. The tourmaline prisms had blocky ends with a slight brownish color tinge (Figure 3).

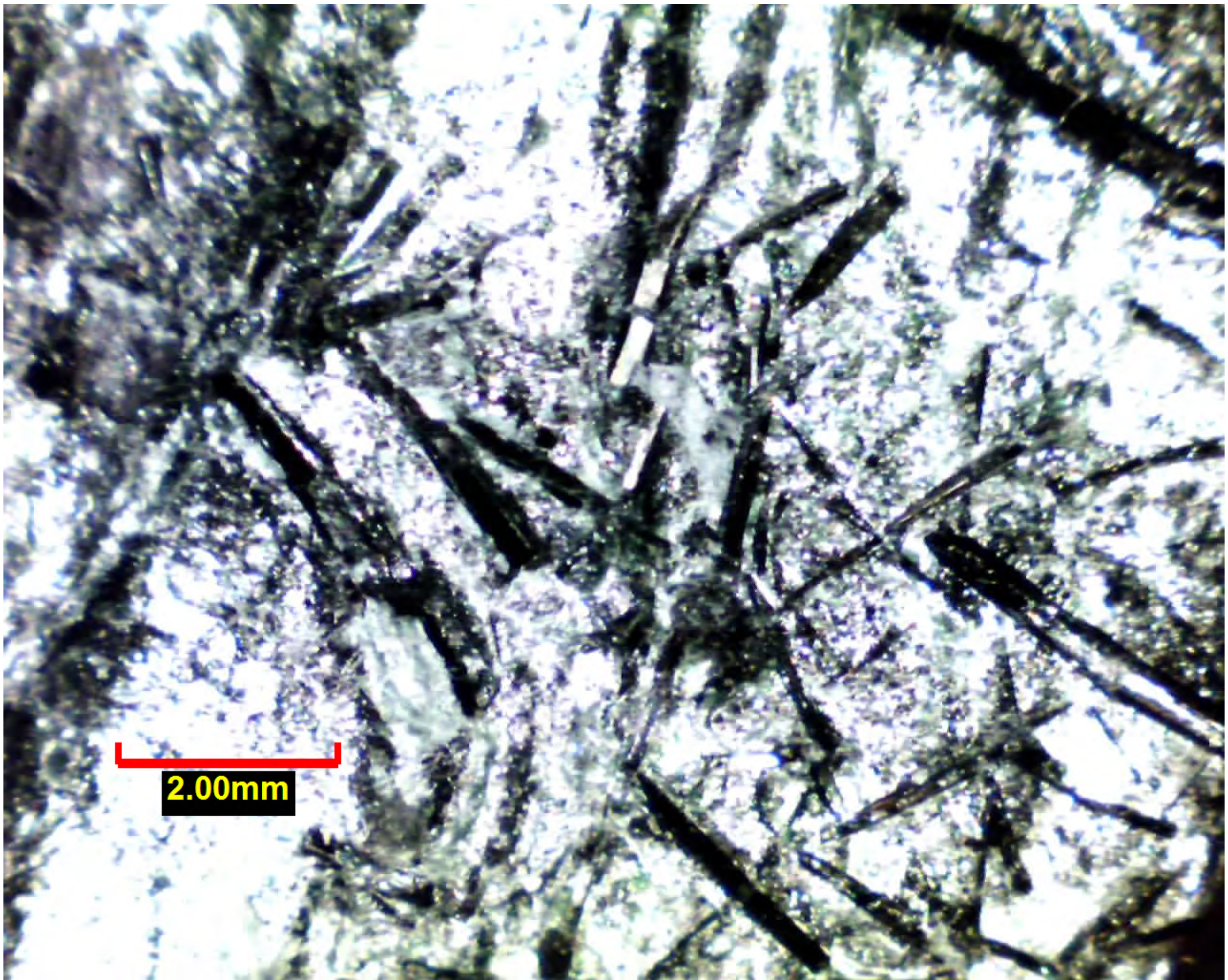

Figure 4: DDH SS-9 @ 78' . Tourmaline rich lamina. Looking down on natural break in core due to numerous tourmaline needles. Sample oriented for reflection of chlorite to enhance contrast with tourmaline for photograph.

Tourmaline manifested itself in a number of styles, and may represent a number of processes to create these different occurrence styles. The regional metamorphism and recrystallization has produced large enough crystals to allow microscopic identification in grain mounts, no matter how fine the original tourmaline may have been. Grains exhibited a brownish pleochroism, although one observed grain was zoned with a bluish center. Drill cores with tourmaline included T-1, ND-1, ND-2, ND-3, S-1, S-2, S-3, SS-9, and TC-36-1. Tourmaline occurred most often as an apparent component of chemical sediment exhalatives, and as a component of early deformed quartz veins or segregations with minor calcite typically.

Veining

Veining in these rocks was variably ubiquitous, as was deformation and fabric formation. The most ubiquitous veining (and alteration) was the relatively late calcite veinlets and void filling/alteration. Most rocks had at least some minor calcite. The ability of veins to scavenge elements from surrounding country rock, may allow for further concentration of more primary mineralization as at the Rainy River Gold Project (Wartman, 2011). Unfortunately, or fortunately, veining may also represent a distal portion of a more heavily mineralized hydrothermal system; or an uneconomic mineralization maximum of the hydrothermal system at a given location.

The earliest episode of veining appears to have been quartz, with variable sulfide and tourmaline, and minor carbonate. Quartz veining was generally deformed and appears to have occurred relatively early in the history of these greenstone volcanics and sediments. The quartz veins are often currently podiform in nature. They appear to have been pinched and boudinaged, folded, and, or irregular in general. These veins typically are not major components of the lithologies in which they occur, and they may be most common in the exhalative portions. Some have adjacent relatively massive chlorite or hornblende, and appear to be segregations.

Tourmaline grains in these quartz veins vary considerably, and includes local more massive portions of a centimeter or more (notably DDH’s ND-1, SS-9), which may also be segregations. As with the quartz, the tourmaline, sulfide, and non-calcite carbonate may be locally derived. When tourmaline prisms extend into the quartz, the tourmaline prisms are often show some breakage, with the pieces slightly offset or no longer aligned.

Most of the minor carbonate in this quartz veining was calcite. Calcite was typically as finer veinlets in these quartz veins and country rock. These were more ubiquitous, and appeared to be a later brittle (generally hairline) fracturing of the rock as a whole, with minimal association with gold mineralization.

The quartz veining often had small amounts of sulfides, silicates, and tourmaline.

More massive, siliceous felsic flows(?) and/or tuffs (some crystal tuffs) occur in DDH’s S-1, S-3, and TC-36-1. The often aphanitic and/or local massive character and general lack of internal textures does not preclude an origin of massive recrystallized siliceous tuffs or cherty metasediment, however. These often have veinlets with K-feldspar, mica, calcite and minor fluorite(?). There is some question as to whether these represent late stage fluids from the containing rock; or are related to later metamorphism and recrystallization.

Alteration

Aspects of alteration have been expressed in previous sections of this report. Alteration has been obscured by metamorphism, deformation, and recrystallization, so visual clues resulting from alteration may be more difficult to see. Since gold often exhibits a nugget effect, the small analytical window size of the XRF may be better at accurately determining gold associated alteration elements. While the larger sample size of laboratory chemistry may dilute some element associations, those associations that ARE visible may be more practical in the larger exploration sense.

The only widespread alteration is the late calcite mentioned earlier. More favorable carbonates associated with gold, such as ankerite were rare, as was any intense silicification. Early deformed quartz-carbonate-sulfide veins with gold were not extensively developed.

No thin sections were made for this work, and the presence of fine-grained alteration such as the sericite alteration and alteration caused pseudo-textures as described by Wartman (2011) is problematic. The massive felsic flows described by Wartman were there, but the alteration was not developed to the same degree. Sericite alteration may be indicated by elevated potassium (K) laboratory chemistry, notably DDH's TC-36-1 and ND-2. The XRF as configured cannot measure K, but Rubidium (Rb) values usually parallel potassium values, and DDH ND-2 is also prominent. A common Archean gold association is the mineral fuchsite, a chromian sericite mica. Any patchy fuchsite is best indicated by elevated XRF chromium (Cr) and Rb, and DDH ND-3 exhibits this best without additional elevated nickel (Ni).

Other gold related trace elements do show up in the chemistry and indicate different possible gold associations, but none appear to strongly predominate over others.

Summary of Each Drill Core – Logging, Chemistry, and Digital Files

The data generated is derived from a number of sources. The rock samples (from drill holes) described and analyzed were from the MnDNR Drill Core Library in Hibbing.

Information for each drill hole came from the MnDNR DDH list. This includes the UTM location, PLS location information, company. Much of this information came from original company documents maintained in the MnDNR-Division of Lands & Minerals Mineral Exploration Archives

Laboratory chemistry was analyzed at the ALS Chemex facilities at xxx Nevada. Sample intervals chosen were based on previous analyses, the new work of this report, and the internal constraints of this project concerning time and monetary spending. Sample information was maintained in a separate spreadsheet, and included DDH identifiers, footage, and lithologies. Contained DDH information came from the DDH inventory list. Unique sample numbers with a "P378" preface were given to each sample. Beside internal standards used during analysis by ALS Chemex, we included pairs of 'blind' standards every twenty to thirty samples, along with duplicate analyses of the prepared pulps. Standards were pulps, or pulps diluted by silica sand, and in this context, they were visually discernible as 'standards', but not labeled as such. A wide spectrum of elements was analyzed for (see files with ALS Chemex data).

The semi-quantitative XRF analyses were done with a vacuum Innov-X Alpha XRF Spectrometer. The analysis target is a slightly ovate circle with an area of about .76 cm^2. The initial instrument configuration, as bought, was for prioritized gold analyses. These internal settings for each element have been kept intact. Certain elements are prone to interference from other elements. The instrument regularly requires that an Innov-X standard be run to maintain the instrument's internal calibration. The MnDNR used a U.S. Geological Survey sample, DGPM-1, to test gold analysis precision. This used EPA Method 6200 as a guide. This procedure was done generally weekly, and consisted of analysis of a pulp holder capsule (with DGPM-1) seven times at a location where gold values were discernible. This was done without moving the sample or changing other instrument settings. Assayed gold values for DGPM-1 is 730 parts per billion (ppb) for gold. XRF values as measured for gold was between one and seven ppm. The XRF, while being able to discern gold, also tends to over-estimate the amount.

Because of the sampling size differences and nature of the XRF semi-quantitative analyses, the laboratory analyses and semi-quantitative XRF analyses cannot be expected to be correlatable with each other, nor should they be combined in chemistry tables.

Results and Conclusions

New core logging from thirteen drill holes found new alteration and features possibly related to gold mineralization. These include quartz-carbonate-sulfide veining; minor copper, zinc, lead sulfides; banded iron formation; quartz, sericite, carbonate, pyrite alteration; pyrite-pyrrhotite transitions; minor stratiform sphalerite; locally abundant vein and possibly exhalative tourmaline; and anomalous gold assays. Weak gold mineralization has also been found in biotite schist that has normally been disregarded as a gold mineralization host.

The new gold assays up to 799 ppb and zinc values to 2160 ppm have verified new observations and measurements using semi-quantitative XRF analyses. The XRF analysis has shown several different small-scale element associations with gold. The gold bearing XRF semi-quantitative anomalies had combinations of associated anomalous Rb (Potassium analog), Mo, Ag, Pb, Zn, Cu, Ba, Sn, Cd, As, Sb, Mn, Ni, Fe, Cr, and possibly Sr and Co. More specifically, Au related to possible Volcanic Hosted Massive Sulfide (VHMS) had anomalous Zn, Cd, Pb, As, Sb, Sn, Fe and Cr. Au related to iron-rich chemical sediment (and possible fuchsite-bearing) lode gold mineralization had associated anomalous Fe, Cr (fuchsite?) and other anomalous elements. An ultramafic parentage of anomalous gold may be indicated by anomalous Fe, Cr, along with Ni. Au related to possible porphyry systems exhibited anomalous Mo, and locally Ag, Mn, Sr, Ba, As, Sn, Hg, and Cd. Lode gold vein mineralization is associated with combinations of Fe, Mn, Ti, Co(?), Cu, Zn, Sr, Ag, Sn, Ba, and Pb; and may reflect scavenging of metals from the other, more primary types of gold mineralization.

International Falls gold mineralization indicates a possible relationship with multiple different geologic processes and modes of occurrence. Several gold mineralization models with proximal and regional relevance appear to apply to these rocks.

These mixed Wabigoon Greenstone Belt rocks have similar lithologies, including massive felsic lava flows, and perhaps associations to the Rainy River Gold Project located 70 kilometers to the northwest in Ontario.

Acknowledgements

Most Minnesota rocks have changed little over the time span of millions and even billions of years, yet new information about them is constantly being uncovered. This information may be voluminous in nature, and it concerns all spatial scales from the microscopic to the continental. The process of generating new information to disseminating it involves numerous people, all of which make the whole process possible; and all should be thanked.

Dennis Martin has helped guide the project and coordinate activities and resources. His review of this report has been most helpful along with discussions about the geology and mineralization of this area and adjacent parts of Canada.

Dave Dahl and Rick Ruhanen (retired) of Lands & Minerals have been essential in retrieving documents related to company work concerning the drill holes and the resulting core; and the core building logistics. They have also discussed geology, mineralization, and mining aspects of this area and adjacent parts of Canada.

Jordan Goodman and Rory Oberhelman have retrieved and returned core samples while maintaining core building logistics. They have also helped with sawing and sampling of drill core.

Don Elsenheimer has generated maps for this and related projects in this area, discussed geologic issues of this area, and also reviewed this report.

Dave Dahl, Matt Oberhelman, and Dale Cartwright have all answered questions about the transition to ArcMap 10.

The leasing section has provided information concerning State Mineral Leases.

George Hudak has provided insightful discussions about the Rainy River Gold Project, and gold mineralization in general.

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Appendix A Description of Listed Digital Files

This Digital File Listing

These digital files are associated with this report document, P378_Report.pdf . Some files have raw data and information presented in a more accessible and usable formats for end users.

FILE	DESCRIPTION
P378_Readme.pdf	**Summary and synopsis of this document; where-to-go shortcuts**
P378_Report.pdf	**This document**
P378_Logging.xlsx	**Spreadsheet with core logging lithologic information**
P378_XRF_IFalls.xlsx	**Spreadsheets with semi-quantitative XRF analyses, lithology information**
P378_Chem_Stat.xlsx	**Spreadsheet with laboratory analyses from ALS Chemex**
P378_Chem_Shape_AB6.xls	**Spreadsheet with laboratory analyses from ALS Chemex, UTM's and "dumb record." This record was for easier shapefile creation.**
P378_COA_RE11023552.pdf	**Original ALS Chemex Laboratory results for 2nd analytical shipment**
P378_COA_RE10075765.pdf	**Original ALS Chemex Laboratory results for 1st analytical shipment**
P378_QCDOC_RE10075765.pdf	**Original ALS Chemex Laboratory internal quality control results for 1st analytical shipment**
P378_QCDOC_RE11023552.pdf	**Original ALS Chemex Laboratory internal quality control results for 1st analytical shipment**

P378_COA_RE11023552.csv	**Original ALS Chemex Laboratory results for 2nd analytical shipment – csv file**
P378_COA_RE10075765.csv	**Original ALS Chemex Laboratory results for 1st analytical shipment – csv file**
P378_QCDOC_RE10075765.csv	**Original ALS Chemex Laboratory internal quality control results for 1st analytical shipment – csv file**
P378_QCDOC_RE11023552.csv	**Original ALS Chemex Laboratory internal quality – csv file**
DNR_blind_standards.xlsx	**Standards and analyses of standards sent to ALS Chemex**
Pilot_database_Kooch_2May (2).xlsx	**Compiled existing geochemistry data for Koochiching County, Mn**
XRF_standard_DGPM-1 (USGS).xlsx	**Published metal values for USGS standard DGPM-1**
ALS Minerals-Service-Schedule-USD.pdf	**Chemistry Lab analytical descriptions –metadata**
2010-02e-Lithium-Technical-Note.pdf	**Chemistry lab description of Li analyses - metadata**
2011-03e-Quality-Technical-Note.pdf	**Chemistry lab description of internal quality control - metadata**
Method Descriptions-ME-ICP41.pdf	**Chemistry lab description of package methodology - metadata**
Method Descriptions-ME-ICP61.pdf	**Chemistry lab description of package methodology - metadata**
Method Descriptions-ME-MS81.pdf	**Chemistry lab description of package methodology - metadata**
Method Descriptions-Sample-PREP-31.pdf	**Chemistry lab description of sample prep metadata**
Method Descriptions-Sulfur-Methods.pdf	**Chemistry lab description of S analyses - metadata**

Method-Descriptions-ME-ICP06.pdf	**Chemistry lab description of package methodology - metadata**
P378_exploration_drill_holes_metadata.pdf	**Metadata concerning the project cores located in the Drill Core Library**

APPENDIX B

Metadata

See “Description of Work Done” and digital file **p378_exploration_drill_holes_metadata.pdf**.

The data generated is derived from a number of sources. The rock samples (from drill holes) described and analyzed were from the MnDNR Drill Core Library in Hibbing.

Information for each drill hole came from the MnDNR DDH list. This includes the UTM location, PLS location information, company. Much of this information came from original company documents maintained in the MnDNR-Division of Lands & Minerals Mineral Exploration Archive.

Laboratory chemistry was analyzed at the ALS Chemex facilities at Reno Nevada. Sample intervals chosen were based on previous analyses, the new work of this report, and the internal constraints of this project concerning time and monetary spending. Sample information was maintained in a separate spreadsheet, and included DDH identifiers, footage, and lithologies. Contained DDH information came from the DDH inventory list. Unique sample numbers with a “P378” preface were given to each sample. Beside internal standards used during analysis by ALS Chemex, we included pairs of ‘blind’ standards every twenty to thirty samples, along with duplicate analyses of the prepared pulps. Standards were pulps, or pulps diluted by silica sand, and in this context, they were visually discernible as ‘standards.’ A wide spectrum of elements was analyzed (see files with ALS Chemex data). Methodologies of ALS Chemex are included in the digital files listed.

The semi-quantitative XRF analyses were done with a vacuum Innov-X Alpha XRF Spectrometer. The analysis target is a slightly ovate circle with an area of about .76 cm^2. The XRF instrument as initially configured when bought, was for prioritized gold analyses. These initial internal settings for each element have been kept intact.

The instrument regularly requires that an Innov-X standard be run to maintain the instrument’s internal calibration. The MnDNR also used a U.S. Geological Survey sample, DGPM-1, to test gold analysis precision. This used EPA Method 6200 as a guide. This procedure was done generally weekly, and consisted of analysis of a pulp holder capsule (with DGPM-1) seven times at a location where gold values were discernible. This was done without moving the sample or changing other instrument settings. Assayed gold values for DGPM-1 is 730 parts per billion (ppb) for gold. XRF values as measured for gold was between one and seven ppm. The XRF, while being able to discern small amounts of gold, also tends to (probably) over-estimate the amount. There is always uncertainty in this because of the known nugget effect for gold.

Mercury values also appear to be generally overestimated by our XRF. Certain elements are also prone to interference from other elements. High iron values appear to promote overestimated cobalt values and perhaps manganese. The reported effect of zinc influencing gold values, does not appear to be a problem with this instrument and the beam energies used. If the interference is real, it is not consistent.

The XRF instrument generates a comma separated variable (csv) file which is easily used by a spreadsheet. Sampling information is maintained in a parallel spreadsheet file. The XRF instrument occasionally has interrupted tests (an instrument problem fail-safe), and sometimes this data is recorded, and sometimes not. Sample integrity between the XRF and sampling information spreadsheet is maintained by recording one element and value (titanium usually used) into the sampling information spreadsheet. This value is copied from the XRF display and is manually entered into the sampling information spreadsheet. When the spreadsheet and csv file are combined, this ensures correct correlation between the two. This value is not necessarily unique. Uniqueness for each XRF semi-quantitative analysis was attempted as a combination of DDH, Footages, and Piece. 'Piece' differentiates different analyses at the same DDH and Footage. It is recommended that a new field with sequential unique numbers be added if record uniqueness for a database creation is needed.

The file P378_XRF_IFalls.xlsx has the combined XRF chemistry and the sample information combined.

Because of the sampling size differences and nature of the XRF semi-quantitative analyses, the laboratory analyses and semi-quantitative XRF analyses cannot be expected to be strictly correlatable with each other, nor should they be combined in chemistry tables.

Lithology information was recorded in the file **P378_Logging.xlsx .** The lithologies and intervals in this file tend to be generalized. More detail for specific locations occurs in the XRF file **P378_XRF_IFalls.xlsx** . It is also recommended that company logs from the Mineral Exploration Archives are examined. Multiple sets of eyes and experiences will boost the understanding of these difficult metamorphosed lithologies and textures. Variable amounts of previous geochemistry, geophysics, and lithologic information can also be found in the Mineral Exploration Archives.

APPENDIX C

Other Associated Mineral Potential Project File Work

A number of past Minnesota Department of Natural Resources (MnDNR) Mineral Potential Projects have relevance to this report. Some of these have published reports, while others have generated available information without formalized reports.

PROJECT #	PROJECT TITLE
231	Compilation of Prospects, Test Pits, Shafts, etc.
242	1984-1985 Geologic Drilling Program
252	LCMR Glacial Drift Geochemistry FY 1986-1987
262	LCMR Strategic Minerals Geochemistry - Analysis of Opaque Oxides in Partial Heavy Minerals Concentrations from Glacial Drift Samples Lake County, Minnesota
263	1987-1989 Overburden Drilling Geochemisty
278	Greenstone Drill Core Examination & Assay 1990-1991
280	1990-1991 Overburden Drilling Geochemistry
282	Inventory of Industrial Pits & Quarries
289	Dimension Stone Inventory Reconnaissance Project
290	Geodrilling
298	Dimension Stone Inventory

330	Gas and enzyme leach geochem orientation survey
379	Regional Survey of Gold in Till - Big Fork Greenstone Belt
385	Geochemistry Survey - International Falls Area
387	Koochiching Bedrock Chemistry Spreadsheet