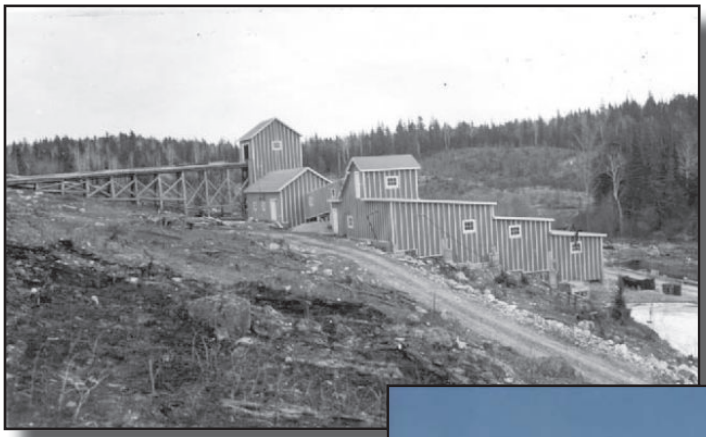
61st Annual Meeting
Institute on Lake Superior Geology

Dryden, Ontario - May 20-24, 2015

Part 2 – Field Trip Guidebook







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The following organizations made generous contributions to the 61st Annual Meeting. We thank them for their commitment to the Institute on Lake Superior Geology. All of the funds contributed this year go toward travel awards for student registrants. For the past 60 years this organization has thrived as a result of the interest of individuals, corporations, universities and government agencies. The dedication to an exchange of scientific ideas and a passion for field trips has enabled the Institute to provide one of its primary objectives – to promote better understanding of the geology of the Lake Superior Region.

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61st Annual Meeting

Institute on Lake Superior Geology

Supported by
Ontario Ministry of Northern Development and Mines

May 20-24, 2015

Dryden, Ontario

HOSTED BY:
Rob Cundari & Peter Hinz
Co-Chairs
Ontario Geological Survey

Proceedings - Volume 61
Part 2 – Field Trip Guidebook

Edited by Al MacTavish & Pete Hollings

Cover photos: Top - Sakoose Mine, circa 1937 (from Humphrey and Tymura: The New Klondike to the Manitou), Middle - Central Patricia Headframe, Pickle Lake (courtesy Mark Smyk), Bottom - Pickle Crow Au mine (courtesy of Rob Cundari)

61st Institute on Lake Superior Geology

Volume 61 consists of:

Part 1: Program and Abstracts

Part 2: Field Trip Guidebook

Trip 1: The Central Red Lake Gold Belt

Trip 2: Western Wabigoon Subprovince Transect, Dryden to Meggisi Lake

Trip 3: *Cancelled*

Trip 4: Thunder Lake (Goliath) Project

Trip 5: Classic Outcrops of the Dryden area

Trip 6: Gold Occurrences of Van Horne Township, Van Horne Gold property - Flambeau explosures

Trip 7: Unique Mineralizing Event at the Pidgeon Molybdenum Deposit Stripped Surface Exposure

Trip 8: Geology and Mineral Deposits of the Pickle Lake Greenstone Belt

Trip 9: The Ghost Lake Batholith and Related Pegmatites

Trip 10: Mattabi/Sturgeon Lake Historic VMS Camp

Reference to material in Part 2 should follow the example below:

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Introduction, safety considerations and acknowledgements

Rob Cundari and Peter Hinz

Ontario Geological Survey, Thunder Bay, Ontario, Canada

This volume is intended to serve not only as a guide for 61st ILSG field trip participants but also as a reference for those planning to revisit these areas at a later date. Consequently we have included UTM coordinates in the NAD 83 Zone 15 datum for the majority of stops, as well as instructions on how to reach them. For some of the stops on private land we have withheld the UTM coordinates to respect the privacy of the property owner. As some of the stops are on private and staked land, please be sure to obtain the land owners' permission before entering their land. For up-to-date information on land ownership please contact the Kenora Resident Geologists' Office at (807) 468-2819 or (for the Pickle Lake Area) the Thunder Bay Resident Geologist's Office at (807) 475-1331. Sample collection is prohibited at some stops on private land or within Provincial Parks.

Many of the fieldtrips will be visiting stops along major and secondary highways or busy logging roads. Please take care when crossing or parking along these roads. For those field trips that are visiting active mine sites personal protective equipment will be required. For those field trips that are visiting past-producing mine sites please be very careful around visible open holes such as shafts, pits, or trenches and keep a wary eye out for hidden holes which may be overgrown with vegetation and therefore are very difficult to see. Please notify the field trip leaders if you have any medical conditions that may be of concern during the trip. Each trip leader is equipped with a first aid kit and satellite/cell phone, so please notify them of any incident.

We would like to thank all authors who contributed to this field guide and also all those who provided comments and assisted with the running of the field trips themselves. We appreciate the assistance and cooperation of the exploration and mining companies in providing us access and information concerning their properties. We are particularly grateful to Goldcorp Inc., Glencore plc, Cadillac Ventures Inc., PC Gold Inc. and Treasury Metals Inc. for running field trips on their properties.

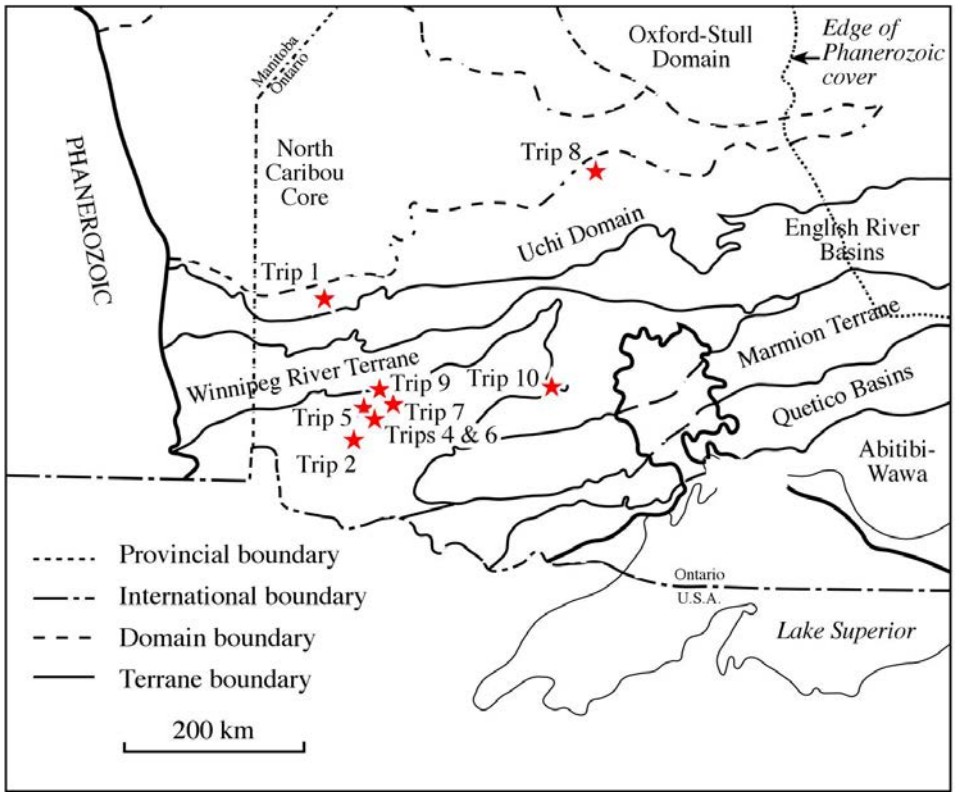


Figure 1. Map showing the general locations of field trips for the 2015 meeting.

Field Trip 1 - The Central Red Lake Gold Belt

Andreas Lichtblau and Carmen Storey

Ontario Geological Survey, Red Lake, Ontario, Canada

A Brief History of The Beginnings Of The Red Lake Mining Camp

This excerpt from Horwood (1940) details the early history of the camp and ends with the first mine that went into production, the Howey, in 1930:

A trading post, known as Red Lake House, was established by the North West Company some time prior to 1786 at Post narrows near the northeast end of the lake. Red Lake itself is shown on Arrowsmith's map of 1801, which outlines the route travelled by Alexander Mackenzie in 1789. The post was taken over by the Hudson's Bay Company in 1821 and has been in continuous operation ever since. In 1926 the site was changed to the west side of Howey bay opposite the Howey mine.

From 1812 to 1872 no mention is made of Red Lake by the various exploring parties that penetrated the west. Its position near the height-of-land and away from the main canoe routes discouraged exploration, and it remained an out-of-the-way but active outpost of the Hudson's Bay Company.

In 1872 A. R. C. Selwyn, who was making an exploratory trip down the English River from Lac Seul to Lake Winnipeg, heard of Onimini Sagaigan or Red Paint Lake from a group of Indians. They told him of the occurrence of slaty rocks, which, to him, suggested the presence of a belt of sedimentary and volcanic rocks to the north. He did not have time, however, to visit the area.

In 1883, Bell made a track survey of the lake and confirmed Selwyn's opinion of the presence of a wide belt of what he termed Huronian rocks. In 1893, Dowling examined the area and made a map, which till 1924 was the only source of geological information.

Some prospecting was done between 1898 and 1924, but no mineral deposits of commercial importance were located. The first recorded discovery of gold was made in 1897 by the Northwestern Ontario Exploration Company, a prospecting venture headed by R. J. Gilbert. This company staked a group of claims near Slate Bay in McDonough township but abandoned the property after doing some development work and sinking a small shaft. In 1912, when the Provincial Geologist issued a report that the Keewatin rocks of the Patricia District should contain deposits of gold, some prospecting was done; but the work did not meet with success.

In 1922, a party of prospectors became interested in the area. A press report of their discovery of a vein containing quartz and argentiferous galena attracted a number of other prospectors and resulted in some activity. Gus McManus, one of the prospectors, found some small gold-bearing quartz stringers near the outlet of Red Lake and staked several claims. Bruce, who was doing geological work to the south for the Ontario Department of Mines, heard of the finds and came in to make an examination. The area proved of such interest that the Department sent him back to complete his preliminary investigation. The map and report, published late in 1924, aroused considerable interest, and early in the summer of 1925 Lorne Howey and George McNeely, representing Haileybury interests, and Ray Howey and W. F. Morgan, representing McIntyre- Porcupine Mines, Limited, came in to prospect. Late in July, Lorne Howey and his partner found quartz stringers containing native gold and staked a group of claims on what is now the property of Howey Gold Mines, Limited. Ray Howey and his partner discovered gold mineralization to the southwest and; staked an adjoining group of claims, now part of the Hasaga property, for the McIntyre. News of the finds quickly reached the outside, and the Red Lake country had its first gold rush. The backers of Lorne Howey and George McNeely interested J. E. Hammell in their property, and he formed the Howey Red Lake Syndicate to develop the showing. In order to get men and supplies into the country before freeze-up seven Forestry planes, which were stationed at Sioux Lookout, were chartered. The success of this freighting venture was directly responsible for the development of commercial flying as an adjunct to mining

development in the more inaccessible parts of the north. By the spring of 1926 a fairly regular air-service had been established. In the fall of that year H. A. Oaks, one of the pioneer fliers, and James Richardson, Winnipeg financier, founded Western Canada Airways. This enterprise was known as Canadian Airways when taken over by Canadian Pacific Airlines in April, 1942.

Late in 1925 Mr. Hammell succeeded in interesting Dome Mines, Limited, in the Howey Syndicate. They took an option on the property and, by the summer of 1926, had completed an extensive diamond-drilling campaign. They decided, however, that the grade of the ore was too low to warrant the expenditure of more funds and in August of that year dropped their option. Many people became discouraged over the possibilities of the camp and left the area. Mr. Hammell, however, still had faith in the Howey property and continued work. With the financial assistance of W. S. Cherry a mill was built and the mine came into production on April 2, 1930. The undertaking proved to be a profitable venture and continued operations till November 3, 1941.

We will drive by an open stope at the Howey mine site during the tour.

Regional Geology

The Red Lake District (Fig. 1) is underlain by Archean rocks of the Superior Province of the Canadian Shield. Rocks of four sub-provinces are found in the Red Lake District:

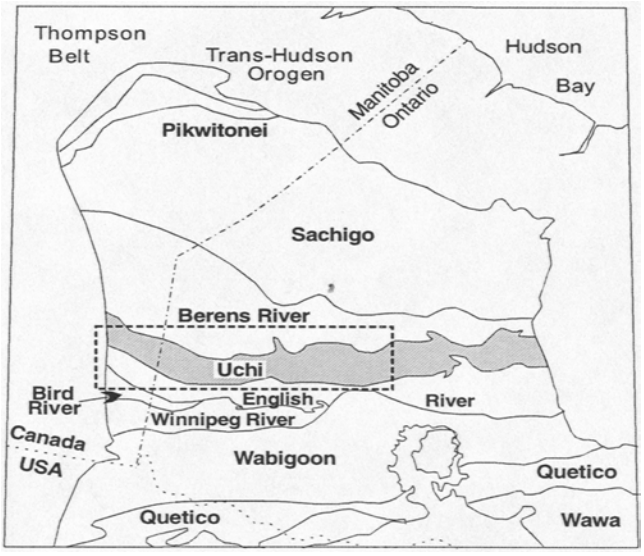


Figure 1. Western Uchi Subprovince (modified from Percival et al., 2000).

1. Uchi Sub-province rocks in the Red Lake District comprise the Red Lake and Birch-Confederation Lake greenstone belts in which the bulk of exploration and mining activity has taken place. The supracrustal rocks of the Red Lake greenstone belt can be subdivided into several assemblages with ages ranging from circa (ca.) 2990Ma to ca. 2700Ma (Table 1). Major granitoid intrusions show a range from ca. 2734Ma to 2699Ma (Table 2).
2. English River Sub-province rocks, south of the Uchi Sub-province, are predominantly metasedimentary and host minor intrusive rocks similar to those in the Quetico Sub-province.
3. To the north, the Berens River Sub-province formed the core of a microcontinent. This area is underlain by ca. 2750-2690Ma felsic plutonic rocks interpreted as a magmatic arc formed at an Andean-style margin that culminated in the Kenoran Orogeny. These plutonic rocks intruded an older substratum (North Caribou terrane) on which Mesoarchean volcanic rocks of the Red Lake belt are also interpreted to have formed.
4. The Sachigo Sub-province comprises crustal blocks ranging from Paleoarchean (>3.4Ga) to Neoarchean (ca. 2.7Ga) in age.

Geology of the Red Lake Greenstone Belt *(adapted from Sanborn-Barrie et al. 2001)*

The geology of the Red Lake greenstone belt (Fig. 2) is dominated by the (ca. 2990Ma) mafic-ultramafic Balmer assemblage, an oceanic plain sequence; minor calc-alkalic volcanic rocks of arc-like affinity terminate the assemblage. The majority of lode gold deposits in the camp are hosted by the basal mafic-ultramafic sequence. A later diverse lithologic association, the Ball assemblage, appears to represent a shallow marine, volcanic edifice built upon the Balmer substrate.

Widespread circa (ca.) 2894Ma calc-alkaline volcanism is represented in Red Lake by the Bruce Channel assemblage. Overlying this is the ca. 2850Ma Trout Bay assemblage which includes substantial basaltic and gabbroic rocks in western Red Lake which are prospective for PGE mineralization, and which includes minor intermediate pyroclastic rocks throughout central Red Lake. The Trout Bay assemblage may correlate with Woman assemblage rocks of the Confederation Lake belt.

A regional angular unconformity is interpreted

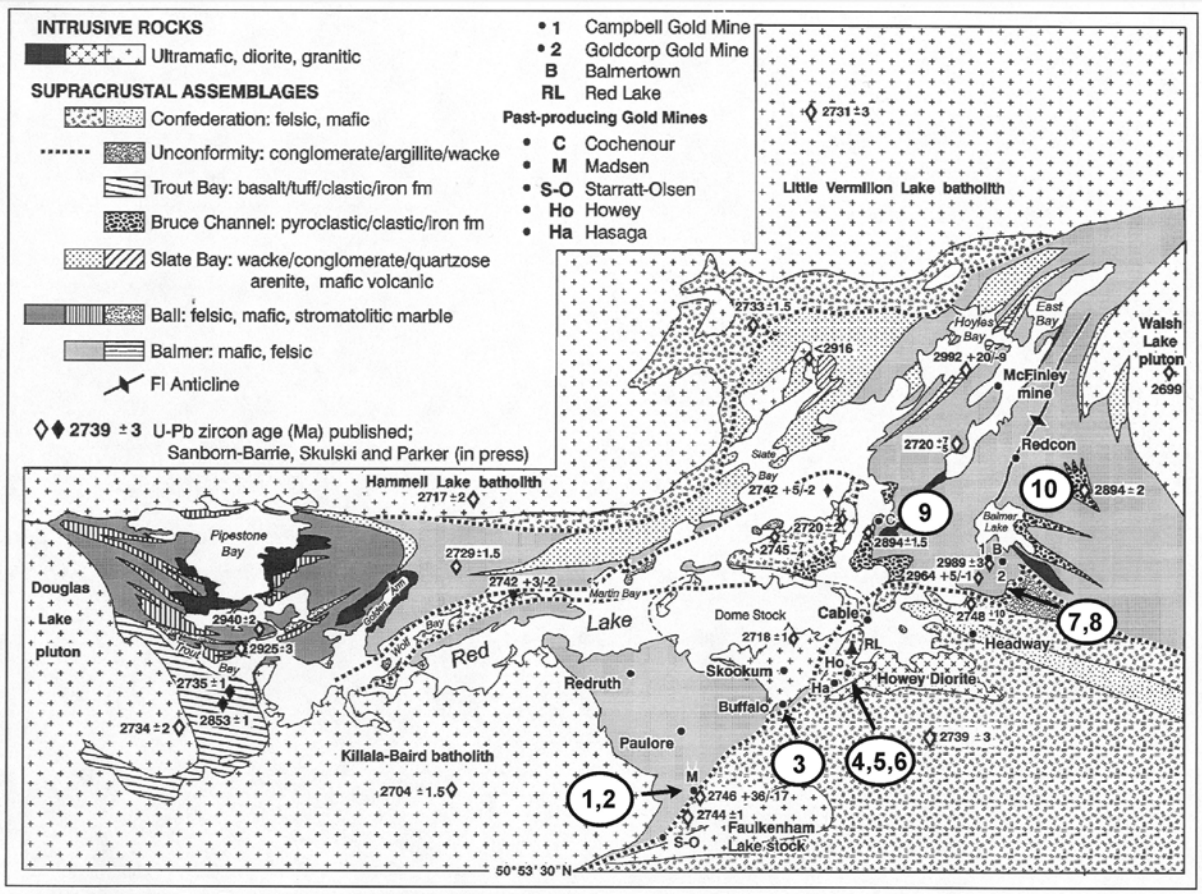


Figure 2. General geology of the Red Lake greenstone belt (after Parker, 2000). Tour stops as indicated.

to separate the Mesoarchean assemblages from the Neoarchean Confederation assemblages. Volcanogenic massive sulphide mineralization is associated with the younger sequence. A significant number of felsic units are classed as FII- and FIII-type rhyolites, considered highly prospective for large (Kidd Creek/Noranda type) massive sulphide deposits (Parker, 1999).

A newly recognized component of the Neoarchean supracrustal package is the Huston sedimentary assemblage that includes surface exposures of polymictic cobble- to pebble-conglomerate and argillite; clasts include jasperoidal chert iron formation, massive sulfide pebbles, mafic flow rocks as well as well-bedded, graded turbiditic wacke and argillite. The Huston assemblage conformably to unconformably overlie the McNeely sequence (Confederation assemblage) and underlies the Graves assemblage (Sanborn-Barrie et al., 2004). The U-Pb age of detrital zircons give single age peaks of 2743 and 2746Ma at the cemetery and Madsen sites, respectively (Skulski et al., 2001), indicating single source derivation from erosion of pre-existing Confederation age rocks, and deposition after ca. 2743Ma.

In the Campbell-Red Lake Deposit area the conglomerate defines the interface between the Balmer or Bruce Channel assemblages and the Confederation assemblage. Exposures on 16 Level of the Red Lake Mine reveal that (Dubé et al., 2004):

> *"... the [Huston] conglomerate is a polymictic proximal conglomerate or breccia (debris flow) dominated by subangular to subrounded laminated cherty clasts with local jasper-rich and green mica fragments; it is similar to the Temiskaming conglomerate… it also contains clasts of andalusite-rich altered basalt and a few local clasts of layered (possibly sheeted) carbonate veins with small crustiform banding and cockade texture."*

Detrital zircon analyses from the conglomerate on 16 Level of the Red Lake Mine define a single population with a mean age of 2747±4Ma (Dubé et al., 2004). This implies that the former two assemblages were exposed at surface by 2747Ma.

The presence of local andalusite-rich clasts and clasts of carbonate vein material in an unaltered matrix demonstrates that there was a period of at least some

Table 1. Summary of supracrustal lithologies and radiometric ages in the Red Lake greenstone belt (modified from Parker 2000; with new ages from Sanborn-Barrie et al. 2001 and Skulski et al. 2001; final error estimates are not cited for the new unpublished ages of T. Skulski).

Supracrustal assemblage	U-Pb Age (Ma)	Rock types and descriptions	References
English River?	<2700±6	Polymictic pebble conglomerate. Thought to correlate with the Austin tuff, host to the Madsen gold deposit.	Sanborn-Barrie et al. 2001
Confederation-Graves (north Red Lake)	2733±1.5	Calc-alkaline andesitic to dacitic pyroclastic rocks	Corfu and Andrews 1987
Huston (Cemetery)	≤2743	Well-bedded argillite and turbiditic wacke; polymictic conglomerate	Skulski et al. 2001
Huston (16 Level, Red Lake Mine)	≤2747±4	Polymictic conglomerate; laminated cherty and jasper clasts; green mica fragments; aluminous-altered basalt and iron-carbonate vein clasts	Dubé et al. 2004
Confederation-Heyson (southeast Red Lake)	2739±3	Basal sequence is commonly tholeiitic to calc-alkaline with lobe-hyaloclastite rhyolite flows; intermediate pyroclastic rocks; basalt; and feldspar-phyric andesite. Calc-alkaline rocks are more abundant at higher stratigraphic levels.	Corfu and Wallace 1986
Confederation-McNeely (central and SE Red Lake)	2742 2748+10/-5	Dominated by calc-alkaline, intermediate lapilli-tuff breccia and lapilli tuff	Sanborn-Barrie et al. 2001
Trout Bay	2853	Lower tholeiitic basalt sequence with associated gabbroic rocks overlain by fine-grained clastic metasedimentary rocks (wacke, argillite) interlayered with subordinate intermediate pyroclastic rocks and chert-magnetite iron formation. Overlain by tholeiitic, pillowed basalts.	Sanborn-Barrie et al. 2001
Bruce Channel	2894±1.5; 2894±2	Strongly calc-alkaline intermediate pyroclastic rocks overlain by pebble conglomerate, thinly bedded wacke and capped by chert-magnetite iron formation	Corfu and Wallace 1986; Corfu and Andrews 1987
Slate Bay	≤2916	Interlayered, feldspathic wacke, lithic wacke and argillite; lenses of pebble and cobble conglomerates and quartz-rich pebble conglomerate and quartz arenite.	Corfu et al. 1998
Ball	2940±2; 2925±3	Typically calc-alkaline intermediate pyroclastic rocks and rhyolite flows; komatiitic to tholeiitic basalt; overlain by chert-magnetite iron formation and dolomitic marble which contains stromatolites.	Corfu and Wallace 1986
Balmer	2992+20/-9; 2989±3; 2964+5/-1	Tholeiitic basalt, basaltic komatiite and komatiite interlayered with subordinate chert-magnetite iron formation; minor clastic metasedimentary rocks; minor intermediate to felsic pyroclastic rocks; and rhyolite.	Corfu and Andrews 1987

Table 2. Summary of lithologies and radiometric ages for major granitoid intrusions in the Red Lake greenstone belt (modified from Parker, 2000; new ages cited in Sanborn-Barrie et al., 2001 and elsewhere do not have final error estimates assigned, as this U-Pb data is not yet published).

Granitoid intrusion	U-Pb Age (Ma)	Rock types and descriptions	References
Cat Island pluton	2699	Potassium feldspar granodiorite	Sanborn-Barrie et al. 2001
Walsh Lake pluton	2699	Potassium feldspar- and quartz-phyric monzogranite; xenolith-rich, diorite or granodiorite; possible oxidized phase at Ranger Lake with broad magnetic anomaly	Noble 1989
Killala-Baird batholith	2704±1.5	Potassium feldspar- and quartz-phyric monzogranite; xenolith-rich, diorite or granodiorite, diorite or granodiorite; oxidized, magnetite-bearing marginal phase.	Corfu and Andrews 1987
Hammel Lake batholith	2717±2	Potassium feldspar and quartz porphyritic monzogranite; associated anorthositic intrusion.	McMaster 1987
Dome stock	2718±1	Granodiorite and augite porphyritic diorite/gabbro.	Corfu and Andrews 1987
McKenzie stock	2720±2	Augite porphyritic diorite-gabbro; some ultramafic rocks; granodiorite	Corfu and Andrews 1987
Red Crest stock	2729±1.5	Augite porphyritic diorite-gabbro	Corfu and Andrews 1987
Little Vermilion batholith	2731±3	Hornblende tonalite-granodiorite	Corfu and Andrews 1987
Douglas Lake pluton	2734±2	Biotite tonalite	Corfu and Stone 1998

aluminous and carbonate alteration prior to deposition of the Huston conglomerate (Dubé et al. 2004). The position of colloform-crustiform iron-carbonate±quartz veins in the Campbell-Red Lake Deposit underneath the interpreted subaerial unconformity also leads Dubé et al. (2004) to interpret the veins as near-surface, epithermal-epizonal products, part of a protracted hydrothermal alteration event spanning pre- to post-Huston assemblage time, a period of more than 35m.y.

Recent age dating (Skulski et al. 2001) has also yielded multiple ages of detrital zircons from a fragmental unit thought to correlate with the Austin "tuff" ore zone at the former Madsen mine. Most of the Meso- and Neoarchean assemblages exposed in Red Lake are represented in this unit. Maximum age of deposition is consequently ≤2700±6Ma.

Deformation *(adapted from Sanborn-Barrie et al., 2001)*

The Red Lake greenstone belt has undergone at least three phases of deformation:

1. D0, a non-penetrative, early (pre-2748Ma) event involving overturning of the Balmer assemblage;
2. D1, (bracketed between 2733-2742Ma) resulted in a north-trending foliation that is axial planar to F1 folds and involved east-west shortening; and
3. D2, (ca. 2720-2700Ma) resulted in a dominantly east- to northeast-striking foliation that refolds F1 folds. A local 'deflection' of S2 around the McKenzie stock created an east-southeast-striking corridor of heterogeneous strain forming the "Mine Trend", from Cochenour through the Balmertown area, hosting the major gold deposits of the camp.

Hydrothermal Alteration *(adapted from Parker, 2000)*

The Red Lake greenstone belt has been affected by a large-scale (10's of kilometres) hydrothermal alteration system, resulting in approximately contemporaneous a) strong to intense, distal calcite carbonatization that affects rocks of all ages, and b) less extensive (kilometre), proximal, strong to intense ferroan-dolomite and potassic alteration, found in almost all areas hosting gold mineralization. Carbonate alteration affects both the Dome (2718±1Ma) and McKenzie (2720±2Ma) stocks and is overprinted by calc-silicate, skarn-like alteration formed during the intrusion of the

Killala–Baird batholith (2704±1.5Ma) and the Walsh Lake pluton (2699Ma). The significant carbonate alteration event is therefore bracketed between 2718 and 2704Ma, during D2.

The main macroscopic features of carbonate alteration are pervasive replacement of rock matrix, open-space filling/replacement of primary porosity (vesicles, pillow selvages, hyaloclastite matrix), filling of extension veins with massive, colloform, crustiform and cockade breccia textures, networks of variably oriented veins, and "jigsaw puzzle" breccia veins.

Multiple stages of carbonate alteration and veining have been recognized, indicating continuous carbonatization during D2 deformation.

Potassic metasomatism takes the form of sericite/muscovite alteration in greenschist-facies rocks; in ferroan-dolomite altered ultramafic rocks fuchsite occurs instead of sericite. Potassic alteration in amphibolite-facies mafic and ultramafic rocks takes the form of pervasive biotite±muscovite. Centimetre- to m-wide, strong to intense, biotite±calcite±ferroan-dolomite±disseminated pyrite alteration halos often enclose ferroan-dolomite veins in amphibolite-facies mafic rocks.

Biotite altered zones in amphibolite-facies rocks are characterized by a diverse assemblage of aluminosilicate minerals such as andalusite, staurolite and cordierite, with garnet, chloritoid, cummingtonite, and anthophylite.

Barren, pervasive silicification within proximal alteration zones may be due to release and remobilization of silica during periods of pervasive carbonatization. The majority of gold deposits in the Red Lake belt are quartz and arsenopyrite rich selective replacement zones of colloform-crustiform ferroan-dolomite veins and breccia.

Geology of the Campbell-Red Lake Gold Deposit *(adapted from Dubé et al., 2002)*

Gold has been continuously produced from the Red Lake (formerly known as the Campbell-Dickenson) deposit since 1948. Current production levels and reserves are given in Table 3. Historic production figures for the Red Lake greenstone belt are shown in Table 4.

Alteration facies in the High Grade Zone at Goldcorp Inc.'s Red Lake Mine have been described by Dubé et al. (2002) as:

1. An outer, metre-wide, garnet-chlorite-magnetite alteration with chlorite-amphibole-andalusite and locally associated centimetre- to metre-wide 'bleached zone' containing andalusite-muscovite-quartz-ilmenite;
2. A proximal, centimetre- to metre-wide, massive to laminated, reddish-brown, biotite-carbonate alteration with disseminated pyrite (3-5%) and carbonate veinlets in well foliated basalt; and
3. A gold-rich, strongly foliated, silicified zone with abundant fine-grained arsenopyrite, sericite, and rutile, and lesser amounts of pyrite, pyrrhotite, magnetite, and stibnite (≤15%). This third alteration facies is adjacent to the silicified auriferous carbonate veins and replaces the biotite-carbonate-rich alteration.

The chronology of gold-rich replacement textures suggests a syn-D2 mineralizing event, dominated by silicification of carbonate veins, contemporaneous with boudinage of the veins. The silicified carbonate veins are hosted mainly by basalt; areas of high-grade gold mineralization are controlled by F2 fold hinges deforming the basalt-ultramafic contact. Multiple periods of silicification and gold deposition overprint and replace the carbonatization in these lower pressure hinge zones.

The extremely high grade ore (>2.0oz/t Au) currently mined at Goldcorp Inc.'s Red Lake Mine, is possibly due to a combination of factors, including the presence of a low-permeability ultramafic cap, allowing the build-up of very high fluid pressure in the footwall basalt; the high iron content of the tholeiitic basalt, creating a chemical, as well as structural, trap for the

Table 3. Current gold production and reserves, Goldcorp Inc., Red Lake Gold Mines

Mine	Production in 2013		Production in 2014		Reserves (Proven and Probable) at end of 2014
	Tonnage @ Grade	Total Commodity	Tonnage @ Grade	Total Commodity	Contained Ounces Gold
Goldcorp Inc. Red Lake Gold Mines (1)	786 900 tonnes @ 20.33 g/t Au	493 000oz Au	684 100 tonnes @ 19.47 g/t Au	414 400 ounces Au	2 060 000
(1) Goldcorp Inc., news release MD&A, February 19, 2015.					

Table 4. Historical gold production, Red Lake greenstone belt

GOLD PRODUCTION IN THE RED LAKE GREENSTONE BELT to December 31, 2014

			GOLD PRODUCED		
RED LAKE BELT PRODUCER	**YEARS OF PRODUCTION**	**ORE MILLED (SHORT TONS)**	**TROY OUNCES**	**OUNCES PER TON**	**GRAMS PER METRIC TONNE**
RED LAKE GOLD MINES	2006 to present[1]	6,906,322	5,285,590	0.694	23.80
CAMPBELL RED LAKE	1949 – 2005[2]	19,944,241	11,216,443	0.510	17.49
GOLDCORP (DICKENSON)	1948 - 2005	9,606,894	5,962,948	0.621[4]	21.28
MADSEN	1938 - 1976, 1997 – 1999[5]	8,678,143	2,452,388	0.283[6]	9.69
COCHENOUR-WILLANS	1939 - 1971	2,311,165	1,244,279	0.538[7]	18.46
MCKENZIE RED LAKE	1935 - 1966	2,353,833	651,156	0.277	9.48
HOWEY	1930 - 1941, 1957[8]	4,630,779	421,592	0.091[9]	3.12
HASAGA	1938 - 1952	1,515,282	218,213	0.144	4.94
STARRATT OLSEN	1948 - 1956	907,813	163,990	0.181	6.19
H.G. YOUNG	1960 - 1963	288,179	55,244	0.192	6.57
MCMARMAC	1940 - 1948	152,978	45,246	0.296	10.14
GOLD EAGLE	1937 - 1941	180,095	40,204	0.223	7.65
RED LAKE GOLD SHORE	1936 - 1938	86,333	21,100	0.244	8.38
BUFFALO	1981 - 1982	31,986	1,656	0.052	1.78
ABINO	1985 - 1986	2,733	1,397	0.511	17.53
LAKE ROWAN	1986 - 1988	13,023	1,298	0.100	3.42
RED SUMMIT	1935 - 1936	591	277	0.469	16.07
MOUNT JAMIE	1976	552	265	0.480	13.30
TOTAL		**57,061,260**	**27,369,086**	**0.335**	**17.4**

1. Includes total production from the Red Lake complex from January 1, 2006, and production from the Campbell complex subsequent to May 12, 2006, the date of acquisition.
2. Includes production figures under Placer Dome (CLA) Ltd., to May 12, 2006.
3. For 1997, 1998 and 1999, no production due to strike by unionized employees.
4. From 1970, includes production from Robin Red Lake.
5. Includes clean up of ore and materials from the mine site.
6. Historic grade, actual grade for 1999 was 0.14 ounce per ton gold.
7. Includes production from Annco and Wilmar properties.
8. Continuous production 1930 to 1941; includes 268 ounces recovered from clean up in 1957.
9. The ore mined at Howey, before sorting totalled 5 158 376 tons. The average production from run-of-mine ore was therefore 0.0817 ounce per ton gold.

auriferous fluids; multiple D2 strain events; repeated episodes of gold deposition and remobilization into a low pressure F2 fold hinge hosting the High Grade Zone.

Field Trip Stops

The Field Trip starts in the west, at the Suffel Lake (Flat Lake) Road turn-off from Highway.618 and continues east and north, to end at the Redcon Prospect, approximately 17.2km north on Nungesser Road.

Stop 1: Suffel Lake Road and Highway 618. Contact between Confederation and Balmer Assemblages (Fig. 3, Table 5)

UTM Coordinates: NAD83; 15U 0434844E / 5645498N

Exposures on the south side of the highway are part of the lowermost units of the Neoarchean Confederation assemblage, the dominantly calc-alkaline McNeely sequence. The outcrops here are amphibolite-facies, quartz-feldspar-porphyritic lapilli-crystal tuff, with thin, dark grey, collapsed pumice fragments; occasional lapilli sized lithic clasts are also observed. Strike of the rocks is generally northeast, facing and dipping steeply southeast. A sample from this unit, 800m northeast of the intersection, gave an age of 2744±1Ma (Corfu and Andrews, 1987).

The north side of the road exposes highly altered tholeiitic, mafic volcaniclastic rocks of the Balmer assemblage. Abundant garnet and biotite rims clasts; minor andalusite is present. This outcrop, barren at this locality, forms part of the Austin "tuff" ore zone, described further below.

Stop 2: Power Line Outcrops, Madsen Deposit

UTM Coordinates: NAD83; 15U 0435235E / 5646040N

Time limitations of the tour do not permit a complete visit of the Madsen deposit; a brief description of the deposit follows:

Geology of the Madsen Deposit (adapted from Dubé et al., 2000)

Madsen is a stratabound, replacement-style, disseminated gold deposit (Fig. 3), exhibiting two alteration facies, the mineralogy of which is now represented by two amphibolite-facies zones:

1. A pervasive aluminous, metre- to tens-of-metres-wide, low-strain, outer zone, containing andalusite-garnet-biotite-staurolite-amphibole; metre-wide stockwork amphibole veins and veinlets alternate with the pervasive alteration. Timing of this alteration is pre- to syn-D1, but its relationship to gold mineralization is not yet known; indeed, it could be classified as the amphibolite-facies equivalent of volcanogenic massive sulphide (VMS) type alteration, related to a Confederation age syn-volcanic hydrothermal alteration system;
2. An inner zone comprising a banded-laminated texture, characterized by bands of actinolite-hornblende-microcline-calcite-tourmaline, alternating with biotite-rich bands. The amphibole is commonly randomly oriented. Diopside locally forms disseminated crystals up to 7-8cm long, or veinlets.

Ore zones occur within the inner alteration zone, and comprise finely layered, sulphide-rich lenses up to a few metres wide. Sulphides (8-10%) comprise pyrrhotite, pyrite and/or arsenopyrite with trace chalcopyrite, and are found as disseminations or veinlets parallel to lamination/foliation. Gold occurs in the native state as inclusions in silicate minerals and locally as coatings on sulphide minerals. The highest grade is found in areas of most intense alteration,

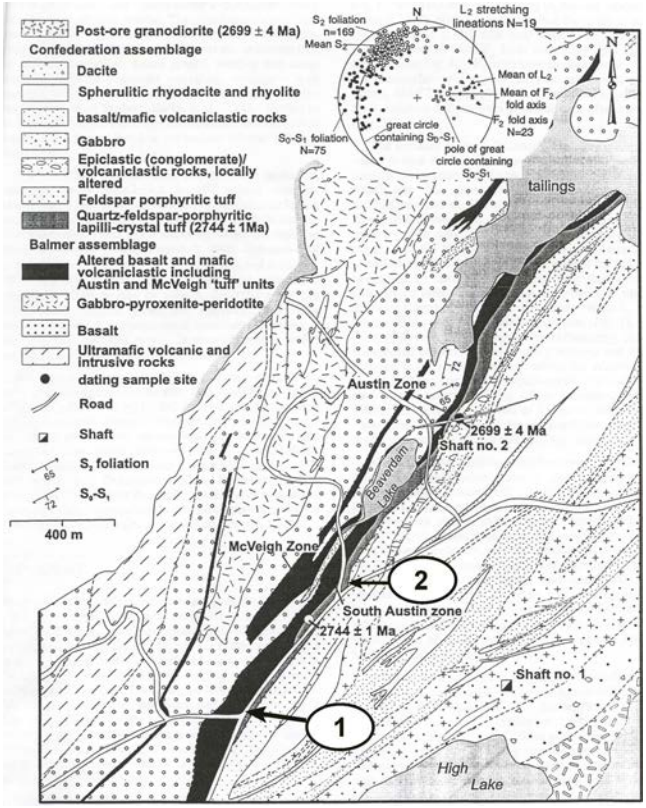


Figure 3. Geology of the Madsen mine area (modified from Dubé et al., 2000)

Table 5. Major and trace element analyses Stop 1 lithologies (major oxides in %, trace elements in ppm).

Sample Number	2009-AL-02	2009-AL-03	Sample Number	2009AL-02	2009AL-03
UTM-Easting	434891	434849	Yb	0.838	4.389
UTM-Northing	5645522	5645513	Lu	0.13	0.68
Rock Type	QFP	Basalt	Y	8.53	41.59
Sample No.	2009AL-02	2009AL-03	Zr	108	67
SiO2	76.19	48.61	Th	15.16	0.99
TiO2	0.1	1.55	U	2.98	0.24
Al2O3	12.06	14.59	Hf	3.21	1.9
Fe2O3	1.58	19.21	Nb	4.33	3.82
K2O	4.86	0.91	Ta	0.4	0.2
MgO	0.36	4.37	Cs	2.5	1.83
MnO	0.03	0.51	Dy	1.68	6.55
CaO	0.94	9.57	Er	0.86	4.36
Na2O	2.53	0.41	Ho	0.31	1.43
P2O5	0.01	0.21	Pr	8.54	2.66
LOI	0.82	0.73	Tm	0.125	0.665
Total	99.48	100.67	Be	0.73	0.57
			Cd	0.11	0.14
Au (opt)	<0.01	0.01	Ga	13.47	19.02
Ag (opt)	<0.1	<0.1	Li	12.9	24.1
			Mo	3	0.95
Rb	88.23	19.66	Sb	1.47	1.11
Ba	1044.1	84.2	Sn	1.03	0.79
Sr	76	44	Tl	0.46	0.1
Sc	3.5	33.9	V	<10	358.45
La	47.57	7.84	W	1.32	0.75
Ce	86.49	18.69	Zn	30.56	146.21
Nd	27.27	12.85	Pb	12.6	1.8
Sm	3.78	3.85	Cu	22	86
Eu	0.47	1.26	Cr	36	109
Gd	2.46	5.23	Ni	5	99
Tb	0.303	0.936	Co	1.7	47.8
			Bi	0.094	0.041
			Ti	605.94	8772.63

represented by a quartz-biotite-muscovite-microcline assemblage in mm-cm bands or layers.

Crenulation of alteration bands, sulphides and calcite veinlets by S2 as well as the large-scale deformation and folding of Austin ore lenses by F2 folds are consistent with pre- to early-D2 timing of gold mineralization. A minimum age on the deposit is 2699±4Ma (Corfu and Andrews, 1987), the age of a cross-cutting post-ore granodiorite dyke. Proximal alteration and style of mineralization may indicate the Madsen Deposit to be related to higher temperature (400º-600ºC) gold deposits and gold-skarn deposits hosted by mafic volcanic rocks (Parker, 2000).

South Austin Zone – Powerline Section

The integrated mapping, geochronological, and lithogeochemical projects completed during the Federal–Provincial NATMAP program in the Red Lake greenstone belt from 1999 to 2004 significantly advanced the understanding of the geological history of the belt. Key outcrops elucidating the 300Ma history of the belt include the surface expression of the main ore zone ("South Austin Zone") of Claude Resources Inc.'s past-producing Madsen Mine (produced 2.5 million ounces Au between 1938 and 1999; see Table 4), which is interpreted to occupy the position of the unconformity between the Mesoarchean Balmer Assemblage and Neoarchean Confederation

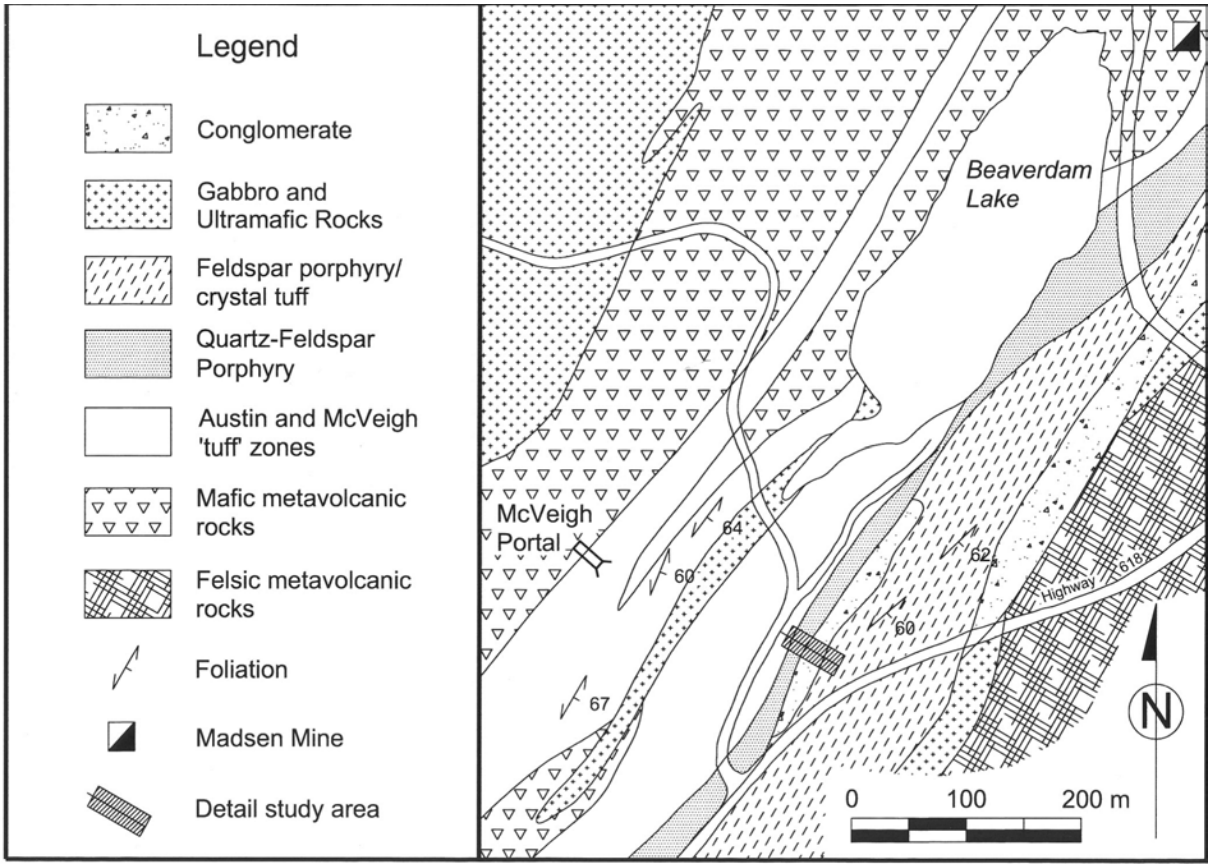


Figure 4. Location of the South Austin Zone (adapted from Dubé et al., 2000).

Assemblage (Sanborn-Barrie et al., 2001).

Geological field tours of the Red Lake mining camp have been given since the start of the Red Lake office of the Resident Geologist Program in 1968. The South Austin Zone outcrop has become an important field trip stop since NATMAP re-interpretation of local geology, illustrating the complex interplay of lithology, alteration, deformation, and economic gold mineralization. The series of poorly exposed hillside outcrops are located approximately 600m southwest of the Madsen shaft (Fig. 4). They were mechanically stripped in the fall of 2009 and power-washed and channel-sampled by S. McDonald in the summer of 2010. The exposure is now complete from the Austin Zone footwall, through the Confederation Assemblage quartz-feldspar rhyolite, to the overlying Huston conglomerate (Fig. 5). Following is a preliminary description of the lithology and geochemistry of the exposure.

The base of the exposure is a well banded/layered, locally contorted, example of Austin "tuff", from which the bulk of the 2.5 million ounces Au of the Madsen deposit were mined. At this locality, the Austin Zone is a strongly altered (biotite, amphibole, garnet) mafic volcaniclastic/epiclastic rock, with up to 20% wacke/tuff (?) clasts, occupying the position of the unconformity between Balmer and Confederation assemblages. Major oxide chemistry (Table 8), uncorrected for alteration, indicates that 11 of 12 samples collected from this unit are tholeiitic (Irvine and Baragar, 1971, Fig. 2). A minimum age on the deposit is 2699±4Ma (Corfu and Andrews, 1987), the age of a crosscutting post-ore granodiorite dike (not exposed at this locality).

Weakly to moderately foliated quartz-feldspar rhyolite porphyry ("QFP") forms the structural and stratigraphic hanging wall of the deposit and marks the beginning of Confederation Assemblage time (McNeely sequence of Sanborn-Barrie et al., 2001). Contact with the underlying Austin Zone is sharp, with the Austin Zone characterized by an 80cm-wide transition zone of contorted and brecciated rock. Whole rock analyses of two samples of porphyry plot in the calc-alkaline rhyolite field of Jensen (1976; Fig. 1).

Overlying the quartz-feldspar rhyolite is a conglomerate unit, part of the Huston Assemblage, which yielded a single peak in detrital U-Pb zircon ages of ≤2746Ma (Sanborn-Barrie et al., 2001). Fragments are generally intermediate to mafic, with a mafic biotite-garnet-andalusite altered matrix. Major

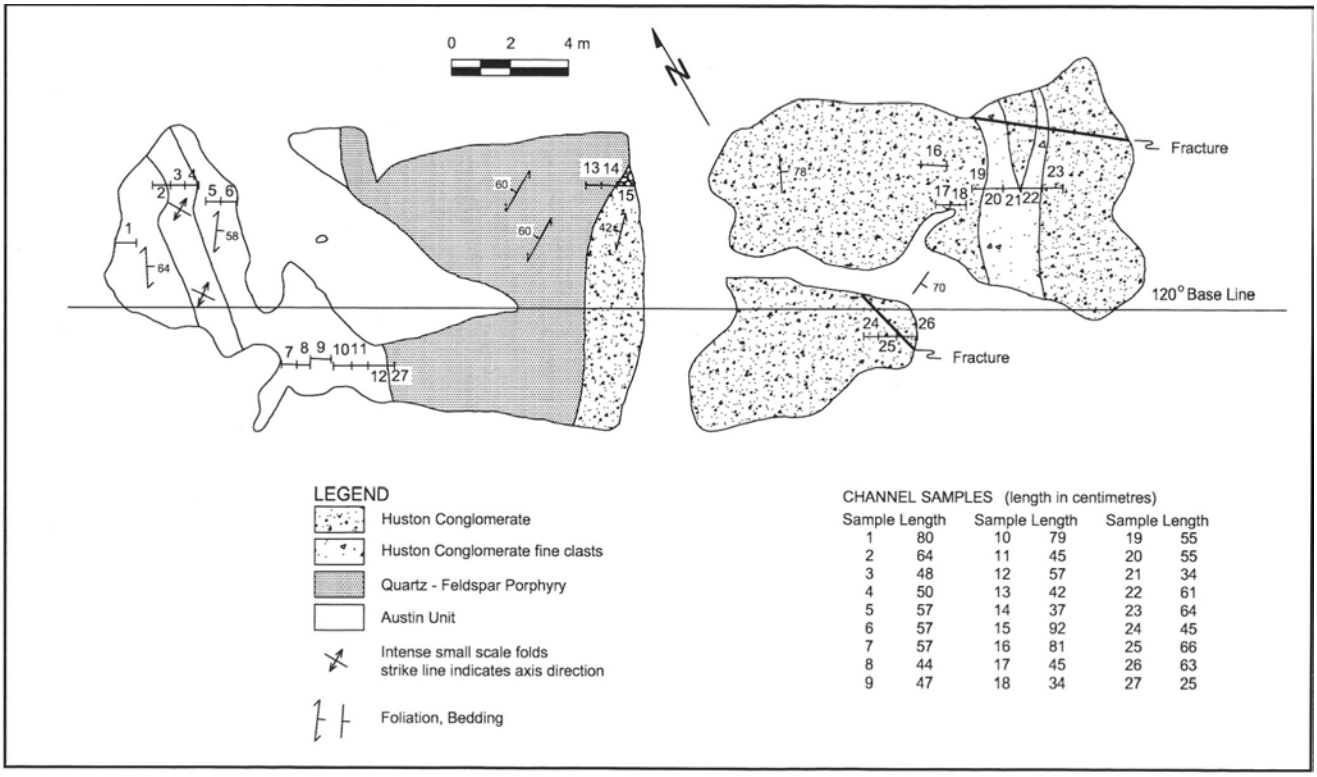


Figure 5. Detail of stripping and sampling, South Austin Zone. Sample series 2010SM-01 through 2010SM-27.

oxide chemistry (Table 8), uncorrected for alteration, indicates that the 4 samples collected from this unit are of tholeiitic affinity (Irvine and Baragar, 1971, Fig. 2). Tables 6 and 7 show the trace element analyses for samples collected during this study.

Heyson felsic volcanic rocks, including spherulitic and lobe-hyaloclastite flows are seen in outcrops on both sides of Highway 618 on the way to Stop 3.

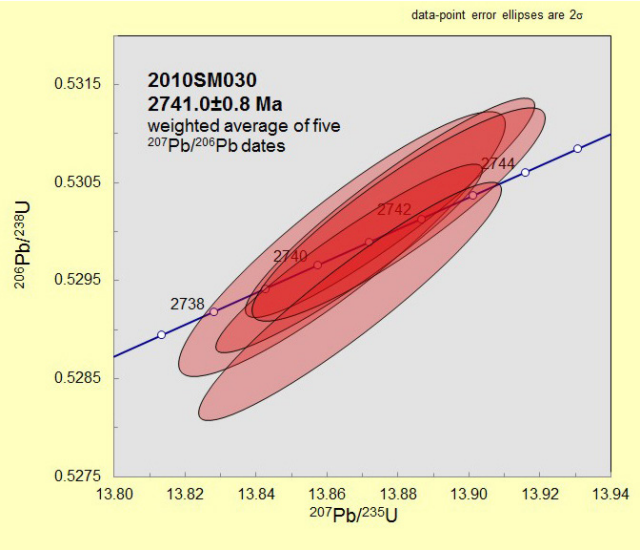
Samples from all three rock units (Tables 6, 7, 8, and 9) were submitted to the Pacific Centre for Isotopic and Geochemical Research ("PCIGR"), Department of Earth and Ocean Sciences, University of British Columbia for geochronological analysis. The almost complete sequence across the interpreted unconformity is exhibited in these outcrops. A cross-section of age data was deemed important to understanding the relationships here, and in the >100km of unconformity interpreted throughout the Red Lake belt.

A 20-litre sample was collected from each unit; sample preparation by PCIGR can be found at http://pcigr.eos.ubc.ca/services/samplepreparation.php#Geochronology. Description of results from PCIGR includes:

Sample 2010SM-029: South Austin Zone-No zircons were found

Sample 2010SM-030: QFP lapilli tuff; U-Pb TIMS dating employing the single grain chemical abrasion (CA-TIMS) technique (Plot 1). Five single grains analysed give results that are concordant and overlapping at 2741Ma. The best age estimate for the rock, 2741.0±0.8Ma, is based on the weighted average of all five $^{207}Pb/^{206}Pb$ dates.

Sample 2010SM-031: The Huston Conglomerate was dated by the laser ablation (LA-U-Pb) technique, with 59 grains analysed (Plots 2 and 3). All analysed grains are less then ±5% discordant and 207Pb/206Pb



Plot 1: Uranium-lead concordia diagram of QFP lapilli tuff.

Table 6. Trace element analyses (ppm) of South Austin Tuff samples (sample number prefix is 2010SM, i.e., 2010SM-01).

Sample No.	**-01**	**-02**	**-03**	**-04**	**-05**	**-06**	**-07**	**-08**	**-09**	**-10**	**-11**	**-12**
Rock Type	Austin	Austin	Austin	Austin	Austin	Austin	Austin	Austin	Austin	Austin	Austin	Austin
Rb	100.79	64.46	73.7	108.19	115.67	104.61	70.52	122.2	109.1	96.68	82.53	142.82
Ba	259.6	199.3	357.5	282.5	264.8	275.1	226.6	249.2	245.9	125.7	166.2	190.8
Sr	31	80	126	98	77	65	41	44	41	6	9	9
Sc	43.3	34.7	42.2	40.1	53.7	51.8	42.9	50.9	53.2	47.9	32.3	31.1
La	5.64	5.4	7.39	6.8	7.66	7.31	6.26	6.58	7.24	11.35	7.01	9.96
Ce	14	13.14	18	16.56	18.96	17.77	16.23	17.16	17.23	24.24	15.08	20.37
Nd	9.5	8.75	12.05	11.61	12.64	11.81	11.37	11.16	11.77	15.18	9.49	12.27
Sm	2.9	2.82	3.8	3.72	3.98	3.58	3.72	3.44	3.55	4.14	2.57	3.11
Eu	1	1.19	1.29	1.25	1.4	1.33	1.45	1.24	1.18	1.37	0.81	0.79
Gd	3.71	3.73	5.03	4.96	5	4.67	4.99	4.1	4.46	4.95	2.89	3.7
Tb	0.686	0.655	0.889	0.896	0.895	0.821	0.925	0.738	0.839	0.863	0.482	0.629
Yb	3.412	2.886	4.092	4.013	3.822	3.41	3.959	3.702	4.158	4.356	2.054	2.415
Lu	0.52	0.43	0.61	0.59	0.57	0.5	0.6	0.57	0.63	0.69	0.31	0.36
Y	28.23	26.63	36.82	36.72	34.9	31.92	38.04	29.44	34.11	34.81	18.05	24.04
Zr	103	54	38	47	99	105	74	106	99	77	67	81
Th	0.99	0.71	0.99	0.96	1.01	1	0.94	1.03	0.95	1.01	0.7	0.97
U	0.25	0.22	0.26	0.25	0.22	0.24	0.24	0.28	0.23	0.25	0.25	0.37
Hf	2.97	1.61	1.3	1.41	2.8	3.05	2.13	3	2.78	2.19	1.99	2.36
Nb	4.13	2.91	4.16	4	4.25	4.1	3.78	4.24	3.92	3.88	2.86	4.28
Ta	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3
Cs	6.25	2.95	2.16	4.1	6.12	5.41	2.99	6.22	5.39	6.27	3.7	6.08
Dy	4.74	4.53	6.15	6.14	6.04	5.58	6.34	5.17	5.87	5.94	3.14	4.15
Er	3.18	2.97	4.15	4.04	3.85	3.47	4.15	3.57	3.99	4.08	2.04	2.6
Ho	1.04	0.98	1.34	1.33	1.28	1.18	1.37	1.14	1.29	1.32	0.67	0.88
Pr	1.98	1.91	2.6	2.4	2.68	2.54	2.39	2.39	2.51	3.39	2.11	2.79
Tm	0.489	0.438	0.61	0.598	0.573	0.513	0.596	0.543	0.604	0.63	0.3	0.371
Be	0.69	3.06	2.23	1.94	1.24	0.87	0.62	0.52	0.49	0.23	0.28	0.75
Cd	0.11	0.1	0.13	0.07	0.07	0.08	0.21	0.12	0.16	0.28	0.07	1.86
Ga	20.34	18.27	20.93	20.51	22.75	22.26	19.38	22.42	20.46	18.14	14.51	18.55
Li	46	20.7	20.6	29.2	40.2	37.4	19.7	38.2	30	26.2	21.1	26.2
Mo	1.25	1.47	1.07	1.21	0.63	0.48	0.51	0.49	0.47	0.66	0.77	1.22
Sb	0.76	2.44	3.46	2.03	0.82	0.8	1.95	1.09	0.97	0.71	0.78	1.14
Sn	0.87	0.83	0.73	0.87	0.75	0.91	0.84	0.81	0.93	0.73	0.67	0.58
Tl	0.52	0.33	0.33	0.51	0.55	0.5	0.37	0.59	0.54	0.52	0.41	0.86
V	403.74	251.4	410.39	398.18	453.66	429	399.06	431.52	420.2	433.06	227.59	267.23
W	9.61	67.03	63.65	45.25	18.88	9.16	19.03	3.21	2.3	3.4	9.59	11.86
Zn	105.7	66.58	81.62	77.45	91.71	69.39	173.52	121.95	108.11	107.27	34.15	388.81
Pb	3.5	3.5	3.7	2.8	2.9	3.1	3.4	2.2	2.7	6.2	2	21.4
Cu	45	74	64	75	114	86	135	107	69	86	37	182
Cr	113	90	111	116	118	116	104	117	111	106	154	162
Ni	87	67	89	100	94	94	70	84	78	75	118	127
Co	44.7	34.9	50.9	52.7	52.7	57.1	43.7	51.9	44.5	39.5	33.1	38.8
Bi	0.031	0.065	0.105	0.086	0.032	0.033	0.083	0.051	0.077	0.066	0.036	0.128
Ti	9630.2	6115.15	9527.75	9381.44	10239.1	10082.4	8816.34	10119.2	9356.36	9089.29	5094.75	6837.98

Analyses by Geoscience Laboratories, Ministry of Northern Development, Mines and Forestry, Sudbury, Ontario.

Table 7. Trace element analyses (ppm) of QFP and Huston conglomerate samples (sample number prefix is 2010SM, i.e., 2010SM-13). Analyses for samples 2010SM-25 and -26 are pending.

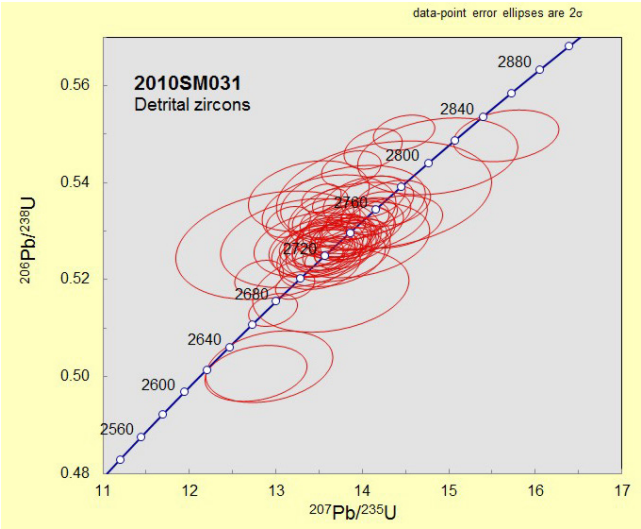
Sample No.	**-13**	**-14**	**-15**	**-16**	**-17**	**-18**	**-19**	**-20**	**-21**	**-22**	**-23**	**-24**
Rock Type	QFP	QFP	Huston	Huston	Huston	Huston	Huston	Huston	Huston	Huston	Huston	Huston
Rb	85.22	74.47	107.78	68.11	64.93	63.87	77.81	77.86	61.36	63.04	53.71	66.62
Ba	722	569.1	495.9	283.4	271.4	584.6	334.3	293.1	250.6	276.9	273.8	261.1
Sr	73	54	217	40	38	77	80	66	56	44	40	41
Sc	5	4	28.5	41.4	37.7	21	28.2	35.7	39.3	45.1	39.9	42.9
La	27.9	20.46	23.3	6.55	7.12	20.45	14.54	7.78	6.57	9.42	7.56	7.78
Ce	52.26	38.29	45.04	14.46	16.56	39.34	27.97	15.81	14.82	20.41	16.52	17.22
Nd	15.14	11.48	17.35	8.39	10.47	15.7	12.19	7.91	8.24	10.52	9.11	9.99
Sm	2.26	1.63	3.29	2.28	3.17	3.09	2.72	2	2.25	2.68	2.42	2.57
Eu	0.58	0.44	1.09	0.82	0.97	0.91	0.76	0.95	0.86	0.87	0.81	0.91
Gd	1.75	1.25	3.04	2.84	4.61	2.69	2.72	2.38	2.77	3.08	2.95	3.12
Tb	0.277	0.199	0.494	0.494	0.818	0.429	0.45	0.426	0.495	0.554	0.505	0.552
Yb	1.037	1.012	1.888	2.086	3.384	1.512	1.624	1.902	2.127	2.398	2.163	2.297
Lu	0.16	0.15	0.29	0.32	0.51	0.23	0.25	0.29	0.33	0.36	0.33	0.35
Y	10.83	8.66	18.68	18.81	35.54	14.91	16.06	16.41	19.34	21.67	19.85	21.14
Zr	125	122	109	72	73	132	87	86	81	98	75	74
Th	12.36	12.32	6.33	1.06	1	8.18	3.38	2.67	1.46	2.37	1.26	1
U	2.36	2.2	1.52	0.38	0.32	2.98	1.06	0.79	0.51	0.73	0.34	0.33
Hf	3.72	3.64	3.19	2.13	2.11	3.74	2.42	2.48	2.39	2.71	2.12	2.17
Nb	4.69	4.46	4.26	3.39	3.25	5.71	4.1	3.9	3.72	4.59	3.48	3.63
Ta	0.4	0.4	0.4	0.2	0.2	0.6	0.3	0.3	0.3	0.3	0.2	0.2
Cs	1.09	1.28	4.78	2.33	2.25	1.56	2.39	1.85	1.82	2.1	1.8	2.38
Dy	1.76	1.35	3.2	3.31	5.53	2.7	2.81	2.89	3.32	3.7	3.43	3.69
Er	1.08	0.93	1.97	2.1	3.66	1.57	1.69	1.88	2.13	2.4	2.21	2.33
Ho	0.36	0.3	0.67	0.7	1.22	0.55	0.59	0.61	0.72	0.8	0.73	0.78
Pr	4.68	3.59	4.84	1.93	2.29	4.43	3.22	1.94	1.93	2.57	2.13	2.28
Tm	0.157	0.144	0.285	0.31	0.518	0.229	0.248	0.288	0.324	0.354	0.326	0.349
Be	1.04	1.11	1.4	0.82	0.65	1.14	0.61	0.61	0.74	0.76	0.46	0.57
Cd	0.03	0.03	0.37	0.69	1.17	0.19	0.27	0.37	0.8	0.39	0.28	0.79
Ga	16.27	15.14	16.66	13.94	14.33	21.19	16.76	16.31	15.24	14.44	9.8	11.78
Li	17.9	18.6	26.7	24.9	26.7	33.5	30.1	25.5	27.9	44.6	25.6	24.3
Mo	1.52	1.05	1.51	1.14	0.93	1.33	1.66	1.81	1.43	1.11	1.06	0.96
Sb	0.34	0.22	0.93	1.25	1.15	0.62	0.61	1.13	1.42	1.49	1.02	0.74
Sn	0.73	0.73	0.8	0.58	0.54	0.87	0.8	0.7	0.56	0.62	0.69	0.59
Tl	0.31	0.29	0.55	0.36	0.32	0.28	0.39	0.35	0.3	0.33	0.29	0.37
V	18.54	12.18	189.3	284.59	263.86	145.66	202.73	249.17	270.06	307.75	270.75	288.7
W	1.76	3.9	2.3	2.43	1.98	3.05	1.39	1.62	1.57	1.46	1.34	2.16
Zn	21.37	26.71	139.65	105.4	131.72	51.19	77.43	99.6	101.71	50.85	30.67	72.94
Pb	6.5	4.8	8.1	9.7	8.8	5.6	5.1	6.6	8.2	4.7	5.7	6
Cu	4	3	382	235	199	44	172	191	191	225	145	197
Cr	32	<24	190	466	326	122	343	428	397	502	388	334
Ni	14	19	119	193	162	76	131	136	162	232	154	170
Co	3.7	5	38.6	62.7	55.8	25.5	39.4	37	53	62.7	47.3	58
Bi	0.024	0.061	0.024	0.088	0.104	0.028	0.088	0.106	0.123	0.086	0.102	0.05
Ti	1274.8	1039.0	4366.4	5646.3	5878.0	3920.6	4674.2	5442.6	6041.0	7120.2	5825.7	6060.0

Analyses by Geoscience Laboratories, Ministry of Northern Development, Mines and Forestry, Sudbury, Ontario.

Table 8. Major element chemistry of all lithologies, South Austin Tuff exposure.

Sample No.	Rock Type	SiO2 (%)	TiO2 (%)	Al2O3 (%)	Fe2O3 (%)	K2O (%)	MgO (%)	MnO (%)	CaO (%)	Na2O (%)	P2O5 (%)	LOI (%)	Total (%)
2010SM-01	Austin	54.33	1.67	15.68	15.38	4.66	3.55	0.37	1.72	0.55	0.15	1.65	99.71
2010SM-02	Austin	52.45	1.07	14.35	14.45	2.34	4.37	0.32	6.79	0.38	0.12	2.26	98.90
2010SM-03	Austin	46.23	1.64	15.22	14.31	3.34	4.97	0.40	10.25	0.20	0.18	2.51	99.23
2010SM-04	Austin	52.95	1.61	15.44	12.90	3.65	4.14	0.28	6.61	0.17	0.18	2.51	100.43
2010SM-05	Austin	53.84	1.68	16.44	11.79	4.37	3.93	0.21	4.47	0.29	0.20	2.39	99.60
2010SM-06	Austin	54.55	1.69	16.71	10.66	4.35	4.03	0.21	4.40	0.34	0.20	2.33	99.48
2010SM-07	Austin	47.39	1.53	14.45	16.10	2.61	5.92	0.45	8.57	0.36	0.16	2.12	99.67
2010SM-08	Austin	49.95	1.69	16.48	15.00	4.74	4.29	0.27	3.86	0.25	0.20	2.79	99.52
2010SM-09	Austin	53.44	1.59	15.49	14.73	4.36	3.74	0.27	3.33	0.21	0.19	2.37	99.71
2010SM-10	Austin	50.62	1.55	14.95	23.23	3.62	3.11	0.48	0.45	0.04	0.17	1.23	99.46
2010SM-11	Austin	64.42	0.86	14.08	12.20	3.57	1.89	0.27	0.24	0.05	0.10	1.76	99.44
2010SM-12	Austin	58.16	1.13	14.19	15.78	4.65	2.30	0.39	0.36	0.04	0.14	2.01	99.15
2010SM-13	QFP	74.89	0.21	14.08	1.64	3.79	0.74	0.04	1.53	1.01	0.03	1.83	99.80
2010SM-14	QFP	76.14	0.17	13.28	2.27	3.27	0.82	0.04	1.17	1.08	0.03	1.78	100.05
2010SM-15	Huston	62.92	0.72	14.84	8.94	3.45	2.79	0.15	2.65	1.88	0.05	1.42	99.83
2010SM-16	Huston	60.37	0.97	14.21	15.04	2.55	3.33	0.29	1.46	0.20	0.07	1.49	99.99
2010SM-17	Huston	59.94	0.99	13.16	16.81	2.34	2.98	0.42	1.58	0.21	0.06	1.04	99.54
2010SM-18	Huston	64.49	0.67	16.82	7.53	2.93	2.24	0.14	2.11	0.84	0.08	1.99	99.84
2010SM-19	Huston	64.50	0.80	13.64	9.40	2.80	2.85	0.17	2.62	0.90	0.07	1.26	99.01
2010SM-20	Huston	62.65	0.94	13.46	12.23	2.73	3.01	0.20	1.85	0.46	0.06	2.23	99.82
2010SM-21	Huston	60.95	1.05	13.82	14.09	2.22	3.10	0.22	1.65	0.33	0.06	1.40	98.89
2010SM-22	Huston	60.45	1.21	14.48	14.76	2.22	3.38	0.19	1.11	0.29	0.06	1.26	99.40
2010SM-23	Huston	63.56	1.04	13.74	14.01	2.05	2.93	0.28	0.98	0.28	0.06	0.99	99.92
2010SM-24	Huston	58.64	1.04	14.61	16.14	2.53	3.08	0.33	1.52	0.27	0.08	0.68	98.92

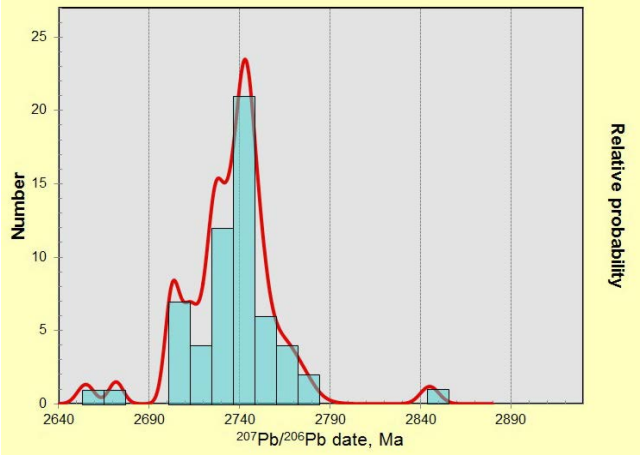
Analyses by Geoscience Laboratories, Ministry of Northern Development, Mines and Forestry, Sudbury, Ontario.



Plot 2: Uranium-lead concordia diagram of Huston conglomerate.

dates for nearly all are likely to record primary crystallization ages. Reversely discordant grains 25 and 33 are the only ones that give results younger than 2700Ma. Data from this sample suggest that the maximum age of the breccia is 2700Ma, and including the very youngest result the maximum age could be as young as 2655±9Ma.

The 2741±0.8Ma age of the QFP lapilli tuff correlates



Plot 3: Uranium-lead probability plot, Huston conglomerate.

Table 9. Precious metal analyses of Austin Tuff exposure samples

	Au	Pd	Pt
Units	ppb	ppb	ppb
Detect Limit	6	1.3	0.4
2010SM-01	37	<1.3	1
2010SM-02	431	<1.3	0.9
2010SM-03	73	<1.3	0.8
2010SM-04	35	<1.3	0.9
2010SM-05	30	<1.3	1
2010SM-06	9	<1.3	0.9
2010SM-07	<6	<1.3	0.9
2010SM-08	8	<1.3	1
2010SM-09	<6	<1.3	1
2010SM-10	29	<1.3	1
2010SM-11	9	3.9	4.1
2010SM-12	36	7	4.7
2010SM-13	<6	<1.3	<0.4
2010SM-14	<6	<1.3	<0.4
2010SM-15	22	3.4	4.3
2010SM-16	11	7.3	8.5
2010SM-17	16	5.8	7.2
2010SM-18	6	2.2	3
2010SM-19	12	4.3	5.2
2010SM-20	15	5.6	6.8
2010SM-21	9	6.1	8.1
2010SM-22	10	6.4	7.9
2010SM-23	8	6.1	8
2010SM-24	<6	8	9.1
2010SM-25	6	6.2	8.2
2010SM-26	13	6.1	7.7
2010SM-15 SP	19	3.2	4.7

well with previous dates of 2744±1Ma obtained by Corfu and Andrews (1987) from the same lapilli tuff or immediately adjacent unit 150m to the southwest, and a felsic spherulitic flow approximately 120m in the hangingwall, dated at 2746+36/-17Ma (Corfu and Andrews, 1987).

The same outcrop of interpreted Huston conglomerate at the present locality and one 15km to the northeast (referred to as the "Cemetery conglomerate") were previously dated by T. Skulski at less than ca. 2746Ma, based on prominent (n=50-60) single age peaks (cited in Sanborn-Barrie et al., 2004). They concluded a single-source derivation from Confederation assemblage volcanic rocks.

The current data from Madsen suggests that this conglomerate unit may have sampled a very diverse substrate, and therefore displays a wider range of detrital ages. A similar unit (called the "Madsen Conglomerate") was sampled by Sanborn-Barrie et al. (2004), approximately 1.2km northeast of the South Austin zone locality. A maximum depositional age of this unit was interpreted to be 2700±6Ma, based on a diverse detrital zircon profile (n=56), with ages that correspond to volcanic assemblage as old as ca. 2.9Ga and younger post-volcanic plutons ca. 2.7Ga. Its relationship to gold mineralization remains unknown.

The questions arising from different age profiles obtained from the same outcrop of conglomerate, and the very young depositional ages of detrital zircons (English River assemblage) can be addressed by additional geochronology, detailed mapping of the units in the immediate area and inspection of core from diamond drilling of the Austin ore zone by Claude Resources Inc. and Pure Gold Mining Inc.

Stop 3: Buffalo Deposit – Dome Stock mineralization

UTM Coordinates: NAD83; 15U 0439890E / 5650800N

The approximately 7km diameter hornblende-biotite granodiorite Dome Stock (Table 2) has been dated at 2718±1Ma (Corfu and Andrews 1987) and is interpreted to have been emplaced during D2 (Sanborn-Barrie et al. 2001). The stock is variably iron-carbonate, sericite, and chlorite altered and deformed. Exposures to be visited are at its southern contact; here it intrudes, and contains xenoliths of, foliated Balmer assemblage mafic volcanic rocks (Fig. 6).

The Dome Stock hosts several gold occurrences and two small, past-producing mines 1) the Red Lake Gold Shore produced 21,100 ounces gold, and 2) the Buffalo Mine produced 1656 ounces gold. The Buffalo Mine was discovered in 1925 and explored several times since then. Note: the adit was reopened by Claude Resources Ltd. in October 1998 to further explore the Buffalo deposit. Rehabilitation of the adit started in 2004.

Gold is hosted within two sets of quartz-tourmaline-pyrite-calcite veins in conjugate orientation (cm-wide northeast-trending veins at 239°/73°N, and decimetre-wide northwest-trending veins at 119°/76°S; Pettigrew, 1999). Their orientation may be a result of the intersection of two previously interpreted (Durocher and Hugon, 1983) deformation zones (St. Paul Bay-Martin Bay and Flat Lake-Howey Bay Deformation Zones). The dominant vein set strikes northwest and primary quartz vein fill was replaced by tourmaline, concomitant with bleached pink metasomatic halos

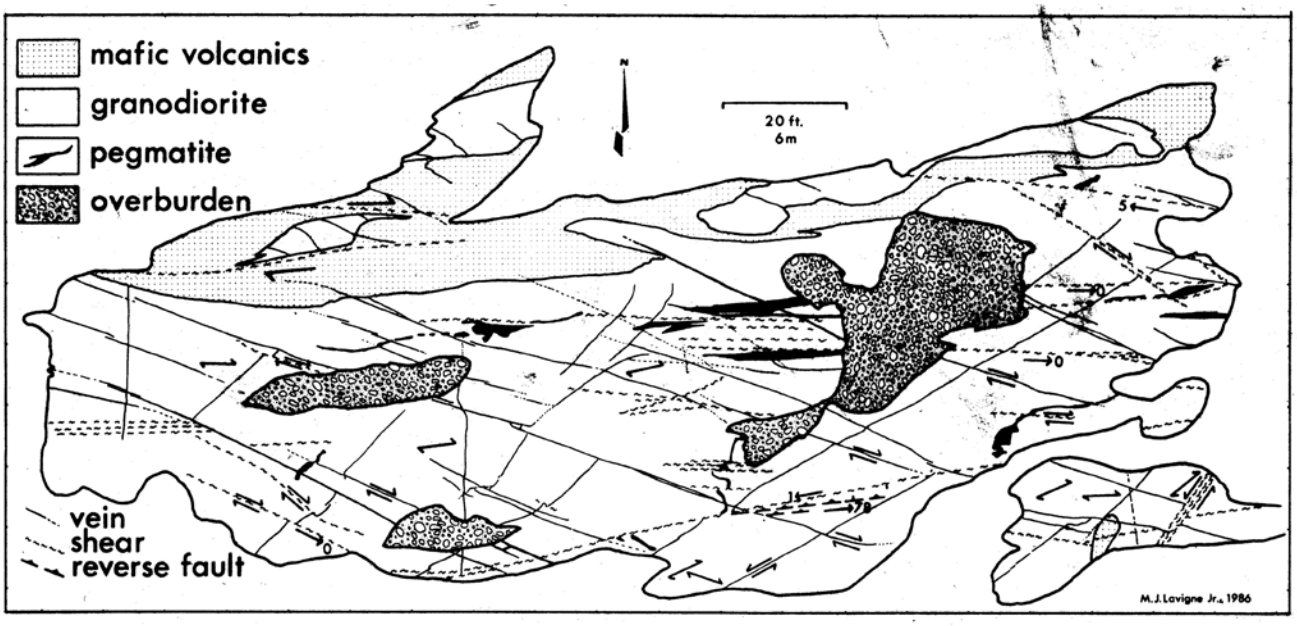


Figure 6. Detailed geology of south side of Buffalo Pit (from Lavigne et al., 1986).

developing around tourmaline-rich portions of the veins. Gold is concentrated in the calcite-albite-sulphide halos, in particular at its outer fringe, where chalcopyrite and tellurides were deposited. A second stage of gold mineralization is associated with Bi-tellurides in fractures and cavity fillings in quartz and late fracture-filling pyrite, hosted within the quartz-tourmaline-pyrite-calcite veins.

Stop 4: Flat Lake–Howey Bay–Flat Lake Deformation Zone

UTM Coordinates: NAD83; 15U 0441670E / 5651602N

The Howey Bay–Flat Lake deformation zone was defined by Durocher and Hugon (1983), and was interpreted to be part of a belt-wide system of transcurrent shear zones hosting most of the major gold deposits. Recent detailed work has led to a reevaluation of this concept (Sanborn-Barrie et al., 2000).

This stop is approximately 750m southwest of the Howey mine. Intense deformation at this stop has destroyed most primary textures that might be used to identify the rocks. They have been recently re-interpreted by Sanborn-Barrie et al. (2004) as mylonitized dioritic rocks (Table 10), representing a mafic border phase to the Dome stock. Pink felsic dikes that cut the mafic rocks are also mylonitized. Iron-carbonate veins are boudinaged and transposed into the sinistral shear direction. The far western extremity of the outcrops exposes a deformed quartz-feldspar dyke (similar in appearance to the Dome stock) containing mafic xenoliths and quartz-tourmaline veinlets.

Table 10. Major and trace element analyses of mylonite, Stop 4 (major oxides in %, trace elements in ppm)

Sample #	2009AL-07	Sample No.	2009AL-7
UTM-Easting	441670	Yb	1.154
UTM-Northing	5651602	Lu	0.18
Rock Type	Mylonite	Y	11.25
Sample No.	2009AL-7	Zr	116
SiO2	61.11	Th	3.12
TiO2	0.62	U	0.88
Al2O3	15.69	Hf	3.03
Fe2O3	5.84	Nb	1.74
K2O	2.04	Ta	<0.2
MgO	2.19	Cs	1.34
MnO	0.07	Dy	2.27
CaO	3.11	Er	1.12
Na2O	4.63	Ho	0.42
P2O5	0.12	Pr	5.01
LOI	5.1	Tm	0.163
Total	100.52	Be	1.07
		Cd	0.05
Au (opt)	<0.01	Ga	18.87
Ag (opt)	<0.1	Li	22.1
		Mo	1.22
Rb	51.6	Sb	2.27
Ba	333.5	Sn	0.79
Sr	518	Tl	0.31
Sc	14.1	V	96.62
La	20.47	W	1.36
Ce	37	Zn	71.04
Nd	19	Pb	7.8
Sm	3.57	Cu	30
Eu	1	Cr	71
Gd	2.95	Ni	60
Tb	0.41	Co	15
		Bi	0.073
		Ti	1730.68

Stop 5: Howey Mine (Fenced In Pit) – Drive-By

UTM Coordinates: NAD83; 15U 0442328E / 5652067N

On the north side of Hammell Road a cement foundation marks the site the former Howey mine. Behind the fenced-off area is the site of the crown pillar mined out in the final stages of the mine. The Howey Mine was the first Au producer (1930-1941) in the Red Lake camp and remains the lowest grade profitable gold mine in Canadian mining history (final average grade 0.08oz/t Au, having produced 422,000oz gold). The Howey (and adjacent Hasaga) ore bodies occur in a boudinaged, variably sericitized and silicified quartz-feldspar porphyry dyke trending approximately 065°/80°S. Cm-wide, auriferous quartz veinlets trend 080°, making an angle of 15° with the contacts of the dyke and dip at 80°S. Gold-bearing quartz veinlets formed as the last of three episodes of quartz veining. Gold is associated with pyrite-sphalerite-galena-tourmaline±tellurides.

Small flat outcrops between the highway and the fence are highly deformed intermediate rocks of the Howey Mine hanging wall. This site lies within the northeast-trending Howey Bay–Flat Lake deformation zone and comprises Confederation age rocks.

Stop 6: Chicken Chef Outcrop; Huston conglomerate

UTM Coordinates: NAD83; 15U 0442396E / 5652067N

This small outcrop is a clast-supported conglomerate, exhibiting cobble-sized, rounded granitoid clasts and stretched lapilli-sized intermediate to mafic clasts in a feldspar-phyric, foliated groundmass. Some of the granitoid clasts are moderately iron-carbonatized; a highly iron-carbonate-altered lense of detritus appears to be partially wrapped around a granitoid cobble.

Similar clast lithologies, but also including rounded cherty fragments, are found in an outcrop 200m south along Highway 105.

Stop 7: Outcrops on west side of Highway 125 and Sandy Bay Road; Calcite carbonatized pillowed flows (distal carbonate alteration facies).

UTM Coordinates: NAD83; 15U 0446915E / 5654682N

Slightly deformed pillows of the Confederation assemblage show pervasive calcite carbonatization, calcite veins, and pods (Table 11). Amygdules are also filled (replaced?) with calcite. Jig-saw puzzle breccias (created by fluid overpressure at depth) are cemented by calcite. This represents the distal, outer halo of carbonate alteration, as discussed by Parker (2000).

Stop 8: Woodland Cemetery Road and Highway 125; Meso–Neoarchean Contact

UTM Coordinates: NAD83; 15U 0447235E / 5655572N

These outcrops show altered, relatively low-strain, pillowed basaltic komatiite flows of the Balmer Assemblage (Table 12) unconformably overlain by polymictic conglomerate of the Huston assemblage. The exposures are in the transition from calcite carbonatization (distal alteration) to ferroan-dolomite (proximal) alteration.

The pillowed and minor massive flows show extensive iron carbonate alteration as well as iron carbonate and quartz veins. Fuchsite is present in the central part of the outcrops on the west side of the highway (cemetery side). The Campbell Mine is approximately 1.5km to the north.

While the mafic flows have not been directly dated at this locality, they are typically variolitic, and show a geochemical similarity with known Balmer-age rocks elsewhere; the massive and pillowed flows here can be traced to Balmertown, where an intercalated rhyolite at the Campbell mine was dated at 2989±3Ma (Corfu and Andrews, 1987).

Variolitic flows occur in the northern part of the outcrops on the east side of the highway. However, they are unconformably overlain by Huston polymictic conglomerate further south along the outcrop. The conglomerate contains a large proportion of rounded cherty, jasperoidal and pyritic fragments. It represents an apron of Confederation assemblage (McNeely-age 2743Ma) detritus deposited at the break in paleoslope between the Confederation volcanic centre and its Balmer-age substrate.

Stop 9: Cochenour Outcrop; Proximal ferroan-carbonate alteration; carbonate veining; silicification; and gold

UTM Coordinates: NAD83; 15U 0443689E / 5658640N

This outcrop was mapped in detail by Williamson and Dubé (2003) at a scale of 1:150. It is situated directly above past-producing workings of the Cochenour Mine. The outcrop is underlain by mafic-ultramafic Balmer assemblage volcanic rocks; the Meso- Neoarchean contact is exposed approximately 900m to the north.

Table 11. Major and trace element analyses, Stop 7 lithologies (major oxides in %, trace elements in ppm)

Sample #	2009-AL-08	2009-AL-09	Sample #	2009-AL-08	2009-AL-09
UTM-Easting	446914	446914	**Y**	13.43	21.16
UTM-Northing	5654682	5654682	**Zr**	47	177
Rock Type	Andesite	Intermediate Dyke	**Th**	1.83	9.93
SiO2	43.93	56.29	**U**	0.47	2.27
TiO2	0.55	0.84	**Hf**	1.19	4.53
Al2O3	14.98	16.27	**Nb**	2.98	8.15
Fe2O3	9.05	6.81	**Ta**	0.2	0.5
K2O	0.18	0.41	**Cs**	0.62	0.63
MgO	3.01	4.28	**Dy**	2.46	4.42
MnO	0.22	0.09	**Er**	1.45	1.9
CaO	12.88	5.64	**Ho**	0.51	0.75
Na2O	3.91	4.74	**Pr**	2.35	16.21
P2O5	0.08	0.42	**Tm**	0.208	0.246
LOI	10.81	4.21	**Be**	0.45	1.46
Total	99.59	100.02	**Cd**	0.14	0.05
			Ga	14.54	21.74
Au (opt)	<0.01	<0.01	**Li**	24	33
Ag (opt)	<0.1	<0.1	**Mo**	1.01	0.79
			Sb	1.58	1.72
Rb	4.3	10.13	**Sn**	0.54	1.26
Ba	117.8	100.5	**Tl**	0.03	0.06
Sr	355	776	**V**	148.81	126.67
Sc	25.2	14.7	**W**	<0.5	<0.5
La	8.72	59.04	**Zn**	85.32	89.72
Ce	18.54	128.13	**Pb**	3.5	8.2
Nd	9.58	64.69	**Cu**	78	19
Sm	2.15	11.54	**Cr**	122	43
Eu	0.63	2.71	**Ni**	169	70
Gd	2.36	7.7	**Co**	48.9	25
Tb	0.378	0.892	**Bi**	0.022	0.14
Yb	1.304	1.483	**Ti**	3160.87	5021.85
Lu	0.19	0.21			

The outcrop contains exposures of iron-carbonate veins and breccia with spectacular colloform-crustiform and cockade textures, as well as a high-grade, auriferous, silicified zone (Williamson and Dubé, 2003). The latter is characterized by strong silicification, with varied proportions of sericite/green mica and carbonate. The presence of green mica hints at a mafic-ultramafic protolith; however, the presence of local subparallel layering in a feldspar- and quartz-rich rock argues for a flow-banded felsic protolith. The silicified zone has been offset 50m to the west by late-stage black line faults.

Extensional iron-carbonate veins are generally barren of gold, except when cut by mm-scale, fine, auriferous arsenopyrite veinlets.

Stop 10. Redcon Carbonate Zone; West and East sides of Nungesser Road; Proximal ferroan-carbonate alteration; carbonate veining

UTM Coordinates: NAD83; 15U 0448918E / 5661396N

This area is approximately 4km north of the Campbell–Red Lake Deposit, still within the proximal, ferroan-carbonate alteration facies. The outcrops are weakly foliated (145°), dominantly massive to pillowed Balmer assemblage basalts (Table 13), occurring within the amphibolite-facies metamorphic aureole of the Walsh Lake Pluton.

Table 12. Major and trace element analyses, Stop 8 basalt (major oxides in %, trace elements in ppm).

Sample #	**2009-AL-10**	**2009-AL-11**			
UTM-Easting	447235	447235			
UTM-Northing	5655572	5655572			
Rock Type	Basalt	Basalt			
Sample No.	**2009AL-10**	**2009AL-11**	**Sample No.**	**2009AL-10**	**2009AL-11**
SiO2	61.58	49.76	**Zr**	32	30
TiO2	0.5	0.81	**Th**	0.19	0.28
Al2O3	6.7	10.58	**U**	0.06	0.07
Fe2O3	18.09	10.92	**Hf**	0.75	0.83
K2O	1.28	1.89	**Nb**	1.3	1.76
MgO	3.85	4.05	**Ta**	<0.2	<0.2
MnO	0.36	0.33	**Cs**	19.34	2.89
CaO	3.13	7.9	**Dy**	1.6	1.69
Na2O	<0.01	0.29	**Er**	0.85	0.78
P2O5	0.04	0.05	**Ho**	0.3	0.3
LOI	3.42	13.02	**Pr**	0.92	1.07
Total	98.86	99.6	**Tm**	0.139	0.114
			Be	0.39	0.43
Au (opt)	<0.01	<0.01	**Cd**	0.03	0.09
Ag (opt)	<0.1	<0.1	**Ga**	8.59	13.4
			Li	52.4	58.5
Rb	86.5	62.09	**Mo**	0.47	0.29
Ba	73.6	122.7	**Sb**	4.1	4.95
Sr	20	91	**Sn**	0.43	0.58
Sc	65.4	40.3	**Tl**	0.76	0.17
La	2.11	2.4	**V**	294.17	286.05
Ce	5.73	6.57	**W**	5.38	3.22
Nd	4.44	5.4	**Zn**	40.48	38.28
Sm	1.44	1.8	**Pb**	1	1
Eu	0.39	0.68	**Cu**	210	139
Gd	1.67	1.97	**Cr**	>600	>600
Tb	0.279	0.305	**Ni**	655	493
Yb	1.041	0.749	**Co**	100.5	83.5
Lu	0.18	0.11	**Bi**	0.037	0.06
Y	6.81	6.86	**Ti**	2827.8	4595.4

The stripped area on the east side of the Nungesser road was mapped in detail (Fig. 7) by Redcon Gold Mines in 1981 (assessment files) and now forms part of Goldcorp Inc.'s holdings. Here, a 1-2m wide carbonate vein is exposed near its southeastern termination. The vein can be traced in outcrop and drilling for approximately 750m to the west-northwest and will be seen at the next stop on the west side of the road. Gold occurs in north-northwest-trending, irregular, cm-thick quartz-actinolite stringers (tension gashes?) within the carbonate vein.

After initial, pervasive potassic (biotite) metasomatism of the basalt, the intrusion of the Walsh Lake Pluton produced a decimetre-scale, mesh-like texture of amphibole-quartz veinlets that are prominently displayed due to their positive weathering features. Cross-cutting relationships suggest the following sequence of formation (from Lavigne et al. 1986):

1. quartz-calcite veins
2. ferroan-dolomite veins
3. mafic dyke
4. auriferous quartz veins

Table 13. Major and trace element analyses, Stop 10 lithologies (major oxides in %, trace elements in ppm).

Sample #	2009-AL-14	2009-AL-15	2009-AL-16
UTM-Easting	448918	448918	448918
UTM-Northing	5661396	5661396	5661396
Rock Type	Fe-Carb vein	Basalt-Si+	Basalt
Sample No.	2009AL-14	2009AL-15	2009AL-16
SiO2	3.05	56.09	50.04
TiO2	0.1	1.88	1.69
Al2O3	0.74	17.14	14.65
Fe2O3	10.34	9.73	15.95
K2O	0.14	0.97	0.86
MgO	13.84	4.71	7.5
MnO	0.64	0.14	0.15
CaO	28.6	5.54	5.74
Na2O	<0.01	1.58	0.77
P2O5	0.02	0.22	0.17
LOI	41.85	2.1	1.89
Total	99.18	100.08	99.42
Au (opt)	<0.01	<0.01	<0.01
Ag (opt)	<0.1	<0.1	<0.1
Rb	3	30.74	22.98
Ba	13.1	89.9	145.1
Sr	46	52	42
Sc	6.8	44.2	46.2
La	2.2	12.76	7.53
Ce	4.18	33.18	19.28
Nd	3.23	21.28	13.99
Sm	1.05	5.72	4.08
Eu	0.53	1.72	1.32
Gd	1.57	5.17	5.09
Tb	0.256	0.741	0.897
Yb	0.816	2.311	3.516
Lu	0.14	0.34	0.51
Y	11.67	21.2	34.71

Sample No.	2009AL-14	2009AL-15	2009AL-16
Zr	11	106	86
Th	<0.09	0.9	0.73
U	0.03	0.23	0.18
Hf	0.26	2.89	2.29
Nb	0.21	5.29	5.33
Ta	<0.2	0.3	0.3
Cs	0.17	3.78	2.9
Dy	1.59	4.43	5.95
Er	0.89	2.55	3.7
Ho	0.32	0.89	1.27
Pr	0.64	4.66	2.92
Tm	0.124	0.368	0.54
Be	0.39	0.39	0.45
Cd	0.23	0.09	0.13
Ga	1.19	20.89	20.82
Li	6.2	54.4	49.7
Mo	0.14	0.35	0.41
Sb	0.91	3.28	4.83
Sn	0.13	1.21	1.13
Tl	0.03	0.23	0.19
V	35.32	476.84	443.67
W	8.7	13.91	4.77
Zn	124.59	124.21	162.95
Pb	1.5	2.8	1.7
Cu	4	193	88
Cr	<24	66	133
Ni	44	70	63
Co	9.4	35.9	45.2
Bi	0.015	0.02	0.038
Ti	441.71	11217.71	10004.7

Silicification evident in the pillowed flow on the northern half of the outcrop is barren and apparently not related to the gold-rich silicification event; rather, it may be due to local silica dumping following pervasive carbonate metasomatism.

A "black line" fault occurs in the northern wallrocks of the main carbonate vein. A mafic (or lamprophyre) dyke (unit 4, above) cuts the vein, but is itself cut by late quartz-actinolite-gold stringers.

The western outcrops are approximately 300m west-northwest of the previous exposures.

Things to note on the western series of outcrops:

- differing colours of cross-cutting carbonate veins
- colloform/crustiform textures in carbonate veins
- andalusite-garnet-biotite alteration of pillows cut by calc-silicate veins (diopside±calcite, quartz, tourmaline; retrograding to epidote, tremolite, actinolite/hornblende, magnetite)
- calc-silicate veins cross-cut by carbonate veins
- folding of carbonate veins by the "Mine trend" S2

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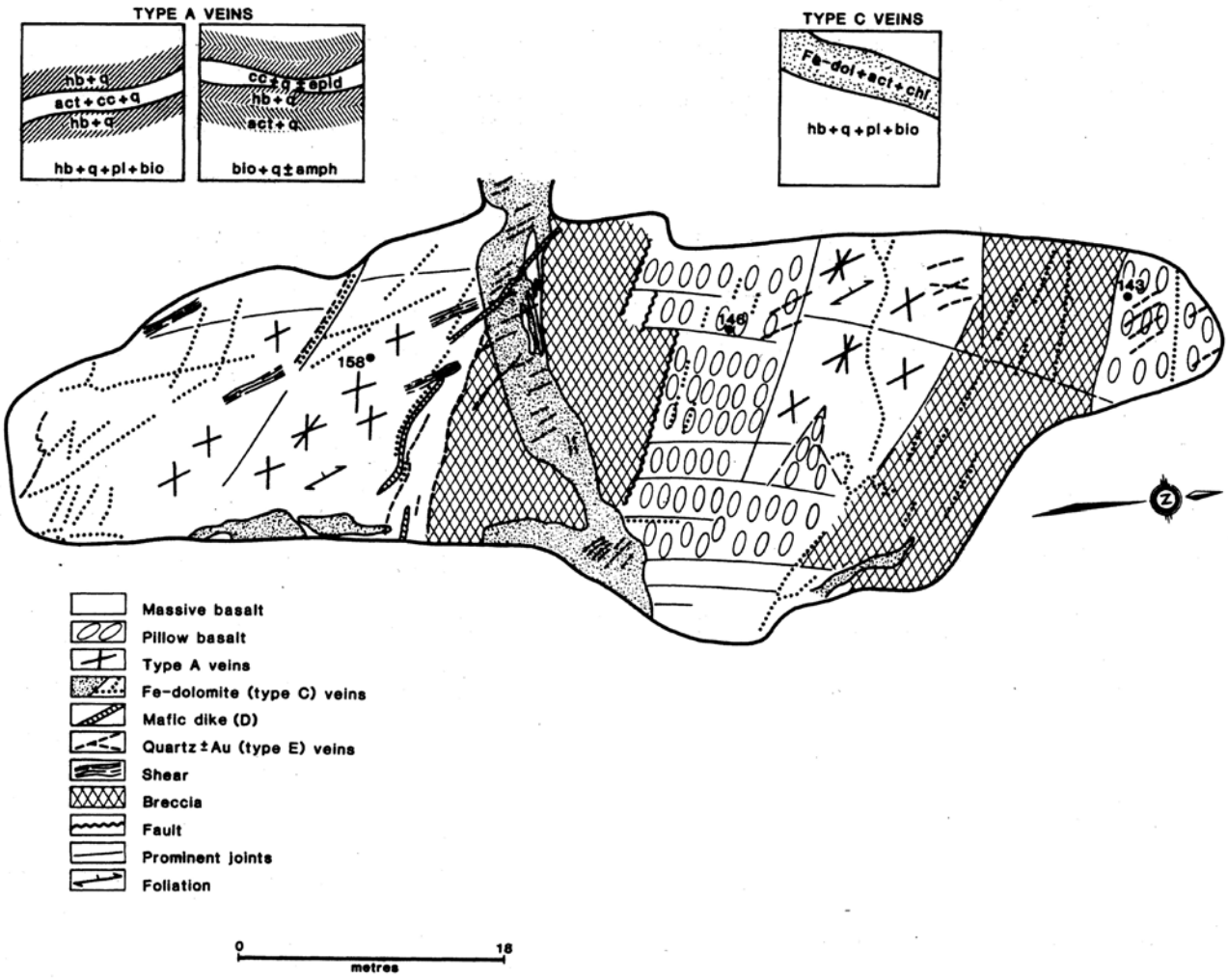


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Field Trip 2 - Western Wabigoon Subprovince Transect, Dryden to Meggisi Lake

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Introduction

This field trip will provide participants with an overview of the geology of a portion of the western Wabigoon Sub-province along an approximately 52km long transect that follows the Highway 502 corridor between the City of Dryden and Meggisi Lake (see Fig. 1, A-B; Fig. 3). The trip will begin in metasedimentary rocks near the southern margin of the Sioux Lookout domain, crossing over the Wabigoon fault into the Atikwa-Manitou volcano-plutonic domain. The majority of the trip will be spent observing supracrustal rocks of the Eagle-Wabigoon-Manitou Lakes (EWM) greenstone belt and plutonic rocks of the Atikwa batholith and Taylor Lake stock. The area has long been known for its gold exploration potential, with modest levels of production (approximately 13,000oz. Au) occurring between 1895 and 1948. As a result, the trip will also include a stop to observe a gold occurrence located near Flambeau Lake.

Regional Geology

Blackburn et al. (1991) describe the Wabigoon Sub-province as a 900km long by 150km wide granite-greenstone sub-province in the northwestern Superior Province. It consists of metavolcanic and subordinate metasedimentary rocks that are surrounded and cut by granitoid batholiths. The Wabigoon Sub-province is bounded on the north by the Winnipeg River and English River Sub-provinces and on the south by the Quetico Sub-province (Fig. 1). The Wabigoon Sub-

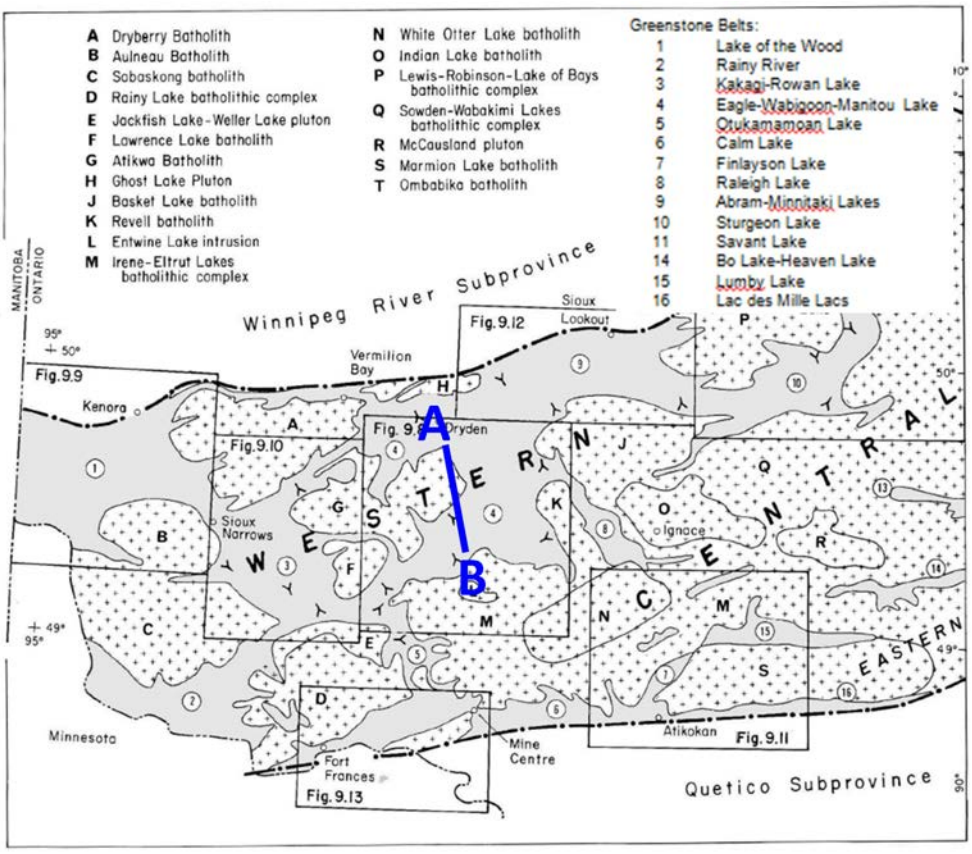


Figure 1. General geology of the western Wabigoon Sub-province, showing its extent, major supracrustal belts and structural features (Blackburn et al., 1991). The transect is defined by the A-B line.

province has been divided into three regions, referred to as: i) the western region; ii) the central region; and iii) the eastern region. As noted above, this field trip will transect a portion of the western region.

The following summary of the regional geology of the western Wabigoon Sub-province is excerpted from Beakhouse et al. (1995).

"The western Wabigoon region is characterized by interconnected, arcuate, metavolcanic dominated 'greenstone belts' surrounding large elliptical batholiths. The metavolcanic component of greenstone belts includes minor ultramafic (komatiitic), through abundant mafic (tholeiitic, calc-alkalic and minor alkalic) to felsic (mostly calc-alkalic) varieties. Except locally, metasedimentary rocks are volumetrically minor but diverse including turbiditic, volcaniclastic deposits, alluvial fan-fluvial deposits and chemical (magnetite ironstone and chert) deposits. Stratigraphic sequences generally comprise basal, laterally extensive, mafic metavolcanic sequences overlain by laterally limited, diverse mafic to felsic sequences. Minor clastic metasedimentary deposits are associated with some of the intermediate to felsic volcanism. Very locally, coarse clastic-dominated metasedimentary sequences with subordinate chemically distinct metavolcanic rocks unconformably overlie the diverse volcanic sequences. The principal exception to the generalized lithologic proportions outlined above occurs in an area north of the Wabigoon fault in the Dryden-Sioux Lookout area where metasedimentary rocks predominate. A more detailed review of the stratigraphy and geochemistry of western Wabigoon greenstone belts is presented in the guide portion of this volume.

Granitoid rocks within the western Wabigoon region include large elliptical to multi-lobate batholiths that define the architecture of the greenstone belts as well as smaller stocks. Most of the large batholiths (Aulneau, Atikwa, Sabaskong) range compositionally from ultramafic to granitic but are predominantly tonalitic to granodioritic. These are closely associated petrogenetically and temporally with the metavolcanic rocks of the greenstone belts and are interpreted to represent sub-volcanic chambers that have risen into their own volcanic ejecta. Exceptions to this generalization include the Dryberry and Ghost Lake batholiths which are younger than and compositionally distinct from metavolcanic rocks in this area. The smaller stocks are predominantly late- to post-tectonic and range compositionally from diorite to granite and syenite. Minor, late alkalic intrusions (e.g., Sturgeon Narrows) occur in the Sturgeon Lake area.

The deformational style of much of the western Wabigoon region, and particularly that portion lying to the south of the Wabigoon fault, is dominated by structural domes cored by large batholithic masses giving rise to apparent synclinal keels of greenstone belts surrounding the batholiths. In detail, it is not possible to correlate units on either side of the apparent 'synclinal axes' and these zones of opposing stratigraphic facing correspond, in part, to faults that have juxtaposed segments of volcanic rock of contrasting ages. Laterally continuous deformation zones exhibiting complex kinematics typically occur along the central axis of the greenstone belts where greenstone sequences face one another and may be related to this faulting. The northern portion (north of the Wabigoon fault) of the sub-province has a distinct structural style reflected in linear, fault bounded panels trending parallel to the sub-provincial boundary that contrasts with that of the remainder of the western Wabigoon region. Here there is evidence for early recumbent folding and thrust faulting as well as a later phase of dextral, transcurrent shear.

Greenschist-grade regional metamorphic mineral assemblages characterize much of the greenstone belts. The principle exceptions to this generalization are narrow amphibolite-grade zones that occur at the contact with granitoid batholiths and at sub-province boundaries. A particularly noteworthy exception occurs in the Dryden area where there is widespread evidence for in situ partial melting of pelitic metasedimentary rocks.

U-Pb geochronological constraints indicate that metavolcanic rocks were deposited between 2775 and 2711Ma, and much of this in the narrow interval of time between 2740 and 2720Ma. Large granitoid batholiths occurring to the south of the Wabigoon fault were emplaced synchronously with adjacent volcanic rocks, whereas those to

the north of the fault tend to be younger than 2710Ma. Small, post-tectonic plutons were emplaced over a 15Ma interval commencing at ~2699Ma."

Manitou-Stormy Lakes Greenstone Belt

The first half of the field trip will be spent viewing rocks located in the Manitou-Stormy Lake portion of the EWM Lakes greenstone belt. Beakhouse et al. (1995) describe the Manitou-Stormy Lakes greenstone belt as follows.

"Stratigraphic and structural relationships in this greenstone belt, supported by age dating (Davis et al., 1982; Davis, 1990; Parker et al., 1989: summarised in Blackburn et al., 1991), suggest a history in which two early mafic tholeiitic sequences, the Wapageisi Lake group (not dated directly, but in the range 2745 to 2730Ma) and the Boyer Lake group (not dated directly, but >2722Ma) have been juxtaposed against an intervening sequence of later calc-alkalic pyroclastics and overlying clastic metasedimentary rocks (Manitou-Stormy groups: <2706Ma and >2696Ma). To the northwest of the Manitou Straits fault, supracrustal units (Upper Manitou Lake, Pincher Lake, Lower Wabigoon volcanics: >2732Ma) that extend northward to the Wabigoon fault are examples of volcanic ejecta that are invaded by their own magma chamber (Atikwa batholith, Dore Lake lobe: 2732Ma). The early mafic suites are distinctly different, and may represent the ensimatic mafic plane within which the emergent pyroclastic edifices rose in island arc-related environments. The mafic plane analogue is supported by the presence within Wapageisi volcanics of two 200m thick, laterally extensive (>10km strike length) plagioclase-phyric flow units, 1500m apart.

Differing lines of evidence from two tabular gabbro bodies (Gabbro Lake, Mountdew Lake) within the Boyer Lake group lead to different interpretations of their relative age of emplacement. Presence of layering in the Gabbro Lake body suggests that they are horizontally-emplaced sills, and regional cross-cutting relationships suggest their emplacement subsequent to major folding. This argument led to the suggestion (Blackburn, 1980) that they were emplaced subsequent to overthrusting of the Boyer Lake volcanics. However, an age of 2722Ma later obtained (Davis et al., 1982) from the same sill is not consistent with a post-thrusting emplacement. These problems remain unresolved."

Economic Geology

Exploration and Production History

The Wabigoon Lake and Upper Manitou Lake areas have long been recognized as having significant gold exploration potential. During the time period between 1895 and 1943, several small gold deposits were developed and modest amounts of gold were produced in these areas. The majority of the historic gold production occurred in the Gold Rock mining camp near Upper Manitou Lake. Past-producers at Gold Rock included the Laurentian, Big Master (aka Kenwest), Elora (aka Jubilee) and Gold Rock mines (Parker, 1989). Total production from these four mines was 12,113.21oz Au. Production statistics for the individual mines are provided in Table 1.

Gold production from the Wabigoon Lake area during the same time period was much less significant, with a total of 613.02oz Au mined from four deposits (Parker, 1989). The past producing mines and their production statistics are listed below (Table 2).

Since 1948, the Wabigoon Lake and Upper Manitou Lake areas have both seen sporadic exploration activity, including a period of base metal exploration during the 1960s and 1970s (Parker, 1989). However, most exploration activity that has been completed in these areas since 1980 has continued to focus on gold.

Table 1. Gold production statistics for the Gold Rock Mining Camp (from Parker, 1989).

Mine	Total Production (oz Au)	Years of Operation
Laurentian	8143	1906-09
Big Master (Kenwest)	2565.52	1902-05, 1942-43
Elora (Jubilee)	1369.69	1936-37, 1939
Gold Rock	35	1929

Table 2. Gold production statistics for the Wabigoon Lake area (from Parker, 1989).

Mine	Total Production (oz Au)	Years of Operation
Redeemer	343.96	1904-06, 1918
Bonanza	243.85	1920, 1923
Rognon	22.21	1916-18
Van Houten	3	1940

The most notable recent exploration activity in the Wabigoon Lake area has occurred on the Laurentian Goldfields Ltd. Van Horne Gold Property. This property will be visited during this field trip, and is described in detail as field trip Stop 11.

In the Upper Manitou Lake area, Manitou Gold Inc. has been active recently on a number of claim groups, including their Elora and Kenwest properties. These properties include the past-producing Laurentian, Big Master, and Elora Mine sites. There are 61 known gold showings, occurrences, prospects, and deposits in the Upper Manitou Lake area (Maunula and Wilson, 2010). These showings include the Starr Gold Occurrence that is described below as an optional self-guided field trip stop (Stop 8).

The location of the Van Horne gold property and the historic Gold Rock mining camp are shown on Figure 2. This map also illustrates mining claims that were in good standing as of April 20, 2015 and the location of mineral exploration projects that were reported by Lichtblau et al. (2015) to have been active during 2014.

Gold Mineralization

Gold occurrences in the Eagle-Wabigoon-Manitou Lakes greenstone belt show strong spatial and genetic correlations with major deformation zones such as the Wabigoon and Pipestone Manitou Straits faults (Parker, 1989).

Parker (1989) noted the following structural and stratigraphic relationships to gold mineralization in the Wabigoon Lake area.

> *"Gold-bearing quartz veins west of Wabigoon Lake are controlled by northwest-trending tension fractures and east- and east-northeast-trending shear zones.*
>
> *The majority of known gold occurrences at Eagle and Wabigoon Lakes are situated within a mixed sequence of mafic to felsic metavolcanics grouped together as the Lower Wabigoon Volcanics: it overlies a thick sequence of massive and pillowed mafic flows, the Eagle Lake Volcanics, and underlies a pillowed mafic flow sequence occurring at the top of the volcanic succession, the Upper Wabigoon Volcanics."*

The stratigraphic and structural controls on gold mineralization in the Upper Manitou Lake area are described as follows by Parker (1989).

> *"It is apparent that stratigraphy plays an important role in the concentration of gold at Upper Manitou Lake. Gold deposits are situated near the contacts between the Blanchard Lake, Upper Manitou Lake, and Pincher Lake Volcanic Groups. The mines at Goldrock, and the significant*

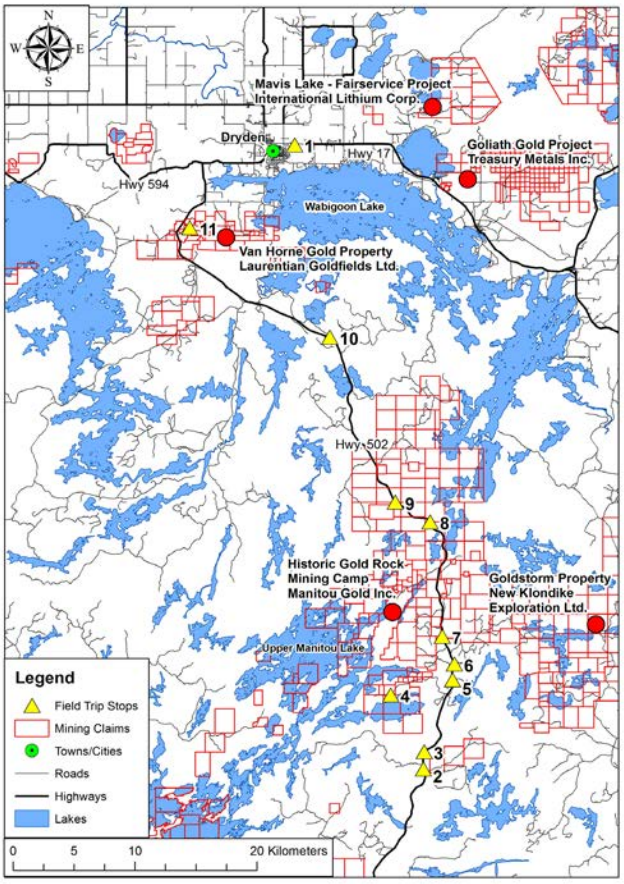


Figure 2. Map illustrating locations of Van Horne gold property and Gold Rock historic mining camp relative to field trip stops. Mining claims and exploration properties active during 2014 are also shown.

gold occurrences and prospects in the area, are situated within the Pincher Lake Group, near its contact with the underlying Upper Manitou Lake Group. The Pincher Lake Group may be identical to the Lower Wabigoon Volcanics, which host numerous gold deposits and past producing mines at Eagle and Wabigoon Lakes. The Pincher Lake Group and Lower Wabigoon Volcanics are mixed sequences of calc-alkaline to tholeiitic, mafic and felsic metavolcanic rocks.

The fact that gold deposits are concentrated northwest of the Manitou Straits Fault is partly due to the fact that geological successions on either side of the fault are substantially different. The rocks southeast and east of the fault consist of the dominantly mafic Boyer Lake Group, and the Manitou Lake Group, both of which host a few scattered gold occurrences. Rocks northwest of the fault are dominantly calc-alkaline to tholeiitic and are more typical of gold-bearing environments elsewhere in the Dryden-Ignace area. Structural disruption is also more significant northwest of the fault, providing numerous dilatant zones for the emplacement of gold-bearing quartz veins. Extensive and intense northeast shearing controls the majority of gold-bearing quartz veins. At Peak Lake, northeast of Upper Manitou Lake, gold-bearing quartz veins are controlled by northwest-trending fractures which crosscut east and northeast-trending shear zones. This style of deformation is similar to gold deposits at Dinorwic Lake, and differs from the dominant northeast controls at Goldrock.

Competency and susceptibility to fracturing of the host rock is the controlling influence on the concentration of the quartz veins: ductility contrasts between felsic dikes and mafic metavolcanics have focussed zones of extension and compression, commonly resulting in fracturing of the more rigid felsic dikes."

Field Trip Stops

Stop 1: Thunder Lake metasedimentary rocks

UTM Coordinates: NAD83; 15U 0513498E / 5514739N

The Walmart store property located on Trans-Canada Highway 17 (Government Street) at the east end of Dryden.

This stop provides an opportunity to view an exposure of folded Thunder Lake metasedimentary rocks in outcrops located adjacent to the Dryden Walmart parking lot.

As noted above, there are significant differences in structural style on the north and south sides of the Wabigoon fault, suggesting that these rocks represent domains that evolved separately and have been juxtaposed against each other along the fault. Rocks located to the north of the Wabigoon fault, including the Thunder Lake sediments, are collectively referred to as the Sioux Lookout domain (Beakhouse et al., 1995).

Blackburn et al. (1991) suggest that the Wabigoon fault displays an early history of thrusting (south side up), followed by dextral strike-slip movement. Evidence for the former is most evident to the south of the fault, where tight folds with sub-horizontal axes occur in the Wabigoon volcanic rocks. Evidence for strike-slip motion is most notable to the north of the fault, where the Thunder Lake metasedimentary rocks are folded about sub-vertical axes.

The Thunder Lake metasedimentary rocks are described as follows by Beakhouse (2000).

"The Thunder Lake sediments include two separate panels of rock separated along a portion of their strike-length by the Thunder Lake volcanics. Thin- to medium-bedded wacke-siltstone characterized by even, continuous bedding is the predominant component in both panels. Thin magnetite ironstone layers are a conspicuous minor component within the Thunder Lake sediments north of the Thunder Lake volcanics but are rare within the southern panel. Minor, thin garnet-rich (<70% garnet) and calc-silicate layers may represent original more pelitic and marly layers, respectively. In one location, the calc-silicate material forms discordant veins, and suggests that some of this material is remobilized or originated by secondary alteration processes. The garnet-rich layers are often closely spatially associated with the ironstone layers.

A limited number of determinations indicate that tops, although locally reversed by tight to isoclinal minor folding, are generally to the south in both the north and south panels. Contact relations with the Brownridge volcanics have not been observed but the data are permissive of a conformable stratigraphic relationship. The contacts with the Thunder Lake volcanics

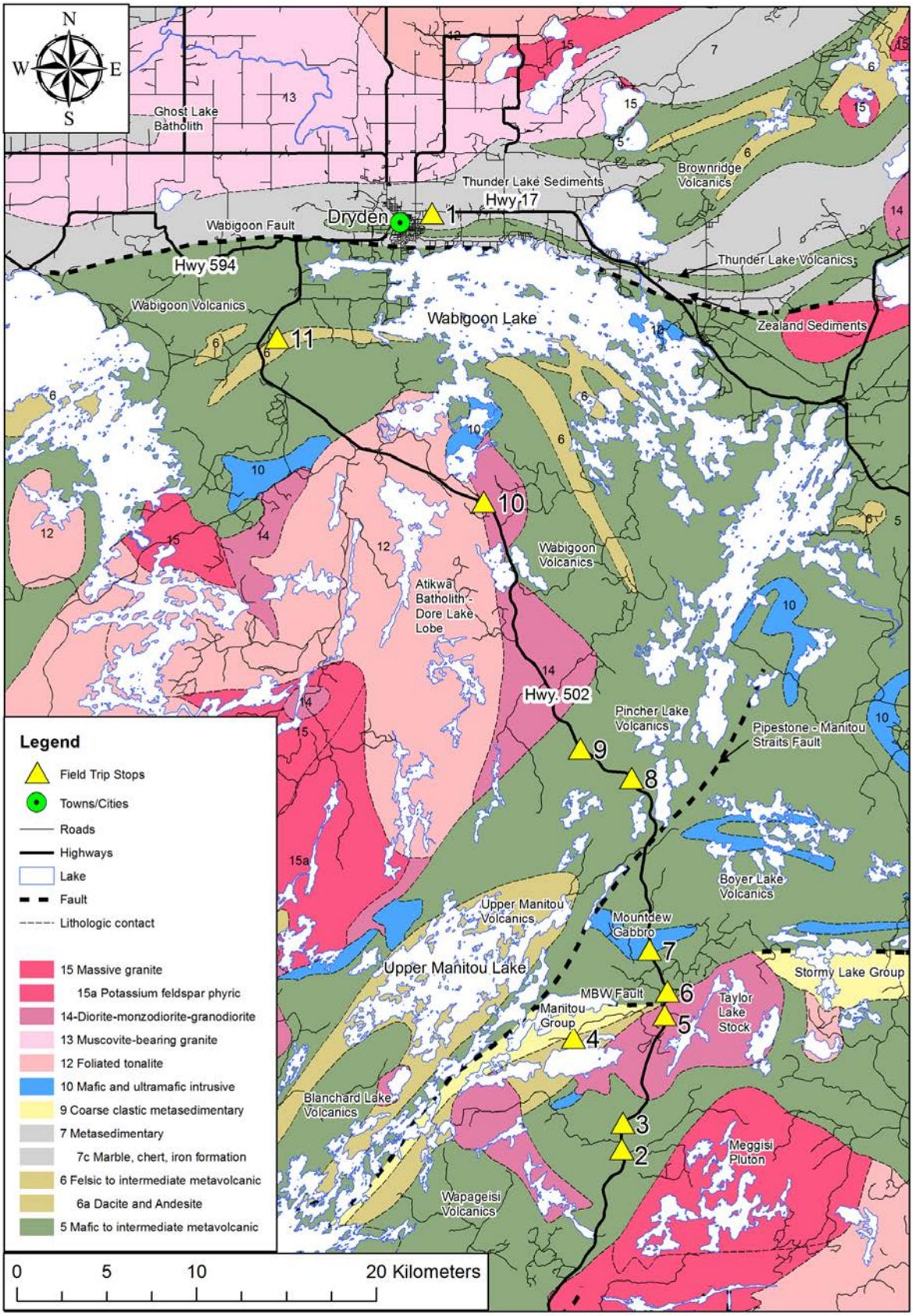


Figure 3. General geology with field trip stops (geology from Ontario Geological Survey 2011).

appear to also be conformable although these are commonly moderately highly strained and a loci of abundant quartz veining."

This outcrop exposure illustrates the effects of two phases of deformation that resulted in the development of refolded folds in the Thunder Lake metasedimentary rocks. The first phase of deformation resulted in the formation of isoclinal folds about steeply-plunging axes. These folds were subsequently refolded into open z-folds indicative of a late phase of dextral transcurrent shear along the Wabigoon fault (Beakhouse et al., 1995). The axial planes of the late folds strike approximately east-northeast. Parker (1989) also noted the presence of structures (e.g., northwest-trending tension fractures) on the south side of the Wabigoon fault that are consistent with a late phase of dextral transcurrent motion.

We will now travel for approximately one hour along Highways 594 and 502 until we reach the southern end of the transect at Meggisi Lake.

Stop 2: Wapageisi metavolcanic rocks

UTM Coordinates: NAD 83; 15U 0524073E / 5463090N to 0524055E / 5463690N

Turn left onto Highway 17 and travel 650m to the traffic lights at the intersection with Highway 594 (Duke Street). Turn left onto Highway 594 and travel 8km to the intersection with Highway 502. Turn left onto Highway 502 and travel 64.5km south to Meggisi Road.

This field trip stop consists of a series of road cuts extending northward from Meggisi Road for approximately 600m along the west side of Highway 502. Uphill Road is intersected at a distance of 350m along the section. These bedrock exposures provide excellent examples of relatively undeformed pillowed and massive flows of the Wapagesi metavolcanic rocks.

The Wapageisi metavolcanic rocks are described as follows by Beakhouse (2011).

"The Wapageisi volcanics comprise a homoclinal, generally northward-facing panel of submarine mafic volcanic and related gabbroic rocks. Plagioclase glomeroporphyritic units are laterally continuous and make up approximately 10 to 15% of the unit. The age of the Wapageisi volcanics is constrained to being older than both the Manitou–Stormy supracrustal association (~2703Ma) and the late- to post-tectonic Taylor Lake pluton (~2698Ma). A laser ablation inductively coupled mass spectrometric (LA-ICP–MS) U/Pb age of 2727±5Ma for a gabbro occurring to the southeast of Stormy Lake (Stone et al., 2010) may approximate the age of the unit; however, the sampled unit occurs at the contact between the Wapageisi and Bending Lake volcanics that both contain gabbro intrusions. The basal contact of the Wapageisi volcanics is in part intrusive where younger phases (Islet Lake Stock, Stone, Hellebrandt, and Lange, 2011b; Meggisi pluton, Blackburn, 1982) are in contact with the basal volcanic units. However, a well-developed, commonly shallowly dipping, penetrative deformation fabric is restricted to the basal 500m of the Wapageisi volcanics with the intensity of fabric development increasing towards the contact suggesting that the local intrusive contacts may be superimposed on a tectonic contact. The character of the northern contact of the Wapageisi volcanics differs across the area."x

The Meggisi-Uphill Roads section through the Wapagesi metavolcanic rocks commences in plagioclase-phyric pillowed basalt (Fig. 4), typical of the two laterally extensive, plagioclase-phyric flow units that provide stratigraphic markers near the base of the Wapagesi metavolcanic rocks (Beakhouse et al., 1995). The flows at this location are upward-facing with a shallow dip (approximately 25°) toward the north.

Moving north, the plagioclase-phyric unit is overlain by aphyric massive basalt that is overlain by pillowed flows and pillow breccia. A 10cm wide mafic dike can be observed cross-cutting the pillow breccia. The



Figure 4. Plagioclase-phyric pillowed flows.



Figure 5. Quartz-carbonate filled "eyebrow" structures.



Figure 6. Roadside exposure of pillowed Wapageisi metavolcanic rocks.

northeast-striking dike parallels shear fractures and dips approximately 70° toward the northwest. This unit is overlain by a second massive flow that passes into another sequence of pillowed material. The massive flow contains large quartz-carbonate filled "eyebrow" structure gas cavities (Fig. 5) whose long axes are oriented approximately parallel to stratigraphy.

More pillowed flows and flow-breccia are present to the north of the Uphill Road turnoff. Cavities in the breccia have been in-filled with quartz, carbonate and epidote.

Stop 3: Pillowed lavas in Wapageisi metavolcanic rocks

UTM Coordinates: NAD83; 15U 0524129E / 5464528N

Travel 1.8km north of Meggisi Road along Highway 502. Because these roadside outcrop exposures are located on a corner, park at a roadside stop located on the west side of the highway at UTM Co-ordinates: NAD83; 15U 0524385E / 5464742N. The outcrops are located approximately 350m to the southwest of the parking spot.

This stop provides a good opportunity for participants to obtain photographs of excellent examples of pillowed mafic metavolcanic flows in the lower, tholeiitic mafic plane sequence of the Wapageisi metavolcanic rocks (Fig. 6). The following description of the outcrop exposures is excerpted from Beakhouse et al. (1995).

> *"In the west face, pillow shape and packing indicates tops to the northwest. Good examples of bun-shaped to mattress-shaped to budding forms can be seen. Sparse feldspar phenocrysts are scattered throughout. Narrow selvages and lack of vesicles suggest deep-water emplacement but the presence of carbonate-filled gas cavities appears to contradict this. Size of pillows ranges from 20cm or less to about 1m. On the east side of the highway, excavation for the road cut, followed by winter frost heave, has exposed exceptionally well preserved three-dimensional pillow shapes. In one specimen, the budding neck of the pillow can clearly be seen in three dimensions."*

Stop 4: Manitou Group conglomerate and quartz-feldspar porphyry

UTM Coordinates: NAD83; 15U 0521390E / 5469239N

Travel 5.4km north from Stop 3 along Highway 502 to the intersection with Mosher Road. Turn west on Mosher Road and travel 6.6km

This stop provides an opportunity to view polymictic conglomerate of the Manitou group that has been intruded by a quartz-feldspar porphyry dike. Beakhouse et al. (1995) describe the Manitou group as follows.

The correlatable Manitou and Stormy Lake groups are typical of upper, emergent, chemically and texturally diverse, predominantly calc-alkaline sequences that provided fill for marginal sedimentary basins. In other greenstone belts these have been termed "Temiskaming" type. The base of the sequence unconformably (in places with high angle) rests on Wapageisi Lake group tholeiites. Calc-alkaline pyroclastics are typically coarse, and intruded by co-magmatic, dacitic, subvolcanic porphyry stocks, one of which has been dated at 2699Ma (Don Davis, personal

communication, 1989). At the top of the pyroclastic sequence lies a mafic alkaline (trachybasalt) flow unit (Sunshine Lake formation) that is unique in the western portion of the Wabigoon Subprovince. Rubble at the top of the unit marks the passage into the epiclastic suite, in which there is vertical and lateral facies variation from alluvial fan and fluvial into resedimented conglomerates, sandstones and mudstones. The resedimented facies show all the characteristics of turbidite sequences: coarse heterolithic conglomerates, graded wacke to mudstone beds, and loading textures (e.g. flame structure) (Teal and Walker, 1977; Blackburn, 1981).

The polymictic conglomerate seen here forms part of the Mosher Bay metasedimentary rock sequence. The Mosher Bay metasedimentary rocks are an approximately 2000m thick, north-northwest facing, steep northerly- to vertically-dipping sequence comprised of conglomerate, sandstone, mudstone and minor iron formation. The lower two thirds of the sequence are dominated by conglomerate, while the upper third is a mixture of conglomerate, sandstone and mudstone. The conglomerates include both volcanic clast-dominated and polymictic horizons (Blackburn, 1981).

The polymictic conglomerates have variable clast sizes (pebbles, cobbles and boulders) and include a mixture of lithologies including granitoid rocks, volcanic rocks, chert, jasper, and magnetite iron formation. The proportion of volcanic clasts found in the polymictic conglomerates decreases upward in the sequence (Blackburn, 1981).

The Mosher Bay metasedimentary rocks are intruded by a concordant quartz feldspar porphyry intrusion that covers a strike length of more than 3 km and ranges in width from tens of metres to 300m. The Mosher Bay porphyry is petrographically identical to nearby porphyries at Sunshine and Thundercloud lakes and contains abundant 2 to 4mm phenocrysts of quartz and feldspar throughout. Several similar, much smaller porphyry intrusions occur in proximity to the Mosher Bay porphyry and are likely to be genetically related (Blackburn, 1981).

Stop 5: Taylor Lake Stock

UTM Coordinates: NAD83; 15U 0526461E / 5470489N

Return to Highway 502 from Stop 4 and turn left back onto Highway 502. Travel 1.3km north along Highway 502 to the intersection with a Domtar forest access road located just to the south of Rattlesnake Creek.

The outcrops on both sides of the highway provide a good exposure of the late- to post-tectonic 2695Ma (Davis et al., 1982) Taylor Lake Stock. The stock is a relatively small intrusion (approximately 11km by 6km) that is completely enclosed by supracrustal rocks. The intrusion is inhomogeneous and ranges in composition from granodiorite to monzodiorite. However, the highway transects the relatively homogeneous, granodioritic, western portion of the stock (Blackburn, 1981). Interesting features that are visible in these outcrops include exfoliation fractures (Fig. 7), shear fractures, a pegmatite dike that parallels a shear, and numerous mafic xenoliths.

Stop 6: Manitou Group alkaline metavolcanic rocks

UTM Coordinates: NAD83; 15U 0526602E / 5471785N

Travel 1.4km north from Stop 5 to outcrop exposures located on both sides of the highway, north of Rattlesnake Creek.

The following description of this stop is excerpted from Beakhouse et al. (1995).

> *"The river valley follows the east-striking Mosher Bay - Washeibemaga (MBW) fault, along which the Boyer Lake volcanics may have been thrust over the Manitou and Stormy Lake groups. In the outcrop on the east side of the highway alkaline volcanics of the Manitou group are intruded by granitic rocks of the late tectonic Taylor Lake stock. Sigmoidal shears in the alkaline volcanics may be related to movement on the MBW fault.*



Figure 7. Exfoliation fractures in the Taylor Lake stock.

To the north across the valley is a narrow gabbro unit, similar to those at the last stop, emplaced into the Boyer Lake volcanics. Although not evident at this stop, the MBW fault is cut out for a portion of its length by the Taylor Lake stock, and has in turn been sinistrally offset along the north-northeast-striking Taylor Lake fault."

Stop 7 (Optional Self-Guided Tour Stop): Mountdew Lake gabbro

UTM Coordinates: NAD83; 15U 0525623E / 5474074N

Travel 2.4km north from Stop 6 along Highway 502 to the intersection with a logging road. Turn right and park on the side of the logging road.

Outcrops of the Mountdew Lake gabbro sill are visible here near Highway 502 and along a logging road on the east side of the highway. This gabbro body discordantly intrudes mafic metavolcanic rocks of the Boyer Lake group (Blackburn, 1981). The intrusion post-dates formation of the Kamanatogama syncline which has affected the surrounding metavolcanic rocks (Blackburn, 1982). Although the intrusion has not been mapped in detail, a number of intrusive phases were identified by Blackburn (1981).

The dominant phase of the intrusion (visible at this stop) is a medium-grained, dark green gabbro exhibiting an ophitic to subophitic texture in which amphibole derived from pyroxene is intimately intergrown with saussuritized plagioclase feldspar (Blackburn, 1981). Other intrusive phases include coarse-grained to pegmatitic gabbro containing considerable quantities of magnetite or ilmenite, altered pegmatitic gabbro with colourless "eyes" of quartz and/or potassic feldspar, and granophyre comprised dominantly of pink potassic feldspar with minor quartz (Blackburn, 1981).

Stop 8 (Optional Self-Guided Tour Stop): Starr Gold Occurrence

UTM Coordinates: NAD83; 15U 0524624E / 5483569N

Travel 10.6km north from Stop 7 along Highway 502. Located immediately north of a paved pull-over area on the east side of the highway.

Visible gold was discovered in a narrow quartz vein located near the south end of the outcrop on the east side of the highway in 1982 by local area prospector E. Starr. Follow-up prospecting identified another gold showing approximately 15m east of the highway. However, follow-up drilling of the occurrence in 1983 by Asamera Inc. failed to identify any significant mineralization at depth or along strike. The location of the original surface showing can be recognized as a notch in the exposure where shallow blasting was carried out following the initial discovery.

Rocks at this location are deformed and altered pillowed mafic metavolcanic flows of the Pincher Lake group. The deformation, alteration and gold mineralization observed here are associated with a structure known as the Gold Rock splay (Beakhouse et al., 1995). It is a subsidiary structure to the Manitou Straits fault, which crosses the highway approximately 4km to the south. As noted previously, the most significant gold deposits in the Manitou-Stormy Lakes greenstone belt occur nearby. They are also located to the northwest of the Manitou Straits fault in rocks of the Pincher Lake group, near its southern contact with the Upper Manitou group.

Alteration includes silicification and carbonatization with numerous quartz-carbonate pods, veinlets and stringers. In many locations, the alteration is accompanied by disseminated pyrite mineralization.

Stop 9: Giant pillows in Pincher Lake metavolcanic rocks

UTM Coordinates: NAD83; 15U 0521772E / 5485196N

Travel 3.5km north from Stop 8 along Highway 502. Park vehicles at the entrance to the Ministry of Transportation gravel pit located on the east side of the highway. The outcrop is located opposite the Fort Frances 140km sign.

Mafic metavolcanic rocks of the Pincher Lake group are exposed on this road cut located on the east side of the highway. These rocks are pillowed flows that show wide shape and size variations. This exposure is notable for the remarkable size of many of the pillows, some of which span the entire height of the road cut (a distance of at least 5m) and are up to 2m thick (Fig. 8). Pillow selvages are narrow, with a few much smaller pillows visible between the giant ones.

In a well-exposed road cut such as this, these rocks can easily be classified as pillowed mafic metavolcanic flows. However, this type of exposure illustrates the potential pitfalls of trying to classify flow morphology in areas where only small surface exposures are available (i.e., giant pillows could easily be mistaken for massive flows).



Figure 8. Giant pillows of the Pincher Lake metavolcanic rocks.

Stop 10: Atikwa Batholith

UTM Coordinates: NAD83; 15U 0516387E / 5498799N

Travel 15.7km north from Stop 9 along Highway 502.

The Atikwa Batholith is one of a number of intrusions in the western Wabigoon Sub-province that may represent subvolcanic magma chambers that have risen into their own volcanic ejecta. The following description of these intrusions is excerpted from Beakhouse et al. (1995).

> *"The Aulneau, Sabaskong and Atikwa batholiths, that are interpreted to represent the plutonic root to much of the volcanism in the western Wabigoon Sub-province, are dominated by rocks within the compositional spectrum tonalite-quartz diorite-granodiorite. The absence of inherited zircons (Davis et. al, 1988) and equivocal nature of field evidence for an unconformable relationship with potential underlying sialic crust, suggest development in an ensimatic regime. These rocks have distinctive geochemical characteristics including low K and Rb and high Ca, Sr and Na/K, moderately fractionated REE with HREE at 1-4x chondrite, LREE at 30-60x chondrite and negligible Eu anomalies and mantle-type radiogenic (Sr and Nd) isotopic signatures. These characteristics have led to the interpretation that many of these rocks were derived from the partial melting of tholeiitic basalt at mantle or lower crustal depths (Davis and Edwards, 1985; Beakhouse and McNutt, 1991). The extent to which a component derived from direct melting of LILE-enriched mantle may be present in these plutons remains a question for further study. These rocks, chemically high-Mg andesites and originally referred to as sanukitoid, have many geochemically overlapping characteristics with basalt-derived tonalite but differ importantly in having high-Mg as well as Ni and Cr (e.g., Stern et. al., 1989; Sutcliffe et. al., 1990). An important difficulty in distinguishing these two origins, however, arises from the probability that even limited fractionation will obscure some of the diagnostic characteristics of primitive sanukitoid magmas."*

The outcrop at this location consists largely of medium-grained, massive to weakly foliated tonalite of the Dore Lake lobe of the Atikwa Batholith. The tonalite contains numerous relatively small, partially-assimilated mafic xenoliths. A prominent feature visible in the exposure on the eastern side of the highway is a 20cm wide mafic dike that strikes 165° and dips 70° to the west (Fig. 9). Such dikes are common near the eastern margin of the Dore lobe and may be indicative of the cooled carapace to an active magma chamber (Beakhouse et al., 1995). The eastern exposure also exhibits a prominent set of joints that strike approximately 135° and dip steeply (approximately 70°) toward the southwest.

Stop 11: Van Horne Gold Property – Pritchard exposure trench

UTM Coordinates: NAD83; 15U 0504890N / 5507870N

Travel 17.2km north from Stop 10 along Highway 502 to the intersection with Flambeau Road. Note that this field trip stop is accessed via a private, gated road,



Figure 9. Mafic dike cross-cutting tonalite of the Atikwa batholith.

and that permission must be obtained from the property owner. The Pritchard trench is located approximately 850m southeast of the intersection with Highway 502.

A summary of the exploration history and geology of the Van Horne gold property is provided below.

Exploration History

Laurentian Goldfields Ltd. initiated an exploration program in 2008 on the Van Horne Gold Property, approximately 8km southwest of Dryden. There are16 historical shafts, 53 test pits, and 73 trenches located on the property. Some have underground workings and gold production has occurred at 4 of these excavations. There are approximately 24 historical gold occurrences on the property (Lengyel, 2007). The majority of this historical work occurred during a period of intense exploration and development activity that occurred between 1897 and the 1940's.

Rock Types

The Van Horne Property is situated in a mixed sequence of mafic to felsic metavolcanic rocks grouped together as the Lower Wabigoon volcanics (Fig. 10). The metavolcanic rocks occur together with synvolcanic diorite to quartz diorite intrusions and contain discontinuous horizons of interflow sedimentary rocks. Mafic and felsic dikes cut all of these rock types. The mafic dikes are mainly gabbro to diorite, while the felsic dikes include both feldspar porphyry and quartz-feldspar porphyry. All of these rock types have been cut by quartz veins. The youngest rock type on the property is diabase that occurs as a prominent west-trending dike that appears to have been emplaced after the formation of the quartz veins (Lengyel and Rennie, 2009).

Structural Geology

All of the rock types on the property exhibit variable strain. Shearing and veining observed on the outcrop-scale in exploration trenches provide the basis for property-scale structural interpretations. With the exception of minor northeast-trending veins (D1 axial planar), most shear structures and veins lie along four dominant orientations associated with D2 dextral transpression. These structures are listed below:

- East-trending (90°) structures parallel to D2 regional

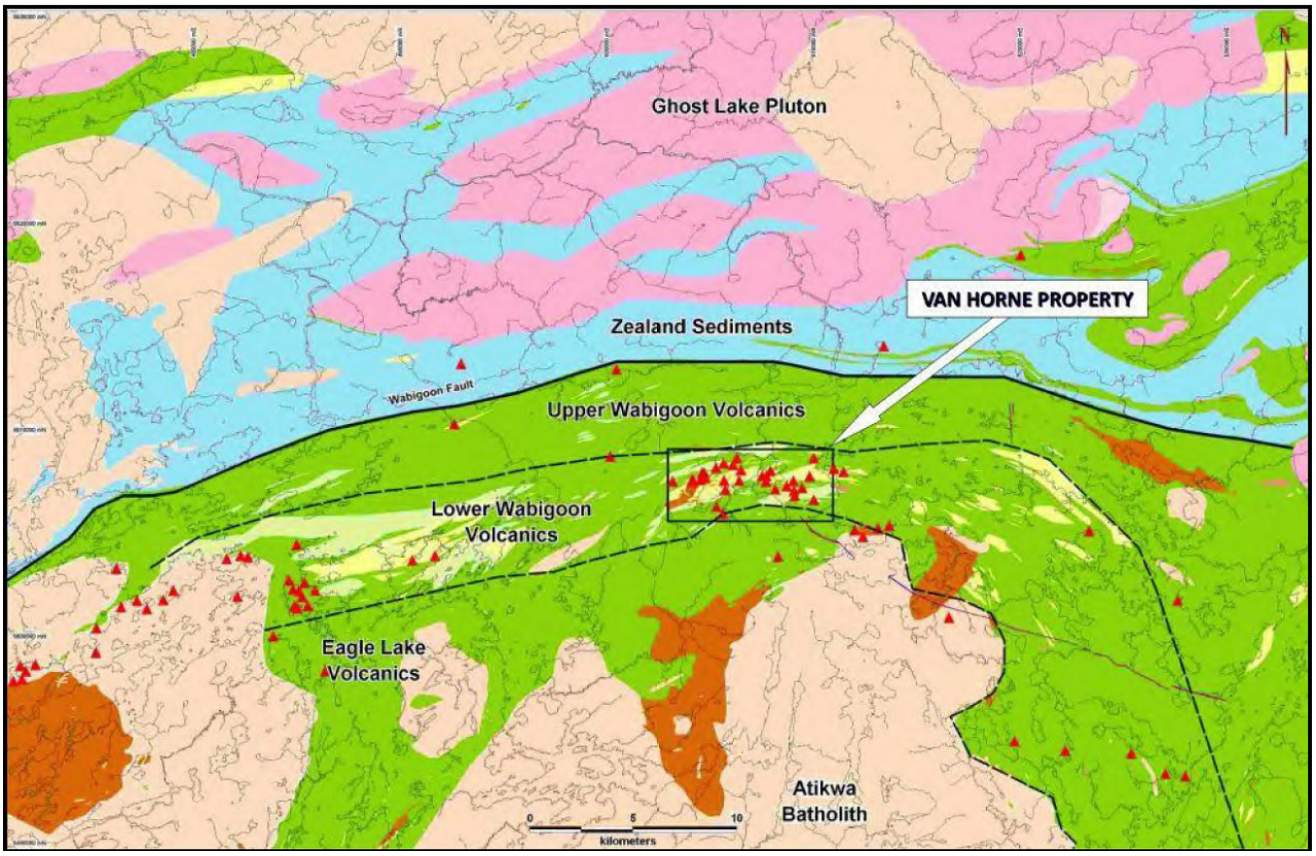


Figure 10. Regional stratigraphy and location of Laurentian Goldfields Ltd.'s Van Horne gold property (from Lengyel and Rennie, 2009).

foliation;

- West-northwest-trending (280° to 290°) D2 Riedel (R) shears;
- North-northwest-trending (325° to 345°) D2 Riedel (R') shears; and
- Northwest-trending (300° to 310°) tension features.

Most historical exploration and development on the property has targeted the gold potential of quartz veins. These quartz veins are structurally controlled and hosted in a variety of rock types (Lengyel and Rennie, 2009). Based on the results of a channel sampling program completed on the Van Horne Property exposures, Rennie and Chiang (2012) were able to identify the quartz vein systems that host gold mineralization and described them as follows:

> *"The vein array consists of west-trending shear veins and northwest-trending tension veins as well as a lesser array of sub-horizontal ladder veinlets. Shear veins tend to show dramatic pinch-and-swell but are locally continuous over up to about tens metres. Tension veins locally form left-stepping, echelon patterns and the individual veins tend to be narrow (up to 20 cm) with openly anastomosing planar forms. The shear veins and tension veins intersect without cross-cutting relation, suggesting that they are coeval and are interpreted to have formed during a single progressive strain event."*

Alteration

All rock types on the property exhibit variable hydrothermal alteration. The intensity of alteration in the exposures often increases where quartz veining is more abundant. Some parts of the exposures that lack quartz veins also display hydrothermal alteration (Lengyel, 2007). Several alteration features were identified during examination of the boundary between the differentiated phases within the mafic intrusive rock by Rennie et al. (2012).

> *"... in many instances the primary mineralogy and textures in the rock are completely replaced by alteration minerals. Multiple phases of alteration are identified in drill core; these include an early phase of sericite and chlorite replacement, overprinted by carbonate and finally pervasively silicified. The main alteration minerals are carbonate, ankerite, chlorite, magnetite and silica with lesser amounts of albite and tourmaline."*

Disseminated euhedral magnetite occurs throughout the property in most rock types. However, greater magnetite concentrations occur on the western part of the property. Rennie et al. (2012) have proposed that the "magnetic anomaly underlying the Flambeau zone is associated with hydrothermal magnetite disseminated through the diorite and quartz-diorite dykes."

Sulphides

Sulphide minerals are found in all rock types, including the quartz veins. Samples collected during a second phase of sampling tested the sulphide-bearing rocks adjacent to gold-bearing quartz veins that were identified during the initial sampling. Some of the channel-cut samples collected from this sampling program returned anomalous gold values (Rennie and Chiang, 2012).

Exposures – Trenching

In 2009, mechanical removal of overburden and pressure washing was conducted at seven areas on the property (Fig. 11). The objective of the trenching was to provide a north-south cut across stratigraphy in areas of high outcrop density. Some of these areas are adjacent to historical excavations, whereas others were testing mineral potential sites identified from Mobile Metal IonTM (MMI) survey results and responses from a helicopter-supported airborne magnetometer geophysical survey. These exposures were geologically mapped and the mineral potential of selected parts of outcrops was tested by two phases of channel cutting and sampling.

Gold Mineralization

Based on the assay results of samples collected by Laurentian Goldfields Ltd. since the initiation of activity on the property, Rennie and Chiang (2012) and Rennie et al. (2012) have proposed the following:

- Both shear veins and tension veins contain anomalous concentrations of gold. However, the gold concentrations are highly variable;
- Gold occurs in both barren and pyrite-bearing quartz veins;
- Altered wall rocks with secondary pyrite locally contain high concentrations (up to 8g/t) of gold, but gold values are highly localized;
- Lithological contacts and mechanically competent rock units are important host rocks for mineralization;

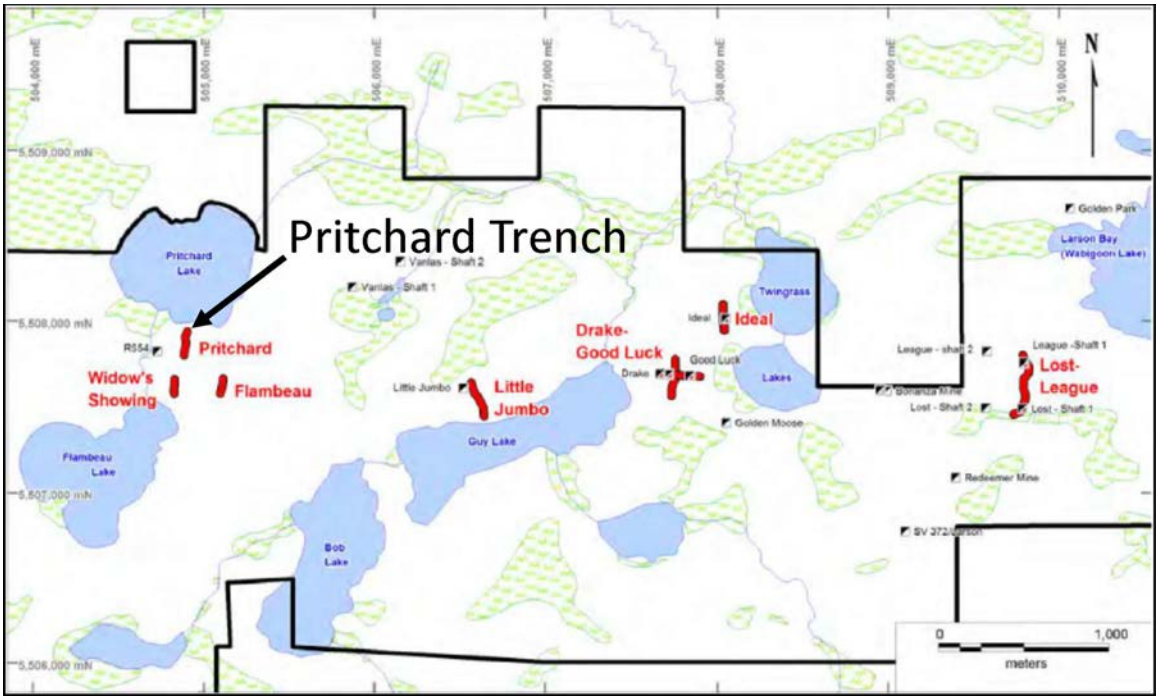


Figure 11. Location of stripped exposures and historical excavation on part of the Laurentian Goldfields Ltd. Van Horne gold property (modified from Lengyel and Rennie, 2009).

- The gold-mineralized zone is enriched in pathfinder elements, such as arsenic, silver and particularly tungsten; and
- Hydrothermal magnetite is disseminated throughout the diorite and quartz diorite dikes.

Future exploration efforts on the property could identify additional quartz-carbonate vein-hosted gold mineralization, and the sulphide-bearing rocks adjacent to known gold-bearing quartz veins may host additional gold-mineralized zones. Quartz veins and hydrothermal alteration zones localized along lithological boundaries between differentiated phases within the interiors of mafic intrusions should also be examined for gold mineralization.

Pritchard Exposure Trench

The Pritchard Exposure trench (Fig. 12) will be visited during this field trip. The following description of this gold occurrence is excerpted from Lengyel and Rennie (2009):

> *"The Pritchard trench is underlain by felsic tuff and tuff-breccia, massive rhyolite, mafic intrusive, and one outcrop of [an] altered and brecciated mafic unit of unknown origin at the north end. Both mafic units and the felsic tuff adjacent to them at the south end of the trench contain strong pervasive ankeritization. Strong*

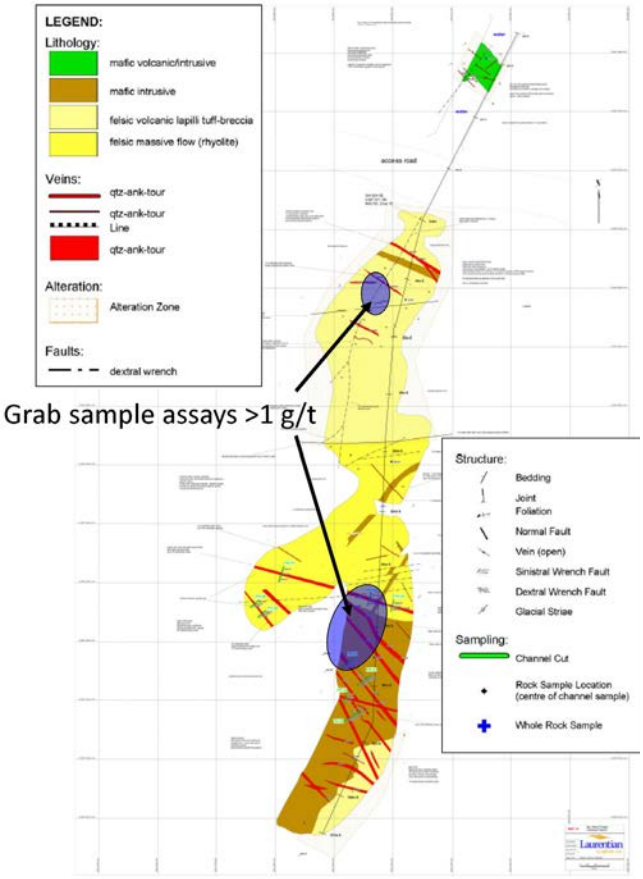


Figure 12. Pritchard trench geology map showing areas where anomalous gold assays have been obtained (modified from Lengyel and Rennie 2009)

pervasive silica is ubiquitous in the trench. Sericitization is moderate to strong in the felsic units, and is also strong in the altered northern mafic outcrop.

Structures observed in the trench were limited to faulting and strong fracturing in the felsic units. A north- to northeast-trending fault (D1 axial planar) in the felsic volcanics immediately south of the access road is defined by a 1-2m deep cleft in the outcrop. The fault extends across the entire unit, and associated tensional faults and quartz veins define a sinistral sense of movement. The rhyolite unit is more strongly faulted, with a 0.5m east-trending (D2) wide fault zone at its northern end and a 5m wide east-trending D2 fault zone at its southern end. A minor northwest-trending normal fault was also observed at the southern end of the rhyolite.

Despite the strongly-fractured, brittle nature of the felsic units, the bulk of the veining observed in the trench exists within the mafic units. The brecciated and strongly altered northern mafic outcrop contains four zones of <1cm wide tensional quartz-ankerite±tourmaline veins over 4m. The larger mafic intrusive unit at the south end of the trench is cut by numerous east-trending (D2) and northwest-trending (tensional), 2-26cm wide quartz-ankerite-tourmaline veins. The east-trending veins typically cut and offset the northwest-trending veins. Veining within the rhyolite is mainly associated with a zone of faulting at its south end, although the east-trending quartz-ankerite-tourmaline-muscovite vein is observed cross-cutting the faulting and local mafic dykes.

Significant assays (>1g/t Au) from the Pritchard trench include grab samples of 7.12g/t Au, 3.58g/t Au, 2.46g/t Au, 2.18g/t Au, and 1.55g/t Au. Significant channel samples include 2.21g/t Au over 0.6 m and 1.52g/t Au over 0.6m.

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Field Trip 4 - Thunder Lake (Goliath) Project

Treasury Metals Incorporated Staff

Wabigoon, Ontario

Please Note: All information presented within this document was taken from the website of Treasury Metals Incorporated and all data is within the public domain. The project site is not open to the public and special permission must be obtained from Treasury Metals before access of any kind is granted.

Project Highlights/Introduction

Treasury Metals Incorporated is a Canadian gold exploration and development company focused on its 100% owned high-grade Goliath Gold Project (Thunder Lake), which currently consists of an Indicated and Inferred resource of 1.7 Moz. The Project, which is near Dryden, Ontario and is slated for near-term Canadian gold production.

Treasury Metals is advancing through the Canadian permitting process to begin production at its open-pit gold mine and 2,500tpd processing facility in the near future. Subsequent underground operations will be developed in the latter years of mine life and will be funded from the project's initial cash flow.

- 100%-owned high-grade, demonstrating an indicated and inferred resource of 1.7 Moz;
- Results of 2013 drilling program have defined high-grade near-surface intersections, indicating significant upside potential for both resource and project economics;
- Low initial start-up CAPEX of C$92M with cash-flows from initial 3 years of open-pit production funding underground development;
- In August 2012, Treasury Metals completed an updated preliminary economic assessment (PEA) on the project. Key highlights include:
- After-tax NPV 5% of $144M and 32.4% IRR
- Producing 80,000 -- 100,000 oz annually over 10+ years of mine life
- Payback Period of 2.8 years
- Low initial start-up CAPEX of $92M
- LOM average feed grade of 2.87 g/t Au and 9.30 g/t Ag

The PEA is preliminary in nature and includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the preliminary economic assessment will be realized. Mineral resources that are not mineral reserves do not have demonstrated economic viability.

Location

Treasury Metals Inc.'s 50-km2 Goliath Property land package (Fig. 1) lies adjacent to the Trans-Canada Highway 17 and is located midway between Thunder Bay and Winnipeg. The closest city is Dryden, Ontario located 15km to the west. The community of Wabigoon is located six kilometres to the east.

Treasury Metals Inc.'s Goliath Gold Project offices are located in former Ontario government industrial offices, workshops, and storage facilities within the community of Wabigoon, Ontario.

Beneficial features of the Project location are:

- Year-round fieldwork can be completed in comfortable working conditions
- Excellent year-round road access
- On-site power supply
- Trans-Canada Natural Gas Pipeline
- Neighbouring major industrial services in Dryden
- Nearby workforce in surrounding communities

Project Geology and Mineralization

The project demonstrates numerous highly prospective targets that show potential to host gold mineralization including about six kilometres of prospective strike along trend from the Goliath deposit.

The Goliath Project is within the Wabigoon Sub-province of the Archean Superior Province, north of the Wabigoon Fault (Fig. 2). An amphibolite metamorphic grade volcanogenic-sedimentary complex topped by an upper layer of greenschist characterizes much of the project area. The assemblage itself comprises quartz-porphyritic felsic to intermediate metavolcanic rocks represented by biotite gneiss, mica schist, quartz-porphyritic mica schist, a variety of metasedimentary rocks, and minor amphibolites. Compositional layering

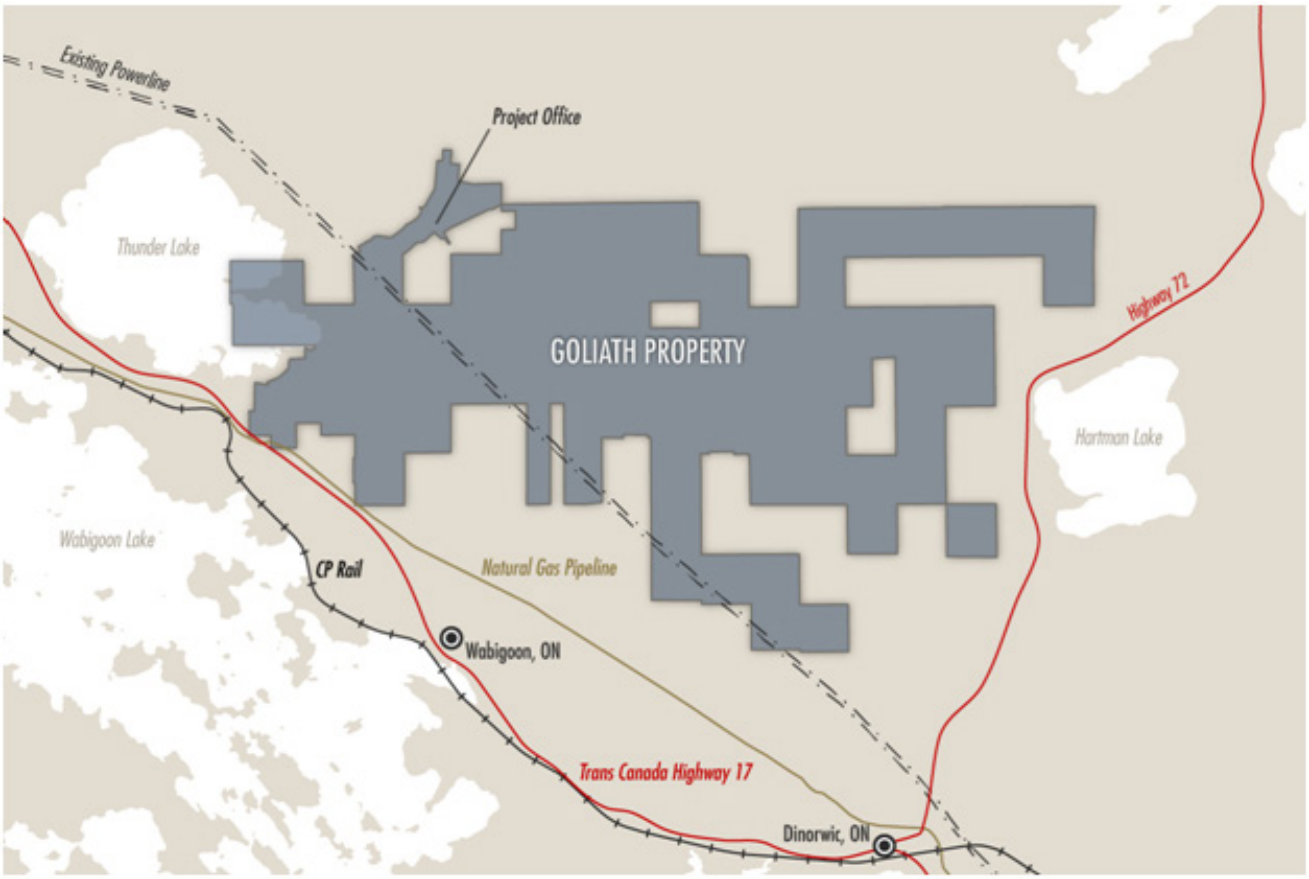


Figure 1: Location of the Goliath Gold Project area.

in metasedimentary rocks strikes ~70 to 90° and dips from 70 to 80· south-southeast. The Thunder River Mafic Metavolcanics underlie the southern part of the property. All rocks have been subjected to folding and moderate to intense shearing with local hydrothermal alteration, quartz veining and sulphide mineralization.

The main zones of mineralization within the Goliath Deposit consist of the Main Zone, Footwall Zone (B, C, and D subzones), and Hangingwall Zone (H and H1 subzones). Mineralized zones strike approximately east-west and dip 70° to 80° to the south-southeast.

Goliath Mineralization

The mineralized zones are tabular composite units characterized by anomalous to strongly elevated gold concentrations, increased lead and zinc sulphide content, and distinctive altered rock units. Stratigraphically, gold mineralization is contained in an approximately 100 to 150m wide central zone composed of intensely altered felsic metavolcanic rocks (quartz-sericite and biotite-muscovite schist) with minor metasedimentary rocks. Overlying hanging wall rocks consist of altered felsic metavolcanic rocks (sericite schist, biotite-muscovite schist, and metasedimentary rocks), with the footwall comprising metasedimentary rocks with minor porphyries, felsic gneiss, and schist. Gold within the central unit is concentrated in a pyritic alteration zone, consisting of quartz-sericite schist (MSS), quartz-eye gneiss, and quartz-feldspar gneiss.

High-grade gold mineralization (>3g/t) is concentrated in several steeply dipping, west-plunging shoots with strike lengths (>50m) and significant down-plunge continuity. The high-grade shoots are interpreted to be the result of the intersection between tight F1 isoclinal folding of the mineralized horizon and regional F2 folding with gold often concentrated in fold noses. These high-grade “shoots”, which appear to occur in regular intervals, are separated by lower grade Au/Ag mineralized rocks.

Exploration Focus

Treasury Metals has completed more than 100,000m of diamond drilling since 2008 (in addition to historic drilling by Teck Resources). The Company’s current exploration and drilling program has focused on targets located in the northeast and east of the Goliath

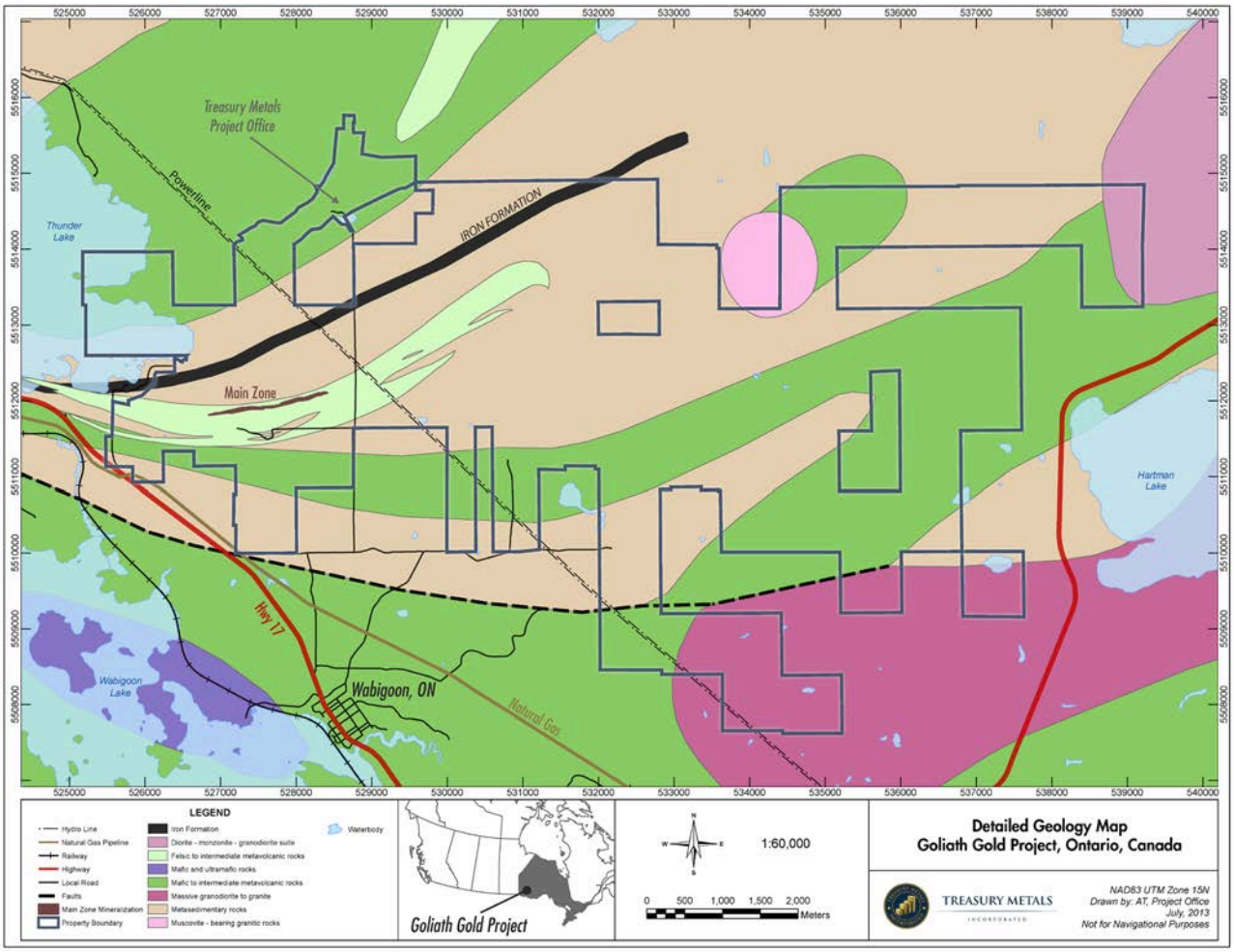


Figure 2: Geology Map of the Goliath Gold Project.

Gold Deposit within the >49 km^2 property block. Significant gold values intercepted in previous drilling campaigns, as well as re-interpreted airborne EM and aeromagnetic geophysical surveys, are being used to guide the current drilling program.

Diamond drilling exploration was completed during 2012 and 2013 to test additional targets projected over 11 km of potential ore zone strike extension. Recent exploration focus has been principally to the northeast and east of the Goliath Gold deposit, in the Project's land package. Significant gold values intercepted in previous drilling campaigns, as well as re-interpreted airborne EM and magnetometer geophysical surveys were used to guide the drilling program.

The program focused on pursuing strike extensions of previously identified mineralization as well as following potential new ore shoots down dip within the currently defined resource area. Most recently the program concentrated on delineating the C Zone mineralization, now largely in the Inferred category, both within and to the east of the proposed open pit boundary. The C Zone in-fill program focused primarily on defining near surface resources, converting inferred ounces to indicated ounces, and defining a recently discovered high-grade C zone ore shoot. A previously sparsely drilled area was delineated measuring approximately 1.2km in strike-length and infill drilling of select targets was also completed. The C Zone has the potential to represent an increase in the current open pit mineable resource and a reduction of the overall waste to ore stripping ratios.

With the completion of the first phase of the C Zone in-fill drilling program, the company completed a gap analysis in 2014 to determine the location of holes required to upgrade all ounces within the current open pit design from inferred to the indicated category including both the Main and C Zones. The scope and size of the in-fill and expansion drill program was determined from the gap analysis.

Refer to Figure 3 below for the location of the

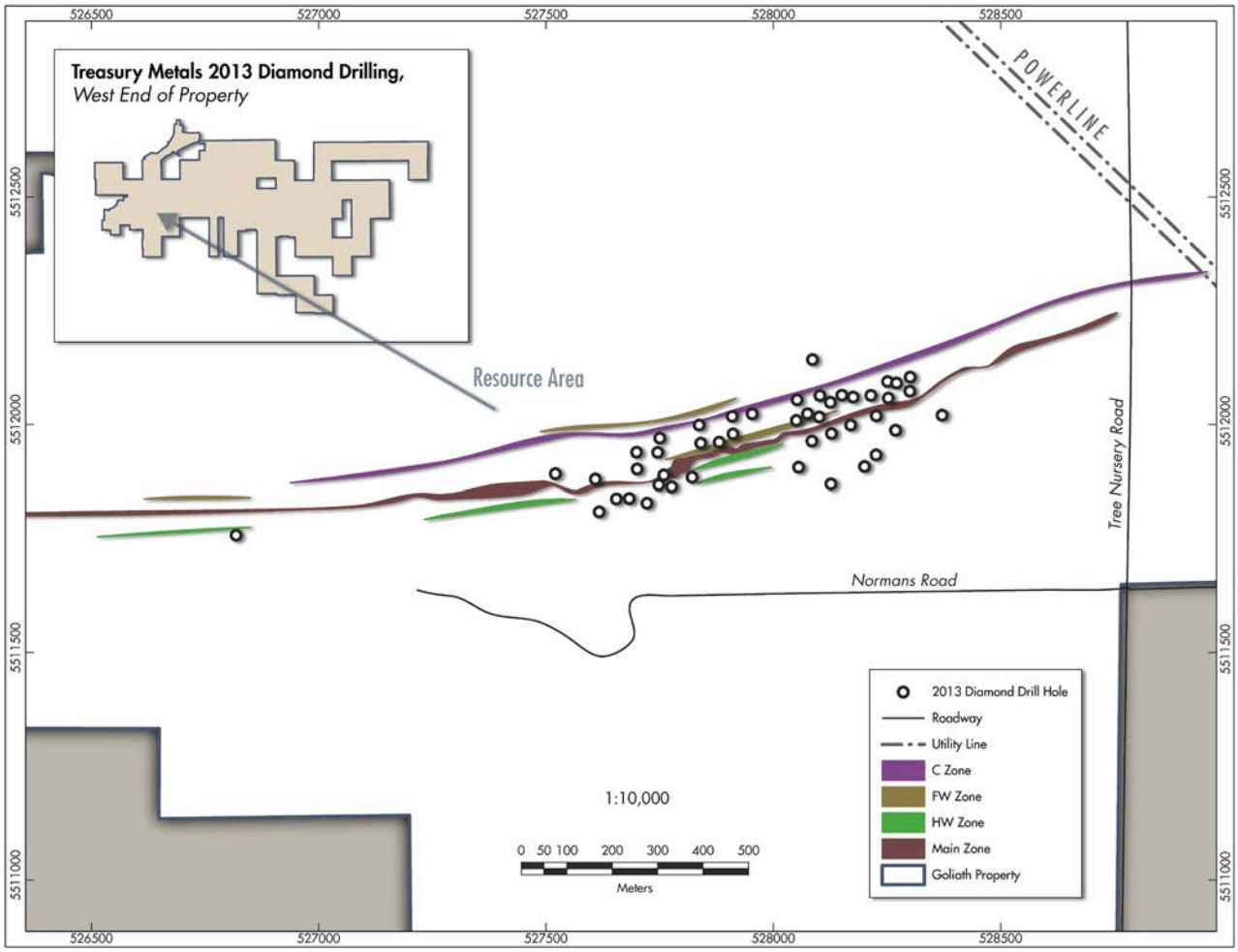


Figure 3: Goliath Deposit mineralized zones and 2103 diamond drill collars.

various Goliath mineralized zones and the locations of drill holes completed in 2013.

Resource Estimate

The detail of the most recent resource estimate (August 2012) for the Project is presented in Table 1, below. At present the deposit consists of an NI-43-101-compliant indicated open pit (OP) and underground (UG) resource of 9.14 million tonnes (Mt) grading 2.6 grams per tonne (g/t) Au and 10.4g/t Ag for 760,000 contained gold ounces and 3,070,000 contained silver ounces. Also included within the estimate is an inferred open pit and underground resource of 15.9Mt grading 1.7g/t Au and 3.9g/t Ag for 870,000 contained gold ounces and 1,990,000 contained silver ounces (AuEq refers to Au equivalent grade; i.e. the value of all payable metals calculated as Au grade).

Project History

The Goliath Gold Project is an amalgamation of two historic properties: the Thunder Lake Property purchased from Teck Resources Limited and Corona Gold Corporation, and the Laramide Property, transferred to Treasury from Laramide Resources Ltd. upon the Company's spin-out in 2008.

Treasury Metals has since brought the Project to a level sufficient to begin the company's Feasibility Study. Successfully completed Goliath Gold Project programs include:

- More than 160,000 metres of diamond drilling.
- Two NI43-101 compliant Resource Estimates since 2008.
- Full Environmental Baseline Study Program completed.
- Robust PEA released in August 2012.

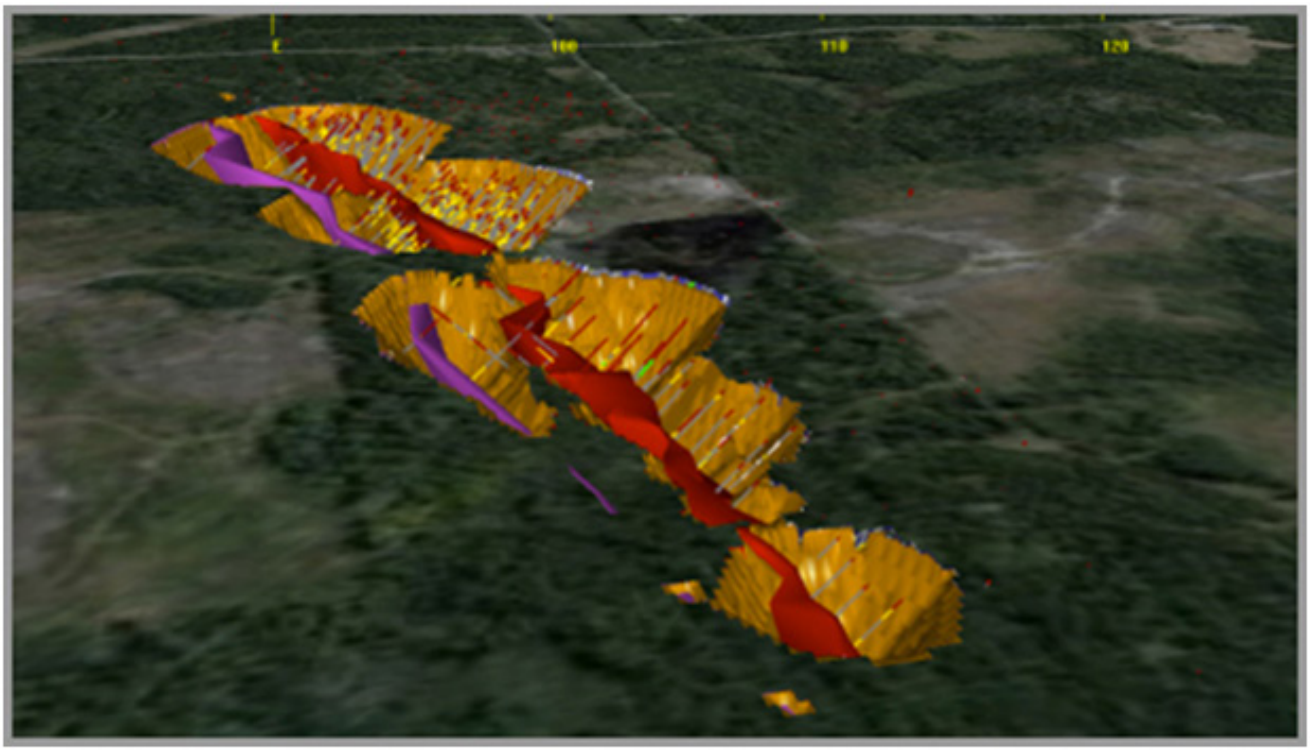


Figure 4: Aerial view of the conceptualized open pit and the main mineralized zones.

- • Feasibility level Metallurgical testing.

The majority of the pre-2008 exploration work was completed by Teck Resources beginning in 1990 with Teck's first discovery hole and continuing through to a 250m underground drift and 2,375 tonne bulk sample taken in 1998 when the project was put on hold before being acquired by Laramide in 2007.

There is only limited documentation of the prospecting and early exploration activity conducted on the Project properties prior to 1989. Material exploration activity on the property completed by Teck, which ultimately defined the Thunder Lake mineralization now known as the Goliath deposit, began in 1989 after reconnaissance work. The discovery hole on the Main Zone of the Goliath Deposit was drilled in 1990 and intersected multiple horizons of gold mineralization. In 1994, Teck and Corona entered into an option agreement for the development of their property, pursuant to which they formed a Joint Venture partnership in 1996 and drilled together until 1998 at which time Teck collected the bulk sample.

Table 1: Treasury Metals 2012 Resource Estimation for the Goliath Gold Deposit.

Resource Category	Cut-off Grade (g/t Au)	Tonnes	Average Grade (g/t Au)	Contained Au (oz)	Average Ag Grade (g/t)	Contained Ag (oz)	Ag AuEq oz	Total AuEq oz (Au+Ag)
Indicated Resource Estimate								
Surface	0.3	6,002,000	1.8	326,000	7.1	1,257,000	22,000	348,000
Underground	1.5	3,136,000	4.3	433,000	18.0	1,812,000	32,000	465,000
	Total	**9,140,000**	**2.6**	**760,000**	**10.4**	**3,070,000**	**54,000**	**810,000**
Inferred Resource Estimate								
Surface	**0.3**	11,093,000	1.0	352,000	3.3	1,184,000	21,000	374,000
Underground	**1.5**	4,789,000	3.3	514,000	5.2	807,000	14,000	528,000
	Total	**15,900,000**	**1.7**	**870,000**	**3.9**	**1,990,000**	**35,000**	**900,000**

By 1999, Teck and Corona's exploration led to the outlining of the Goliath deposit and the reporting of a historic (non-NI43-101-compliant) inferred mineral resource estimate of 2.974 million tonnes at 6.47g/t Au, using a 3.0g/t Au cut-off and a minimum thickness of 3.0 metres.

Strategic land continued to be held by Laramide, an exploration and development company involved in advancing U.S. and Australian uranium projects to development and permitting. The Laramide Property, historically referred to as the Goliath Gold Project, was located immediately south of the western portion of the Thunder Lake Property (Teck and Corona). Laramide completed preliminary exploration in 1994 and 1996 that included 1,622m of diamond drilling in eight holes. In 2008, Treasury Metals acquired all properties surrounding the deposit. New discoveries at targets outside the Goliath Gold Project's current resource area could add significant resources to the Goliath Gold Project.

Metallurgical Studies

Treasury has completed several detailed metallurgical tests including a 2375 tonne bulk sample and a 400kg sample. The studies were completed by ALS Metallurgy (G&T Metallurgical Systems) of Kamloops to Feasibility level standards. The project consistently returns extremely high recoveries that are easily scalable with low leach times and low reagent consumptions.

- 2375 tonne sample previously completed with 97% recovery. 70% recovery from gravity alone.
- G&T Metallurgical Services obtained 95+% Au recovery, 60-70% recovery by gravity, 8-12 hours leach time, medium hardness rock.
- Gekko Systems Australia are currently testing their Python Process to confirm amenability of Goliath gold ore to treatment using VSI and continuous gravity concentration CGR. This would significantly reduce treatment and permitting requirements.

Permitting and Mine Development

The permitting process has been under way since 2012 with the acceptance of Treasury Metals Inc.'s Goliath Project Description by the Canadian Environmental Assessment Agency (CEAA). The CEAA subsequently issued its Environmental Impact Statement (EIS) guidelines to the company in February 2013. A full bankable feasibility study (BFS), including the company's latest metallurgy results, is scheduled for 2015, a major milestone in the mine permitting process. Present metallurgy by G&T Metallurgical Services demonstrates 95+% gold recovery, 60-70% of which is recoverable by gravity, with 8-12 hours leach time, and a medium hardness rock.

Engineering activities are progressing to support advancement of this full feasibility study.

Environmental Baseline Study Program

Baseline studies are completed to gain an understanding of the current natural environment of the site, support mine development decisions and management plans, and to provide support to rigorous on-going monitoring and mine closure plans. Treasury Metals is completing baseline studies to provide the necessary data to support the Goliath Gold Project. Treasury Metals began a complete program of baseline studies in 2010 in support of the Goliath Gold Project with an operational team of professionals based locally and nationally. Baseline studies have continued to present day supporting current physical, biological, and socio-economic decisions. Baseline study results will be provided and reported as part of the federal and provincial permitting regulations.

Field Trip 5 - Classic Outcrops of the Dryden area

Peter Hinz

Ring of Fire Secretariat, Ontario Ministry of Northern Development and Mines, Thunder Bay, Ontario, Canada

Foreword

This trip will examine three stops of an eight-stop field trip which was developed for the Dryden High School Geography Department by the author in 2000. The three stops (Fig. 1) represent the most photo-worthy of the eight stops and display some of the more significant depositional, structural, and metamorphic features in the Dryden Area. The field trip area lies within the Western Wabigoon Terrane formerly known as the Wabigoon Sub-province. The geological discussions related to tectonic setting, lithologies, and structure has been compiled from work completed by Beakhouse between 1999 and 2010. The field trip stop discussions include observations by the author and interpretations of host lithologies noted by Beakhouse. The photograph below of Dryden area pillowed mafic basalts is from Satterly (1943).



Introduction and Tectonic Setting (Beakhouse, 2005)

The Wabigoon-Dinorwic area is transected by the Wabigoon fault, which is a major regional structure that separates two geologically distinct domains within the Wabigoon Sub-province. Distinct mineral deposit types and styles also characterize these domains.

The Sioux Lookout domain, lying to the north of the Wabigoon fault, is characterized by a series of alternating sedimentary-dominated and volcanic-dominated panels that consistently face to the south. Many of these panels are regionally interpreted to have fault contacts; however, some of the contacts appear to be conformable depositional contacts with minimal superimposed strain. This area has a complex deformational history with an early, generally bedding-parallel fabric (D1) deformed into a series of megascopic to regional-scale, southwest-plunging, Z-asymmetric folds with the development of a second fabric (D2) parallel to the axial surface of these folds. Metamorphic grade varies regionally from upper greenschist to upper amphibolite with the lowest grade generally occurring nearest to the Wabigoon fault.

The Atikwa domain occurs to the south of the Wabigoon fault and is characterized by dominantly volcanic sequences that face away from large, coeval batholiths (e.g., Atikwa Batholith, Aulneau Batholith). Within the map area, the Wabigoon Metavolcanics are typical of these sequences with a thick basal portion consisting almost entirely of mafic metavolcanic rocks overlain by a more heterolithic portion, which, although still dominantly mafic metavolcanic, includes minor intermediate to felsic metavolcanic rocks and rare metasedimentary rocks. Mineral assemblages indicative of regional middle to upper greenschist facies predominate with narrow amphibolitic contact metamorphic aureoles adjacent to some of the plutons.

Lithologies (Beakhouse, 2000 & 2002)

Wabigoon Metavolcanic rocks

The Dinorwic area occurs within the Atikwa domain and, with the exception of several small, late intrusions, is underlain by the Wabigoon Metavolcanics.

Mafic metavolcanic rocks dominate the Wabigoon Metavolcanics in the Dinorwic area. Massive and pillowed flows are approximately subequally abundant with minor, widely distributed flow breccia and hyaloclastite. Massive flows range from fine- to medium-grained. Many of the pillowed flows and some of the massive flows are moderately vesicular. Equigranular flows are most abundant with conspicuous moderate to coarse plagioclase porphyritic flows occurring locally. Massive flows include both magnetite-poor (magnetic susceptibility ~0.5 to 1.0) and magnetite-rich (magnetic susceptibility commonly greater than 50) varieties, whereas the pillowed flows consistently have magnetic susceptibilities comparable

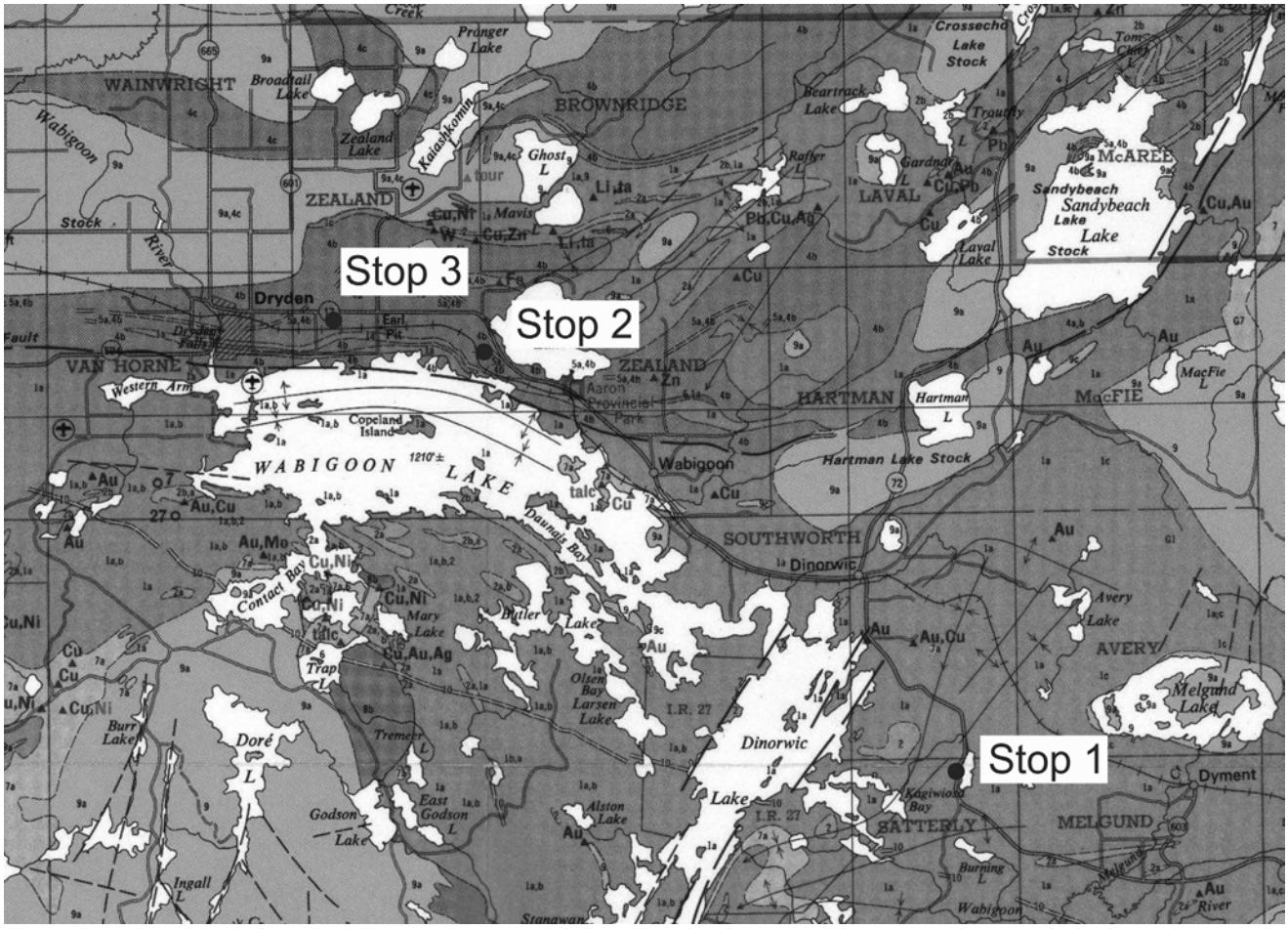


Figure 1. Field trip stop locations (from Blackburn et al., 1981).

to the magnetite-poor massive flows. The colour of both weathered and fresh surfaces is highly varied due to a range in intensity of a variety of types of alteration including carbonatization (both calcitic and ferroan carbonate), silicification, and epidotization.

Thunder Lake Sediments

The Thunder Lake Sediments include two separate panels of rock separated along a portion of their strike-length by the Thunder Lake Volcanics. Thin- to medium-bedded wacke-siltstone characterized by even, continuous bedding is the predominant component in both panels. Thin magnetite ironstone layers are a conspicuous minor component within the Thunder Lake sediments north of the Thunder Lake Volcanics but are rare within the southern panel. Minor, thin garnet-rich (<70% garnet) and calc-silicate layers may represent original more pelitic and marly layers, respectively. In one location, the calc-silicate material forms discordant veins, and suggests that some of this material is remobilized or originated by secondary alteration processes. The garnet-rich layers are often closely spatially associated with the ironstone layers.

A limited number of determinations indicate that tops, although locally reversed by tight to isoclinal minor folding, are generally to the south in both the north and south panels. Contact relations with the Brownridge Volcanics have not been observed but the data are permissive of a conformable stratigraphic relationship. The contacts with the Thunder Lake Volcanics appear to also be conformable although these are commonly moderately- to highly-strained and a loci of abundant quartz veining.

Structural Geology (Beakhouse, 2000)

The areas north and south of the Wabigoon fault have markedly different deformational styles. South of the Wabigoon fault, the dominantly volcanic sequence is a northward-younging homocline, but penetrative fabrics are sporadically and weakly developed. Primary form of pillows and other primary structures is well-preserved in horizontal sections, although there is currently little constraint on the extent of possible vertical stretching.

The area north of the Wabigoon fault is characterized by alternating volcanic- or sedimentary-dominated units that are generally southward-facing and has heterogeneous, weakly- to strongly-developed penetrative fabrics. An earlier (D1), ubiquitous, weakly- to strongly-developed fabric is parallel to bedding with the exception of one outcrop where it is interpreted to be parallel to the axial surface of rootless, tight to isoclinal folds. The D1 fabric development heterogeneity is, in part, controlled by primary lithological characteristics (e.g., fabric in mafic volcanic sequences is better developed in interflow hyaloclastite/breccia units than massive, fine- to medium-grained units). The D1 fabric, along with bedding, is deformed on a variety of scales into southwesterly plunging (D2) folds having Z-asymmetry. These regional-scale folds, as well as the contrasting characteristics to the south of the Wabigoon fault, are readily apparent on regional aeromagnetic maps. On a detailed scale, most outcrops having suitable markers or well developed D1 fabrics display Z-asymmetric minor folds that commonly have a D2 fabric (spaced cleavage to pervasive penetrative schistosity) developed parallel to the axial surface of the minor folds.

Alteration (Beakhouse, 2001)

Noteworthy abundances of garnet, that may be indicative of alteration, occur in two settings. In the Thunder Lake Sediments, extremely garnet-rich (60-80% garnet) rocks form layers that are commonly, though not exclusively, closely associated with magnetite layers and calc-silicate mineral assemblages. It is not clear if these layers are indicative of hydrothermal alteration or whether they may represent isochemical metamorphism of unusually aluminous sedimentary rocks.

Field Trip Stops

Depart Dryden from the traffic lights by McDonalds Restaurant on Trans-Canada Highway 17. Travel 39.7km east to the Snake Bay Road. Turn around and return 0.8km to the west. Park the vehicles at the MTO rest stop. Walk approximately 200m to the north to the low outcrops on the east side of the highway.

Stop 1: Pillowed mafic metavolcanic and interflow sedimentary rocks of the Wabigoon Volcanics.

UTM Coordinates: NAD83; 15U 0540211E / 5496631N

The southern portion of this outcrop contains pillowed mafic metavolcanic rocks which are part of the Boyer Lake group. U-Pb age determinations of 2719±3Ma and 2722 ±5Ma are reported for the Boyer Lake group by Davis (1990). The pillows display distinct thick selvages and provide excellent younging direction (Fig. 2). Small, well-developed vesicles are observed which suggest a high confining pressure and emplacement in deep water. Small sections of pillow breccia are also seen amongst the well developed pillows. Further north along the outcrops sections of interflow sediments may also be observed, suggesting a hiatus in eruptive activity.



Figure 2. Pillows with younging direction to the upper right.

Moving northward a 2 to 3m thick unit of interflow sedimentary rocks is observed, suggesting a hiatus in extrusive activity. The sediments display bedding as well as cross-bedding.

Overlying the interflow sedimentary rocks is a massive flow unit, the lower portion of which does not contain vesicles. Oriented vesicles appear in the upper portion of the flow unit (Fig. 3).

From the MTO rest stop turn right and travel for 23.8km to Elm Bay Road, turn left and after 75m turn left again. Continue for approximately 350m and turn



Figure 3. Oriented vesicles within the massive flow unit.

left. Drive an additional 100m and park. Walk 45m eastward along a trail to the large smooth outcrop.

Stop 2 – Isoclinal folding in Thunder Lake Sediments

UTM Coordinates: NAD83; 15U 0522545E / 5512553N

The description below (Beakhouse et al., 1995) is for an outcrop located approximately 300m to the east along-strike and on Highway 17. The outcrop we are visiting was identified subsequent to Beakhouse et al. (1995) and was exposed as part of an aggregate operation.

> *"Road-cut outcrops on either side of Highway 17 show style of folding and order of superposition of folding in this portion of Warclub group metasedimentary rocks. On the south side of the highway, on a smooth sloping glaciated surface, two phases of folding can be seen. Transposition of bedding into the plane of schistosity is seen where the limbs of first phase isoclinal folds have been sheared through, producing isolated fold noses. The form of these folds is a tight Z, in which axial planes are parallel to the local east-southeast formational strike. Differentially weathered beds in the metapelites and wackes serve to outline these folds, portions of some having been completely detached by shearing. A second phase of open folding refolds the first phase."*



Figure 4. Folding in iron formation and pelitic sedimentary rocks of the Thunder Lake sediments.

The outcrop displays distinctive z-fold asymmetrical folding as well as parasitic folds. Detailed descriptions of the structural components that are visible at this stop are provided above in the Structural Geology section.

Return to Highway 17, turn left and continue for approximately 10km, turn left into the Walmart parking lot and proceed to the low outcrop located on the west side of the building.

Stop 3 – Folding and metamorphism/alteration of Thunder Lake Sediments

UTM Coordinates: NAD83; 15U 0513496E / 5514716N

At this stop pelitic sedimentary rocks and iron formation of the Thunder Lake sediments display a similar deformation history as observed at Stop 2. Thin beds of iron formation display striking Z-asymmetrical folding as well as parasitic folds on fold noses and limbs across the outcrop (Fig. 4).

Garnet-rich beds are also observed throughout the outcrop. As noted in the discussion it is unclear whether the garnets are a result of hydrothermal alteration or isochemical metamorphism (Fig. 5).

For detailed descriptions of the structural and alteration features at this stop, refer to the Structural Geology and Alteration sections above.

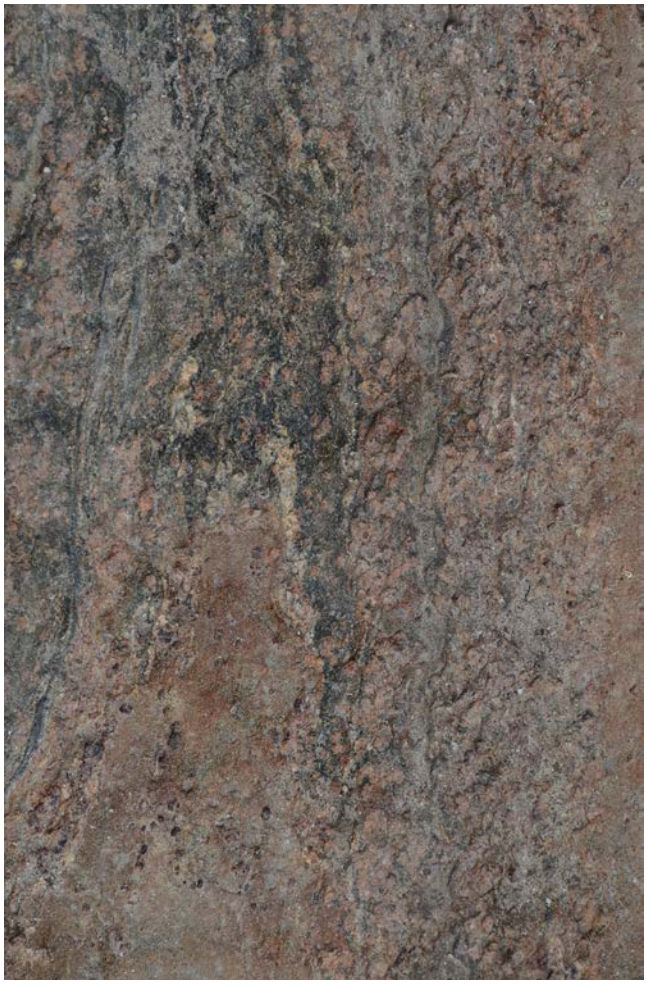


Figure 5. Abundant garnet in pelitic sediments.

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Field Trip 6 - Gold Occurrences of Van Horne Township, Van Horne Gold property - Flambeau explosures

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Location and Access

The Van Horne Gold Property and the Flambeau Exposures are located 8km southwest of Dryden. The exposures are located on private lands and can be accessed from Highway 502 (Fig. 1).

Exploration Activity

Laurentian Goldfields Ltd. initiated an exploration program in 2008 on the Van Horne Gold Property (Hogg, 2009). There are 16 historical shafts, 53 test pits, and 73 trenches located on the property. Some have underground workings and gold production has occurred at 4 of these excavations. There are approximately 24 historical gold occurrences on the property (Lengyel, 2007). A majority of this historical work is the result of the intense exploration and development activity occurring in the area between 1897 and the 1940's.

Rock Types

The Van Horne property is situated in a mixed sequence of mafic to felsic metavolcanics rocks grouped together as the Lower Wabigoon Volcanics (Fig. 2). These rocks have been intruded by synvolcanic diorite to quartz diorite intrusions. Discontinuous interflow sedimentary rocks occur throughout the property. Mafic and felsic dikes cut all of these rocks types. The mafic dikes are mainly gabbro to diorite. The felsic dikes include both feldspar porphyry and quartz-feldspar porphyry. All of these rock types have been cut by quartz veins. One of the youngest rock types on the property is the prominent west-trending diabase dike that appears to been emplaced after the formation

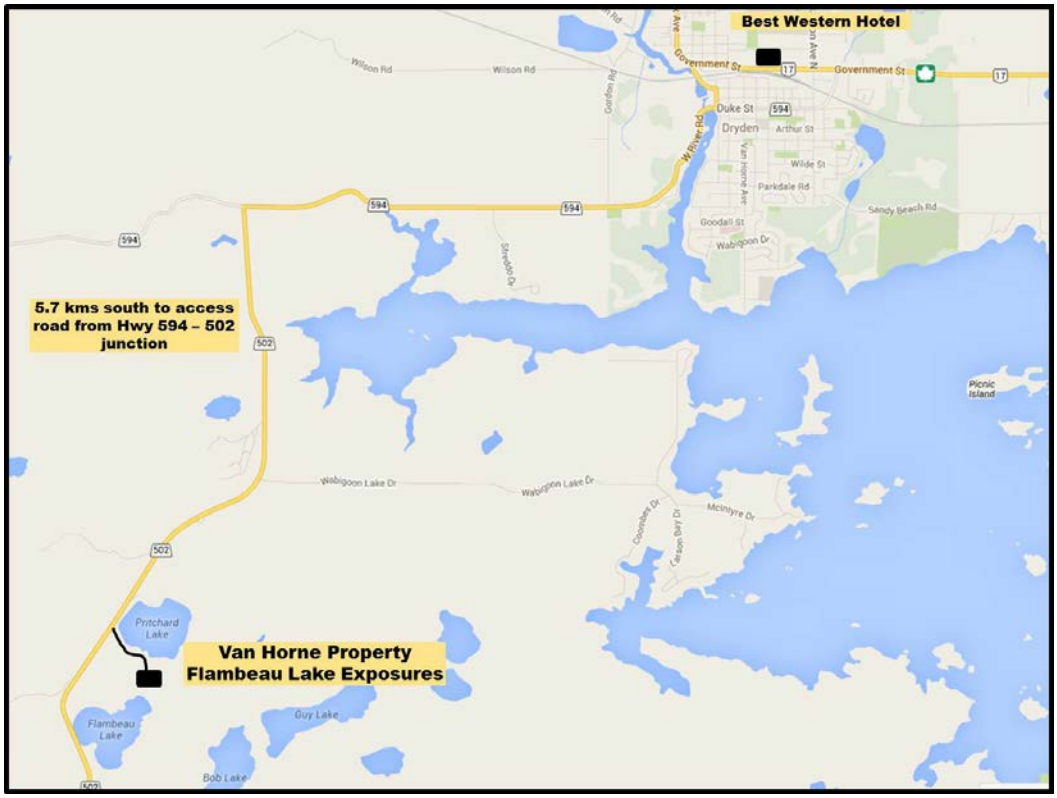


Figure 1. Location and access to Van Horne Property and the Flambeau Exposures.

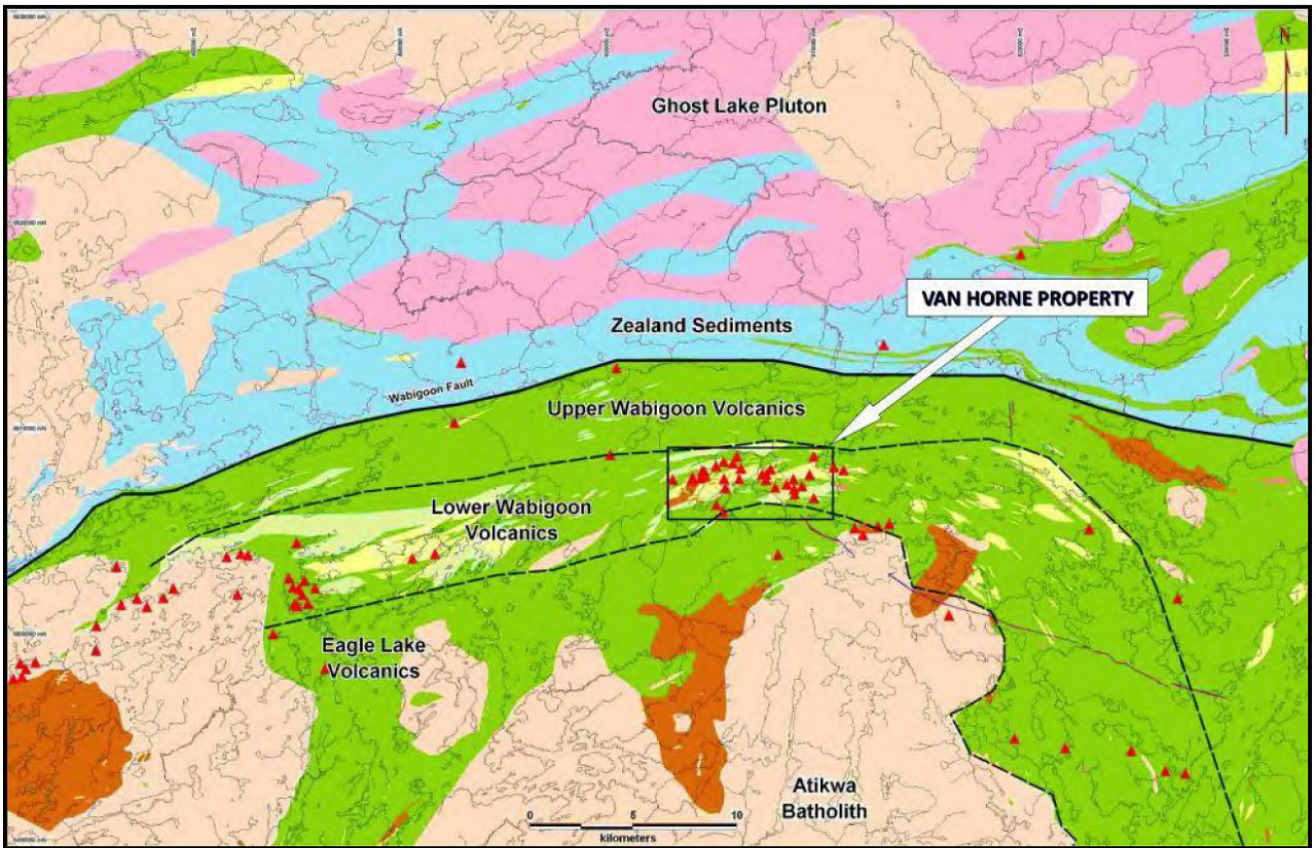


Figure 2. Regional stratigraphy and location of the Van Horne gold property (from Lengyel and Rennie, 2009).

of quartz veins (Lengyel and Rennie, 2009).

Strain

All of the rock types on the property exhibit varying amounts of strain. Shearing and veining within the trenches are consistent with structural interpretations for the property. With the exception of minor northeast-trending veins (D1 axial planar), structures and veins lie along four dominant orientations associated with D2 dextral transpression.

Orientation of structures and quartz veins:

- east-trending (Az 090), parallel to D2 regional foliation;
- west-northwest-trending (Az 280 to 290) D2 Riedel (R);
- north-northwest-trending (Az 325 to 345) D2 Riedel (R'); and
- northwest-trending (Az 300 to 310) tensional features.

Quartz Veins

A majority of the historical exploration efforts and development has targeted the gold potential of quartz veins on the property. These quartz veins are structurally controlled and hosted in a variety of rock types (Lengyel and Rennie, 2009). Based on the results from the Phase II channel sampling program completed on the Van Horne property exposures, Rennie and Chiang (2012, p.29) identified the quartz veins that hosted gold mineralization:

> *"The vein array consists of west-trending shear veins and northwest-trending tension veins as well as a lesser array of sub-horizontal ladder veinlets. Shear veins tend to show dramatic pinch-and-swell but are locally continuous over up to about tens metres. Tension veins locally form left-stepping, echelon patterns and the individual veins tend to be narrow (up to 20cm) with openly anastomosing planar forms. The shear veins and tension veins intersect without cross-cutting relation, suggesting that they are coeval and are interpreted to have formed during a single progressive strain event."*

Alteration

All rock types on the property exhibit varying amounts of hydrothermal alteration. The intensity of alteration in the exposures often increases where quartz veining is more abundant. Some parts of the exposures which lack quartz veins also display hydrothermal alteration (Lengyel, 2007). Several alteration features were identified during examination of the boundary between the differentiated phases within the mafic intrusive rock by Rennie et al. (2012, p.31):

> *"... in many instances the primary mineralogy and textures in the rock are completely replaced by alteration minerals. Multiple phases of alteration are identified in drill core; these include an early phase of sericite and chlorite replacement, overprinted by carbonate and finally pervasively silicified. The main alteration minerals are carbonate, ankerite, chlorite, magnetite, and silica with lesser amounts of albite and tourmaline."*

Disseminated euhedral magnetite occurs in a majority of the rock types on the property. There is a higher magnetite content in the rocks underlying the western part of the property. Rennie et al. (2012, p.31) have proposed that the "magnetic anomaly underlying the Flambeau zone is interpreted to be associated with hydrothermal magnetite disseminated through the diorite and quartz-diorite dykes".

Sulphides

Sulphides are found in all rock types, including the quartz veins. Samples collected during the Phase II sampling program tested the sulphide-bearing rocks adjacent to gold-bearing quartz veins identified from the Phase I program. Some of the channel-cut samples collected from this Phase II program returned anomalous gold values (Rennie and Chiang, 2012).

Exposures - Trenching

In 2009, mechanical removal of overburden and pressure washing was conducted at seven areas on the property (Fig. 3). The objective of the trenching was to provide a north-south cut across stratigraphy in areas of high outcrop density. Some of these areas are

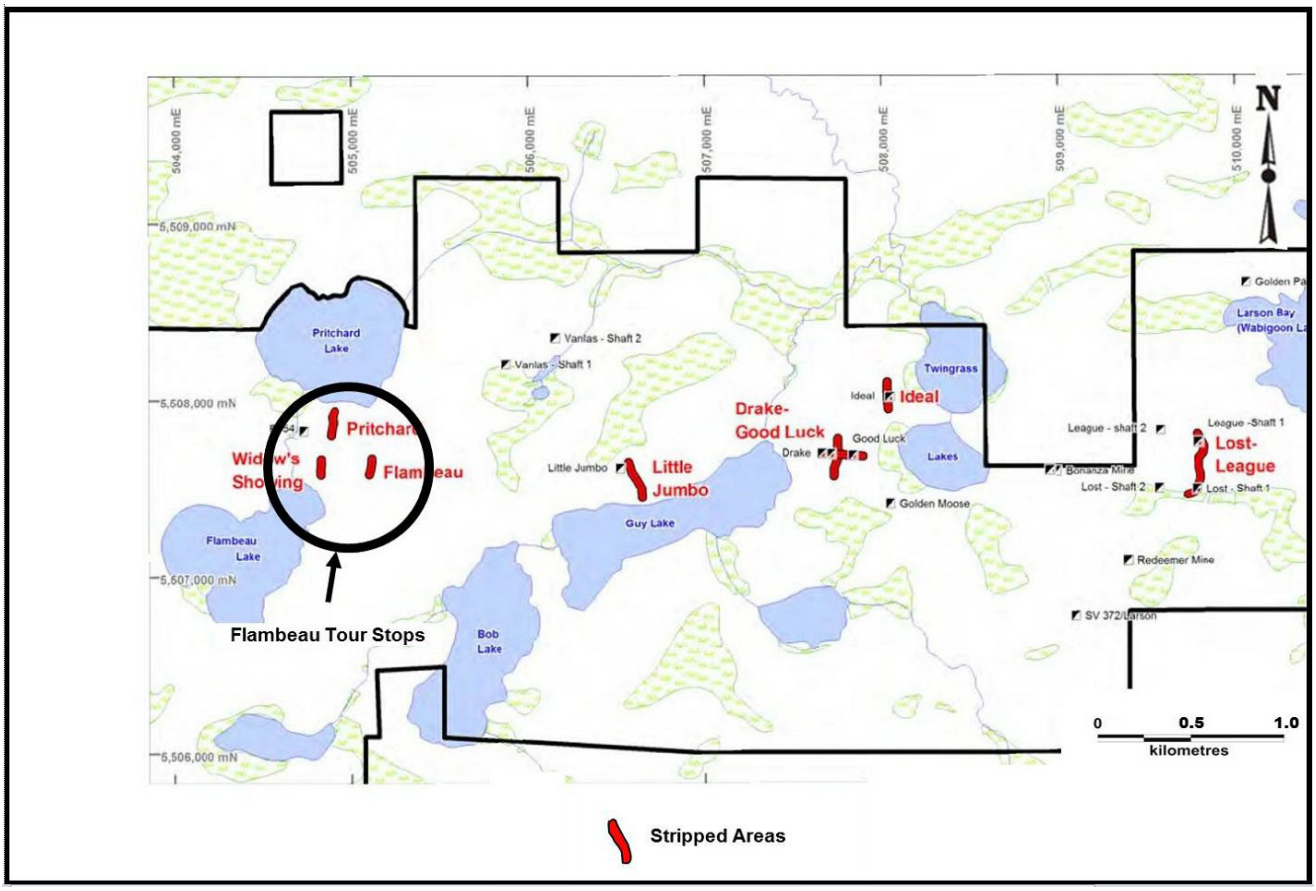


Figure 3. Location of stripped exposures and historical excavation on part of the Van Horne Gold Property (modified from Lengyel and Rennie, 2009).

adjacent to historical excavations, whereas others were testing mineral potential sites identified from Mobile Metal IonTM (MMI) survey results and responses from a helicopter-supported airborne magnetometer geophysical survey. These exposures were geologically mapped and the mineral potential of selected parts of the exposed outcrops were tested by two phases of channel cutting and sampling.

Gold Mineralization

Based on the assay results of samples collected by Laurentian Goldfields Ltd. since the initiation of activity on the property, Rennie and Chiang (2012) and Rennie et al. (2012) have proposed:

- Both shear veins and tension veins contain anomalous concentrations of gold; however, the gold concentrations are highly variable;
- Gold occurs in both barren and pyrite-bearing quartz veins;
- Altered wallrocks with secondary pyrite locally contain high concentrations (up to 8g/t) of gold, but gold values are highly localized;
- Lithological contacts and mechanically competent rock units are important host rocks for mineralization;
- The gold-mineralized zone is enriched in pathfinder elements, such as arsenic, silver, and particularly tungsten; and
- Hydrothermal magnetite is disseminated throughout the diorite and quartz diorite dikes.

Exploration efforts could identify additional quartz-carbonate vein-hosted gold mineralization. The sulphide-bearing rocks adjacent to known gold-bearing quartz veins could represent additional gold-mineralized zones. Quartz veins and hydrothermal alteration zones localized along lithological boundaries between differentiated phases within the interiors of mafic intrusions should also be examined for gold mineralization.

Field Trip Stops

The following tour stop exposures descriptions and figures are gleaned from Rennie and Chiang (2012). The locations of the exposures are shown in Figure 3. The geological legend for Figures 4 through 7 is shown

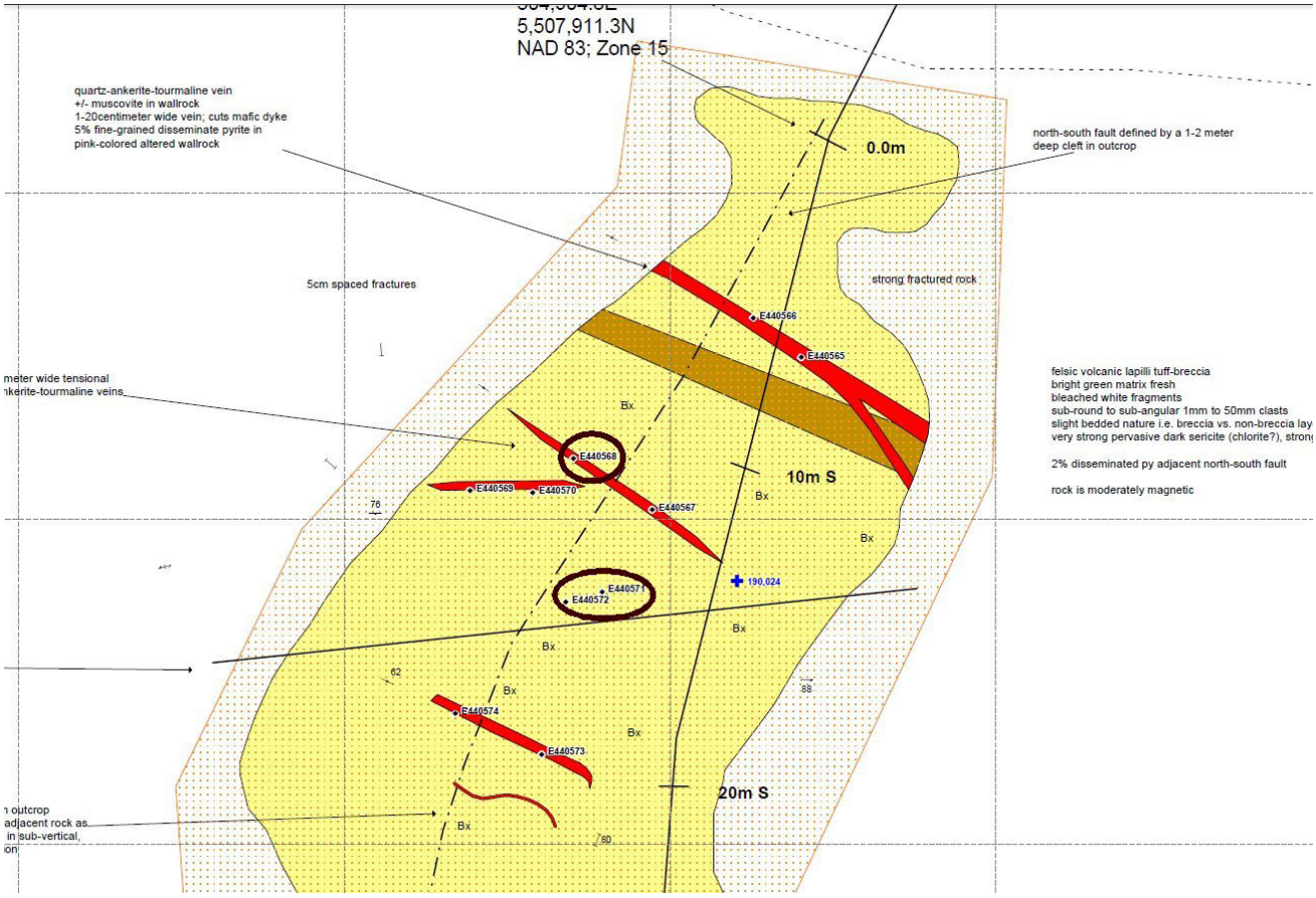


Figure 4. Pritchard exposure – North part highlighting sample sites which returned assay results >1.0g/t Au.

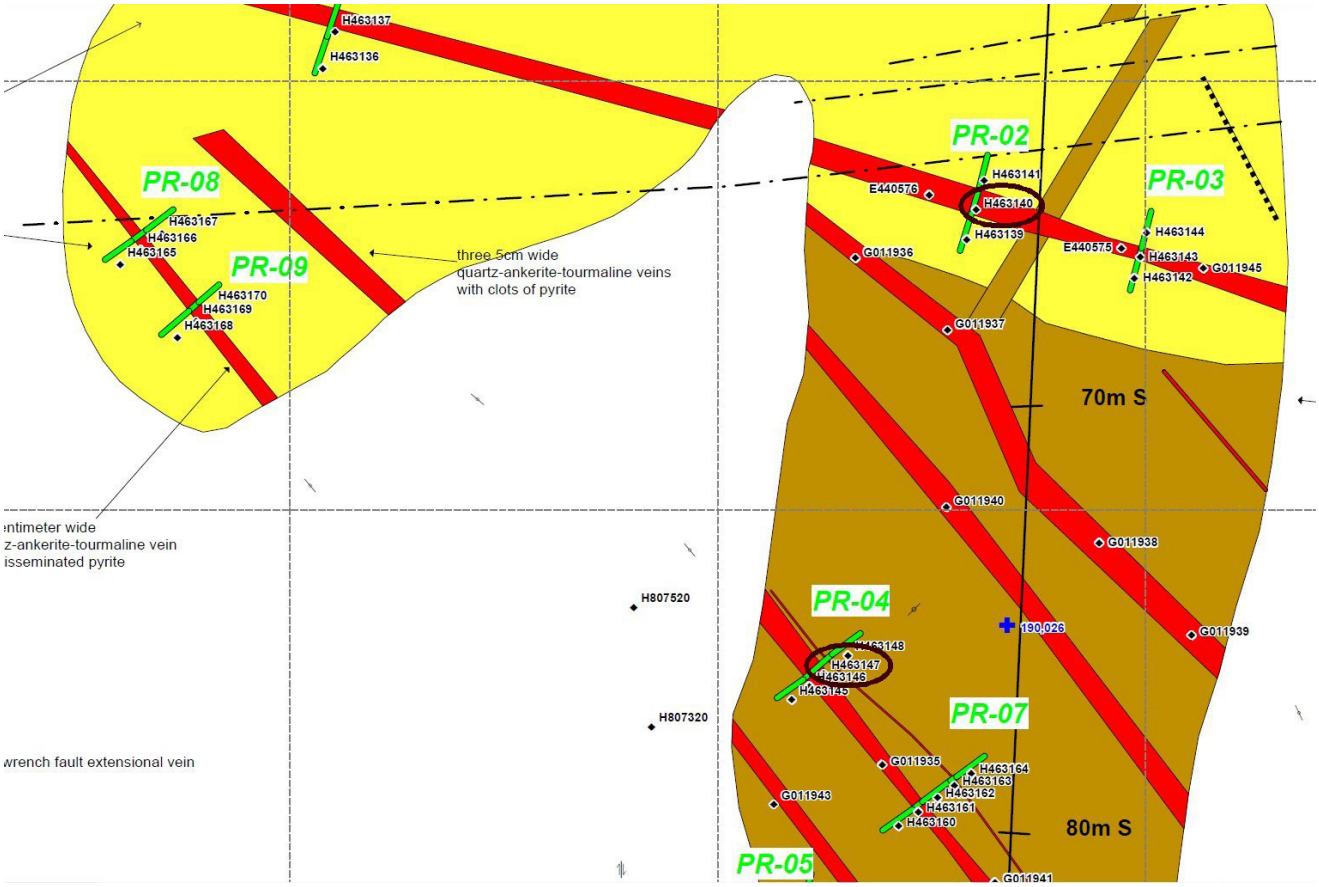


Figure 5. Pritchard exposure – Central part highlighting sample sites which returned assay results >1.0g/t Au.

in Figure 8.

Stop 1: Pritchard Exposure (Figs. 4 and 5)

UTM Coordinates: NAD 83; 15U 0504905E, 5507910N

The Pritchard trench exposure is underlain by felsic tuff and tuff-breccia, massive rhyolite, mafic intrusive rocks, and one outcrop of an altered and brecciated mafic unit of unknown origin located at the north end of the trench. Both mafic units and the felsic tuff adjacent to them at the south end of the trench contain strong pervasive ankeritization. Strong pervasive silica is ubiquitous in the trench. Sericitization is moderate to strong in the felsic units and is also strong in the altered northern mafic outcrop.

Structures observed in the trench were limited to faulting and strong fracturing in the felsic units. A north- to northeast-trending fault (01 axial planar) in the felsic volcanics immediately south of the access road is defined by a 1-2m deep cleft in the outcrop. The fault extends across the entire unit, and associated tensional faults and quartz veins define a sinistral sense of movement. The rhyolite unit is more strongly faulted, with a 0.5m wide east-trending (02) fault zone at its northern end and a 5m wide east-trending (02) fault zone at its southern end. A minor northwest-trending normal fault was also observed at the southern end of the rhyolite.

Despite the strongly-fractured, brittle nature of the felsic units, the bulk of the veining observed in the trench exists within the mafic units. The brecciated and strongly altered northern mafic outcrop contains four zones of <1cm wide tensional quartz-ankerite±tourmaline veins over 4m. The larger mafic intrusive unit at the south end of the trench is cut by

Pritchard Exposure (assay results >1.0g/t Au)

Channel Cut Samples (H 463_ _ _ sample series)
Samples mainly from quartz veins and adjacent wall rock

Cut #	Sample #	g/t Au	Rock-types
PR-02	140	1.52	quartz vein and felsic massive flow
PR-04	147	2.21	quartz vein and mafic intrusive

Grab Samples (H E44_ _ _ sample series)
Samples mainly from quartz veins and adjacent wallrock

Sample #	g/t Au	Rock-types
569	3.58	quartz vein and felsic volcanic lapilli tuff-breccia
571	2.00	felsic volcanic lapilli tuff-breccia
572	2.46	felsic volcanic lapilli tuff-breccia

numerous east-trending (02) and northwest-trending (tensional), 2-26cm wide quartz ankerite-tourmaline veins. The east-trending veins typically cut and offset the northwest-trending veins. Veining within the rhyolite is mainly associated with a zone of faulting at its south end, although the east-trending quartz-ankerite-tourmaline-muscovite vein is observed cross-cutting the faulting and local mafic dykes.

Stop 2a: Widow's Showing Exposure (Fig. 6)

UTM Coordinates: NAD83; 15U 0504870E, 5507610N

The Widow's Showing exposure is entirely underlain by massive mafic volcanic flows with 4% 0.1-0.5mm, euhedral magnetite and local strong ankerite associated with veins and fault zones. The outcrop is cut by two main structures, a main east-trending 02 fault adjacent to the east-trending D2 vein that displays dextral wrench movement with later normal dip-slip, and an associated northwest-trending dilatational fault. Sense of motion on the east-trending structures is evidenced by northwest-trending tensional shears and drag-folded

Widow Showing Exposure assay results > 1.0 g/t Au

Channel Cut Sample (H 463_ _ _ sample series)
Samples mainly from quartz veins and adjacent wall rock

Cut #	*Sample #*	g/t Au	Rock-type
WSB-01	120	1.77	mafic volcanic
WSB-02	125	2.08	quartz vein & mafic volcanic
WSB-03	128	2.50	quartz vein & mafic volcanic
WSB-04	131	1.12	quartz vein & mafic volcanic

Grab Samples (G011_ _ _ sample series)
Samples mainly from quartz veins and adjacent wall rock

Sample #	g/t Au	Rock-type
822	1.54	quartz vein and mafic volcanic
823	2.68	quartz vein and mafic volcanic
824	8.96	quartz vein and mafic volcanic
827	5.07	quartz vein and mafic volcanic
828	5.61	quartz vein and mafic volcanic
830	1.25	mafic volcanic



Figure 6. Widow's Showing exposure –Highlighting sample sites which returned assay results >1.0g/t Au.

tension veins.

The outcrop contains numerous veins, which are dominantly northwest- and north-northwest-trending, with one main east-trending vein. The northwest-trending tensional veins and north-northwest-trending R' veins dip 60° to the northeast, and are observed being dragged into the east-trending fault with dextral sense of motion. Veins are 1-30cm wide and composed of quartz, ankerite, and tourmaline with 10% pinkish-white feldspar and minor light brown feldspar.

Stop 2b: Widow's Trench Exposure (Fig. 7)

The Widow's Trench is underlain by three main lithologies, quartz diorite, quartz-K-feldspar crystal tuff, and diorite. The quartz diorite is cut by plagioclase-phyric mafic dykes. Alteration in the quartz diorite comprises strong pervasive ankeritization, and approximately 4% euhedral disseminated 1-2mm diameter pyrite and trace chalcopyrite is observed throughout. Alteration in the quartz-K-feldspar crystal tuff is dominated by strong pervasive silicification and sericitization, with local mo derate pervasive ankerite. The diorite is very weakly deformed and altered, and contains strong pervasive magnetite.

Widow Trench Exposure (assay results >1.0 g/t Au)

Channel Cut Samples (H 463_ _ _ sample series)
Samples mainly from quartz veins and adjacent wall rock

Cut #	Sample #	g/t Au	Rock-types
WS-02	088	1.54	quartz vein and mafic volcanic

Grab Samples (G011_ _ _ sample series)
Samples mainly from quartz veins & adjacent wall rock

Sample #	g/t Au	Rock-types
805	9.37	quartz vein and mafic feldspar porphyry
808	1.29	quartz vein and mafic feldspar porphyry
809	4.22	quartz vein and mafic feldspar porphyry
810	1.59	quartz vein and mafic feldspar porphyry
811	2.50	quartz vein and mafic feldspar porphyry
812	3.06	quartz vein and mafic feldspar porphyry
815	1.18	quartz vein and mafic feldspar porphyry
818	1.29	quartz vein and mafic feldspar porphyry

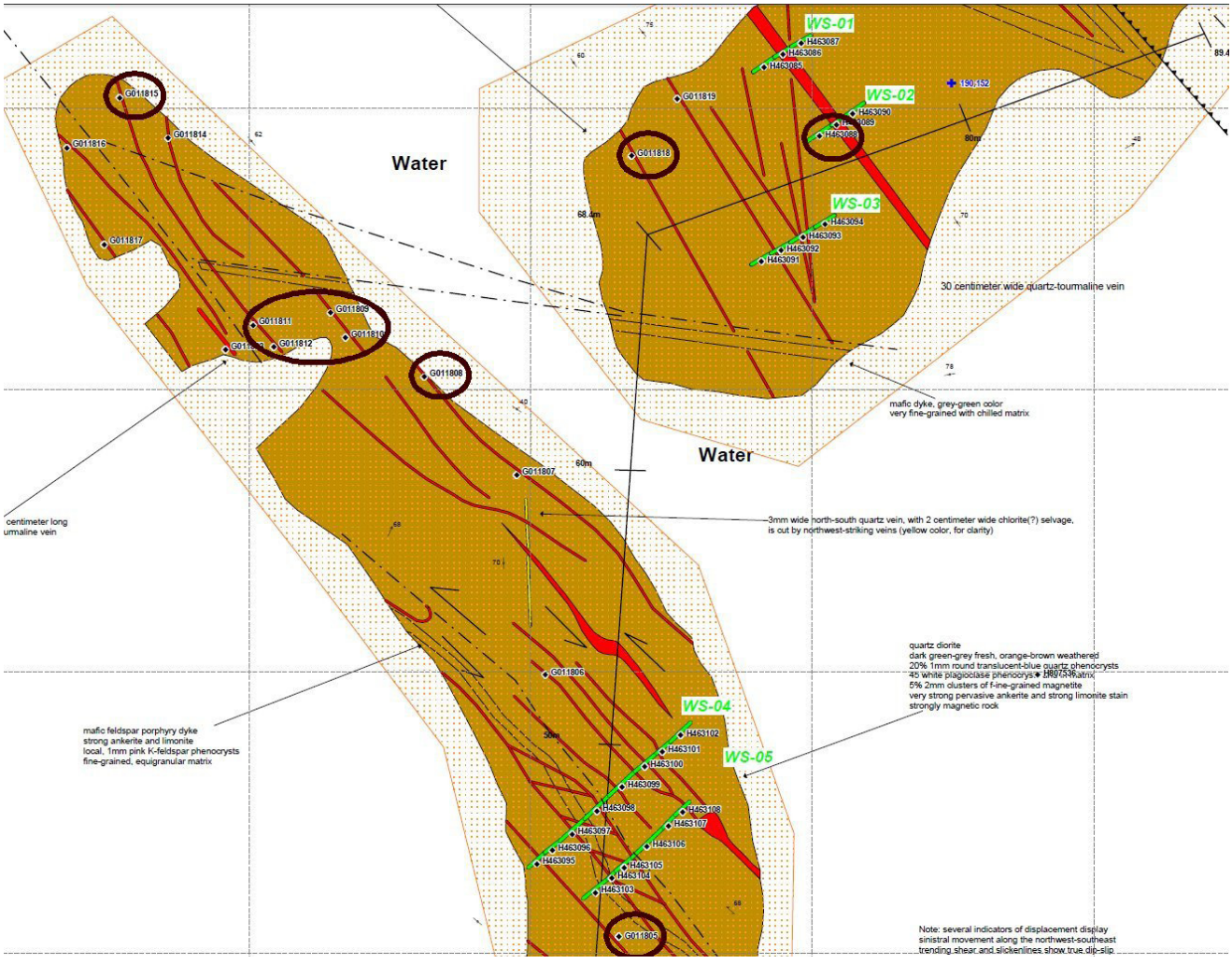


Figure 7. Widow's Trench exposure – North part highlighting sample sites which returned assay results >1.0g/t Au.

The main structural features in the Widow's Trench are northwest-trending faults and quartz veins that are restricted to the quartz diorite and quartz-K-feldspar crystal tuff. The two most dominant structures are a northwest-trending high-angle reverse fault in the northeast corner of the trench and a northwest-trending shear zone that crosses the baseline at 47m (5507635 mN). Several indicators of displacement indicate sinistral movement on the shear zone. The sense of motion and orientation of the shear zone are consistent with the interpretation that it is an R' Riedel shear related to the main east-trending dextral shear observed in the Widow's Showing.

In addition to the dominant northwest-trending quartz veins, minor north-trending quartz veins occur and are observed being cross-cut by the northwest-trending veins. Tourmaline is observed locally in the northwest-trending vein set, but is absent in the north-trending set.

The number of northwest-trending veins displayed on Map 7 is under-represented. Many 0.5-2cm quartz and quartz-feldspar veins exist within the northwest-trending exposure north of 40m and west of 68m.

Stop 3: Flambeau Exposure (Fig. 8)

UTM Coordinates: NAD83; 15U 0505100E, 5507620N

The Flambeau trench totals 95m in length; however, the bulk of the exposed bedrock exists within the southernmost 45m. The trench was continued northward to determine structural relationships between the large northeast-trending, faulted cliff face and any newly-exposed bedrock. Approximately 3ft (1m) of overburden was removed from the northern half of the trench exposing mafic flows, mafic lapilli tuffs, and a mafic dyke. The area quickly filled in with water, and was subsequently backfilled for safety reasons, therefore only the southern exposure is described in detail below.

The trench is underlain by three lithologies, with sharp east-northeast-trending contacts except where they are in northwest-trending faulted contact. The units comprise felsic quartz crystal tuff at the northern and southern ends of the exposed trench, with fine-grained mafic flows and medium-to coarse-grained mafic lapilli tuffs in the middle of the exposure. The

Flambeau Exposure (assay results >1.0g/t Au)

Channel Cut Samples (H 463_ _ _ sample series)
Samples mainly from quartz veins and adjacent wall rock

Cut #	Sample #	g/t Au	Rock-types
FL-03	181	1.20	quartz vein and mafic lapilli tuff
FL-05	187	1.92	quartz vein and mafic lapilli tuff
FL-06	192	1.72	quartz vein and felsic quartz crystal tuff
FL-08	200	1.49	quartz vein and felsic quartz crystal tuff
FL-09	205	24.80 **	quartz vein and mafic volcanic
FL-10	209	1.49	quartz vein and felsic quartz crystal tuff
FL-11	212	2.84	quartz vein and felsic quartz crystal tuff

Grab Samples (G011_ _ _ sample series)
Samples mainly from quartz veins & adjacent wall rock

Sample #	g/t Au	Rock-types
833	5.01	mafic volcanic
836	1.87	mafic lapilli tuff
837	3.85	mafic lapilli tuff
838	2.47	mafic lapilli tuff
842	1.99	quartz vein and mafic volcanic
844	2.14	quartz vein and mafic volcanic
902	1.50	quartz vein and mafic volcanic
905	2.44	quartz vein and felsic quartz crystal tuff
907	47.80 **	quartz vein and felsic quartz crystal tuff



Figure 8. Flambeau exposure – Highlighting sample sites which returned assay results >1.0g/t Au.

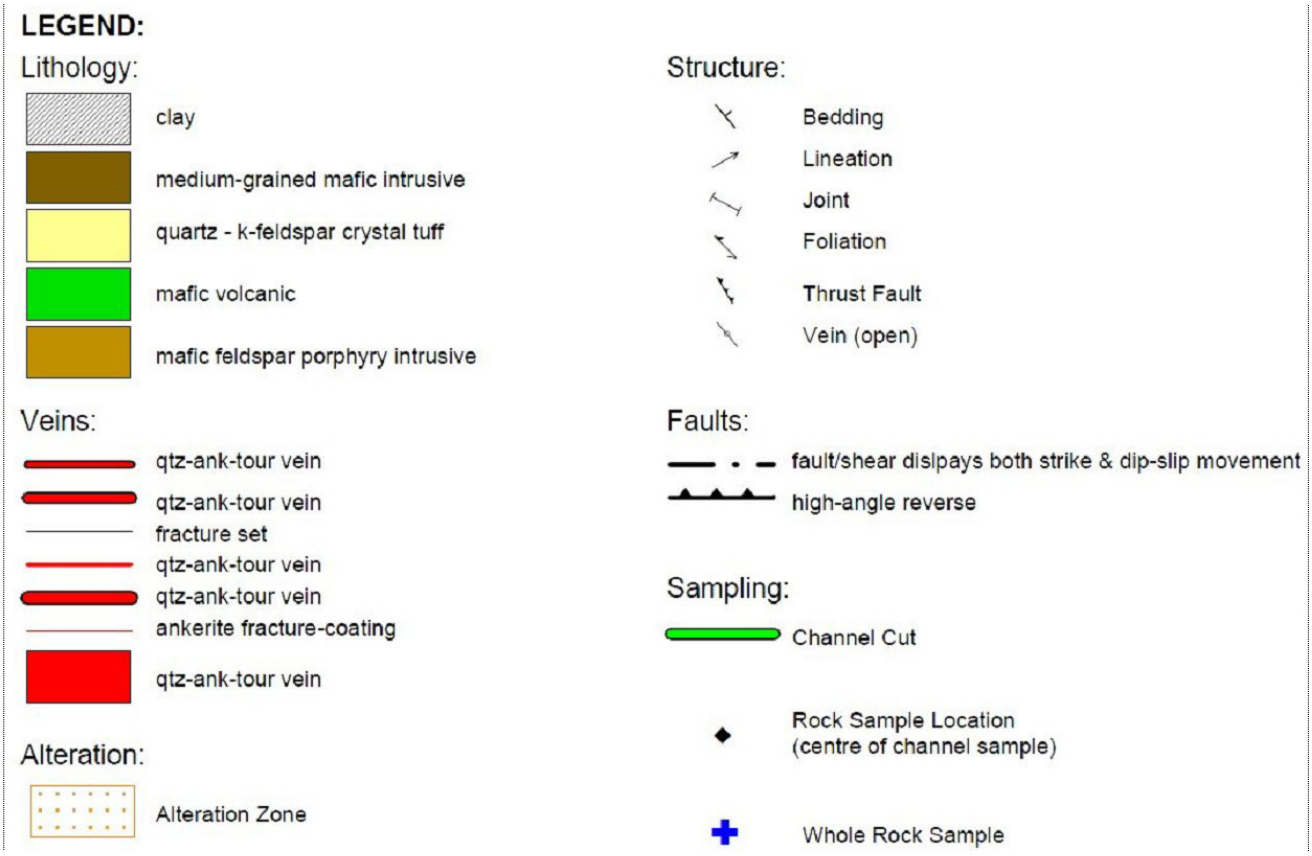


Figure 9. Legend for all Flambeau exposure figures.

fine-grained mafic dykes are observed cross-cutting the mafic lapilli tuff and the felsic quartz crystal tuff with sharp contacts.

Structurally, the Flambeau trench has two distinct features. Firstly, a northwest-trending high-angle reverse fault that crosses the baseline at 34.5m has resulted in blocky/broken ground at the topographic apex of the trench. A conjugate fracture set measured around 29m on the baseline indicates pure dip-slip movement (reverse). Secondly, an east-northeast-trending (D2) well-developed 7m wide shear zone centered at 20m on the baseline (5507604 mN) has deformed the mafic and felsic host rocks into fissile schists.

Strong chloritization and ankeritization are pervasive. The felsic tuffs are strongly sericitized and locally silicified, and the mafic units are moderately silicified toward the central fault zone. The large fine-grained mafic unit and the adjacent felsic tuff unit to the north contain 10% fine-grained, euhedral magnetite.

The Flambeau trench contains three distinct orientations of 1-10 cm wide quartz-ankerite veins:

1. West-northwest-trending, closely-spaced (10-30cm) Riedel veins in the southern half of the exposed bedrock;

2. Northwest-trending tensional veins in the northern half of the exposed bedrock; and

3. Minor northeast-trending 01 axial-planar veins within the central shear zone.

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Field Trip 7 - Unique Mineralizing Event at the Pidgeon Molybdenum Deposit Stripped Surface Exposure

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Introduction

The Pidgeon Molybdenum Deposit (Pidgeon Mo) mineralization occurs within a granodiorite body referred to as the Lateral Lake Stock (Figure 1). The known molybdenum mineralization is situated near the east-south-eastern margin of the stock and consists of molybdenite within quartz-pegmatite veins and as clots and disseminations within the rocks flanking the veins. Molybdenite is also present within unaltered and non-quartz vein parts of the stripped exposure.

MPH Ventures Corp., who completed the last phase of exploration work on the property, have proposed that a 30m wide envelope containing molybdenite occurs within the eastern portion of the Lateral Lake Stock and that envelope appears to follow the boundary between the stock and adjacent supracrustal rocks (Figure 3). Mineralization has been traced for 2km in a north-easterly direction (30°) and has a dip of approximately 45° to the southeast.

The field trip will examine the rocks, structural features, alteration, and mineralization exposed by a recently stripped exposure located above the historic Pidgeon Mo adit.

Exploration History

The exploration history for the Pidgeon Molybdenum Deposit described below was summarized from Colvine and McCarter (1977), Busch (2008), and Duke (2012).

1906: Molybdenum was discovered in a pegmatite south of Gullwing Lake by C.D. Coates.

1946: Molybdenite occurrences are reported by the Ontario Department of Mines at the east end of Lateral Lake.

1950: Initial claims are staked by G.L. Pidgeon.

1954: Claims are optioned to Detta Minerals Ltd., who drilled two sub-horizontal holes, totalling 107m. A 35m adit, located at the stripped exposure, was driven to collect a 115kg bulk sample for metallurgical testing.

1957: Pidgeon Molybdenum Mines Ltd. (PPLM) was incorporated.

1957 and 1958: Rio Tinto Canadian Exploration Ltd. optioned the property from PMML and drilled 21 holes, totalling 2348 metres. A possible, historic and non-NI43-101 compliant, resource of 568,000 tons grading 0.57% Mo was estimated.

1958: DeCoursey Brewis Minerals Ltd. completed 612m in 5 diamond drill holes along the south contact of the Lateral Lack Stock, north of Moly Lake.

1963: Denison Mines Ltd: completed 858 m in eight diamond drill holes.

1965 to 1966: Rio Algom completed a magnetometer survey and 29 diamond drill holes, totalling 3474m. The company released an internal, historic and non-NI43-101 compliant, mineral resource of 416,000 tons grading 0.57% Mo.

1977: The Lateral Lake stock was mapped by A.C. Colvine and P. McCarter of the Ontario Geological Survey and released in Miscellaneous Paper MP55.

1979 to 1980: Rio Algom completed 27 diamond holes, totalling 3710 metres. A capital and operating cost analysis was completed by Strathcona Mineral Services Ltd. who outlined an historic and non-NI43-101 compliant mineral resource of 9.0 million tonnes (Mt) grading 0.096% Mo.

1981: Rio Algom completed 3 diamond drill holes, totaling 352 metres.

2006 to 2011: MPH Ventures Corp. optioned the property in 2006. In 2007 the company completed 7 diamond drill holes, totalling 1210 m, and calculated an NI43-101 compliant revised Mineral Resources Estimate containing an inferred resource of 8.5 Mt grading 0.099% Mo. The next year (2008) MPH completed 31 diamond drill holes, totalling 2644 m, removed overburden to expose the mineralized zone above the historic adit, and completed a detailed mapping and sampling program on the stripped zone.

2012: NI43-101 Mineral Resource Estimate. During 2012 MPH Ventures completed another NI43-101 Technical Report and revised Mineral Resource

Estimate on the Mo mineralization (MPH Ventures Ltd. September 13 2012 Press Release; and Duke, 2012). The resource estimate using a cut-off grade of 0.04% Mo was calculated at:

- 2.66 million tonnes (Mt) indicated @ 0.117% Mo; and
- 12.39 Mt inferred @ 0.084% Mo.

Location and Access

The Pidgeon Molybdenum Deposit is located between the towns of Dryden and Sioux Lookout (Fig. 1). The stripped exposure to be examined is accessed by following Trans-Canada Highway 17 east of Dryden for a distance of 28km to the town of Dinorwic. Turn left (north) onto Highway 72 and drive for approximately 32km until you reach the junction with the Kathyn Logging road. Turn left onto the Kathyn Road and travel northwest for a distance of 8.8km to a trail that leads 250m west into the Field Trip Stop at the Pidgeon Mo stripped exposure.

Regional Geology

The Pidgeon Molybdenum Deposit is located within the eastern part of the Lateral Lake Stock (Figures 1 and 2). The Lateral Lake Stock is an elongate body extending approximately 12km from Gullwing Lake easterly to Lateral Lake and it is up to 2.8km in width. It consists predominantly of granodiorite with gradational contacts into a marginal quartz monzonite and larger country rock inclusions. Biotite is the principal mafic mineral and contains 1 to 2% epidote intergrowths. Foliation within the Lateral Stock varies from indistinct in the central part of stock to strongly foliated near the margins. The contact of the stock is concordant with the dip of the surrounding supracrustal rocks, varying from 45° on the southern side tod 30° on the northern side (Colvine and McCarter, 1977).

The axial plane of a regional anticline structure trends along the central part of the Lateral Lake Stock. This regional anticline also extends into the supracrustal rocks (Fig. 2). The flanks of the anticline dip 40 to 60°, while the crestal zone plunges 25 to 30° in the east, 25 to 30° in the west. The fold is probably

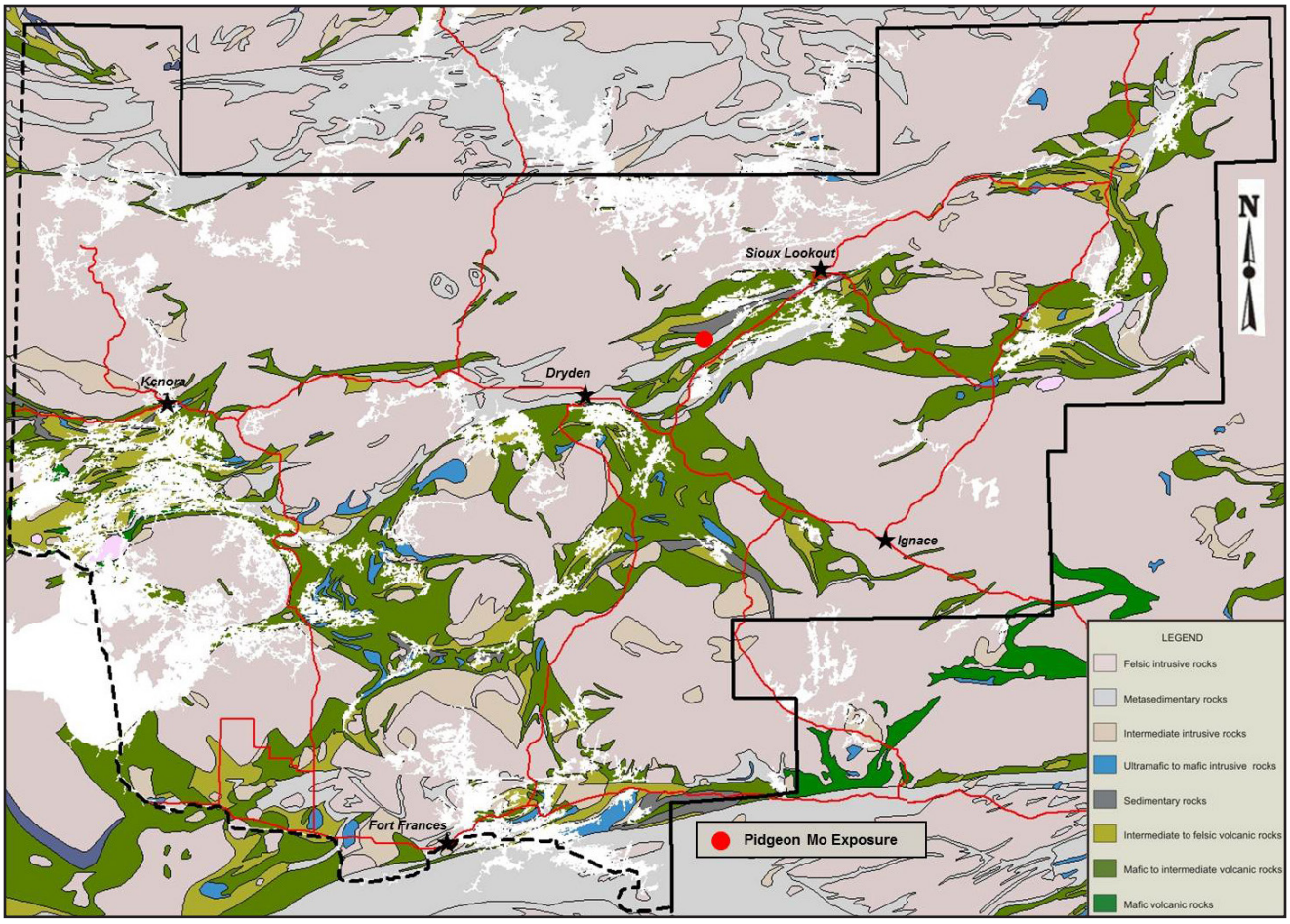


Figure 1. Kenora District geology map with location of Pidgeon Molybdenum Deposit (geology from OGS 2011).

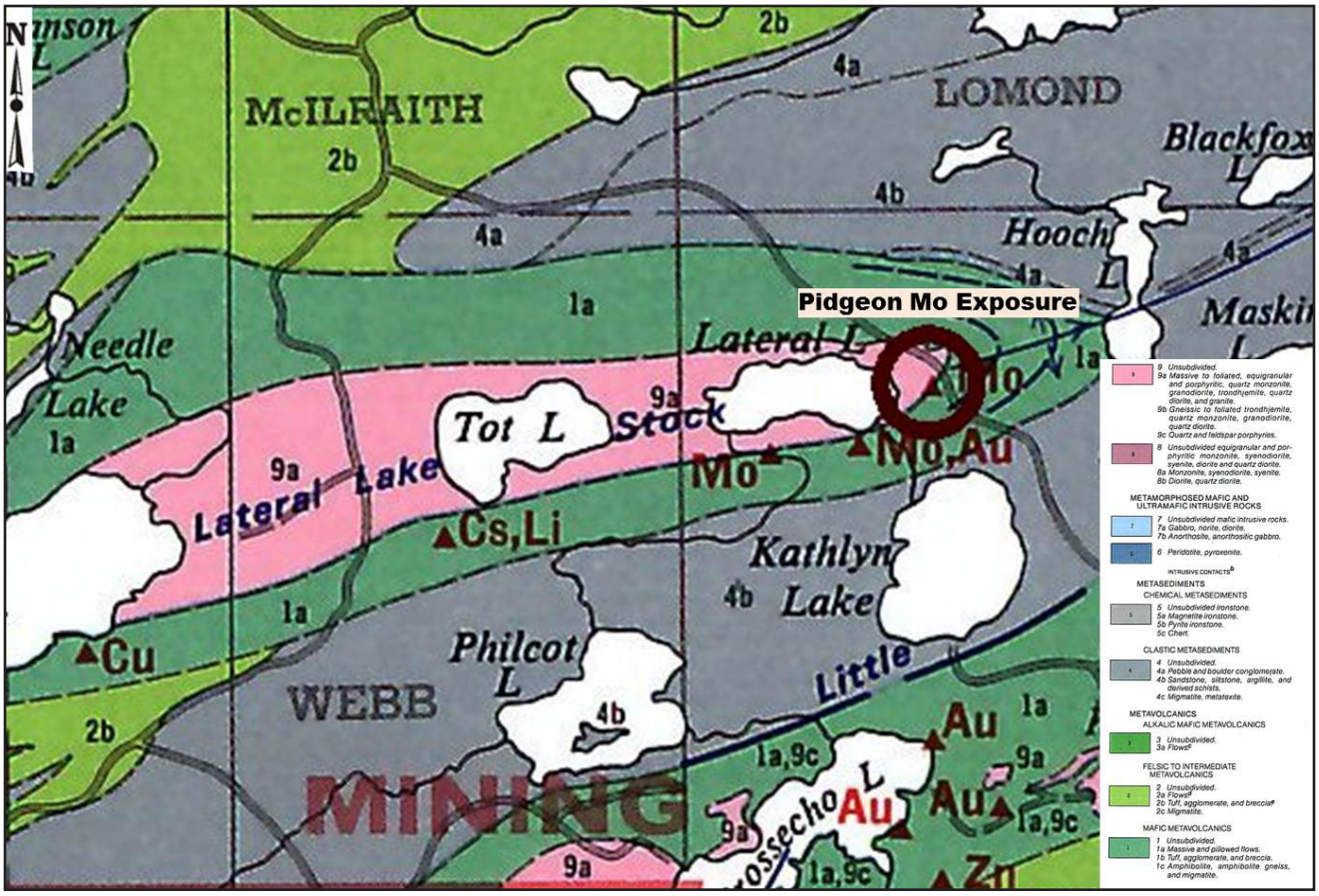


Figure 2. Regional geology and location of the Pidgeon Molybdenum Deposit and the stripped surface exposure (Blackburn, 1978).

the combined result of gentle doming associated with the emplacement of the Lateral Lake Stock (Colvine and McCarter, 1977).

The property and stripped exposure is situated at the eastern end of the Lateral Lake Stock, near the axial plane of the regional anticline (Fig. 2).

The metavolcanic rocks surrounding the stock consist of fine-grained chloritic units interbedded with medium- to coarse-grained amphibolitic units. Metaconglomerate units overlie the metavolcanic rocks both north and south of the stock; they contain well rounded trondhjemite (leucotonalite), chert, aplite, and mafic volcanic clasts in a quartz-feldspar-biotite matrix (Busch, 2008).

Field Trip Stop

UTM Coordinates: NAD 83; 15U 0545830E / 5533428N

Previous exploration has mainly focused on the mineral potential near the eastern boundary of Lateral Lake Intrusion (Fig. 3). The Pidgeon Molybdenum Deposit, exposed by stripping during the last phase of exploration activity by MPH Ventures Ltd. provides a good exposure to view rock types, structure, alteration, and mineralization associated with the occurrence.

Exposed Rock-types

The felsic intrusive rocks underlying the stripped exposure (Figs. 3 and 4) consist of coarse-grained granodiorite and quartz monzonite that are composed of quartz, albite plagioclase, orthoclase, microcline, and biotite with minor chlorite, muscovite, carbonate, sericite, sphene (titanite), epidote, and apatite (Busch, 2008).

Structural Features

All observed structural features are illustrated on Figures 4 and 5.

At the stripped exposure the contact of the Lateral Lake Stock with the supracrustal rocks is 70° and dips 45° SE (Fig. 3).

Colvine and McCarter (1977) mention that "foliation varies from indistinct in the centre of the Lateral Lake

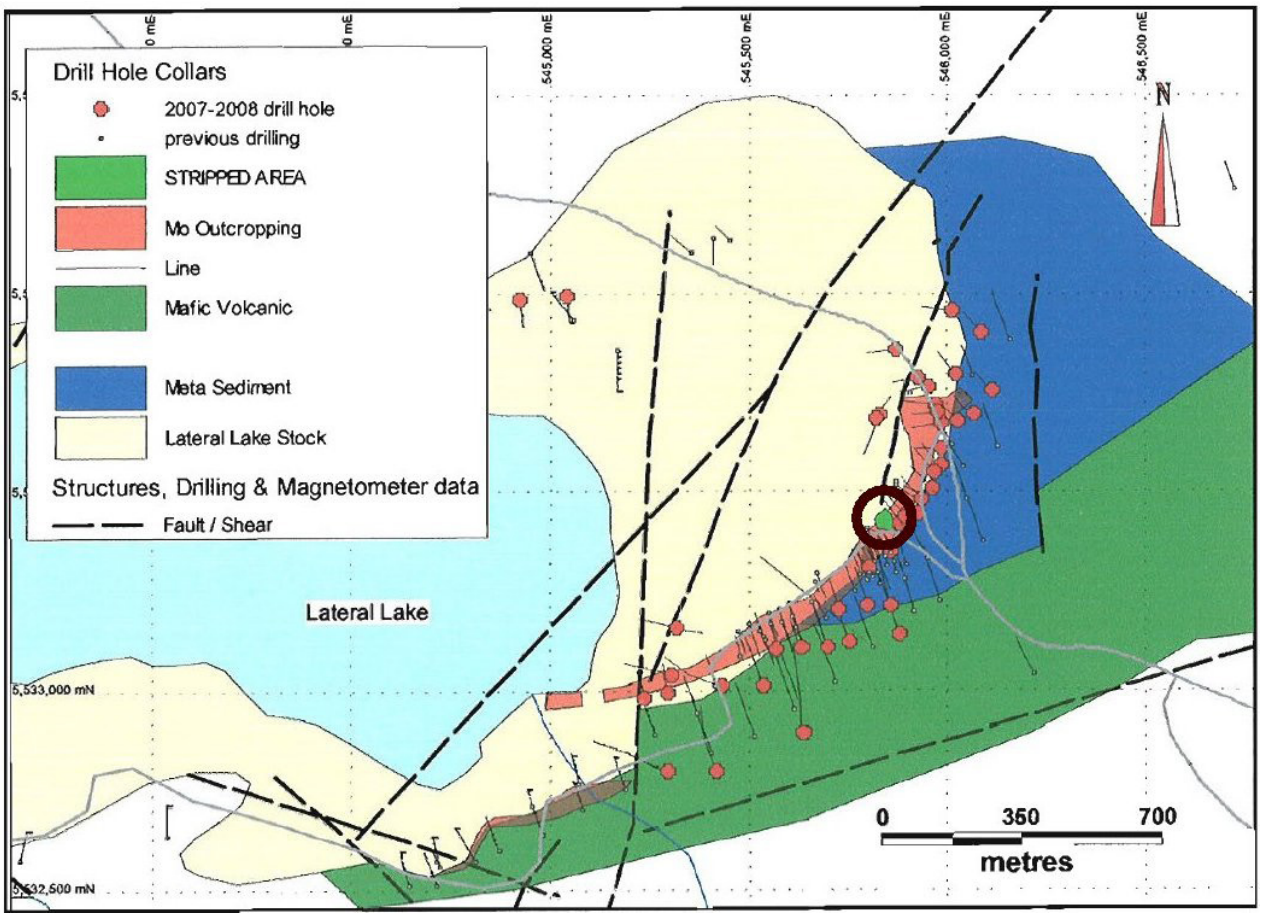


Figure 3. Rock-types and location of exposed rocks and mineralization and MPH Ventures Corp. diamond drill holes (Busch, 2008).

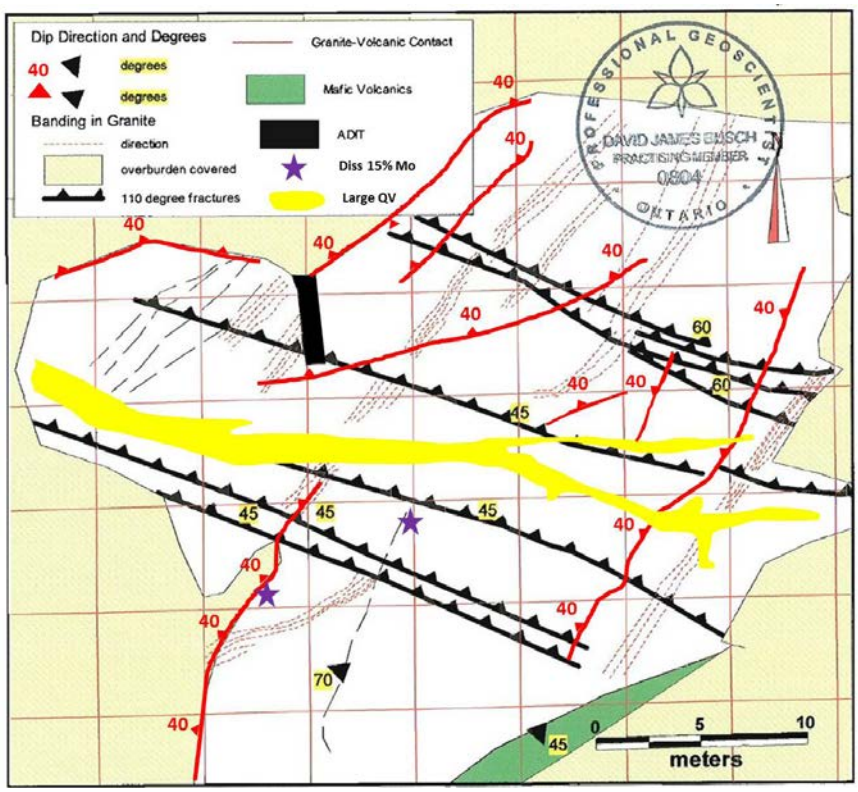


Figure 4. Structural features, compositional banding, adit, and the large quartz vein in Pidgeon Mo stripped exposure (modified from Busch, 2008).

Stock to very strong on the margins, producing a finely banded to gneissic texture through separation of biotite, quartz and feldspar bands". This compositional banding trends 42° and dips 80°E. The intrusion of several magmatic phases probably resulted in the formation of pink and grey-white banding (Busch, 2008). The pink banding is dominantly quartz and feldspar; whereas the gray bands are composed almost entirely of feldspar. The trend of this banding (42°) is not parallel to the contact of exposed supracrustal rocks (70°). The banding was overprinted by all of the other structural features present.

Prominent fractures observed within the stripped exposure have a strike of 110° and dip to the northwest. The dip of these fractures near the boundary with the supracrustal rocks is 45°NW, whereas that dip increases to 60°NW as the distance from the contact increases. The spacing between these fracture sets varies from 1 to 5 m.

A second prominent fracture set within the stripped exposure trends north-easterly between 30° and 80° and exhibits a consistent dip of 40°N irrespective of distance from the intrusion/supracrustal rock contact. There also appears to be increase in number of these 40°N-dipping fractures as distance increases from the contact and they overprint the 110°-trending fractures.

The sloping edges of the outcrop, located in the western part of exposure near the adit entrance, appear to follow 30 to 80°-trending, 40° N dipping fractures. A similar feature comprising the slope of stripped exposure situated south of adit also appears to be associated with a 40° N-dipping fracture (Fig. 4). These slopes could comprise the footwall of a fracture.

The 45-60° N-dipping and the 40° N-dipping fractures could be classified as joints and appear to have formed before the hydrothermal quartz veining event. There are also other randomly trending fractures such as a weak set of north-northeast-trending; vertically dipping fractures that overprint the quartz veins, the 45 to 60° N-, and the 40° N-dipping fracture/joint sets.

It is interesting to note that the contact of the Lateral Lake stock and the supracrustal rocks dips at 45°SE, which is opposite to the dip direction of the all fracture sets observed within the stripped exposure.

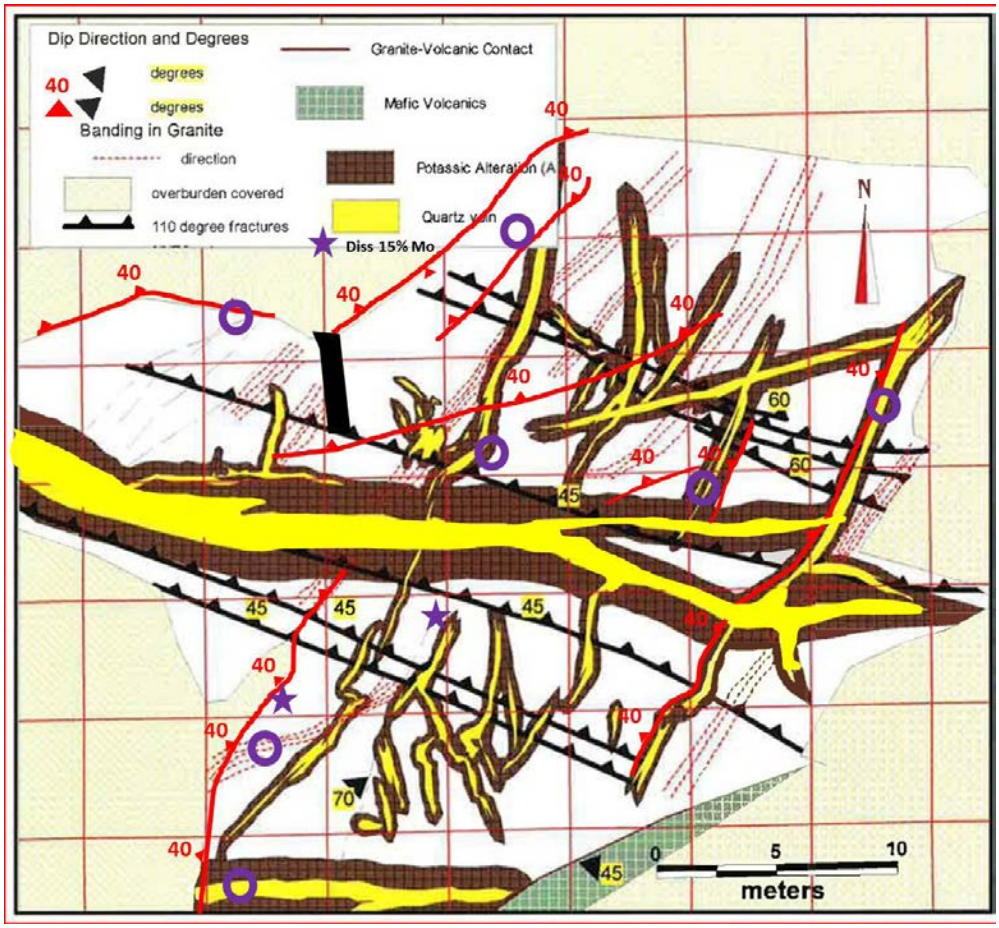


Figure 5. Fractures, quartz veining, alteration, and sample sites with high Mo values in the Pidgeon Mo stripped exposure (modified from Busch, 2008).

Quartz Veins

Quartz has filled some of the fractures present within the stripped exposure (Fig. 5). Quartz is not observed in the 110° trending fracture/joints but is often present within the northeast-trending 40°N dipping fracture/joints. Quartz is not found in the northerly trending vertical dipping fractures. Quartz is also not observed along the contact of the intrusion nor extending from the intrusive rocks into the adjacent the supracrustal rocks.

A majority of the quartz veins observed within the stripped exposure occur within the randomly trending fractures. These fractures could be related to strain associated with the regional anticlinal flexure. A large easterly-trending quartz vein, present in the central part of the stripped exposure, cuts the prominent 110°-trending fracture/joints (Figs. 4 and 5).

Alteration

Based on regional mapping and diamond drill intersections Busch (2008) proposed that "aplitic sills and potassic feldspar-bearing pegmatite are concentrated in the mineralized zone". Busch (2008) also suggested that "based on mapping of the exposure these pegmatite and aplitic sills are [a] succession of coarse-grained alkali feldspar immediately adjacent to and within the quartz vein flanked by a uniform fine-grained zone of alkali feldspar".

This alteration halo is up to 1.5m thick flanking the large easterly-trending quartz veins and is considerably narrower adjacent to other, smaller quartz veins (Figure 5). The compositional banding is commonly (but not always) destroyed in the vicinity of the alteration flanking the quartz veins.

Biotite is irregularly distributed in the felsic intrusive rocks, sometimes as large patches, and is not abundant in the quartz-pegmatite veins.

Mineralization

Colvine and McCarter (1977) presented a summary of the molybdenite mineralization they observed at the Pidgeon Mo Deposit as follows:

- Isolated grains in quartz veins and pegmatites;
- Comminuted along vein margins;
- Isolated grains and rosettes in wall rocks adjacent to pegmatite veins and quartz vein stockworks;
- Narrow bands and lenses parallel to foliation (where present) in wallrocks;
- Comminuted along fractures and slippage planes in wallrocks not parallel to foliation (where present).

Exploration activity, especially by MPH Ventures Corp, has outlined a 30m wide envelope containing molybdenite, extending for at least 1200 m, which occurs within the eastern part of the Lateral Lake Stock and appears to follow the boundary with the supracrustal rocks (Fig. 3). A majority of these exploration programs targeted the mineral potential of the Lateral Lake Stock along the boundary zone and associated quartz veins.

The following summary of mineralization is based on examination of the exposures by Busch (2008), Duke (2012), and field visits by Kenora District OGS geological staff. Figure 6 shows the location of sample sites that returned anomalous Mo values.

Molybdenite mineralization occurs in the quartz and pegmatite veins and is disseminated within the felsic intrusive rocks adjacent to veining. Molybdenite is very clotty in the quartz veins and pegmatites with a preference for the boundary between quartz and pegmatite and the boundary between the pegmatite and aplite. These clots comprise near solid molybdenite aggregates up to 3cm wide by 30cm long. Molybdenite also occurs as finer, more evenly distributed disseminations within the wallrock adjacent to the veins (Busch, 2008).

Disseminated fakes of molybdenite are found in a majority of the 30 to 80°-trending, 40°N-dipping fracture/joints (Fig. 4). Molybdenite can also be found within micro-fractures cutting the felsic intrusive rocks adjacent to the 40°N-dipping fracture/joints.

The mineralization present within the quartz veins can be disseminated, occur within fractures, or can concentrate along vein boundaries. Not all quartz veins present contain molybdenite (Fig. 5).

Portions of the stripped exposure contain concentrations of disseminated molybdenite. These zones can contain up to 15% molybdenite, with rosettes ranging up to 1cm diameter, but do not occur within or adjacent to quartz veins, pegmatites, fractures, or fracture/joints sets (Fig. 4).

Fluorite, amethyst, epidote, and tourmaline have been reported in drill logs, but were not directly related to molybdenum mineralization. Weak correlations associated with anomalous Mo mineralization are evident with B, Cd, S, SE, Th, and U values (Busch, 2008).

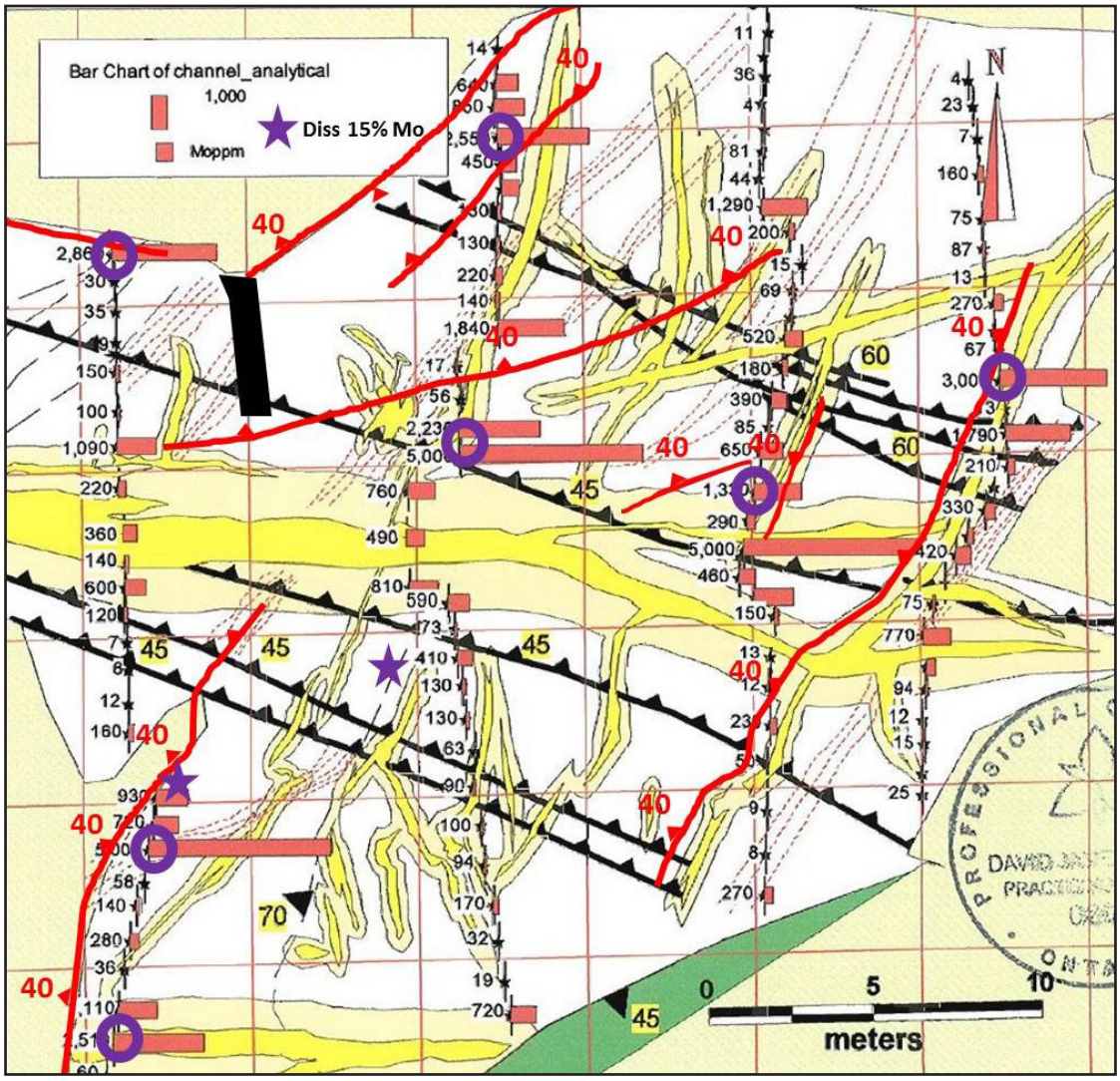


Figure 6. Channel samples cuts, quartz veining, alteration, and sample sites with high Mo values in the Pidgeon Mo stripped exposure (modified from Busch, 2008)

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Field Trip 8 - Geology and Mineral Deposits of the Pickle Lake Greenstone Belt

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Introduction

Despite the fact that the Pickle Lake area has been the subject of geological mapping, mineral exploration, and mining for over a hundred years, it still remains a relatively unknown and poorly understood greenstone belt in northwestern Ontario. Renewed academic and exploration interest over the last two decades has provided new data and insights into its tectonic evolution and metallogeny in a modern context.

This field trip will provide an overview of this greenstone belt, focusing on gold and base metal deposits in the vicinity of Pickle Lake (Pickle Lake Greenstone Belt Map below). To the authors' knowledge, this is the first "formal" field trip that has been conducted in the Pickle Lake area. Many of these field trip stops are on mine properties which require access permission from the property owners. Resident Geologist Program staff (Ontario Geological Survey, Ministry of Northern Development and Mines) can provide current ownership and contact information for these properties. Field trip participants should adhere to all safety protocols and exercise caution around highways, mine workings and other potential hazards.

Acknowledgments

The authors have benefited from the guidance and support of a number of individuals and company personnel in developing this field guide and gaining access to mine properties:

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- Jim Hickey (Sigfusson Northern Ltd.)
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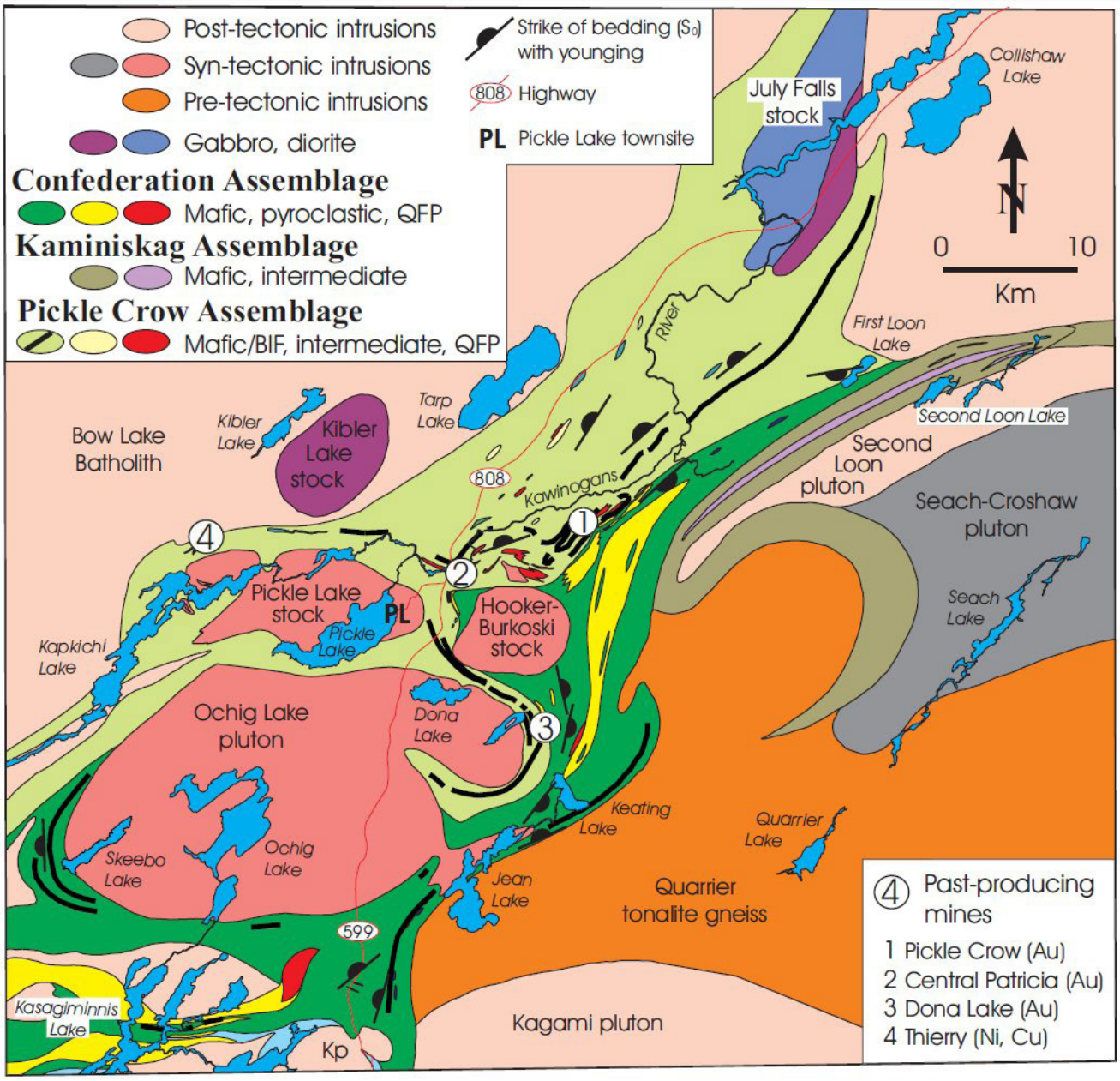
Exploration and Mining History

The Uchi domain has a long history of economic mineral production, including several current and past-producing gold mines in the Red Lake and Pickle Lake areas, and two past-producing base metal mines at Confederation Lake (South Bay volcanogenic massive sulphide (VMS) copper-zinc deposit) and Pickle Lake (Thierry copper-nickel-platinum group elements (PGE) deposit). The past-producing mines (Map 1) in the Pickle Lake belt are listed in Table 1 along with their production statistics and most recent published reserve figures. More detailed statistics are provided in the individual stop descriptions.

This synopsis of the exploration and mining history of the Pickle Lake camp has been modified from those of Thomson (1939) and Hennessey et al. (2011).

A reconnaissance survey was made along the Crow River between 1903 and 1905 by McInnes (1906) of the Geological Survey of Canada. Prospecting in the Pickle Lake area commenced in 1926. In 1927, Louis Cohen of Haileybury formed a prospecting group and sent Alex and Murdock Mosher in to stake the first claims in December, 1927 on what ultimately became the Central Patricia Gold Mines Property. These claims were optioned by F. M. Connell & Associates in August 1928, and Central Patricia Gold Mines Limited was incorporated on February 19, 1929. Diamond drilling commenced at Central Patricia in February 1929 and production in March, 1930. In the spring of 1930 a mining plant was assembled at the Central Patricia and underground work was done during that summer. An ore body was outlined and a 50-ton mill recommended, but, because of financial conditions, the mill was ordered only in 1933 and was completely installed by May, 1934.

In 1928, gold was discovered by Albany River Mines Ltd. at the No. 16 Vein on the Albany River claims to the east of the then Pickle Crow Property. The Crow River area had attracted little attention until the summer



Map 1: Pickle Lake greenstone belt geology and past-producing mine locations.

of 1928, when these promising gold discoveries were announced and a gold rush ensued. During the following winter months an area extending 20km east of Pickle Lake was largely staked and subsequently prospected in the summer of 1929. Following the gold rush of 1928, M. E. Hurst (1931) made a preliminary geological examination of the Pickle Lake-Crow River area. Articles on the Central Patricia mine were written by J. M. Connie and J. A. Reid. Up to that time the most promising discoveries were at the Central Patricia Mine, the showings of Northern Aerial Minerals Exploration (**NAME**), a company set up in 1928 by J. E. (Jack) Hammell (later becoming the Pickle Crow Mine), and a vein on the Springer claims, which were under option to F. M. Connell and associates. Development on other groups of claims did not provide much encouragement, although on many claims very little rock was exposed and no real exploration could be done.

The Central Patricia discovery paved the way for exploration in the region which led to the discovery and initial drilling (1929) of the first Pickle Crow ore body, the No. 1 (Howell) Vein, by **NAME**. The original discoveries on Central Patricia and **NAME** ground were drilled in 1929. Pickle Crow Gold Mines, Limited was organized and took over the property of Northern Aerial Canada Golds, Limited, successors to **NAME**. Underground work had commenced at the

Table 1: Past-producing mines in the Pickle Lake area (modified after Puumala, 2009).

Mine Name	UTM Zone	Easting (m)	Northing (m)	Years of Production	Total Production	Reserves
Central Patricia #1	15	697509	5707914	1934–1951	621 806oz (17,628kg) Au	None published
Central Patricia #2	15	703404	5708271	1938–1940	13,158oz (373kg) Au	5080t @ 8.05g/t Au open pit reserves (1993)[1]
Dona Lake	15	702034	5699957	1989–1994	246 500oz Au	40,000t @ 5.95g/t Au (1994)[1]
Golden Patricia	15	629877	5692270	1988–1997	619,796oz (17,572kg) Au	None published
Pickle Crow	15	704366	5709757	1935–1966	1,446,214oz (41,000 kg) Au	10.150Mt @ 3.9g/t Au[2] (2011) (~1.26M oz)
Thierry	15	684148	5708433	1976–1982	51,528,960kg Cu	Measured and Indicated Resources: 8.131Mt @ 1.46% Cu, 0.18% Ni, 3.7g/t Ag; Inferred Resource: 11.507Mt @ 1.46% Cu, 0.15% Ni, 6.1g/t Ag[2] (2012) K1-1 Deposit: Inferred Resource: 51.044 Mt @ 0.31% Ni, 0.08% Cu, 1.5g/t Ag[2] (2012)

[1]*Historical reserve estimates that cannot be confirmed to comply with the reporting standards of National Instrument 43-101.*

[2]*Resource estimate determined in compliance with the reporting standards of National Instrument 43-101.*

original discovery (Howell vein) in the fall of 1933 and soon indicated an ore body. A 125-ton mill was ordered and production commenced on April 17, 1935. The immediate success attained at both properties led to a resumption of activity in the area. In the summer of 1936, 14 companies were at work. Owing to the large areas of overburden, detailed examination of the country was carried on by means of geological mapping, geophysical surveys, surface trenching, and diamond-drilling. Albany River Mines Ltd. sank the Albany Shaft to a depth of 190m (625ft) between 1933 and 1938 and completed extensive underground development. Winoga Patricia Gold Mines was created in 1936 and drilled 73 surface diamond drill holes on a pie-shaped property located between PCGM's holdings and the Albany River Mines ground to the east. A shaft was subsequently sunk on the property in 1938. That same year, PCGM took over ownership of both Albany River Mines and Winoga Patricia Gold Mines through a new company called Albany River Gold Mines Ltd. It is believed that the Winoga Patricia Gold Mines shaft later became the No. 3 Shaft of the Pickle Crow operation. The Cohen-MacArthur zone, located 2km to the north of the developing Pickle Crow Mine, was discovered in 1933. A total of 14 surface diamond drill holes were drilled at Cohen-MacArthur in the winter of 1936. This property also was optioned by PCGM in 1938. With the acquisition of the Cohen-MacArthur claims, PCGM became one of the largest land holders in the Pickle Lake area. The Geological Survey of Canada completed a regional synthesis of the Pickle Crow greenstone belt during this period as well. Ground and airborne geophysical surveys have been completed over all or parts of the Pickle Crow property at various times during its early history. A dip-needle survey completed in 1936 on the Pickle Crow property was useful in tracing out the bands of iron formation. A detailed magnetic survey was carried out over the property by Teck (or its predecessor companies) around 1960.

With the outbreak of World War II and the shortage of labour, mine operations slackened off considerably. Prospecting virtually came to a standstill, although both Pickle Crow and Central Patricia Mines continued production throughout the war. Pickle Crow was the last of the original gold mines to close, ending operations in 1966.

Central Patricia Gold Mines began copper-nickel exploration in the Kapkichi Lake area in the mid-1940s. Kapkichi Nickel Mines Limited followed, carrying out surveys and drilling from 1956 to 1966. Mining claims covering the Thierry copper-nickel deposit were optioned by Union Minière Explorations and Mining Corporation (UMEX) from Kapkichi Nickel Mines in 1969. UMEX's follow-up work led to a decision to proceed with development of the deposit in 1974. The Thierry Mine was in production from 1976 to 1982 (Puritch et al., 2012). The property is currently held and is being explored by Cadillac Ventures Inc. In 2012, Cadillac revised the Resource Estimate for the underground portion of their Thierry Project, based upon the operating costs of conceptually combining the operations of the Thierry underground

and the K1-1 open pit deposits.

In early 1984, exploration by Dome Exploration (Canada) led to the discovery of the Dona Lake gold deposit, southeast of the main Pickle Lake camp (Cohoon 1986). Jointly owned by Dome Mines and Campbell Red Lake Mines, the Dona Lake Mine began production in 1988. After producing approximately 250,000oz of gold, it suspended operations in 1997; the property is now maintained by Goldcorp Canada Inc.

The Golden Patricia Mine, 65km west of Pickle Lake, was discovered by St. Joe Gold Corp. Operated by Bond International Gold/LAC Minerals, the mine produced over 600,000oz of gold from 1988 to 1997.

There has been ongoing exploration in the Pickle Lake camp since the suspension of mining operations. The most notable of the gold exploration projects has been that of PC Gold Inc. on the Pickle Crow Mine property. Since assuming ownership in 2008, the company's exploration efforts have generated a 1.26 million-ounce, NI 43-101-compliant gold resource (10,150,000 tonnes averaging 3.9g/t gold).

Mapping of the Pickle Lake area has been undertaken by the Ontario Department of Mines and its successor, the Ontario Geological Survey. The reader is referred to a number of maps and reports, including: Hurst (1931); Harding (1936); Thomson (1939); Evans (1941); Pye (1956; 1975; 1976); Ferguson (1966); Sage and Breaks (1982), Stott et al. (1989a, b) and Stott (1996).

Regional Geology of the Pickle Lake Greenstone Belt

The regional geology of the Pickle Lake belt has recently been elucidated by modern lithostratigraphic, geochemical, geochronologic and structural studies. These include research and mapping conducted by Stott (1996), Hollings (1998, 2002), Hollings and Kerrich (2004), Young (2003), Young and Helmstaedt (2001) and Young et al. (2006), among others. The Pickle Lake greenstone belt is located within the central Uchi Sub-province (Fig. 1). Stott and Corfu (1991) divided the belt into four volcanic assemblages based on stratigraphic relationships, isotopic age data, and aeromagnetic data (Fig. 1); in order of decreasing age these are the Northern Pickle (~2900Ma), Pickle

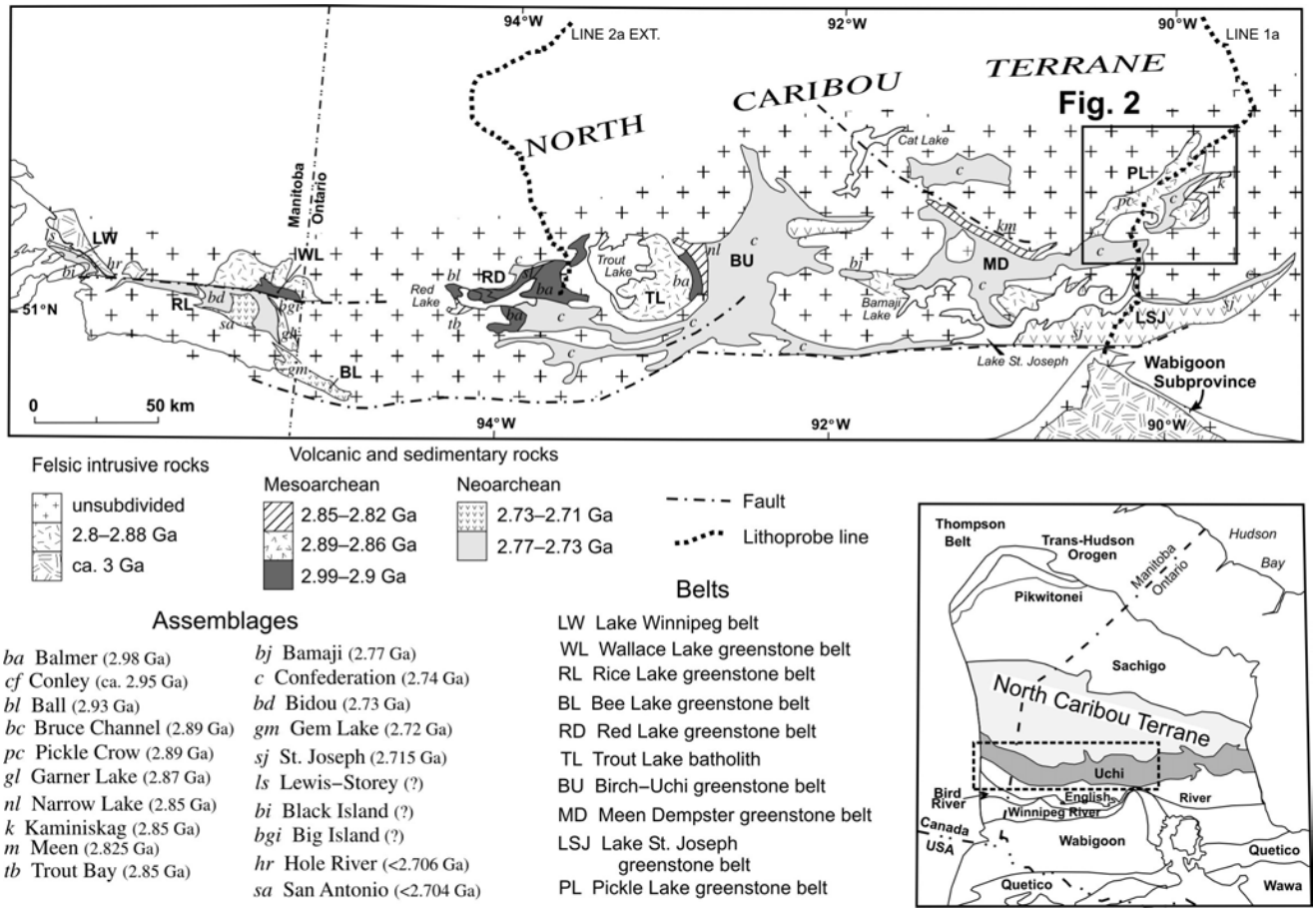


Figure 1. Regional geology of the Pickle Lake Greenstone Belt (from Young et al., 2006).

Crow (2870Ma), Woman (2820Ma), and Confederation (2750Ma) assemblages (Fig. 1; cf. Sage and Breaks, 1982; Corfu and Stott, 1989). More recently, a revised stratigraphy has been developed by Young et al. (2006), from which the following synopsis is taken:

> *"The Archean Uchi subprovince of the western Superior Province contains an imperfectly preserved record of over 300 million years of crustal evolution, characterized by episodic volcanism and plutonism initiated at ~3.0 Ga and culminating with subprovince-scale orogenesis at ~2.7Ga (Stott and Corfu 1991; Corfu and Stott 1993a, 1993b, 1996; Sanborn-Barrie et al. 2001; Thurston et al. 1991). The east–west-trending Uchi subprovince consists of narrow supracrustal belts surrounded by broad plutonic domains that occur at the southern margin of the North Caribou terrane (NCT, Fig. 1; Thurston et al. 1991).*

Neoarchean regional scale deformation and metamorphism is widespread along the southern margin of the NCT (Stott and Corfu 1991) at ~2.72 and ~2.70Ga, which probably identifies the time of amalgamation of the Winnipeg River and Wabigoon subprovinces, respectively, against the NCT (White et al., 2003). These regional tectonic fabric-forming events are associated with gold mineralization throughout the Uchi subprovince (Stott and Corfu 1991). In particular, gold mineralization at the world-class Red Lake mining district is well studied and is most likely associated with ~2.718Ga regionally penetrative structures (Sanborn-Barrie et al. 2001; Dubé et al. 2003). In contrast, structures hosting gold mineralization in the Pickle Lake belt were thought to have formed prior to ~2.744Ga (Stott and Corfu 1991; Stott 1996); however, we can show that these structures are younger, approximately correlative with the timing of mineralization in Red Lake.

The Pickle Lake greenstone belt comprises a 25km wide and ~70km long belt of Archean supracrustal rocks and internal granitoid plutons surrounded by large granitoid batholiths (Fig. 2). The supracrustal rocks have been metamorphosed to greenschist facies with amphibolite facies

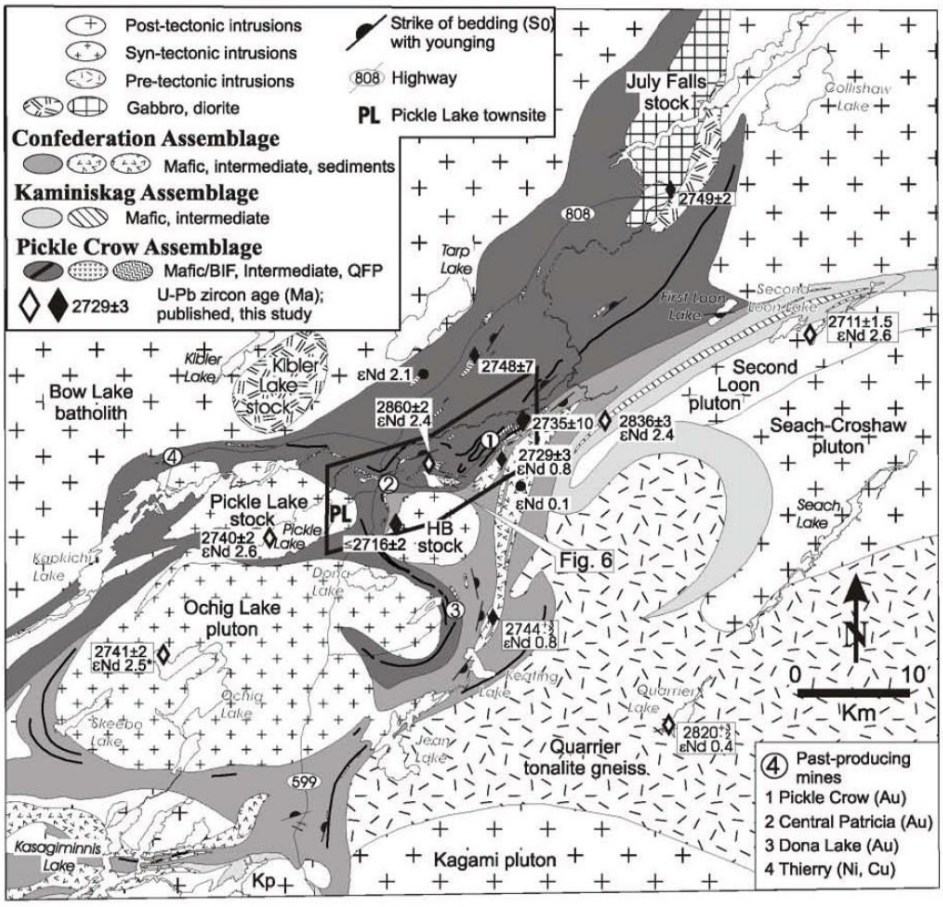


Figure 2. Geology of the Pickle Lake Greenstone Belt (from Young et al., 2006).

occurring within the narrow (<1km wide) thermal aureoles of younger plutonic bodies (Stott 1996). Although all of these rocks have been metamorphosed, in this paper the prefix "meta-" is dropped for convenience. Up to three phases of deformation, variably developed, are recognized in the Pickle Lake belt and are described in detail later.

Corfu and Stott (1993a, 1993b) and Stott (1996) described a tectono-stratigraphy in the Pickle Lake belt. New field work, U–Pb ages, geochemical data, and Sm–Nd isotopic analyses have established the timing and determined the nature of volcanism, deformation, and tectonic assembly of the Pickle Lake greenstone belt [Young and Helmstaedt 2001, Young 2003, Young et al. 2006].

The >2860Ma ***Pickle Crow assemblage*** *has been redefined to include the former Northern Pickle assemblage on the basis of stratigraphic continuity and similar volcanic geochemistry between the two units across a previously inferred fault contact. The Pickle Crow assemblage consists of tholeiitic basalt with thin, but laterally extensive, oxide-facies iron formation overlain by alkalic basalts and minor calcalkaline andesites to dacites with primitive Nd isotopic compositions (ε_{Nd} 2.89 Ga = +2.1 to +2.4) suggestive of deposition in a sediment-starved oceanic basin.*

The ~2km thick 2836Ma ***Kaminiskag assemblage*** *(former Woman assemblage) consists of tholeiitic basalt interbedded with intermediate and rare felsic pyroclastic flows with primitive Nd isotopic compositions (ε_{Nd} 2.836 Ga = +2.4). Two samples of intermediate volcanic rocks interbedded with southeast-younging pillowed basalt, previously inferred to be part of the Pickle Crow assemblage, yielded U–Pb zircon ages of 2744+3/-2Ma and 2729±3Ma. These rocks are thus part of the younger* ***Confederation assemblage****, which consists of intercalated basalt and dacite (ε_{Nd} 2.74 Ga = +0.1 to +0.8) exhibiting diverse compositions probably reflecting eruption in a continental margin arc to back-arc setting. The contact between the Confederation and Kaminiskag assemblages is assumed to be a fault.*

The greenstone belt is intruded by late syn- to post-tectonic plutons including the composite quartz dioritic to gabbroic July Falls stock with a U–Pb zircon age of 2749+4/-2Ma, and the ~2741 to 2740Ma trondhjemitic to granodioritic Ochig Lake pluton and Pickle Lake stock, as well as the ~2697 to 2716Ma Hooker–Burkoski stock.

The earliest recognized deformation (D1) is recorded by a local bedding-parallel foliation in the Pickle Crow assemblage. This foliation is truncated by the ~2735Ma Albany quartz–feldspar porphyry dyke and is not recognized in the volcanic rocks of the Confederation assemblage. The early deformation event is attributed to overturning of the Pickle Crow assemblage prior to deposition of the ~2744 to 2729Ma Confederation assemblage. Subsequent deformation and development of a regionally penetrative planar fabric (S2) postdates ~2729Ma volcanism, pre-dates the intrusion of the ca. <2716Ma Hooker–Burkoski stock and is host to gold mineralization.

Integration of new and previously published field, geochronological, and geochemical data has permitted revision of the distribution and contact relationships of supracrustal assemblages in the Pickle Lake greenstone belt. The revisions can be summarized as follows:

1. Based on the lateral continuity of lithologic units and Nd isotopic compositions, the rocks formerly attributed to the inferred ~3Ga Northern Pickle assemblage have been assigned to the ~2.89Ga Pickle Crow assemblage. An earlier assumed accretionary boundary between these two assemblages is not supported by the present work.

2. Based on new geochronology, the limits of the ~2.74–2.73Ga Confederation assemblage are known to extend further north and east in the belt and include rocks formerly assigned to the Pickle Crow assemblage. Opposite younging directions and enriched isotopic compositions suggest that the Confederation assemblage unconformably overlies the Pickle Crow assemblage.

3. The ~2836Ma Kaminiskag assemblage (formerly Woman assemblage), previously assumed to have developed autochthonously on the Pickle Crow assemblage, is thought to be in fault contact with the younger Confederation assemblage, having developed outboard of the North Caribou terrane.

The proposed tectonic evolution incorporates the revised supracrustal assemblages and can be

summarized as follows:

1. Deposition of the Pickle Crow assemblage in a back-arc to emergent-arc setting prior to 2.86Ga. The isotopically enriched tholeiitic lower sequence may represent deposition on or near a thinned or juvenile continental margin; whereas, compositionally diverse and more evolved rocks of the upper sequence may have formed in a transitional arc to back-arc setting.

2. North- to northwest-vergent shortening (D1), widely bracketed between 2892 and 2744Ma, may have been responsible for overturning the Pickle Crow assemblage and producing a major recumbent fold. Prior to the deposition of the Confederation assemblage, the upper limb of this recumbent fold was eroded, preserving the downward-younging lower limb. This episode of deformation is one of the few documentations of pre-2.75Ga tectonism and, by implication, metamorphism in the western Superior Province other than in the North Caribou greenstone belt (Thurston et al. 1991) and cryptic evidence in the Red Lake belt (Sanborn-Barrie et al. 2001).

3. The isotopically juvenile ~2836Ma Kaminiskag assemblage developed parautochthonously with respect to the North Caribou terrane in an arc to back-arc setting followed by intrusion of isotopically enriched ~2821Ma tonalite (Quarrier tonalite gneiss).

4. The ~2744 to 2729Ma Confederation assemblage was deposited unconformably on the overturned Pickle Crow assemblage. Arc-derived plutonic rocks (the Ochig Lake pluton and Pickle Lake stock) intruded the Pickle Crow and Confederation assemblages during this interval of Neoarchean volcanism.

5. Subsequent to ~2739Ma Confederation assemblage volcanism, and prior to the intrusion of the ~2697–2716Ma Hooker–Burkoski stock, regionally penetrative deformation resulted in steep foliations and telescoping of the Kaminiskag assemblage against, and possibly tectonically interleaved with, the Confederation assemblage. Gold mineralization in the Pickle Lake belt is associated with these tectonic fabrics and is therefore contemporaneous with mineralization in the Red Lake camp, possibly reflecting a NCT-wide mineralization event."

Geochemical evidence shows that the older (>2.9Ga) assemblages of the Uchi Sub-province are dominated by plume-related magmatism (c.f. Hollings et al., 1999; Tomlinson et al., 1998) whereas younger assemblages (<2.8 Ga) are characterized by arc related magmatism (c.f. Hollings et al., 2000; Hollings and Kerrich, 1999). The Pickle Lake belt (Fig. 2) offers the opportunity to investigate the transition between these regimes as he ~2.8Ga Pickle Crow assemblage offers a valuable opportunity to evaluate the tectonic processes occurring on the margins of the ancestral Superior Province during this significant transition. Hollings (2002) reported data on the Northern Pickle assemblage and distinguished three distinct volcanic suites (Fig. 3). Suite I, from the north of the assemblage, comprises tholeiitic basalts with unfractionated rare earth elements (REE). Suite II basalts are light REE (LREE) enriched with negative mantle normalised Nb anomalies relative to Th and La, similar to the CA suite of Sajona et al. (1996). Basalts from Suite III are also LREE enriched but lack negative Nb anomalies. Normalised Nb abundances are either similar to, or higher than Th and La, comparable to Nb-enriched basalts (NEB) from Phanerozoic arcs. Variable high field strength elements and heavy REE (HREE) systematics support the subdivision of Suite III basalts into two spatially distinct suites. Suite IIIa is interpreted to have melted at relatively shallow depths in the presence of Nb-Ti-bearing silicates whereas Suite IIIb melted in the presence of garnet. Variations in the geochemistry of the three suites can be accounted for by interaction between primitive mantle, adakite melts, and subduction modified mantle. The association of the three suites is interpreted to be the result of rifting of Suite I tholeiites in a back-arc environment, characterized by Suite I tholeiites, permitting asthenospheric upwelling of subduction modified NEB and associated arc-like volcanic rocks (Suites II and III). The association of arc like basalts (Suite II) with NEB (Suite III) in the Northern Pickle assemblage extends the known occurrence of Archean NEB beyond the ~2.7 Ga age of previously recognised examples.

Hollings and Kerrich (2004) showed that the ~2.89Ga Pickle Crow assemblage comprises a basal unit of tholeiitic basalts with uniform SiO_2 contents, and MgO spanning 12.4 to 3.1 wt.%. The basalts plot on a hyperbolic mixing array from a high Nb (4-8ppm), La/Ybn, but low Zr/Nb member to a low Nb (2-4 ppm), La/Ybn, but high Zr/Nb counterpart, indicative of a heterogeneous sub-arc mantle source (Fig. 3). The tholeiites were interpreted to have formed in a back-arc basin to the later calc-alkaline rocks found

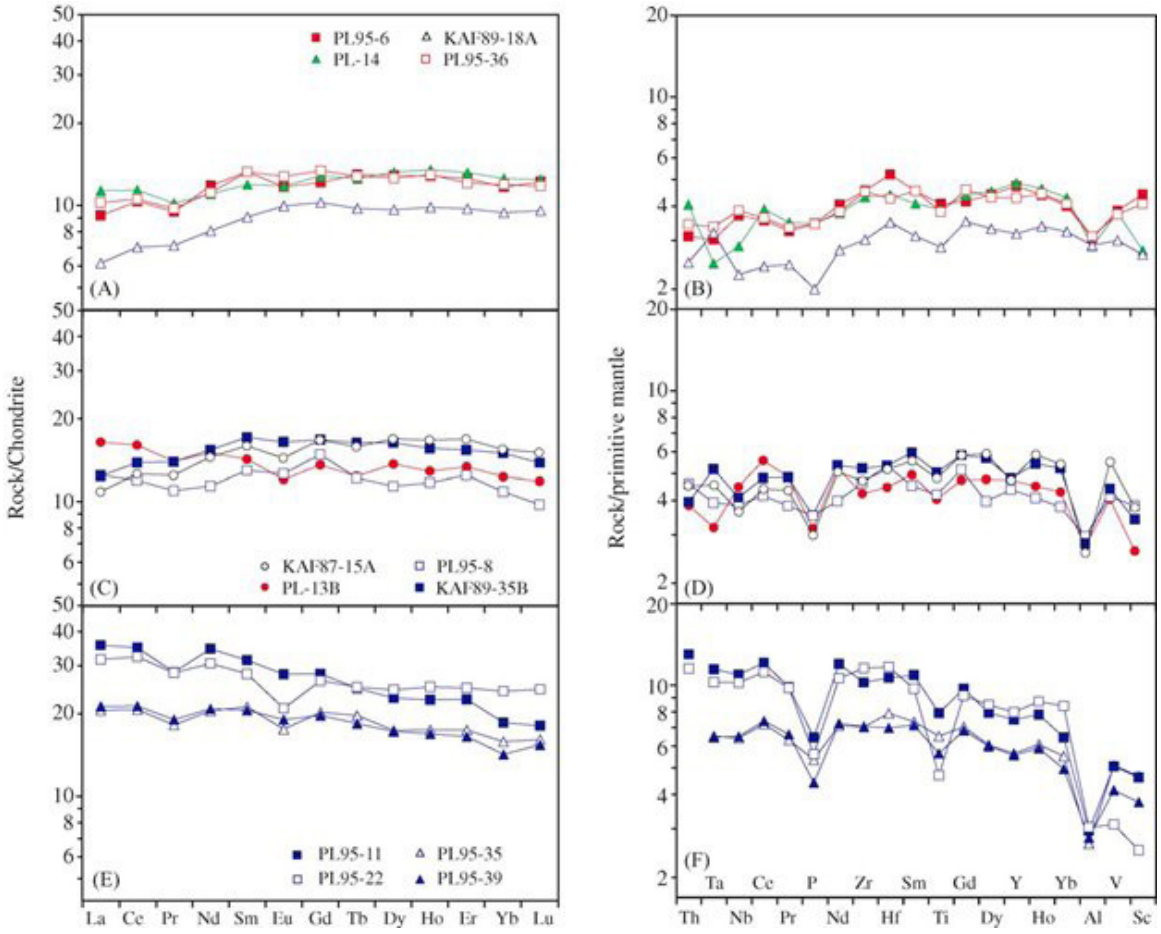


Figure 3. Chondrite- and primitive mantle-normalised plots for representative samples from the Pickle Crow Assemblage. Normalizing values are those of Sun and McDonough (1989).

stratigraphically above them (Stott and Corfu, 1991; Young and Helmstaedt, 2001). The presence of NEB within the Northern Pickle assemblage, interpreted by Young and Helmstaedt (2001) to stratigraphically underlie the Pickle Crow assemblage is consistent with that model and overall the geochemical data are consistent with a paired back-arc and arc, where the high-Nb basalts are generated from back-arc mantle, and the lower-Nb basalts from sub-arc mantle.

Field Trip Stops

The field trip stops are shown in Figure 4 and a road log for the field trip is presented in Table 2.

Stop 1: Pillowed Basalt, Pickle Lake Turn-Off

UTM Coordinates: NAD83, 15U, 0696981E / 5706785N

Two large, glacially polished outcrops just south of the junction of Highway 599 and Pickle Lake Road expose pillowed basalt (Fig. 5) of the tholeiitic Lower Sequence of the Pickle Lake Assemblage (Young, 2003). The tholeiitic rocks of the lower sequence display SiO_2 contents of 44–51 wt. %, MgO of 4–11 wt. % and Fe_2O_3 of 9–15 wt. %. The majority of samples are characterized by unfractionated or weakly depleted light REE (LREE) and mildly fractionated heavy REE (HREE) (La/Sm_{pm} = 0.75–1.10; Gd/Yb_{pm} = 0.97–1.35). The Th/La and Zr/Y ratios are generally less than the primitive mantle values of 0.11 and 2.44, reflecting the depleted character of the tholeiites. In addition, some samples show negative Zr and Ti anomalies relative to neighbouring elements on a primitive mantle-normalized plot (Young, 2003).

Unfortunately, the westernmost of the two large outcrops has fallen victim to geo-vandals, who have applied white paint and localized spray paint to much of the outcrop. Despite this, recessively weathered sections and unpainted surfaces suggest that it is, indeed, pillowed basalt. The easternmost outcrop has escaped the fate of its neighbour and does offer a great exposure of the same pillowed basalt. Pockmarked by recessively weathered selvages, possible drainage cavities and fractures, these grey-weathering bun

Table 2: Road Log for Field Trip; trip stops are shown in Figure 4. All UTM co-ordinates on road log and field trip stops are stated as NAD83, UTM Zone 15.

STOP NAME	STOP NO.	LANDMARK	DISTANCE (km)	EASTING	NORTHING
Starting Point		Junction Highway 599 and Pickle Lake Road	0.0	679055	5706910
		Turn south on Hwy. 599; to Pull-off / parking area on right	0.05		
Pillowed Basalt	1			696981	5706785
		Junction Highway 599 and Pickle Lake Road (reset)	0.0		
		Central Patricia Mine	0.9		
		Bridge across Crow (Kawinogans) River	1.0		
		Junction, Highway 599 and Thierry Mine Road	3.2		
THIERRY MINE AREA		Reset, turn west onto Thierry Mine Road	0.0		
		Road to K1-1 Zone pit	10.3		
Sheared basalt	2a		10.8	687610	5709480
		Mine Gate	14.4		
Pillowed basalt, south of West Pit	2b			684010	5708540
Sheared basalt and gabbro, north of East Pit	2c			684107	5708717
Mafic dyke in sheared basalt, north of East Pit	2d			684140	5708686
"Ribboned" basalt, north of East Pit	2e			684122	5708670
"Breccia ore", northwestern end of East Pit	2f			684086	5708638
		Junction Highway 599 and Pickle Lake Road (reset)	0.0		
		Junction, Highway 599 and Pickle Crow Road	0.5		
PICKLE CROW MINE AREA		Reset, turn east onto Pickle Crow Mine Road	0.0		
Field office and core yard	3a	Mine Gate	7.1	703600	5709080
Trench C (No. 5 and No. 11 veins)	3b		7.5	703890	5709300
No. Vein stockpile and Shaft Pit	3d		8.2	704355	5709860

Table 2: Continued

Trench A (Conduit Zone)	3c		10.3	705820	5711200
		Junction Highway 599 and Pickle Lake Road (reset)	0.0		
		Junction Highway 599 and Dona Lake Mine Road	11.0		
DONA LAKE AREA		Reset, turn onto Dona Lake Mine Road	0.0		
Dona Lake Mine Portal	4a			702099	5699732
Sulphidic Banded Iron Formation	4b			701767	5699990
Pillowed Basalt	4c			701686	5700056
Banded Iron Formation	4d			701708	5699991
BIF, southern end of pit	4e			701764	5699994
		Junction Highway 599 and Dona Lake Road (reset)	0.0		
Ochig Lake Pluton	5		3.2	693228	5693898

pillows are outlined by thin, dark selvages and locally developed pillow breccia. Pillow cusps and packing indicate "tops" to the southwest. A foliation, striking at ca. 125° may parallel flow contacts. Localized flexures and crenulations in this fabric were also noted.

Stop 2: Thierry Copper-Nickel Mine (Sub-stops are described below**)**

(N.B. Permission to enter the site must be granted by Cadillac Ventures Inc.)

The exploration and development history of the Thierry Mine property has been taken and modified from Puritch et al. (2006).

Despite Pickle Lake's reputation as a gold camp, base metal occurrences were discovered in the late 1940s and became a significant focus of exploration and mining activity in the late 1970s. Central Patricia Gold Mines Limited completed diamond drilling from 1946 to 1950 on several gabbro-hosted copper-nickel prospects in the Kapkichi Lake area, west of Pickle Lake. Kapkichi Nickel Mines Limited conducted geophysical surveys and diamond drilling in this area between 1956 and 1958. The actual claims covering the mine site were optioned by Union Miniere Explorations and Mining Corporation (UMEX) from Kapkichi Nickel Mines in 1969. UMEX completed further exploration and drilling that eventually outlined four high-priority areas of copper-nickel mineralization: the K1-1, K2-1, G, and J anomalies, respectively. The K2-1 anomaly eventually became the Thierry Mine Deposit.

In 1969, following a joint-venture agreement with Kapkichi, UMEX crews started ground electromagnetic, magnetometer and geologic surveys on the Kapkichi property. As a follow-up of the McPhar and UMEX geophysical surveys, drilling intersected low-grade (0.40% Cu, 0.11% Ni) mineralization in mafic and ultramafic rocks underlying Kapkichi Lake. This discovery was later named the "J" and "G" deposits.

In September 1970, the first hole drilled outside the area covered by the joint-venture agreement with Kapkichi Nickel Mines, intersected 6m (20ft) of sulphides in biotite-chlorite schist containing 1.24% Cu and 0.14% Ni. This drill hole marked the actual discovery of the Thierry deposit, which was completely covered by overburden and thus had escaped discovery by earlier prospectors. Immediately following the discovery drill hole, the Thierry Deposit was drilled off, on a grid of cross sections 200ft apart, by 77 holes, totaling 45,000ft.

In December 1971, at the end of the surface drilling campaign, the undiluted in-situ, drill-indicated reserves were estimated at 11,500,000 tons averaging 1.68% Cu and 0.18% Ni. In view of these results, UMEX decided to proceed with an underground development and

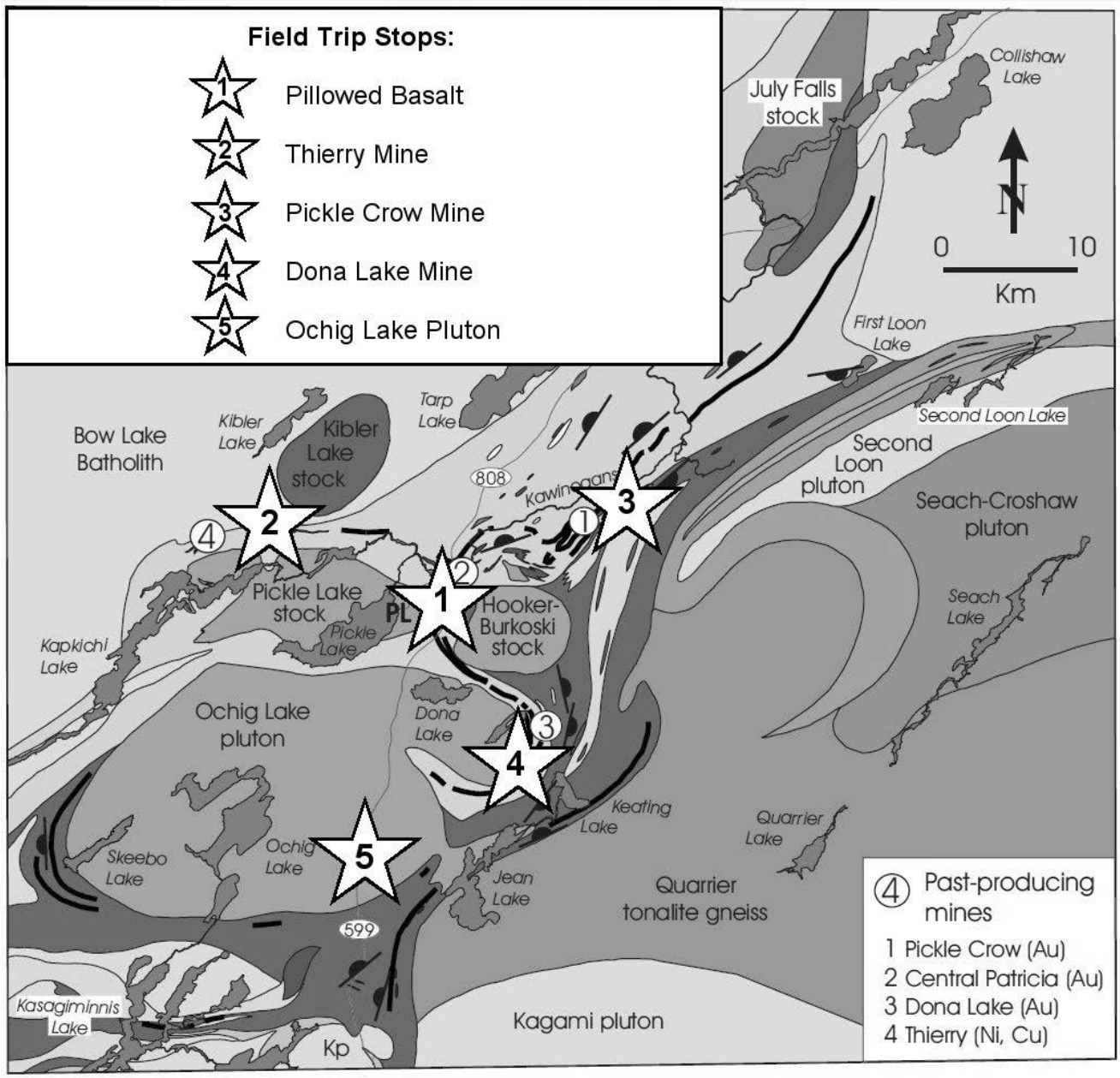


Figure 4. Field trip stop locations, Pickle Lake Greenstone Belt geology (geology from Young et al., 2006).

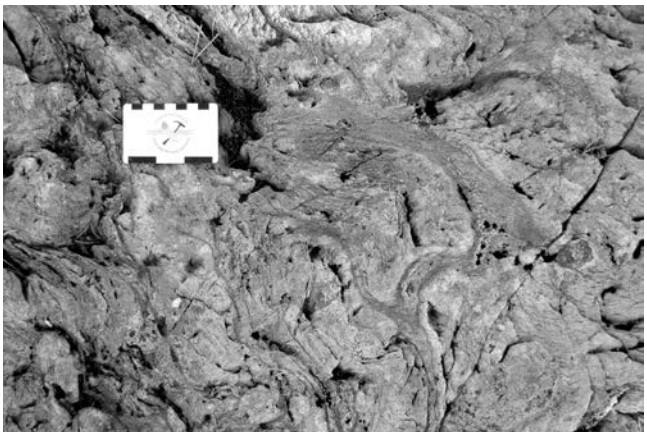


Figure 5. Pillowed basalt, Pickle Lake turn-off (Stop 1).

exploration program. Kilborn Engineering was awarded a contract to prepare a preliminary feasibility study of the deposit and to assume the project engineering.

After studying Kilborn Engineering's feasibility report, it was decided to proceed with the development of the deposit. The official decision to place the property into production was made in 1974. Shaft Sinking started on June 27, 1972 to a planned depth of 2200ft. On December 8, 1973, after installing the cage and skip, cross-cut stations were started at the 600-, 1200-, and 1600-foot levels. At the end of 1974, the cross-cuts on these levels were completed. Work progressed to complete the drifts in the hanging wall at the 600-

and 1600-foot levels and the drift in the footwall at the 1200-foot level. Horizontal and inclined holes were drilled from stations at 100-foot intervals in the drifts. Underground development, mill construction (started late 1974), and infrastructure development (town site, upgrading of access road, upgrading of the power line, etc.) were accelerated as much as possible to be ready for start-up by July 1, 1976.

On July 1, 1976 the 4000 short tons per day mill was completed and production started at the Thierry Deposit in two separate small open pits (West and East) from the surface down to the 170-foot level. Dilution was very high (approximately 30%) due to the transverse mining method applied by the contractor. Ore was separated in two stock piles: high-grade (above 0.5% Cu), and low-grade (below 0.5% Cu). Underground production, utilizing the sub-level (blast hole) stoping method started in 1977. Underground work went on continuously but the milling rate was reduced from 4000 short tons per day to 2000 short tons per day in July 1977 given the low copper prices. At the same time, underground primary development was halted until October 1978. Production continued until April 1982 when the mine and mill were decommissioned.

Production from the Thierry Deposit was accomplished by two open pits followed by underground operations. Underground development of the deposit included the development of a three-compartment shaft to a depth of 543m (1778ft) and 2890m of excavations at the 180, 360 and 850m levels. A total of 15,850m of underground diamond drilling was completed. Approximately 5.8 million tons of ore were mined and processed, with an average grade of 1.13% Cu and 0.14% Ni, between October 1976 and April 1982. This resulted in the production of approximately 217,750 short tons of concentrate that contained 113.6 million pounds of copper and 2.8 million pounds of nickel. Initially, only a copper concentrate was produced; however, by 1981 UMEX recognized the value of the nickel and a limited amount of nickel concentrate was produced which slightly enhanced the net smelter value of the ore. In addition, minor payable amounts of precious metals and PGE were also reported: 17,500 troy oz platinum; 47,000 troy oz palladium; 17,000 troy oz gold, and 900,000 troy oz silver. Mine production data were estimated from available UMEX production records and was tabulated by Novak and Mlot (2004). The estimate is summarized in Table 3 below. The mine was shutdown in 1982 due to low metal prices, and lower than anticipated ore grades. In June 1987, the mine was allowed to flood.

Table 3: Thierry Mine Estimated Historical Production (Novak and Mlot, 2004).

Year	Production (tons)	Cu (%)	Ni (%)	Pt+Pd+Au (ounces)	Concentrate (tons)
1976	215,017	1.17	0.10	0.043	9,072.44
1977	956,428	1.26	0.13	0.037	40,071.89
1978	913,103	1.29	0.11	0.041	38,365.67
1979	1,021,572	1.15	0.11	0.04	39,140.70
1980	1,160,558	1.08	0.11	0.033	43,304.39
1981	1,309,298	0.90	0.09	0.018	35,871.18
1982	255,556	1.32	0.10	0.043	11,924.59
TOTAL	**5,831,532**	**1.13**	**0.13**	**0.04**	**217,749**

After the mine closure in 1982, very little additional exploration was carried out; however, between 1987 and 1989 analyses were carried out for platinum and palladium. Between 1974 and 1975, 221 drill core samples from the Thierry Deposit were assayed by UMEX for Pt and Pd. In 1987, UMEX staff geologist D. Unger, implemented re-sampling and assaying of selected diamond drill holes. In 1987, R. Dahl was retained by UMEX to undertake a complete re-evaluation of the PGE potential of the Thierry Mine and vicinity. An airborne geophysical survey (EM/Resistivity/Magnetometer/VLF-EM) was flown by DIGHEM in 1988 over the Kibler Lake Stock.

In 1989, UMEX Inc. re-evaluated the economic potential of the deposit with a view to reopening of the Thierry Cu-Ni Mine. UMEX, as a result of the PGE studies undertaken between 1987 and 1988, was aware that the mine contained nickel-copper zones that were coincident with anomalous PGE concentrations. UMEX also reported a large, low-grade zone of disseminated copper-nickel mineralization at the K1-1 anomaly. The K1-1 zone is tabular, 1500m long and up to several hundred metres thick. Test mining of this zone was undertaken in 1981. The average grade of the zone is 0.31% Cu and 0.1% Ni, at a cut-off of 0.2% Cu.

Etruscan Resources Inc. purchased the property in 1990 with a view to placing the property into production. In 1991, Watts, Griffis and McOuat Limited (WGM) were engaged by Etruscan to prepare an economic analysis for the reactivation of the Thierry operation. WGM reported non-NI43-101-compliant diluted underground "mineral reserves" of 2.7 million short tons with average grades of 1.78% copper and 0.25% nickel. Etruscan completed reclamation of the mill and shaft facilities from 1993 to 1995. During this period, the entire drill core storage facility, including the contained core, was destroyed.

PGM Ventures Corporation acquired the property from Etruscan under an asset purchase agreement

in late 2000. PGM Ventures reviewed and initiated development of a digital database from available UMEX data. In 2002, PGM Ventures undertook a drilling campaign of 25 drill holes, totaling 8952m, to test mineralization at the Thierry Deposit and at other targets on the property. In total, PGM Ventures drilled 11 holes to confirm the presence of economically interesting mineralization at the Thierry Deposit. Drilling confirmed mineralization on the eastern and western portions of the deposit. Five drill holes intersected mineralization from depths of 1200ft to 1800ft below surface. PGM Ventures also took samples of ore representative of that previously mined from surface stockpiles to confirm the presence of consistently attractive PGE values in the well-developed breccias and massive sulphide ores. PGM engaged JVX Ltd. to complete a Time-Domain electromagnetic and magnetometer survey. The work was designed to identify geophysical targets along the main west-trending structure, which hosts both the Thierry and the Ros Zone (K1-1 zone). The survey results outlined coincident magnetic and EM anomalies, similar in intensity and extent to those at the Thierry Mine itself.

Richview Resources Inc. acquired the property and commenced a diamond drilling program to explore the Thierry deposit and other areas of the property from October, 2004 through March 2005. Apart from the drilling program no other exploration work was complete by Richview.

Puritch et al. (2012) outlined the subsequent work at Thierry. An NI43-101-compliant resource estimate with an effective date of February 1, 2006 consisted of 4,623,000 tonnes of Measured and Indicated material at a grade of 1.81% Cu, 0.20% Ni, along with 4,366,000 tonnes of Inferred material at a grade of 1.71% Cu and 0.18% Ni.

Richview commenced its summer validation and exploration program on May 9, 2007 and completed a 14,000m drilling program. Surface drilling around the K1-1 open pit area to confirm and validate the historic drilling was also undertaken. A compilation of all mine data was conducted. A 3km corridor of unexplored ground between the Thierry Mine and the K1-1 deposit was cleared of overburden. A summer work program including excavation, geological mapping, prospecting, and geochemical sampling was completed by October 2008. A Mobile Metal Ion (MMI) geochemical survey of the Thierry Project was also conducted.

The amalgamation of Cadillac Ventures Inc. and Richview Resources Inc., pursuant to a three-cornered agreement, became effective on Jan 15, 2010. Cadillac assumed 100% control of the Thierry Project. The following synopsis of the post-amalgamation period is taken from Cadillac's Management's Discussion and Analysis, January 26, 2015.

Following the amalgamation, Cadillac obtained access to all the detailed geological and technical information on Thierry that was available. This data was then evaluated with the objective of developing a comprehensive work program. Cadillac revised the resource estimate for Thierry to include the additional data generated by the drilling of 20 holes in 2007 and 2008 by the former operators of the property as well as the drilling used in previous NI43-101-compliant resource estimates. Cadillac reported (press release, June 9, 2010) that the resource estimate update for the former Thierry Mine then consisted of a Measured and Indicated resource of 6,228,000 tonnes containing 1.92% Cu and 0.2% Ni and an Inferred resource of 8,379,000 tonnes containing 1.79% Cu and 0.16% Ni, using an NSR cut off of $46/tonne. This report enabled Cadillac to identify target areas for a surface diamond drilling campaign in conjunction with a dewatering initiative at Thierry. The objective of the planned drilling program was to infill drill an area at depth where there had been a lack of information in the Thierry Deposit model.

Cadillac commenced the drilling program in May 2010 and in May 2011 reported the successful completion of all six holes, totalling 6800m. Assay results from each of the six holes drilled indicated a successful intersection of the Thierry mineralized zone at depth. Additionally, a diamond drilling program designed to test for shallower extensions of mineralization from the known and modeled deposit, commenced in January 2011. Cadillac subsequently reported that the assay results from these drill holes confirmed the extension of mineralization both to the west and to the east of the known deposit with both directions remaining open. The results of this drilling program, together with the extensions of the strike length to the west and east, formed the basis of an updated resource estimate (press release, September 1, 2011). This updated resource consisted of a Measured and Indicated resource of 8,281,000 tonnes containing 1.73% Cu and 0.2% Ni and an Inferred resource of 14,639,000 tonnes containing 1.70% Cu and 0.16% Ni, using an NSR cut off of $46/tonne. Cadillac subsequently completed an NI43-101-compliant Technical Report and Resource Estimate in December 2011.

Following a successful drilling program on the nearby K1-1 deposit in November and December 2011, Cadillac further revised the Thierry underground resource based upon conceptually combining the operations of the Thierry underground and the K1-1 open pit deposit (which resulted in a $5/tonne decrease in the NSR cut-off to $41/tonne). The further updated resource consisted of a Measured and Indicated resource of 8,815,000 tonnes containing 1.66% Cu and 0.19% Ni and an Inferred resource of 14,922,000 tonnes containing 1.64% Cu and 0.16% Ni, using the revised NSR cut-off of $41/tonne (press release, February 23, 2012). Cadillac subsequently completed an NI43-101-compliant Technical Report and Resource Estimate in March 2012.

Outside of the Thierry underground mine area, the eastern component of the property encompasses a project referred to as K1-1. This area, which lies 3 km east of the Thierry Mine, was drill-tested by UMEX who defined the mineralization in 1973 and 1981. UMEX had identified an estimated, non-compliant 75,000,000 tonne resource containing 0.38% Cu and 0.11% Ni. During February and March 2011, Cadillac completed three shallow drill holes on the K1-1 occurrence in order to test previous UMEX results and intersected wide zones of mineralization. During the first quarter of fiscal year 2012 Cadillac completed an additional 13-hole drilling program on the K1-1 deposit designed to confirm the historic data calculation and facilitate an NI 43-101-compliant resource. Cadillac subsequently reported the results of the 13 holes drilled, with each of the holes intersecting widespread shallow mineralization with localized higher-grade occurrences.

The results of this drilling program enabled Cadillac to calculate the size of this open pit deposit and in October 2011, Cadillac reported the completion of a mineral resource estimate and exploration target for the K1-1 open pit project. This estimate was based on a combination of historic drilling by previous project operators and more recent drilling by Cadillac. The Inferred mineral resource estimate for K1-1 within a whittle pit shell consists of 19,897,000 tonnes containing 0.42% Cu and 0.10% Ni, using an NSR cut off rate of $ 15/tonne. The exploration target for K1-1 located outside and below the resource pit shell was also estimated to contain 45,000,000 to 55,000,000 tonnes grading 0.32% to 0.36% Cu and 0.08% to 0.12% Ni. Cadillac subsequently completed a NI 43-101-compliant Technical Report and Resource Estimate in December 2011.

Cadillac then completed a further exploration program on the K1-1 deposit during November and December 2011 utilizing two diamond drill rigs and completing a total of 26 holes. The purpose of this program was to upgrade and expand the mineralization and models at K1-1 by infill drilling within the area of the pits and adjacent to the modeled pits, as well as targeting areas under the pits and along strike in the exploration program. Cadillac reported that the assay results of samples from the 26 holes enabled Cadillac to further update the initial K1-1 resource estimate. The updated Inferred mineral resource at K1-1 had been estimated within an economically optimized Whittle pit shell consisting of 53,614,000 tonnes containing 0.38% Cu and 0.10% Ni, using an NSR cut off rate of $11/tonne (press release, February 14, 2012). Cadillac subsequently completed an NI43-101-compliant Technical Report and Resource Estimate in March 2012.

The K1-1 deposit consists of a Global Mineralized inventory including the optimized pit and adjacent mineralization of 75,857,000 tonnes containing 0.38% Cu and 0.10% Ni, using an NSR cut off rate of $11/tonne (press release, February 14, 2012). This updated K1-1 resource estimate will impact on a future production decision at Thierry as the close proximity of both the K1-1 deposit and the Thierry underground mine to each other will allow cost efficiencies based on the sharing of the infrastructure and the processing plant capacity which should enable Cadillac to realize lower production costs and therefore process material of a lower grade than would be envisioned if either deposit were operating independently of each other.

In May 2012, Cadillac received a positive Preliminary Economic Assessment (PEA) which demonstrated the technical and potential economic viability of reopening the Thierry Mine and processing material from both the underground Thierry Mine deposit and the K1-1 open pit deposit on a combined basis (press release, May 12, 2012). Cadillac had reported that it had commissioned a dewatering plan for the Thierry mine site.

During fiscal year 2013, Cadillac completed more drilling at K1-1 (8 DDH, totalling 2200 m) to potentially increase the mineralized resource. Cadillac subsequently reported that each hole had successfully encountered mineralization outside of the current Whittle Pit-defined compliant resource and returned assay grades comparable, or better than, those contained within the current Whittle Pit-defined compliant resource (press release, September 13,

2012). Cadillac also completed a field prospecting/ mapping program designed to provide field testing and sampling of correlated geophysical and coincident magnetic anomalies on the property outside of the area of the Thierry Mine and K1-1 during the year.

Cadillac continues to evaluate the results of the aforementioned drilling, prospecting and mapping programs with a view to determining the next phase of the exploration program at the Thierry Mine and K1-1.

Geology of the Thierry Mine

The description of the geology of the Thierry Mine, below is taken from Anderson (2007). A vertical cross-section through the deposit showing the pit and some of the underground workings is present in Figure 6.

Regional setting

The Thierry deposit is situated in the northwest portion of the Archean Pickle Lake greenstone belt in the Uchi volcano-plutonic subprovince of the western Superior Province. Supracrustal rocks in this portion of the Pickle Lake belt are included in the Mesoarchean (>2860Ma) Pickle Crow assemblage, which consists of massive and pillowed tholeiitic basalt flows, with minor intercalated sedimentary rocks, iron formations, and calcalkaline andesite and dacite (Young et al., 2006).

Along the northwest margin of the Pickle Lake belt, the Pickle Crow assemblage is intruded by stocks, plugs and sills of mafic to ultramafic composition. The largest of these intrusions, the July Falls stock, is composed of gabbro, diorite and quartz diorite, the latter of which has yielded a U-Pb zircon age of 2749Ma (Young et al., 2006). South of the Thierry deposit, these rocks are intruded by the 2740Ma Pickle Lake stock, which is interpreted to be broadly syntectonic

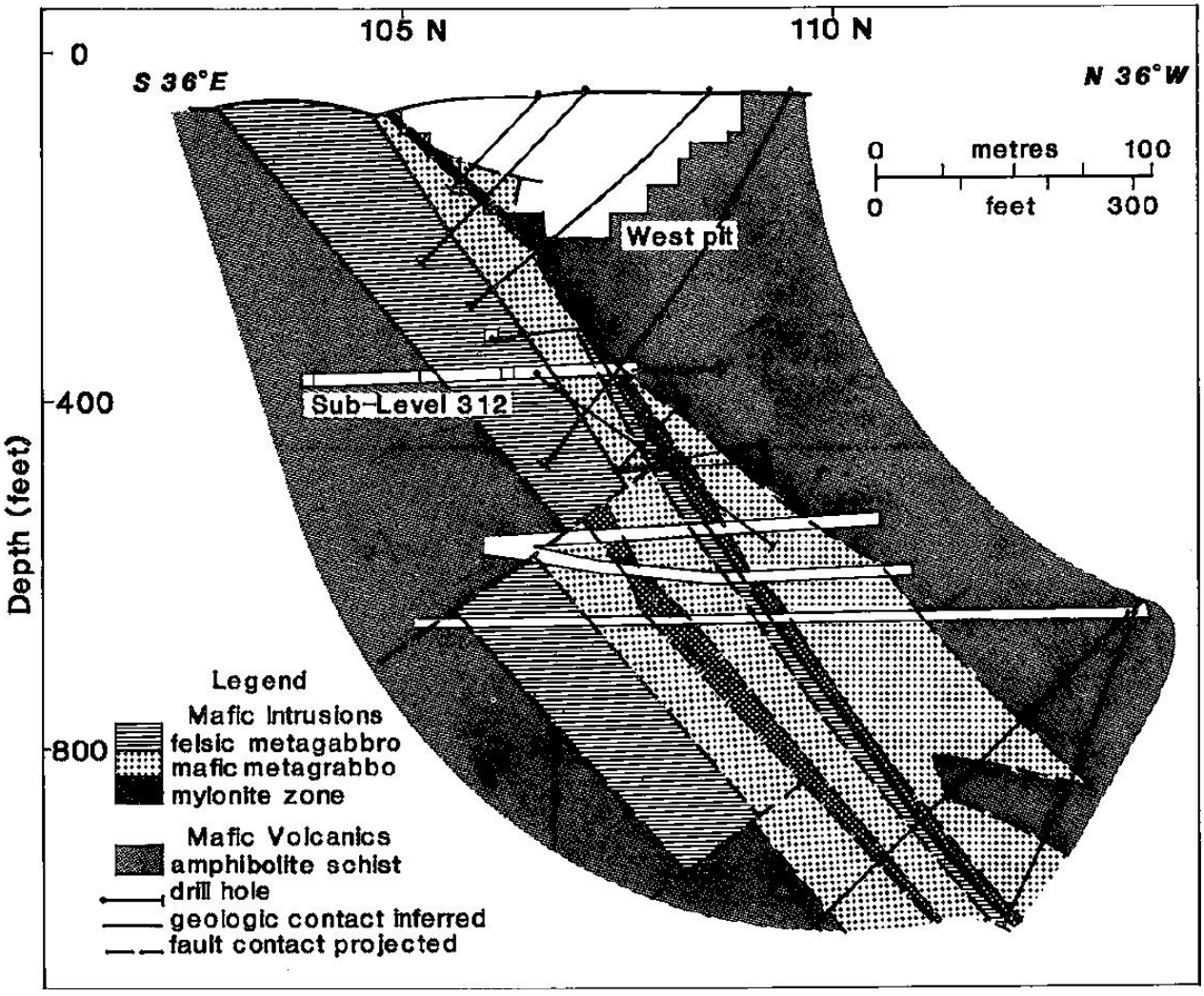


Figure 6. Cross section of the Thierry deposit (Patterson and Watkinson, 1984).

(Young et al., 2006). To the north, the Pickle Crow assemblage is intruded by the post-tectonic Bow Lake batholith.

Metamorphic mineral assemblages indicate middle greenschist-facies regional metamorphism, although amphibolite-facies assemblages are developed in the thermal aureoles of the Neoarchean plutons. Overprinting relationships described by Young et al. (2006) indicate a relatively simple deformation history. A regionally pervasive and penetrative planar shape fabric, which is oriented subparallel to bedding and the general trend of the supracrustal belt, is assigned to the D2 deformation phase (Young et al., 2006). In the northern portion of the belt, the S2 fabric dips steeply northwest and is axial planar to tight to isoclinal, moderately to steeply-plunging, F2 folds. This fabric also contains a variably developed L2 stretching lineation that plunges steeply to the northeast or north-northeast.

Local geology

Bedrock exposures in the footwall of the Thierry deposit consist mainly of pillowed mafic flows and intercalated flow-breccia, with subordinate mafic intrusions. The mafic flows weather greenish-grey to black and are fine-grained, aphyric and non-amygdaloidal. Well-preserved, bun-shaped to amoeboid pillows range up to 1.5m in maximum dimension, with 1–2cm thick selvages. Interpillow material consists mainly of strongly recrystallized and altered hyaloclastite. On the southwest margin of the East pit, individual pillowed flows range from 1 to 5m thick and are intercalated with similarly-thick units of monolithic mafic breccia and pillow-fragment breccia. The subvertical flow contacts trend roughly north and a pillow cusp in one location indicates tops to the east.

In this location, the mafic volcanic rocks are intruded by minor dikes and sills of medium to coarse-grained gabbro/pyroxenite. In the largest of these intrusions, leucogabbro, melagabbro and pyroxenite exhibit highly contorted and locally gradational contact relationships that are suggestive of magmatic-mixing.

In the hanging wall of the Thierry deposit, on the northwest margin of the East pit, bedrock exposures exhibit significantly higher finite strain than those in the footwall. Along the northwest edge of the open pit, most outcrops consist of strongly foliated mafic tectonites, which appear to be derived from pillowed mafic flows and flow-breccia, with subordinate intercalations of sedimentary rocks. Individual pillows are typically strongly flattened and attenuated, although convincing, bun-shaped examples of pillows are observed locally. Intercalated mafic breccia layers tend to be more strongly tectonized than the pillowed flows, and locally exhibit moderate to strong epidote- calc-silicate alteration. Layering in these rocks dips moderately to steeply northwest. Mafic sills and dikes are abundant and consist mainly of medium-grained equigranular leucocratic and mesocratic gabbro.

On the northwest flank of the East pit, the mafic volcanic and intrusive rocks are structurally overlain to the north by a 10–20m thick unit of well-layered chloritic tectonite, which appears to have been derived from stratified mafic to intermediate volcaniclastic rocks. These rocks are weathered dark green to light grey and are fine-grained, chloritic and feldspathic.

Mafic tectonites in the hanging wall of the Thierry deposit are intruded by fine-grained, late- to post-tectonite felsic dikes that weather pale brown and contain sparse quartz and feldspar phenocrysts.

Structural geology

Overprinting relationships in a single outcrop of pillowed basalt in the area roughly midway between the fenced shaft and West pit indicate at least three generations of ductile deformation fabric. In this outcrop, an early penetrative planar fabric that trends generally north is defined by foliated chlorite and amphibole, and a variably developed tectonite layering. This early fabric is overprinted by open to tight, symmetric to Z-asymmetric folds that trend northeast and plunge steeply to the north. These folds are, in turn, transected by a finely-spaced crenulation cleavage that dips subvertically and trends east-northeast.

Although these relationships clearly indicate three generations of ductile deformation, the available information is insufficient to determine the relationship (if any) of these structures to those observed in the East and West pits, or their significance with respect to the regional deformation history described by Young et al.

(2006). It is noteworthy however, that the overall style, orientation and sequence of deformation structures observed in these outcrops correspond closely to structures assigned to the regional D1, D2 and D3 deformations by Young et al. (2006).

As described above, finite strain appears to be considerably lower in the footwall of the Thierry deposit, as compared to the hanging wall. The stratification observed in the outcrops of pillowed mafic flows and breccia on the south margin of the East pit trends generally north, at a high angle to the strike of the mineralized zone. Open to tight, west-trending folds, such as those observed south of the West pit, could account for this marked obliquity. In this regard, it is possible that the localization and orientation of the shear zone that hosts the Thierry deposit was controlled by the axial surfaces or limbs of pre-existing, west-trending fold structures. Alternatively, the obliquity could simply result from progressive folding along the margins of the mineralized zone during shearing, in which case the strata further down in the footwall would be expected to gradationally change orientation into the more regional easterly trend.

As described previously, rocks in the hanging wall of the deposit consist mainly of variably tectonized mafic volcanic rocks. The tectonite fabric in these rocks consists of both planar and linear fabric elements. The planar fabric element dips steeply to the north-northwest or northwest and is defined by flattened primary features (e.g., pillows, clasts), transposed veins and primary layering, and foliated chlorite and amphibole.

The linear fabric element is defined by aligned hornblende porphyroblasts, rare quartz ribbons and, in the mafic intrusions, aligned aggregates of amphibole and chlorite that likely represent pseudomorphic replacements after primary pyroxene phenocrysts. Some of these rocks approach pure L-tectonites. On the northwest margin of the East pit, the L-fabric plunges 65o towards the north. On the east flank of the East pit, the L-fabric plunges 40o toward the northwest.

Asymmetric boudins and shear bands are abundant on horizontal outcrop surfaces and consistently indicate dextral shear. Tectonite zones exhibiting well-developed kinematic indicators on horizontal outcrop surfaces and steeply plunging stretching lineations are a common feature of the generally east-trending greenstone belts in the Superior Province. Such features can be interpreted in terms of two distinct generations of structure (e.g., early vertical stretching overprinted by transcurrent shearing), or a single generation of structure formed during progressive deformation within a transpressional shear zone (i.e., a shear zone with a significant component of zone-normal shortening). In the present case, the available data is insufficient to differentiate between these, or other, possibilities.

The tectonite fabric is overprinted by at least two generations of folds, which are particularly well-developed in the layered mafic to intermediate tectonite on the northwest margin of the East pit. The earlier folds are open to tight, strongly asymmetrical, similar-style structures. The fold hinges plunge moderately to steeply toward the northwest or north. Z-asymmetrical folds predominate over S-folds, although both are observed in single outcrops. This opposing vergence is consistent with the local occurrence of sheath-like fold closures. A sheath-fold interpretation for these closures is supported by the fact that the fold hinges are oriented subparallel to a locally observed quartz-ribbon lineation and the more extensively-developed L-fabric in the underlying mafic tectonites.

The presence of steeply plunging sheath folds and stretching lineations in the mafic to intermediate tectonite indicates a significant component of dip-slip shear, in apparent conflict with the abundance of dextral kinematic indicators on the horizontal outcrop surfaces. Although such features are not inconsistent with transpressional shear zones, they may be more readily interpreted in terms of a two-stage deformation history involving early dip-slip shear, overprinted by later strike-slip (dextral) shear. Such complex deformation paths would have important implications for the localization and geometry of Cu-Ni ore bodies in the Thierry deposit (see below).

The tectonite fabric and early asymmetrical folds are overprinted by gentle to open, upright folds with steeply plunging hinges and northwest-trending axial planes.

In the mafic tectonite, the mineral assemblage appears to comprise chlorite, hornblende, feldspar, epidote, biotite and quartz, consistent

with upper greenschist- to amphibolite-facies metamorphism. Hornblende porphyroblasts are strongly aligned in the planar shape-fabric, and locally define a penetrative mineral lineation that plunges parallel to the stretching lineation. In one location, hornblende porphyroblasts are also randomly oriented within and across the planar shape-fabric, suggesting that hornblende growth outlasted penetrative ductile deformation.

In the western portion of the large stripped outcrop on the northwest flank of the East pit, the mafic tectonites are cross-cut by a series of widely-spaced, discrete, brittle-ductile faults. These faults dip steeply toward the north-northeast and are defined by very planar slip-surfaces that sharply truncate the tectonite fabrics in the wall-rocks. The faults contain narrow (<20cm), laminated fault-fill quartz veins which locally widen into more irregular quartz breccia veins. Oblique internal fabrics in the laminated portions of the veins indicate dextral strike-slip shear. The most significant of these faults contains narrow, discontinuous veins and irregular blebs of remobilized chalcopyrite with minor pyrrhotite.

Discrete shear-fractures and faults locally form complex, diffuse networks within, and along the margins of, the zone of mafic-intermediate tectonite, and are particularly well-developed in the massive, equigranular gabbro sills. Asymmetric fabrics and minor offsets of the main tectonite fabric consistently indicate dextral strike-slip shear. The shear fractures dip steeply to the north and northeast, and appear to define a Riedel-type shear-fracture system to which the brittle-ductile faults described above may be related. Riedel-type systems comprise multiple orientations of synthetic and antithetic shear factures that, in a strike-slip system, will exhibit a common, sub-vertically plunging line of intersection. Orebodies overprinted by these types of shear-fracture systems would be expected to exhibit significant structural complexities.

Host-rocks to mineralization

Identification of primary rock-types in the examined intervals of mineralized drill core from the Thierry deposit is significantly complicated by the combined effects of intense metamorphic recrystallization, penetrative deformation and local hydrothermal alteration, which have obscured or destroyed primary textures. Patterson and Watkinson (1984) describe the host-rocks as consisting of 75% metagabbro, 20% mafic metagabbro and 5% talc-carbonate schist, and provide convincing textural evidence of a peridotitic to dunitic protolith for the talc-carbonate schist. Novak and Mlot (2004) cite previous drill-log descriptions of chemical sedimentary rocks in the mine sequence, which were not described by Patterson and Watkinson (1984).

The rock-types tentatively identified by this author in the mineralized drill cores from the Thierry deposit include possible chemical or siliciclastic sedimentary rocks, ultramafic intrusive rocks, and mafic intrusive/extrusive rocks.

The possible ultramafic rocks are dark green to black, fine- to medium-grained and equigranular, and composed almost exclusively of chlorite (±carbonate, talc, serpentine and amphibole).

The possible sedimentary rocks are light to dark grey or reddish-brown, fine-grained, siliceous and biotitic, and typically exhibit a finely laminated to layered structure. Evidence of intense transposition is provided by the common occurrence of tight to isoclinal, strongly asymmetric and rootless folds. From the descriptions in Patterson and Watkinson (1984, p.4), Novak and Mlot (2004), Keller (2005) and Puritch et al. (2006), it seems likely that most of these rocks were previously described as 'mylonite' or 'chlorite-biotite schist', with the implication that they were derived through intense deformation and hydrothermal alteration of mafic or ultramafic intrusive precursors. However, this interpretation appears inconsistent with the observation that these rocks commonly lie in very sharp contact with ultramafic and mafic intrusive rocks that lack mesoscopic deformation fabrics, which would require very abrupt strain-gradients from the mylonite into the precursor rocks.

The gabbro is fine- to medium-grained and typically massive and equigranular, with a weak to moderate foliation defined mainly by chlorite. Leucogabbro grades continuously into melanogabbro, consistent with the descriptions of Patterson and Watkinson (1984), and the occurrence of possible magma-mixing textures in gabbro exposed on the south margin of the East

pit.

Blocky, relatively undeformed inclusions of melanocratic gabbro in the layers of possible sedimentary origin are tentatively interpreted as gabbro dikes that underwent boudinage and segmentation during intense transposition of the host-rocks. Unless the host-rocks were significantly strained prior to emplacement of the gabbro dikes, the relatively undeformed aspect of the boudins would tend to support a sedimentary, rather than tectonic, origin for the fine-grained and laminated aspects of biotitic layers.

Styles of mineralization

Patterson and Watkinson (1984) describe four types of sulphide ore in the Thierry deposit: breccia ore, mylonite ore, bornite ore and disseminated sulphides. Novak and Mlot (2004) propose a similar classification, but instead refer to the mylonite ore as 'chlorite-biotite schist' ore and include an additional, poorly defined, 'oxidized' ore-type.

"… sulphide mineralization in the Thierry deposit is subdivided on the basis of texture into disseminated, matrix-textured, net-textured and breccia styles. It is recommended that the terms 'mylonite' or 'chlorite-biotite schist' should be avoided, as these describe only the host-rocks to the sulphide mineralization, not the mineralization proper…"

Disseminated mineralization consists of isolated, monomineralic to polymineralic grains of pyrrhotite (po), chalcopyrite (cp) and/or pentlandite that typically do not exceed 2mm across and are evenly distributed throughout the host-rock. Typically, this style of mineralization contains less than 5% total sulphide. Disseminated mineralization is observed in ultramafic and mafic rocks of inferred intrusive origin, and has been interpreted to represent recrystallized primary magmatic sulphide (e.g., Patterson and Watkinson, 1984). It should be noted however, that disseminated sulphides are also locally observed in the finely laminated rocks of possible sedimentary origin, indicating that alterative mechanisms may be required to explain at least some of this mineralization.

Matrix-textured mineralization consists of blebs and irregular veinlets of [chalcopyrite] and [pyrrhotite] that form the matrix to equant to irregular-shaped fragments or grains of silicate gangue. This style of mineralization typically contains 5 to 10% total sulphide.

Net-textured mineralization consists of irregular, inter-connected veinlets of [chalcopyrite] and [pyrrhotite] which surround fragments or grains of silicate gangue. Typically, this style of mineralization contains 10 to 25% total sulphide and, with increasing sulphide content, grades into breccia mineralization.

Breccia mineralization consists of near-solid (50-80% total sulphide) to solid (>80% total sulphide) [chalcopyrite] and [pyrrhotite] that contains angular to sub-rounded inclusions of wall-rocks or other silicate gangue. Breccia mineralization tends to form discrete, relatively sharp-walled veins that are apparently controlled by irregular fracture arrays in relatively undeformed (i.e., weakly to non-foliated) wall rocks. These veins may result from ductile flow of sulphides during deformation (i.e., piercement veins) or fluid-state remobilization during, or subsequent to, deformation (e.g., Gilligan and Marshall, 1987). The breccia veins typically do not exceed 50cm in maximum thickness, and are composed mainly of [chalcopyrite], with subordinate to subequal [pyrrhotite]. Some veins exhibit a marked segregation of [pyrrhotite and chalcopyrite].

Late-tectonic emplacement of the breccia veins is indicated by their relatively undeformed state, and the local presence of multiphase deformation structures in wall-rock inclusions. In addition, breccia mineralization is observed to discordantly cut tight to isoclinal folds in the laminated rocks of possible sedimentary origin, indicating emplacement subsequent to development of the intense transposition fabrics. These aspects, coupled with the relatively fine-grained, non-annealed nature of the breccia mineralization indicate emplacement late in the tectono-thermal evolution of the host-rocks.

Nevertheless, some of the breccia veins do preserve evidence of a more protracted, multiphase emplacement history. One of the breccia veins intersected in DDH PGM 05-60, for example contains two generations of breccia mineralization. In this vein the early generation of breccia is inclusion-poor and distinctly layered and is sharply cross-cut by a later generation of

relatively massive and inclusion-rich breccia.

Although most examples of breccia mineralization are relatively undeformed, some exhibit evidence of ductile and brittle-ductile deformation, in the form of a moderate to strong planar fabric defined by aligned inclusions of silicate gangue. This mineralization is appropriately referred to as 'durchbewegt' (Marshall and Gilligan, 1989). In [one] example…the ductile fabric is cross-cut by en-echelon arrays of [chalcopyrite]-filled extension veins (i.e., tension-gashes).

Puritch et al. (2012) provided another synopsis of copper-nickel-PGE mineralization at the Thierry Deposit:

"Mineralization at the main Thierry and adjacent K1-1 deposits, is more or less coincident with what is best characterized as a chlorite-biotite-hornblende altered mylonitic shear zone (the "CBS shear zone"). The shear zone extends across the ultramafic intrusive along a strike length of about one kilometre and a width up to 50m. Within the shear zone mineralization is hosted by highly schistose rocks containing stringer sulphides to less schistose ultramafic rocks containing massive stringers or veins and disseminated sulphides. Primary sulphides, listed in approximate order of decreasing abundance are pyrrhotite, chalcopyrite, pyrite and pentlandite. Cubanite, bornite, magnetite and minor ilmenite have also been identified. Violarite and mackinawite have developed from alteration of pentlandite.

Outside of the main mineralized zone, chalcopyrite and bornite occur as stringers as well as finely dissemination sulphides. Bornite is commonly associated with carbonate and quartz veins. Oxidized mineralizations are reported to contain violarite, millerite and bornite.

Copper-nickel-PGE mineralization at the Thierry and K1-1 deposits is hosted within a highly deformed and altered ultramafic sequence. Copper-nickel-PGE mineralization consists of:

- *Sulphide matrix breccia;*
- *Blebs and small stringers, occasionally net textured sulphides; and*
- *Disseminated sulphides.*

The sulphide mineral assemblage consists of chalcopyrite, pyrrhotite, pentlandite and pyrite.

Four principal types of sulphide mineralization are recognized at the Thierry Deposit (Patterson and Watkinson, 1984) with Patterson (1980) noting a fifth:

- *Breccia Mineralization: 40% of all mineralized rock and composed of 20-30% sulphide, consisting of rounded to angular fragments of gangue in a matrix of chalcopyrite, pyrrhotite, pyrite and pentlandite. Breccia mineralized rock grades into CBS mineralized rock.*
- *Chlorite-Biotite Schist Mineralization (mylonitic mineralization): 56% of all mineralized rock (CBS ore), containing 5-20% sulphide as stringers of chalcopyrite, pyrrhotite, pentlandite and pyrite; the stringers parallel foliation and where gradational with breccia mineralized rock, the breccia fragments are flattened and elongated.*
- *Bornite Mineralization: 2% of all mineralized rock, containing 1-5% sulphide as stringers and disseminations of chalcopyrite and bornite in carbonate veins associated with blocks of amphibolite schist in the main shear zone.*
- *Primary Disseminated Sulphide Mineralization: 1% of all mineralized rock, occurring as blocks of chalcopyrite (with exsolution of bornite or cubanite) plus pyrrhotite and pentlandite between remnants of olivine.*
- *Oxidized Mineralization: 1% of all ore comprised of several varieties of ore, characterized by violarite, millerite, bornite etc.*

The mylonite and breccia mineralization has a copper-to-nickel ratio of 8:1, compared to a 2:1 ratio in the disseminated sulphides. In addition, the chalcopyrite:pyrrhotite ratio is approximately 1:1 in the mylonite mineralization and 1:10 in the disseminated sulphides (Patterson, 1980).

Precious metal minerals have been found in the Thierry Deposit in two distinct associations:

- *In the breccia mineralization, the precious metal minerals merenskyite, moncheite, stutzite and an unnamed mineral Ag3BiTe3 occur with chalcopyrite, pyrrhotite. pentlandite, pyrite and violarite.*
- *In the bornite mineralized rock, the precious metal minerals, native silver, acanthite, stutzite and merenskyite are associated with chalcopyrite,*

bornite and copper bismuth sulfosalt (wittichenite and emplectite).

The strongest positive correlation of metals is between silver and copper. There is a corresponding negative correlation between silver and nickel at values of nickel greater than 0.5%. A plot of Pt/(Pt+Pd) versus Cu/(Cu+Ni) shows average head grades of the Thierry Deposit to be enriched in copper and somewhat in platinum relative to other similar deposits (Naldrett and Cabri, 1976). From a PGE perspective the Thierry mineralization falls into two groups, both of which fall well off a characteristic trend line defined by Naldrett and Cabri (1976) for typical PGE ores. The first group is pyrrhotite-rich and correspondingly has a high Ni content. This group is platinum poor compared to the second Cu-rich, chalcopyrite rich fraction which has a high platinum content.

Ores at the Thierry Deposit underwent intense modification after their initial deposition as magmatic sulphides. Dynamic metamorphism has mobilized much of the breccia and mylonite mineralization.

Sub-Stop Descriptions, Thierry Mine (Fig. 7)

Geochemical sampling and analyses conducted by Young (2003) ascribed all the mafic metavolcanic rocks along the Thierry Mine access road (STOP 2a) and at the mine site (Stops 2b to 2f) to the tholeiitic Suite I Upper Sequence of the Pickle Lake assemblage, correlative with Suite I of Hollings (2002). These basalts are characterized by unfractionated or weakly depleted light REE and mildly fractionated heavy REE (La/Sm_{pm} = 0.70–1.5; Gd/Yb_{pm} = 1–1.2).

Stop 2a: Mafic Metavolcanic Rocks, south of K1-1 Zone, south side of Thierry Mine access road

UTM Coordinates: NAD83; 15U 0687610 E / 5709480N

This stripped area exposes strongly sheared amphibolitized and epidotized mafic metavolcanic rocks south of the K1-1 mineralized zone (Fig. 8). Metre-scale M- and S-folds are visible, as are boudinaged or ptygmatically folded felsic dykelets and quartz veins. A pervasive, sub-vertical foliation strikes 090° and is also locally folded. Millimetre-scale shear bands and spaced cleavages are ubiquitous. Disseminated pyrite generates localized gossan. No primary features are noted in these metavolcanic rocks.

Stop 2b: Thierry Mine, open pits; pillowed basalt, south of the West Pit

UTM Coordinates: NAD83; 15U 0684010E / 5708540N

Outcrops north of the exploration office and near

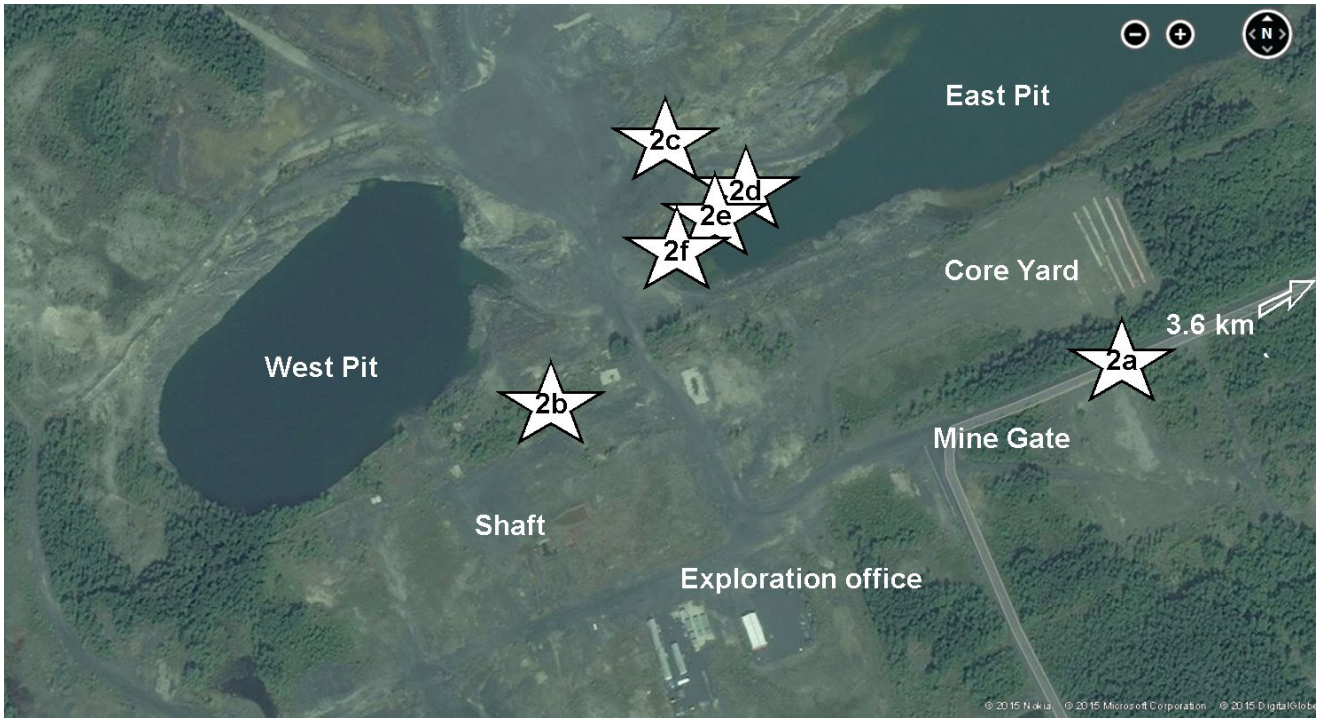


Figure 7. Field trip stop locations, Thierry Mine Property.

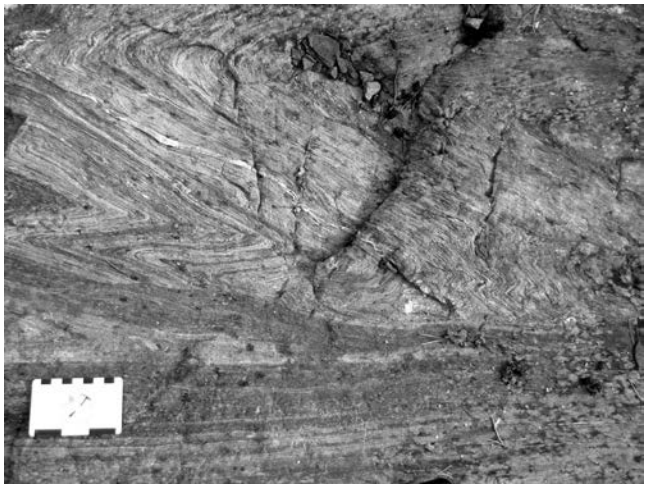


Figure 8. Sheared and folded mafic metavolcanic rocks, Stop 2a, Thierry Mine access road.

the capped shaft and vent raises expose sheared and locally pillowed mafic metavolcanic rocks with pervasive epidote veins and patches and ptygmatically folded quartz-feldspar-epidote veins. Flattening and stretching have produced pillow aspect ratios of up to 10:1, molar-shaped pillows and preclude unequivocal "tops" direction determination. Pillows have dark, chlorite-, biotite- and amphibole-rich selvages and variably bleached cores (Fig. 9). Foliations in this area are more-or-less east-striking and have variable dips. Felsic dykes may be discordant to foliation or may be sheared and Z-folded, suggesting a protracted intrusion history.

Recognizable pillowed basalt gives way to strongly foliated, phyllitic, amphibolitic equivalents closer to the southern margin of the west pit. The access ramp at THE southeastern end of the West Pit provides a cross-section through these phyllitic rocks, dipping circa



Figure 9. Deformed pillowed basalt flow, south of West Pit, Thierry Mine (Stop 2b).

(ca.) 50° north. Local malachite staining was noted in some of the feldspathic neosome of some of the banded amphibolite. An ~100m wide deformation zone (aka CBS Shear Zone) extends through the middle of the West Pit. In the West Pit, the main mineralized zone is situated on the southern margin of the deformation zone. Around the margins of the pit, contacts are exposed between phyllitic mafic metavolcanic rocks and weakly foliated, synvolcanic (?) gabbroic rocks. These gabbroic rocks are thought to host the bulk of the Thierry mineralized zone at depth, whereas chlorite-biotite schist hosts the mineralization at surface to shallow levels of the mine (A. Carlson, Richview Resources Inc., pers. comm., 2008). Minor fold axes are generally northeast-plunging, as are ore shoots within the main mineralized zone. Steeply plunging stretching lineations are evident on foliation planes.

On the eastern margin of the West Pit, massive mafic metavolcanic rocks locally host a chloritic, 110°-striking cataclasite unit which may offset the mineralized zone between the West and East pits. Biotite schist is locally developed along the contacts with gabbroic units.

Stop 2c: Thierry Mine, open pits; sheared Basalt and Gabbro, north of East Pit

UTM Coordinates: NAD83; 15U 0684107E / 5708717N

Sharp contacts between sheared, locally laminated basalt and medium- to coarse-grained gabbro are well-exposed on these glacially polished exposures north of the western end of the East Pit and just east of the road that extends between the two pits.

Stop 2d: Thierry Mine, open pits; mafic dyke in sheared basalt, north of East Pit

UTM Coordinates: NAD83; 15U 0684140E / 5708686N

Stop 2e: Thierry Mine, open pits; "ribboned" basalt, north of East Pit

UTM Coordinates: NAD83; 15U 0684122 / 5708670N

Sheared amphibolite/pillowed basalts predominate north of the East Pit and in some places are highly stretched and ribboned. Felsic dykes are folded and millimetre-scale shear bands are developed in sheared intermediate dykes. A distinctive, 25cm-wide dyke, hosted in amphibolite, is characterized by numerous, rounded granitoid xenoliths (Fig. 10).

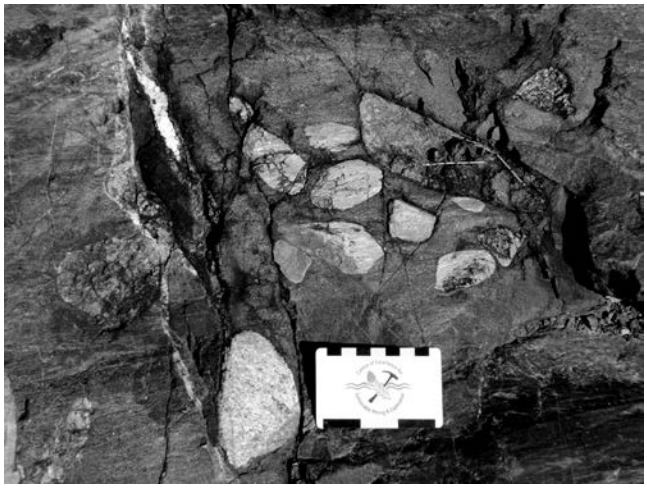


Figure 10. Mafic dyke with rounded granitoid clasts in deformed metabasalt, north of West Pit, Thierry Mine (Stop 2d).

Stop 2f: Thierry Mine, open pits; "breccia ore", northwestern end of East Pit

UTM Coordinates: NAD83; 15U 0684086E / 5708638N

At the northwestern end of the East Pit a rusty, malachite-coated exposure displays chalcopyrite- and pyrrhotite-rich, "breccia ore"-style-mineralized zones that crosscut folded metavolcanic rocks. Host rocks are well-foliated and resemble the main chlorite-biotite schist host to sulphide mineralization. Small, lenticular "islands" of more competent or xenolithic (?) material are enveloped by schistose rocks. Felsic dykes are dismembered.

Stop 3: Pickle Crow Mine

(N.B. permission to access the site must be granted by PC Gold Inc.)

The Pickle Crow Mine was discovered in the early 1930's by Northern Aerial Mineral Exploration which began sinking the No. 1 Shaft in 1933. Northern Aerial was acquired by Pickle Crow Gold Mines (PCGM) in 1934 and commercial production at the mine began in 1935. The Pickle Crow mine operated until 1966, during which time it produced 1,446,214 troy oz gold and 168,757 troy oz silver from 3,070,475 short tons of ore milled (at an average grade of 0.47oz/t or 16.14 g/t Au).

After the mine closed in 1966 there was little work done until Highland Crow/Noramco Mining Corporation acquired the property in the 1980's. Noramco completed over 46,000m of surface drilling, dewatered the mine workings to the 750 foot level, and completed an additional 9,000m of underground drilling. With the end of the flow-through era the property sat dormant until Wolfden Resources Inc. acquired the property in 1999. Wolfden subsequently entered into a surface mining agreement (top 100m of the deposit) in June, 2000 with privately held Cantera Mining Limited, resulting in fragmentation of the property ownership. Cantera constructed a 225 ton per day (tpd) extreme gravity mill on the site, submitted a partially completed production closure plan with MNDM, and began constructing a tailings management facility within the historic Pickle Crow tailings area. Cantera also commenced stockpiling of material mined from the historic No. 1 Vein shaft and crown pillar area. Cantera ceased work in 2002 and was placed into receivership in 2004.

On November 5, 2007, Premier Gold Mines (successor to Wolfden) and Don Ross (successor to Cantera) announced the signing of a Letter of Intent (LOI) to sell their interests in the property to PC Gold, at that time a private company. A definitive agreement was signed on December 21, 2007. On May 13, 2008 PC Gold satisfied the terms of the definitive agreement and completed the acquisition by completing an initial public offering and listing on the TSX.

PC Gold Inc. has been actively exploring the Pickle Crow property since 2008. The mineral concessions of the Pickle Crow project consist of 106 patented mining claims and 119 unpatented claims for a total area of approximately 21,690ha. Since acquiring the property PC Gold has completed a massive program of digitizing historical data and building a detailed 3D model of the mine and surrounding property. PC Gold has to date has completed 98,000m of drilling, as well as several trenching, mapping, and geophysical programs. Most recently, PC Gold has been pursuing financing for small-scale production using the onsite 225tpd mill with ramp access on the near surface, high-grade No. 22 and 23 veins.

The Pickle Crow deposit currently hosts an NI43-101-compliant inferred resource of 1.3 million ounces, including 637,000 high-grade vein-hosted ounces at an average grade of 9.1g/t Au.

Local Geology

Many geological investigations have been completed on the Pickle Crow Property (Fig. 11). Detailed rock descriptions on a property scale have been completed by Thomson (1939), Pye (1956, 1975), Ferguson (1966), and MacQueen (1987). Other workers, such as former PCGM employees R. J.

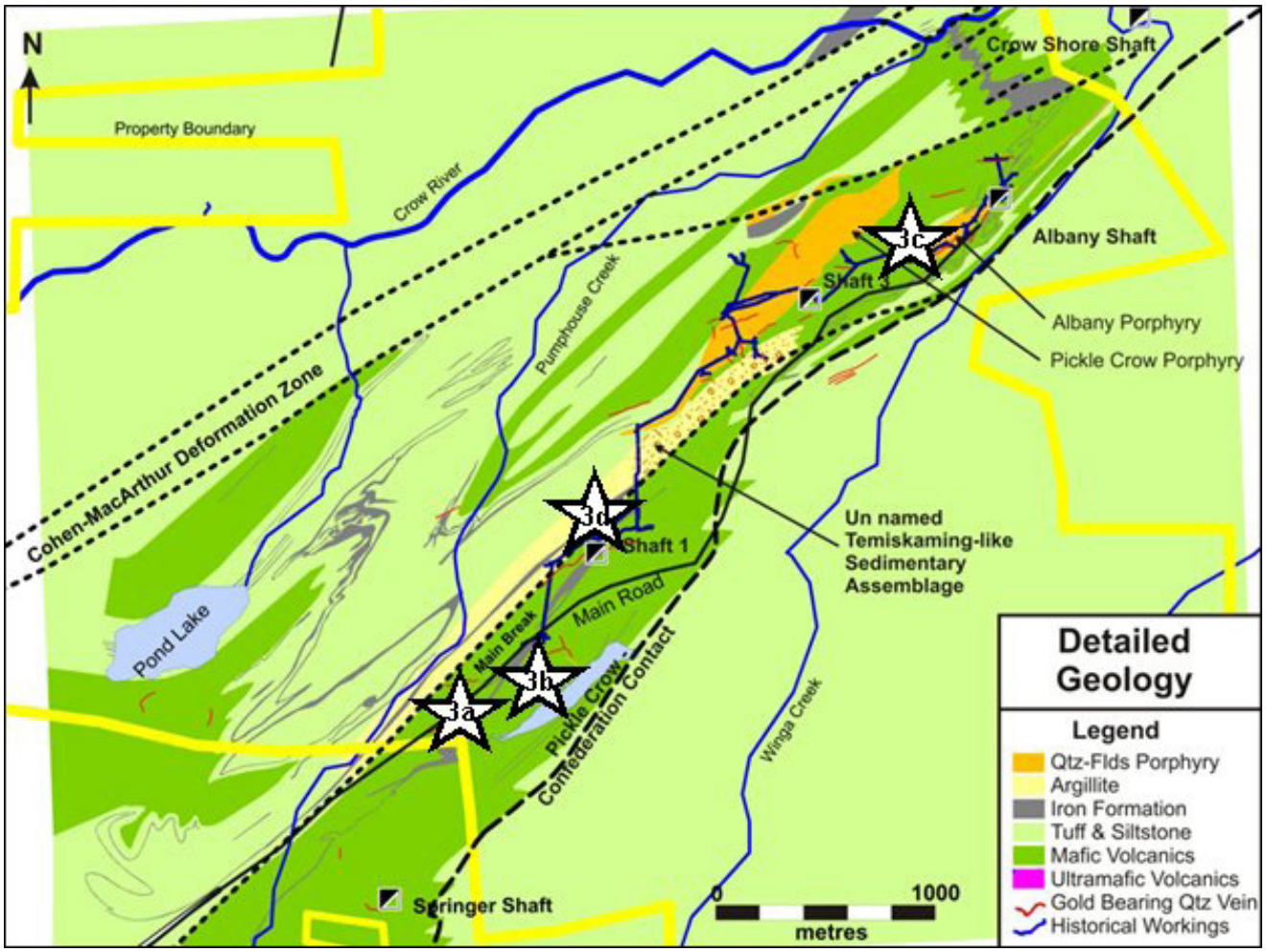


Figure 11. General geology of the Pickle Lake Mine area, showing Field Trip Stop locations.

Graham and L. D. S. Winter, wrote unpublished reports that contain much valuable information. The following descriptions of the geological units of the Pickle Crow Property are derived from the detailed, property-scale work referenced above, and placed into the tectonic-stratigraphic framework of Young et al. (2006).

The Pickle Crow Property in the immediate vicinity of the mine is underlain by rocks of both the Pickle Crow and Confederation assemblages; rocks of the Kaminiskag assemblage occur to the east. On the property, the Pickle Crow assemblage is dominated by tholeiitic basalts with intercalated sedimentary rocks, primarily banded iron-formation (BIF), and rare calc-alkaline volcanic and volcaniclastic units. The assemblage is interpreted to be unconformably overlain by the Confederation assemblage.

An unnamed, Temiskaming-like sedimentary assemblage was identified and dated (<2752.2±2Ma) by PC Gold in 2009 and comprises polymictic conglomerate, sandstone, siltstone, argillite, and argillaceous iron formation. The assemblage occupies a small, fault-bound basin near the contact between the Pickle Crow and Confederation assemblages, and likely represents the erosional unconformity between the two assemblages. The assemblage appears to represent a similar event to that which produced the Houston Lake assemblage of the nearby Red Lake greenstone belt.

Pickle Crow Assemblage

Rare ultramafic rocks (>20 wt% MgO) were noted in drill core, particularly in deep drilling in holes PC-08-014A and PC-10-085 at Shaft 1 and 3, respectively. These units are typically 5 to 20m thick and are intensely talc-altered, sometimes presenting a severe obstacle to drilling. Due to their alteration and deformation, the protolith cannot be accurately determined. No relict spinifex texture has been observed. These ultramafic units are always found intercalated with tholeiitic basalt and are currently interpreted to represent sub-volcanic sills.

The tholeiitic lavas are compositionally consistent; no flows of intermediate composition have been noted.

Greenish-grey-weathering, massive basalt is generally fine-grained. Although pillowed units are ubiquitous, it has not been possible to subdivide or map individual flows. Some flow contacts are marked by beds of iron formation. Pillows range in size from 0.5 to 1m and have narrow selvages ~1cm thick. Generally, there are no amygdules in the pillows. They display a variety of shapes and in only a few places on surface has it been possible to make top determinations. Flow-top breccias locally contain light-coloured, angular fragments up to 30cm in diameter.

Parts of the flows are medium-grained with individual crystals up to 1.5mm in diameter. These rocks are of medium-grey colour with small light grey feldspars. All these medium-grained rocks have been included with the volcanic rocks and no dykes or sills have been mapped separately on surface. The medium-grained metabasalts consist essentially of fibrous amphibole, chlorite, and highly altered plagioclase with small amounts of carbonate, epidote, saussurite, and quartz, and subordinate leucoxene, apatite, sphene, and sometimes pyrrhotite (Pye, 1956).

One main band of banded iron formation (BIF) is known to be interbedded with the basalts adjacent to the workings of the Pickle Crow Mine but, in places, there are additional local bands. This BIF has been traced in the Shaft 1 area by surface mapping and by drilling for 2700m and ranges in thickness from ~1m up to 25m or, where it has been thickened by folding, to ~45m. In the No. 1 Shaft workings the BIF is known to extend down-dip for 1200m and is thought likely to persist to much greater depths.

Magnetite-carbonate BIF is prominently banded with alternating layers, varying in thickness from thin laminae up to 5cm. The more siliceous layers may be light or dark grey, laminated chert. No jasper bands are known to be present. Some of the darker layers contain a high proportion of magnetite but the magnetite content varies along strike; consequently, magnetic surveys have been only partially successful in tracing these beds. The weathering of some BIF produces a rusty iron oxide alteration. This variety of BIF consists of bands of cryptocrystalline quartz and siderite, varying amounts of magnetite and pyrrhotite, and occasional streaks of chlorite (Hurst, 1931). Some of the bands are composed almost wholly of magnetite in small, angular grains. Pyrrhotite occurs as patches, streaks, or grains replacing iron carbonate and chlorite or as veinlets traversing the various bands. Streaks of chlorite, which probably represent inclusions of schistose greenstone, are often associated with the carbonate bands.

Carbonate (ankerite) BIF is exposed in outcrops and old trenches on Pickle Crow claims PA774 and 777 in the Cohen-MacArthur area. This BIF is ~550m in length, with thicknesses up to 10m and has sharp contacts. Limonite from the weathering of this BIF has stained adjacent host rocks. At the northeastern end of this zone some outcrops are typically BIF but elsewhere, the more siliceous bands do not weather in relief and the weathered surface of the rock has a uniform surface. The fresh surface of the rock varies in colour from light to dark grey and some specimens of this BIF are very hard and siliceous.

Sulphide-chert-rich argillaceous BIF is abundant in the Central Pat East Zone where it typically occurs as interbedded, magnetite-poor, chert-rich BIF and sulphide-rich (pyrite) argillite with minor intermediate tuff. Thin section work (Kolb, 2011) indicated that this BIF is also very carbonate-rich. Although extensive, this BIF displays great local variation in thickness and type (e.g. oxide- versus sulphide-facies). It is not well-exposed at surface and is known almost entirely from diamond drilling.

The Pickle Crow assemblage contains significant amounts of calc-alkaline rocks. Although rare in the core mine trend, dacites are the most common rock type outside of it. Most units are lenticular and in cannot be easily correlated between adjacent outcrops. The presence of beds containing breccia fragments is a widespread and characteristic feature. There is no known interbedding between the basic metavolcanic rocks and the acid to intermediate metavolcanic rocks. In places, the contact is marked by interbedded sedimentary rocks. Feldspar-phyric dacite occurs in the northwestern part of the property, often in tuff-breccia units. Such rocks outcrop, or have been recorded in drill core, in the area between the No. 1 Shaft and Powderhouse Lake. Quartz–phyric rocks are very rare, but have been reported in the Central Pat East Zone.

Although portions of the local Temiskaming-like sedimentary assemblage, notably the argillite and conglomerate, had been reported historically (Graham, 1965) it was not recognized as a separate unit from the Pickle Crow assemblage until 2009 (Lynch, 2010). The sedimentary basin is quite restricted in its dimensions extending from just northeast of Shaft 3 (hole PC-09-050) to just north of the Springer Shaft. The unit appears to be a fault-bound basin that contains polymictic conglomerate at its northeastern end, grading into fine-grained wacke, siltstone, argillite, and argillaceous

BIF to the southwest. The assemblage is particularly pyrite-rich, specifically the conglomerate (interstitial pyrite) and argillite (bedded nodular pyrite). Locally, this pyrite has been remobilized and converted to pyrrhotite, especially in the conglomerates.

The Confederation assemblage unconformably overlies the Pickle Crow assemblage on the property and includes:

- The lowermost basaltic unit.
- A thick succession of intermediate to felsic metavolcanic rocks in the southeastern part of the property.

A thin, discontinuous unit of pillowed basalt occurs at the base of the Confederation assemblage and is distinguished from the lower sequence of the Pickle Crow assemblage on the basis of trace element geochemistry. This lower basalt unit, or geochemical Suite I, is characterized by elevated FeO contents (13 to 16 wt%) and displays weak LREE enrichment and HREE fractionation with minor negative niobium anomalies (Young et al., 2006).

The southeastern part of the property is underlain by calc-alkaline felsic to intermediate volcanic and volcaniclastic material that is similar in most respects to the calc-alkaline rocks in the Pickle Crow assemblage. Feldspar-phyric dacite and related breccias predominate and are both widely distributed in this part of the Pickle Crow Property. The dacites contain feldspar, quartz, and sericite together with minor amounts of chlorite, epidote and leucoxene (Pye, 1956; Ferguson, 1966). The dacite breccias contain scattered, light-coloured angular felsic fragments, usually less than 5cm in maximum dimension. Near the eastern boundary of the property the fragments in the volcaniclastic rocks are rounded and were termed “agglomerate” or “volcanic conglomerate” by Thomson (1939).

There are two porphyry stocks and several porphyry dykes within the property boundaries. The Pickle Crow porphyry stock occurs northwest of No. 3 Shaft and the Albany River porphyry stock outcrops near the Albany shaft. Dikes have been mapped on claims PA729, 1139 and 2011 (Ferguson, 1966).

The Pickle Crow porphyry (2909+15Ma; Young et al., 2006) is elliptical in plan, 1.8km long and 200m wide. The major axis strikes 055° and appears to be generally conformable in strike and dip with the enclosing rocks. But, on the 229m (750ft) level plan it is shown to crosscut the trend of the volcanic units at a small angle. The complete outline of the stock has not been established on the 869m (2850ft) level, but over this vertical distance the porphyry appears to maintain its shape, becomes slightly wider, dips at 77° to the northwest, and does not appear to plunge. A few porphyry dykes or sills are present near the stock but the outline is regular, without apophyses extending outward from the main intrusion. On the 229m (750ft) level the southern contact of the intrusion with the adjacent country rocks is sharp.

The Pickle Crow porphyry is distinguished by large (2 to 10mm) quartz phenocrysts which are rounded to oval in cross-section, but a few are rectangular with rounded corners. On the light grey weathered surface, quartz phenocrysts are enclosed in a matrix of kaolinized feldspar. Microscopically, the rock contains distinct, well-formed, but smaller, fractured crystals of albite (Ferguson, 1966). The matrix of the rock is an aggregate of tiny anhedral grains of quartz and altered plagioclase with accessory amounts of magnetite-ilmenite, leucoxene, apatite, sphene, and rutile.

The Albany porphyry (2735+10Ma; Young et al., 2006) is 670m long and 120m wide, striking 060°. This stock is somewhat irregular at the ends, with lobes and dyke-like apophyses. Some of the associated dikes are parallel with the trend of the enclosing rocks but others are crosscutting. From surface to the 625ft (190m) level, the stock dips 65° northwest. On surface, the major axis of the stock makes a small angle with the strike of the enclosing rocks. The stock appears to maintain a similar shape and extend down the dip with no known plunge. This faintly pink porphyry contains abundant feldspar phenocrysts, scattered quartz phenocrysts, and a few biotite crystals, all of which are about 2mm in size. In its most unaltered state it appears granodioritic in composition. In thin section the feldspar is considerably altered to white mica and in some local areas to saussurite. Some of the quartz phenocrysts are individual crystals, but other phenocrysts consist of clusters of crystals. Quartz and carbonate occur as trains of interstitial material between the larger feldspar phenocrysts. Small crystals of apatite are enclosed within the large biotite crystals.

Miscellaneous feldspar porphyry dykes also occur on the mine property.

A prominent northwest-trending diabase dyke cuts across the western portion of the property. Narrow, fine-grained diabase dykes have also been mapped in the workings and encountered in underground drilling at the Pickle Crow Mine. One dike occurs in the

hanging wall of the No. 1 Vein and appears to be earlier than the vein, but another dike of similar appearance cuts this vein on the 411 m (1,350 ft) level (Pye, 1956). Diabase dykes also occur in the Pickle Crow porphyry. Although some of these dykes are parallel to the margins of the stock, others are at angles of from 20°to 40° to the contact. All of these dykes within the porphyry are cut by the mineralized veins.

A biotite lamprophyre dyke outcrops along the southern side of the rock exposures on claim PA760, in the northwestern part of the Pickle Crow property and, a dyke of similar composition occurs in the Pickle Crow porphyry and cuts a mineralized vein. The lamprophyres are massive, dark grey to black, medium-grained rocks with large (locally >5mm) biotite phenocrysts. Two varieties have been recognized. One, which cuts the Howell Vein, is composed chiefly of biotite, orthoclase, chlorite, and carbonate, and may be an altered minette. A second, post-ore dyke, which cuts the No. 2 Vein system, is made up of biotite, andesite, quartz, subordinate clinopyroxene, and accessory apatite and zircon (Pye, 1956). Lamprophyre dykes, similar to those exposed at Shaft 1, are also very common and are intimately associated with gold mineralization at the Central Pat East Zone.

The Hooker-Burkowski quartz-phyric trondhjemite stock, southwest of the Pickle Crow property, is undeformed and intrudes all Pickle Lake greenstone belt assemblages.

Structural Geology

The structural history of the Pickle Crow Property, although extensively studied, is by no means definitely understood. The focus has been mainly on the Pickle Crow assemblage and is largely based on the descriptions of Ferguson (1966) and the deformation history of MacQueen (1987). Stratigraphic younging determinations and structural-facing directions have been based on rare, unequivocal pillow tops and graded argillaceous beds. One persistent magnetite-carbonate BIF forms an important marker unit within the Pickle Crow tholeiites.

The general strike of rocks on the property is northeast and the dip is 75° to 80° northwest. The plunge of folds in the BIF near No. 1 Shaft is due north at 75° to 80°. The rake of the three productive veins in the No. 1 Shaft area is 70° at 020°. The Pickle Crow porphyry stock and the Albany porphyry stock both extend down the dip and do not appear to plunge. Several of the anticlines narrow and plunge beneath the younger rocks in a pattern that would be consistent with a plunge to the northeast. Some other anticlines maintain a constant width for considerable distances and some anticlines have a shape, in plan, which suggests a plunge to the southwest. Along some fold axes the stratigraphic sequence is repeated in reverse order which indicates plunge reversals. The major anticlines on the property are: the Pickle Crow; Albany Shaft; Pumphouse Lake; Sawmill; Pumphouse Creek; Powderhouse Lake south; Powderhouse Lake central; and Powderhouse Lake north. The major adjacent synclines are: the Albany Shaft; Township Line; No. 3 Shaft; Pickle Crow No. L; Pickle Crow No. 2; and Pumphouse Lake (Ferguson, 1966). It is important to note that this complex folding is essentially confined to the Pickle Crow mine area, and that the upper (northerly) part of the Pickle Crow assemblage outside of the property is a simple, north-facing, homoclinal sequence (Young et al., 2006). The general trend of the fold axes is northeast, but the Pickle Crow No. 2 syncline, the Pumphouse Creek anticline, and the Township Line syncline have fold axes which curve across the major fold axes. The folds strike northeast and dip steeply northwest, forming isoclinal folds with overturned southeastern limbs.

A well-developed schistosity is present in the metavolcanic rocks in the mine area and on the limbs of folds. This schistosity conforms with the dip of the bedding and with the axial planar cleavage of the latest period of folding. The porphyries are not strongly sheared, but the platy minerals developed in the matrix are aligned in conformity with the schistosity of the adjacent volcanic rocks.

Lithologic units in the Pickle Crow area have been metamorphosed to greenschist facies. The greenschist-amphibolite facies isograd was defined below the mine workings in Shaft 1 (at approximately 1600m depth) and is identified by the appearance of hornblende and abundant garnet. Greenschist mineral assemblages in basaltic rocks were petrographically determined to be: chlorite+actinolite+epidote+quartz+albite; and chlor ite+sericite+quartz+albite. The chlorite and actinolite have a preferred orientation parallel to the second deformation foliation, suggesting that this was the peak metamorphic episode.

MacQueen (1987) described a complex polyphase deformation history that includes four tectono-metamorphic episodes summarized below (Figure 12):

"The earliest generation of structures (D1) is present as rare 1- to 3m isoclinal fold closures or

hinge zones (F1) within BIF units that have been subsequently refolded inside second generation (F2) fold closures. Due to refolding, the F1 folds have axial planes with a mean strike direction between east-northeast to east and a steep dip to the north with hinge lines (L1) plunging steeply (60° to 70°) to the northeast (Pye, 1956).

D2 structures are the most prominent in terms of metamorphic overprint and the current distribution of rock units and mineralization on the property. In the mine area, D2 is characterized by a penetrative axial planar schistosity (S2), parallel, or at a small angle, to bedding/S1, striking northeast and dipping 75° to 87° to the northwest. Stretching lineations (L2) in the S2 plane, defined by chert and magnetite in BIF, quartz phenocrysts in quartz feldspar porphyry and varioles in tholeiites, are steeply plunging (70° to 85°) to the north-northeast. The effect of this stretching lineation cannot be overstated, as pillows have been measured with stretching ratios in excess of 30 to 1. The lineation is typically the strongest and most consistent fabric, with the S2 foliation often a distant second. As a result, the most continuous direction of lithological continuity (and mineralization) on the property is vertical. D2 fold closures (F2) have axial surfaces that strike northeast and dip steeply (75° to 85°) to the northwest, and hinge lines (L2) that plunge 60° to 80° to the northeast. D2 closures are characterized by 1 to 200m wide, tight, to isoclinal, similar folds, (best developed in BIF). They have thickened hinge zones, attenuated limbs and wavelengths of 300m. The large D2 folds outlined by the BIF include the Pickle Crow Anticline, Pickle Crow Syncline, Sawmill Anticline, and Powder House Anticline (Ferguson, 1966).

D2 shear zones occur throughout the Pickle Crow property as zones parallel to S2 surfaces (Type 1) and as discrete shear zones (S2') that splay off the Type 1 shear zones in a east-northeast direction, connecting Type l shear zones. Type 1 shear zones are strongly foliated zones greater than 30m wide which dip steeply (75° to 85°) to the northwest. They include the Pickle Crow Fault, Highland Crow Shear Zone, Pumphouse Shear Zone and Powderhouse Shear Zone. Shear fractures in outcrop surfaces (Stott, 1996) trend east-northeast at low to moderate angles (20° to 40°) to S2. These east-northeast-striking sets of shear fractures have, in some instances, developed into discrete 2 to 5m wide Type 2 shear zones that are strongly foliated and run between substantial Type 1 structures. These Type 2 shears are an important structural control on gold mineralization. D2 deformation was contemporaneous with gold-bearing vein emplacement and deformation definitely continued sometime after vein emplacement, as evidenced by Z-folding of the No. 1 Vein in Shaft 1 and even more intense folding and boudinaging of veins in Shaft 3.

The third generation of structures on the Pickle Crow property (D3) consists of northwest- and north-striking conjugate faults, steeply dipping to the northeast, and crosscutting and displacing earlier structural fabrics. Late undeformed veins, felsic dikes and lamprophyre dikes have been emplaced along fractures parallel to northwest- and north-striking conjugate sets of fractures which crosscut D2 fabrics.

The final (D4) deformation generation is represented by the development of late, continuous, northwest-striking, en-echelon extensional fractures that crosscut earlier fabrics (Sage and Breaks, 1982). These fractures are up to 20m wide and have considerable strike lengths, up to hundreds of metres.

The Pickle Crow diabase dike, and other diabase dikes hosted in these structures, crosscut all strata, including the Hooker-Burkowski stock and the granitic terrane to the north and south of the Pickle Lake greenstone belt. The Pickle Crow diabase dike has been displaced sinistrally along a northeast-trending fault, the only record of post-D4 deformation within the Pickle Crow area."

Gold Deposits

PC Gold considers the gold occurrences in the Pickle Lake mining camp to be classical examples of deposits grouped under the descriptive model of Archean low-sulphide, gold-quartz veins. The major gold ore bodies at Pickle Lake are hosted by the Pickle Crow assemblage, which locally hosts at least two such large structural discontinuities or "breaks": the core mine-trend break, which preserves Temiskaming-like sedimentary rocks; and the Cohen-MacArthur deformation zone, which is up to 100m wide. The gold-bearing veins at Pickle Crow fill pre- or syn-ore

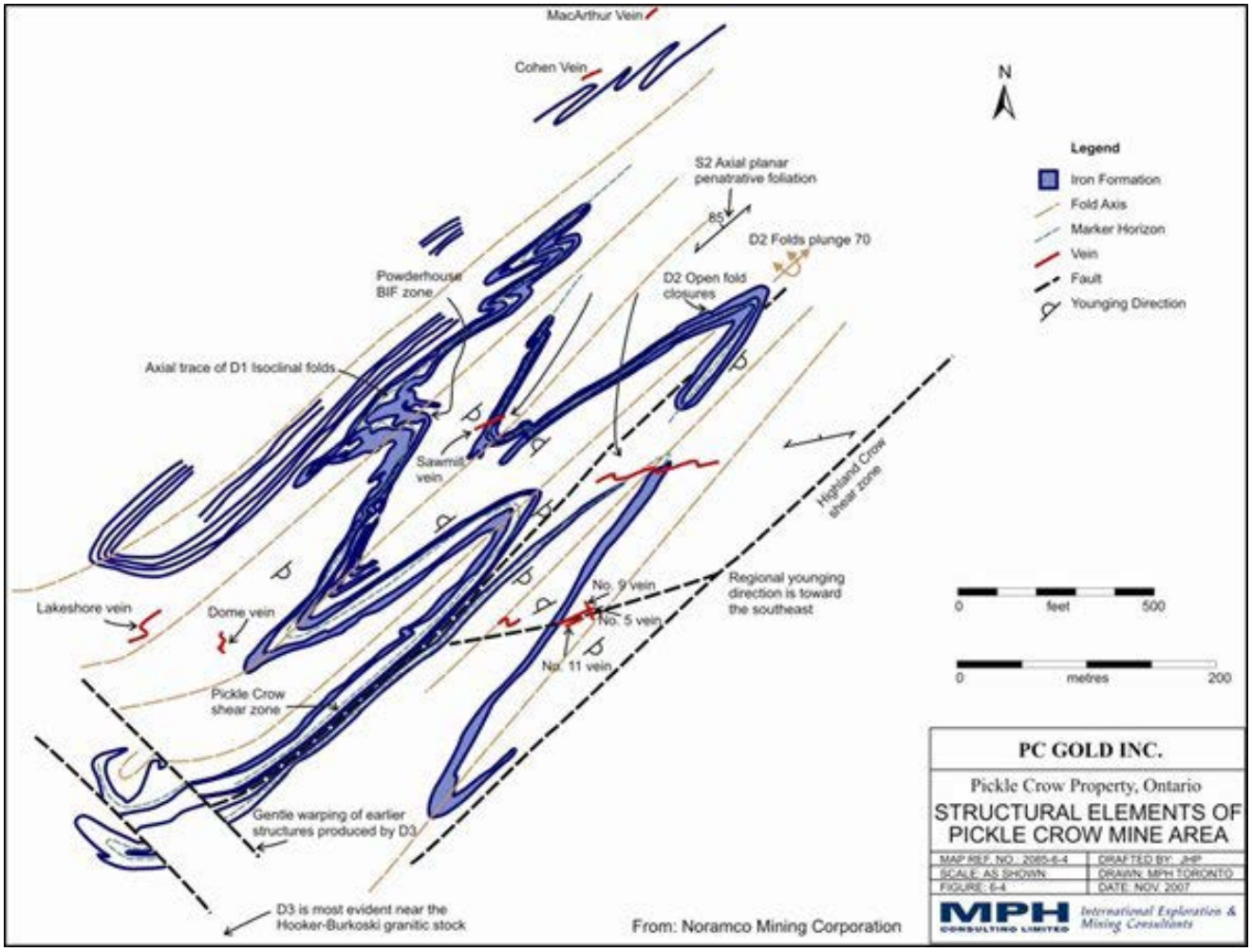


Figure 12. Structural elements of the Pickle Crow Mine area.

faults, shears, and fractures in the various host rocks. Auriferous sulphide zones that are stratabound and contained within BIF occur adjacent to shear zones in some areas.

The historically mined ore at Pickle Crow was contained in quartz veins that are generally banded (crack-seal) with tiny streaks of tourmaline, chlorite or sericite, and in fracture fillings. Quartz is by far the main vein mineral, with lesser carbonates, including siderite, ferruginous dolomite, and calcite. Minor albite, chlorite, sericite, and local traces of tourmaline, magnetite, and scheelite have been noted. Native gold was the main ore mineral. The main sulphide minerals are pyrrhotite and pyrite, which combined are usually less than 2% of the vein material, along with trace arsenopyrite, chalcopyrite, galena, and sphalerite. Some gold is closely associated with the sulphides and traces are found in the altered wall rock but, in general, the gold is free and occurs along sericite-chlorite-fuchsite-lined fractures and seams in-filling minute fractures in the quartz. Spectacular samples of visible gold have been observed in a number of places in the mine. As a general rule, however, the gold is very finely divided and practically invisible to the naked eye (Pye, 1956). At Pickle Crow, alteration minerals include silica, sericite, chlorite, carbonate, and pyrite.

Host rocks for the gold mineralization at Pickle Crow include tholeiitic basalts, BIF, intermediate volcanic/volcaniclastic rocks, and quartz feldspar porphyry. Gold occurrences are associated with four styles of mineralization:

- Narrow, high-grade, gold-scheelite-bearing quartz veins, which were the main source of gold produced at the Pickle Crow Mine from 1935 to 1966.
- BIF-hosted gold mineralization adjacent to vein structures. BIF contains stringers and discontinuous lenses of quartz and the iron-bearing minerals have been replaced by sulphides. Both quartz and sulphides are gold-mineralized. Only a limited amount of this type of material was processed at the Pickle Crow Mine. However, BIF-hosted gold was

the main ore type at the adjacent Central Patricia Mine to the southwest.

- Shear zone-hosted gold mineralization, consisting of complex, wide zones of intense shearing and alteration which are intimately associated with the intrusion of the Albany porphyry and characterized by disseminated pyrite, discontinuous quartz veining, and sulphidation of interflow BIF.
- Arsenopyrite-associated gold mineralization which typically occurs as disseminated to semi-massive arsenopyrite and quartz-arsenopyrite stockworks hosted by BIF, but can be also found, to a lesser extent, in shear zones and/or quartz veins in volcanic rocks. Similar arsenopyrite-rich BIF-hosted gold was the main ore type at the adjacent Central Patricia Mine.

A substantial number of auriferous quartz veins have been located on the property, along with several occurrences of BIF-hosted mineralization. The following quartz vein descriptions are mainly from the work of Thomson (1939), Pye (1956), and Ferguson (1966), while the subsequent BIF mineralization descriptions also include information from MacQueen (1987) and Winter (1988).

Gold was produced from the No.1, No. 2, No. 5, No. 6, No. 7, No. 8, and No. 9 Veins during the life of the Pickle Crow Mine. The only additional mineralization of this type that was processed at the Pickle Crow mill came from exploration drifts at the Albany Shaft area. The most productive of the quartz vein ore bodies was the No. 1 Vein (Fig. 13). This vein has been traced on surface over a strike length of 900m and extends below the lowest level of the mine, or beyond a depth of 1500m (almost 700m below the lowest historically mined level of the deposit). The average thickness of this vein is 0.9m. The eastern part of the vein is highly contorted with an overall strike of 083°, cuts across the lithologic units at an angle of 30° to 40°, and has an average dip of 73° north. The western part of the vein has an overall strike of 058°, cuts the formations at about 10°, and has an average dip of 75° northwest. The No. 1 ore body is a 'shoot' within the No. 1 Vein, with the eastern boundary determined by gold content and the western boundary by diminishing vein thickness (Pye, 1956).

Although the No. 1 Vein is typical of the vein-style mineralization at the Pickle Crow Mine there are variations throughout the mine property. Veins in the Shaft 1 area (Fig. 14) are relatively undeformed, and more laminated, with more fine-grained gold.

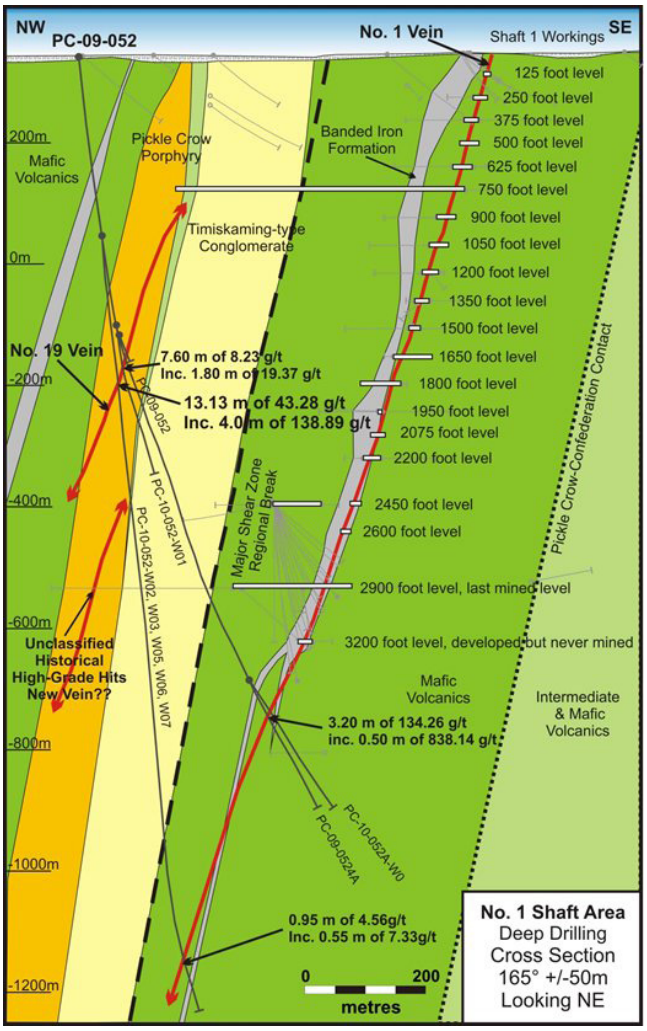


Figure 13. Cross-section through the No. 1 Shaft area, Pickle Crow Mine.

They have very little shearing or wall rock alteration and have significant down-dip continuity. Veins in the Shaft 3 area (e.g., No. 2), are more deformed, have few laminations with more coarse-grained gold, and possess wider zones of shearing and alteration in the wall rock. They are more en echelon in nature and have less down-dip continuity. Veins in the Albany Shaft area (e.g., No. 16) are even more deformed, with few laminations and generally rare visible gold, possess wide zones of shearing and intense alteration of the wall rocks, and generally poor continuity.

The No. 1 Vein consists largely of white or greyish, coarse- to fine-grained, almost sugary quartz, a little ferro-dolomite, tourmaline, scheelite, and subordinate amounts of metallic sulphides. The ankerite, tourmaline, and scheelite, although locally occurring as patches completely enclosed by the quartz, generally occur in thin seams replacing chloritized basalt in 'book and ribbon' structures or in the walls, and so

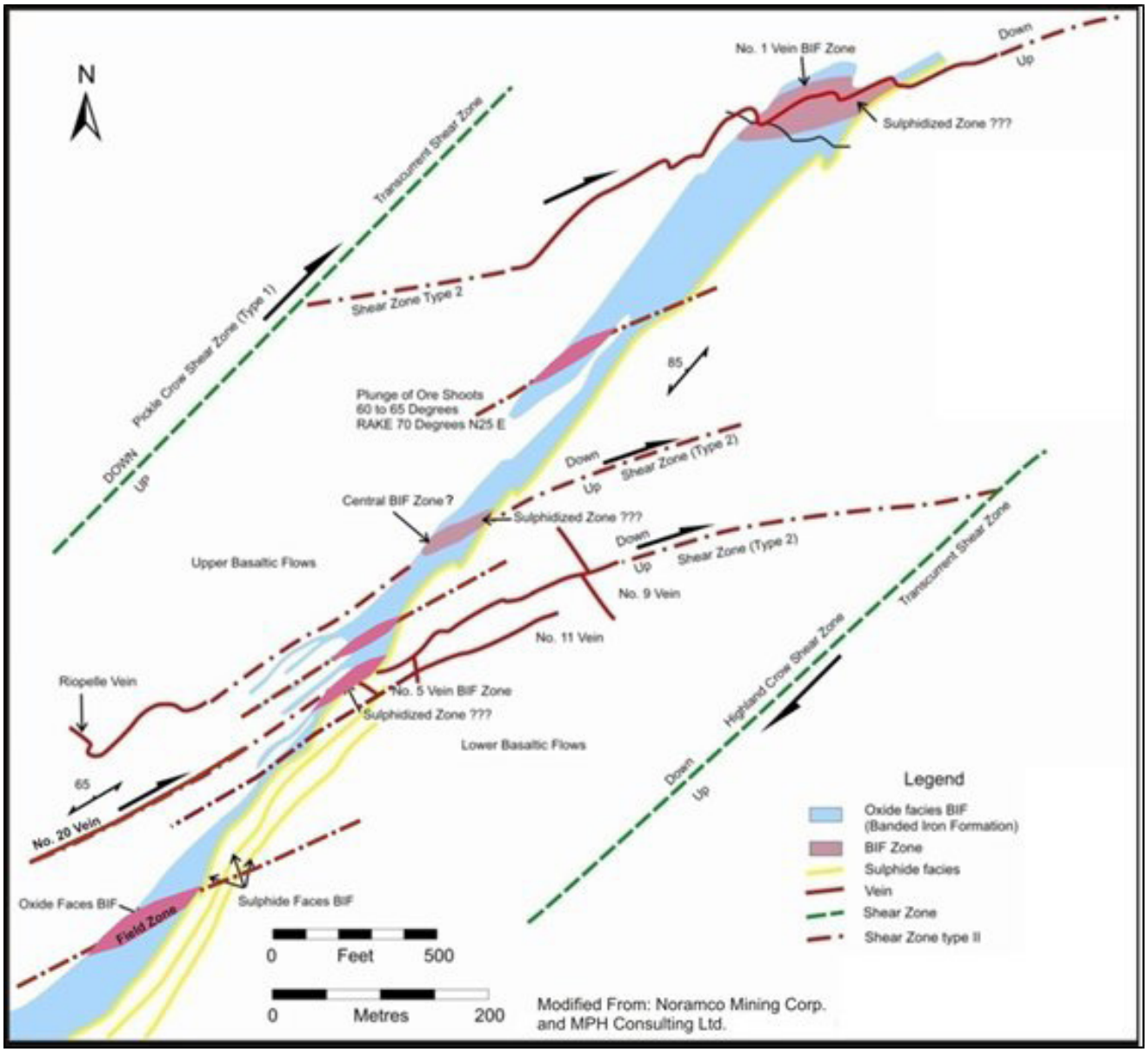


Figure 14. Structural relationship between mineralized zones, No. 1 Shaft area (Coates and Anderson 2008).

help accentuate the banded character of the vein. Two distinct generations of quartz are recognizable; one gold-bearing and making up the body of the No. 1 Vein, the other barren and occurring, along with calcite, in narrow transverse veinlets that cut sharply across the earlier type.

Most of the other mineralized veins at the Pickle Crow property have similar characteristics to the No. 1 Vein. Quartz is by far the most abundant mineral of all the veins and the two generations of quartz are found in many of the veins. The quartz in other veins in the metabasalt is a light grey colour and is banded due to the presence of inclusions of schist and dark coloured minerals. Similarly, the second generation of quartz consists of veinlets, generally less than a centimetre in thickness, which are approximately at right angles to the veins and extend completely across the veins but rarely extend into the wall rock. These veins consist of quartz with abundant white or pink calcite (Ferguson, 1966; Pye, 1956).

Pyrite and pyrrhotite are the most abundant sulphides and both are about equally common in the veins in the metabasalt, but pyrite is more abundant in the No.2 Vein, and only pyrite occurs in the No.16 Vein. In the metabasalt and iron formation wall rocks, pyrrhotite occurs as irregular masses, disseminated grains, and narrow seams. It occurs in fractures in the veins, or the wall rock, or both, and as grains healing broken crystals of arsenopyrite and pyrite. The pyrrhotite is later than the quartz and the late variety of pyrite, but is

replaced by sphalerite, chalcopyrite and galena.

The second style of mineralization at Pickle Crow is the gold-bearing BIF type. Considerable mineralization of this type was identified by PCGM on the property during its exploration and development work, mainly in the No. 1 Shaft area. These were locations adjacent to the No. 1 ore body (the No. 1 Iron Formation Zone or Eastern Iron Formation), the No. 5 ore body (the No. 5 Iron Formation Zone), and an area approximately midway, at depth, between the No. 1 and No. 5 Veins known as the Central Iron Formation Zone. After running iron formation material from test stopes in all three zones, PCGM found that it was unable to satisfactorily process both vein and iron formation mineralization styles due to their different metallurgical characteristics (Winter, 1987). It has also been reported that the average auriferous iron formation grade, believed to be about 6.85g/t Au (0.20oz/ton Au), was below the then cut-off grade of 8.57g/t Au (0.25oz/ton Au) (MacGregor, 1989). The Eastern, Central, and No. 5 iron formations or quartz-sulphide zones comprise stringers and discontinuous lenses of quartz within BIF. The iron-bearing minerals of the BIF have been replaced by sulphides adjacent to the veins and gold is present in the veins and the associated sulphides. Approximately 15,000t of this type of mineralization, taken from test stopes in each of the above occurrences, were processed during the historic mining operations. The BIF-hosted mineralization consists of bleached and altered iron formation with variable amounts of pyrite, pyrrhotite, and occasionally arsenopyrite, often with heavy secondary magnetite and quartz, and carbonate veins and veinlets.

The gold mineralization at Pickle Crow (both quartz vein- and iron formation-hosted) is localized along, or adjacent to, Type 2 shear zones, i.e., shear zones that are developed oblique to greenstone belt lithological trends and cross between adjacent Type 1, lithologically concordant shear zones, or faults.

The shear zone-hosted type of mineralization is restricted to the Albany Shaft area, and is referred to as Conduit style mineralization after Conduit Zones 1, 2, and 3 (formerly the A, B, and C zones). The mineralization is characterized by wide, highly complex zones (both lithologically and structurally) of shearing with discontinuous quartz veining, sulphidized interflow BIF, and disseminated pyrite. All rock types can be mineralized, with a preference for the interflow BIF where the highest grades occur, often in association with a pronounced crenulation fabric and abundant Z-folds. Lithological complexity is a key component, providing abundant small-scale competency contrasts. Conduit-style mineralization, when present in homogeneous rocks such as massive basalt, is much less intense and lower-grade. Alteration mineralogy includes widespread carbonate (some calcite, but primarily ankerite), strong sericitization, chlorite, silicification, quartz veining, and abundant disseminated pyrite. Visible gold was not observed although grades greater than 1oz/ton have been recorded. Minor alteration minerals include tourmaline, hematite, and fuchsite. The geometry of the mineralization is poorly understood. In the case of Conduit Zone 1 it has been defined by drilling to be an approximately 40m wide, northerly-plunging (~55°), pipe-shaped body; however Conduit Zones 2 and 3 do not mimic this geometry. There is also strong evidence that the Conduit style of mineralization is simply a much stronger manifestation of the shearing that surrounds the high-grade quartz veins at the Pickle Crow Mine. For instance there is evidence that Conduit Zone 2 is the southwest extension of the No. 16 Vein. The mineralization is often moderate- to low-grade and possibly amenable to open pit or bulk underground mining methods.

Arsenopyrite-bearing gold mineralization was described early on in the history of the Pickle Crow property when it was discovered at the Cohen-MacArthur Zone and MacArthur Vein in the 1930s. These are located north of the core mine trend and just south of the Kawinogans (Crow) River. While historically it was not a significant style of mineralization at Pickle Crow, it was the principal ore at the nearby Central Patricia Mine. Subsequent work by PC Gold has found this style of mineralization to be much more widespread on the property than previously thought. The Cohen-MacArthur deformation zone is a wide (up to 100m) zone of intense shearing and carbonate (ankerite)-sericite alteration that roughly parallels the core mine trend and runs the entire length of the property. It was identified through geophysics and drilling in 2010. The Cohen-MacArthur structure is the strongest structure present on the property and forms a dividing line between mineralization styles. All mineralization north of this structure is associated with arsenopyrite whereas the mineralization south of it (with the rare exceptions of the Arsenide Vein and No. 21 Vein) are associated with minor scheelite and low arsenopyrite contents. Arsenopyrite mineralization can occur in several forms such as localized shear zones, quartz veins, quartz stockworks, and disseminations in

both volcanic and chemical sedimentary rocks. The most widespread mineralization and highest grades occur within iron formation such as the Central Pat East Zone, where the mineralization is also spatially associated with several late unmineralized lamprophyre dikes which presumably used the same structures as the gold mineralization originally exploited. The tenor of the gold mineralization is very closely tied to arsenopyrite content, as well as the degree of silicification, quartz flooding and/or veining. Alteration minerals associated with arsenopyrite mineralization are widespread and include often intense carbonate (ankerite) alteration and strong silicification, quartz flooding and/or veining, and moderate sericite alteration. Minor alteration minerals include tourmaline, pyrrhotite, and chalcopyrite. Petrographic studies by Kolb (2011) on the Central Pat East indicate that the gold is free, located within fractures or next to arsenopyrite crystals.

An important structural component of the arsenopyrite-associated gold mineralization is the presence of fractures and/or veinlets at high angles to bedding. At the Central Patricia Mine, the host BIF possessed an easterly strike; however, the mineralization was present in sulphide-rich fractures oriented perpendicular to the strike of the BIF. On the 750 level, mineralized fracture patterns occur at a high angle to the strike of the BIF, generating ore bodies (Tigert, 1949). At Central Patricia miners exercised care to drill holes at approximately right angles to the locally prevailing fracture pattern (i.e. parallel to bedding). Normal drilling, at right angles to the drift (i.e. perpendicular to bedding), would produce very false results (Tigert, 1949). These fractures plunge approximately 55° to the east and formed very consistent high-grade shoots within the BIF. Similar structures have been observed at the Central Pat East Zone, where arsenopyrite-filled fractures and arsenopyrite-quartz veinlets cut bedding at high angles. Similar high-angle quartz veinlets, plunging to the northeast and perpendicular to the strike of the host iron formation, have been observed in the arsenopyrite-poor iron formation mineralization at the Sawmill Vein and may play an important role in controlling the geometry of this style of gold mineralization as well.

Mineral Resources

The NI43-101-compliant inferred mineral resource estimate was compiled by Fladgate Exploration Consulting Corporation and audited by Micon Internation Limited in April 2011. It was amended by Fladgate in August 2014 with the inaugural estimates on the No. 22 and 23 veins. The Pickle Crow project resource estimate is divided into three distinct areas within the core mine trend: the Shaft 1 area; the Shaft 3 area; and the Albany Shaft area. The drill hole database used for the resource estimation comprised drill holes, underground chip samples, and surface trench channel samples. In total, 1597 drill holes, totalling ~138,000m, were used, of which 167 drill holes (~50,000m) belonged to PC Gold drilling campaigns. A total of 27,826 chip samples taken by PCGM and 45 surface trench channel samples, taken by PC Gold, were used for estimation purposes. Tables 4 and 5 detail the resource estimate and Figure 15 is a longitudinal section showing resource areas for the Pickle Crow property.

Table 4: Updated Pickle Crow Inferred Mineral Resources – August, 2014

Category	Cut-off Grade (g/t Au)	Tonnes	Grade (g/t Au)	Ounces	Percentage of Total Ounces
High-Grade Vein Underground	**2.8**	**2,165,000**	9.1	637,000	49%
Bulk Underground*	**2.0**	**4,510,000**	3.7	536,000	41%
Total Underground	**2.25****	**6,680,000**	5.5	1,173,000	90%
Total Open Pit	**0.35**	**3,628,000**	1.1	126,000	10%
Grand Total		**10,303,000**	3.9	1,299,000	100%

*Bulk Underground resources comprises primarily Banded Iron Formation (BIF) hosted mineralization.

**Represents a combination of potentially bulk mineable underground resources (2.0 g/t cut-off) and cut-and-fill underground resources (2.8 g/t cut-off, with vein intersections diluted to a minimum of 1 metre).

Table 5: Pickle Crow Updated Inferred Mineral Resources – August, 2014; Detailed Breakout by Shaft and Zone

Area	Zone	Host	Mining Technique	Grade Au g/t	Metric Tonnes	Contained Ounces	Au Cut-off Grade g/t
Shaft 1	BIF	BIF & Vein	Open Pit	1.1	3,628,000	126,000	0.35
	BIF	BIF & Vein	Bulk Underground	3.7	4,320,000	508,000	2.0
	No. 1 Vein	Vein	Underground	10.1	718,000	233,000	2.8
	No. 5 Vein	Vein	Underground	5.2	141,000	24,000	2.8
	No. 9 Vein	Vein	Underground	5.4	203,000	35,000	2.8
	No. 11 Vein	Vein	Underground	6.5	18,000	4,000	2.8
	No. 19 Vein	Vein	Underground	14.0	381,000	171,000	2.8
		Shaft 1 Total Ounces		**3.6**	**9,409,000**	**1,100,000**	
Shaft 3	No. 2 Vein	Vein	Underground	9.1	96,000	28,000	2.8
	No. 6 Vein	Vein	Underground	8.2	156,000	41,000	2.8
	No. 7 Vein	Vein	Underground	5.8	49,000	9,000	2.8
	No. 8 Vein	Vein	Underground	7.9	64,000	16,000	2.8
	No. 12 Vein	Vein	Underground	11.9	14,000	5,000	2.8
	No. 13 Vein	Vein	Underground	6.5	103,000	22,000	2.8
	No.22 Vein*	Vein	Underground	5.9	28,000	5,000	2.8
	No.23 Vein*	Vein	Underground	7.9	125,000	32,000	2.8
		Shaft 3 Total Ounces		**7.7**	**635,000**	**158,000**	
Albany Shaft	CZ1	Conduit-Style	Bulk Underground	4.9	168,000	27,000	2.0
	CZ3	Conduit-Style	Bulk Underground	2.7	22,000	2,000	2.0
	No. 15 Vein	Vein	Underground	4.7	42,000	6,000	2.8
	No. 16 Vein	Vein	Underground	6.3	28,000	6,000	2.8
		Albany Shaft Total Ounces		**4.9**	**260,000**	**41,000**	
Total Pickle Crow		Total	Open Pit	1.1	3,628,000	126,000	0.35
		Total	Bulk Underground	3.7	4,510,000	536,000	2.0
		Total	Underground	9.1	2,165,000	637,000	2.8
			Grand Total	**3.9**	**10,303,000**	**1,299,000**	

*2014 Resource Estimates

Notes:

1. The mineral resource estimate is entirely classified as inferred mineral resources. 2. CIM Definition Standards were followed for mineral resources. 3. The cut-and-fill (high-grade vein) underground component of the mineral resource has been estimated at a cut-off grade of 2.8 g/t Au over a minimum width of 1 metre. Vein widths less than 1 metre were diluted to 1 metre prior to application of the 2.8 g/t Au cut-off grade. Grade and tonnes for the cut-and-fill component of the mineral resource are reported as diluted grade and tonnes. 4. The long-hole bulk underground (moderate-grade) component of the mineral resource has been estimated at a cut-off grade of 2.0 g/t Au. 5. The open pit (low-grade) component of the mineral resource has been estimated at a pit discard cut-off grade of 0.35 g/t Au, using a preliminary Whittle pit shell to constrain the resource estimate and other assumed pit parameters. 6. The open pittable mineral resource extends to a depth of approximately 150 metres below surface. Only mineralization located within the pit shell has been reported at open pit cut-off grades. 7. The mineral resource has been estimated using a gold price of US$1,100 per ounce. 8. High-grade assays have been capped. Each domain was capped with respect to their unique geology and statistics. Caps for cut and fill (high-grade vein) underground resources range from 35 g/t to 145g/t. 9. Bulk density of 3.14 t/m3 was used for BIF and 2.70 t/m3 was used for veins. 10. The mineral resource was calculated via block model. Three dimensional wireframes were generated using geological information. A combination of Kriging and inverse distance estimation methods were used to interpolate grades into blocks of varying dimensions depending on geology and spatial distribution of sampling. 11. Mineral resources that are not mineral reserves do not have demonstrated economic viability. 12. Mineral resources have been adjusted for mined out areas. Small rib and sill pillars around old stopes have not been considered. 13. Numbers may not add due to rounding.

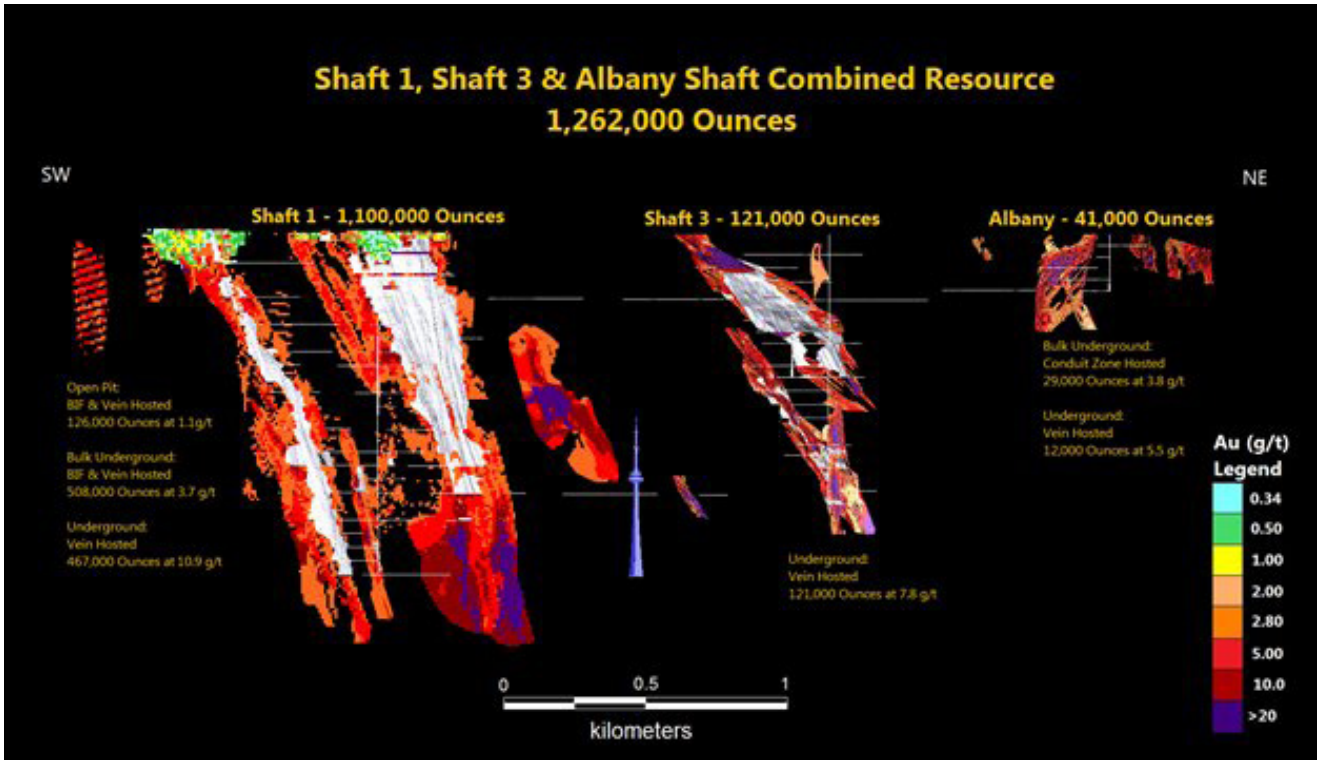


Figure 15. Longitudinal section showing resource areas, Pickle Crow property

Sub-stop Descriptions, Pickle Crow Deposit Property (Fig. 16)

Stop 3a: PC Gold Inc. field office and core yard

UTM Coordinates: NAD83; 15U 0703600E / 5709080N

The geological setting of the Pickle Crow deposit along with various styles of mineralization will be discussed in detail at this stop. The property's core library, which covers all rock types, alteration, and mineralization styles found on the property will be laid out for display and discussion.

Stop 3b: Trench C

UTM Coordinates: NAD83; 15U 0703890E / 5709300N

This trench is an excellent example of the Core Mine Trend BIF-style mineralization (Fig. 17). The trench exposed the No. 5 vein in the northeastern corner and the No. 5 BIF zone in the centre of the trench, as well as extensive low-grade BIF mineralization. The high-grade, but narrow No. 11 vein is also exposed in the southeastern corner of the trench. It should be noted that although these structures appear to be relatively narrow and have a short strike-length, they have incredible down-plunge continuity, having been traced to more than 1150m at depth.

Stop 3c: Trench A (Figure 18)

UTM Coordinates: NAD83; 15U 0705820E / 5711200N

This trench is the best exposure of what is referred to as the conduit-style mineralization. This mineralization is part of the high-grade vein Au-W style, but with some notable differences. In the Albany shaft area, the deformation of the vein is much more intense and hence continuity is diminished. In addition to this, the degree of alteration is also much more intense, with wide (tens of metres) alteration halos surrounding the veins. In the Albany area, the veins have been deformed to the point that they often form boudinaged fold hinges. These hinges have limited strike extent and complex internal structure, but with strong down-plunge continuity.

Stop 3d: High-grade No. 1 Vein stockpile and Shaft Pit (Fig. 16)

UTM Coordinates: NAD83; 15U 704355E / 5709860N

This high-grade stockpile is composed of vein material from the No. 1 Vein crown pillar (Fig. 19). The larger stockpile behind it is composed of BIF-style mineralization which surrounds the No. 1 Vein, also from the crown Pillar. Abundant fine free gold can be observed along the chlorite-sericite-filled seams in the high-grade veins. Sheared, isoclinally folded (F2) BIF

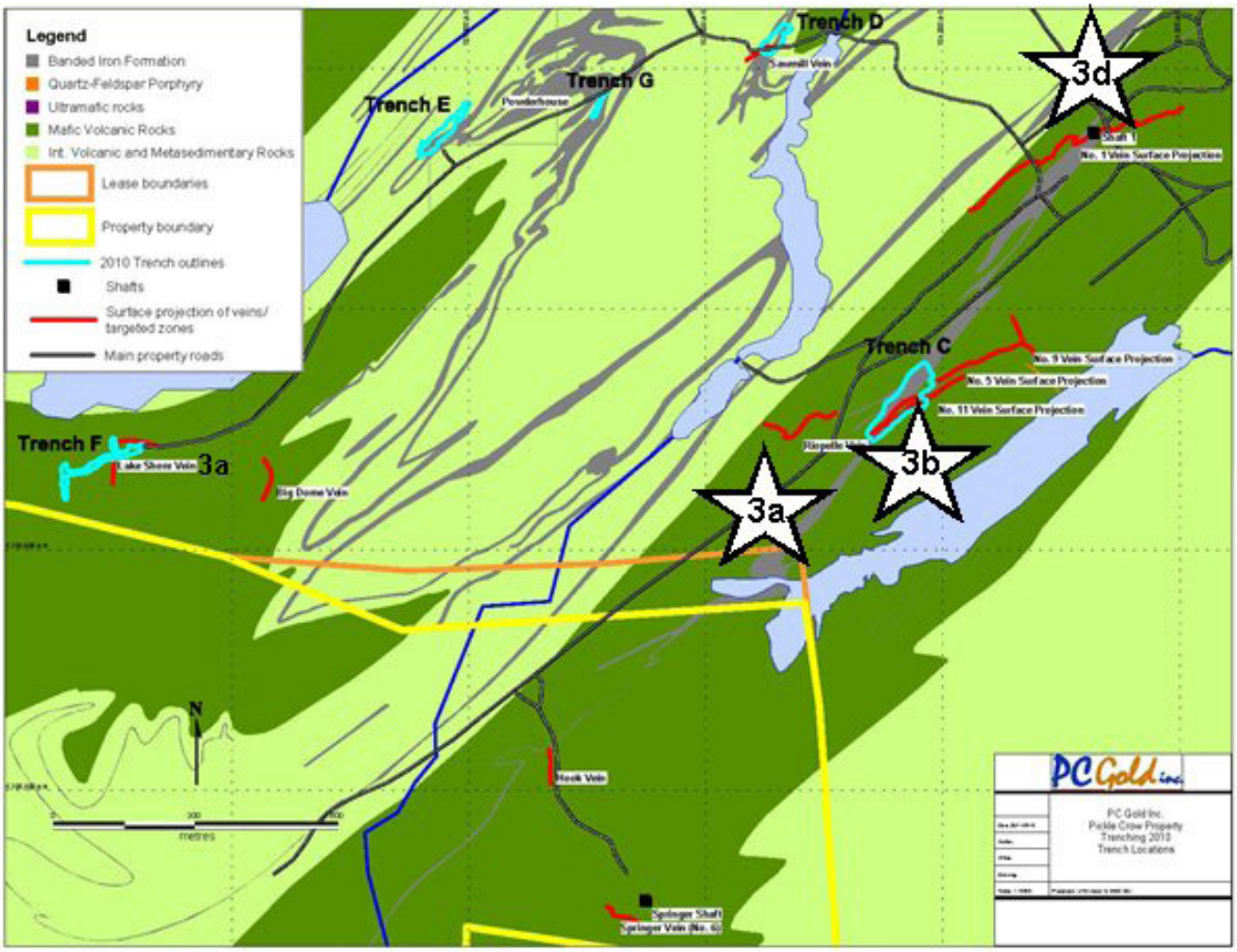


Figure 16. General geology of the southern half of the Pickle Crow property, showing veins, trenches and Field Trip Stop locations.

is well-exposed in the nearby No. 1 Shaft Pit (Figure 20). Carbonate-altered lamprophyre dykes are also present in the No. 1 Vein surface stockpile and exposed in the No. 1 Shaft Pit. The 225tpd extreme gravity mill build by Cantera in 2002 lies a short distance away.

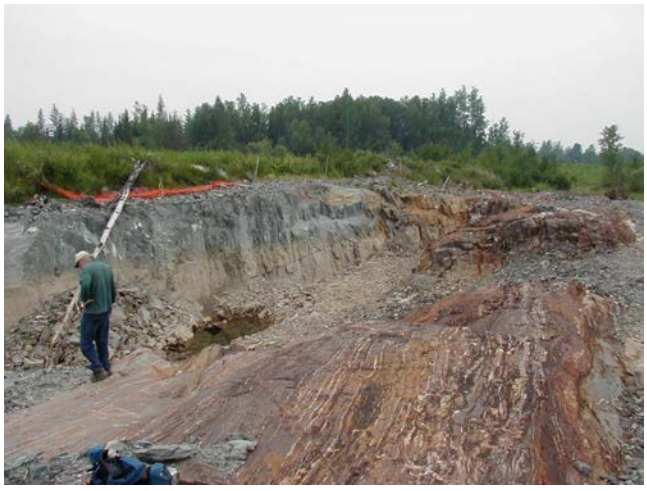


Figure 17. Stripped area at Trench C (Stop 3b), Pickle Crow property, showing contact between No. 5 Zone BIF and metavolcanic rocks.

STOP 4: Dona Lake Mine

UTM Coordinates: NAD 83; 15 U listed with sub-stop descriptions

(N.B. permission to enter the site must be granted by Goldcorp Canada Inc.)

The past-producing Dona Lake Mine deposit, approximately 9km southeast of Pickle Lake, was discovered by Dome Exploration Limited in 1980 (Cohoon, 1986). Between 1980 and 1985 geophysical and geological surveys and diamond drilling were carried out by Dome Exploration. Advanced exploration, including sinking of a 176m exploration shaft, was conducted by Dome Mines and Campbell Red Lake Mines between 1985 and 1987. Developed jointly by Dome Mines and Campbell Red Lake Mines, it was put into production by Placer Dome Canada Limited

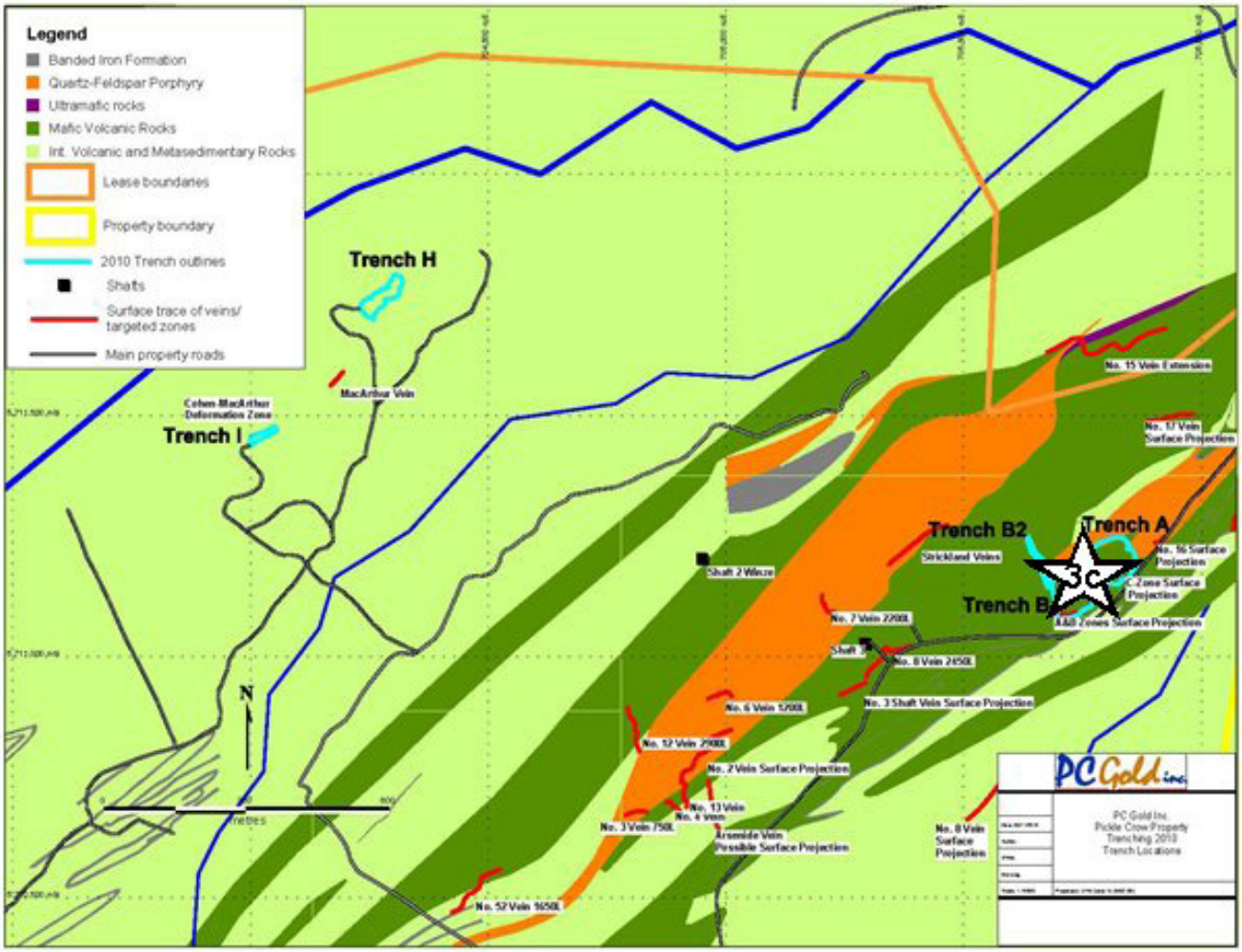


Figure 18. General geology of the southern half of the Pickle Crow property, showing veins, trenches and Field Trip Stop locations.



Figure 19. Broken chunks of No. 1 vein on stockpile at Stop 3d, showing typical laminated ("crack-seal") structure (gloves for scale). Mill is in background.



Figure 20. F2 fold in BIF, No. 1 Shaft pit, Stop 3d. Field of view is 2 metres.

in February 1989 at a rated concentrator capacity of 550tpd, with Proven and Probable reserves totalling 754,000 tons (684,000 tonnes), averaging 0.24oz/t Au (8.23g/t Au; Coates and Anderson 2008). Placer Dome Canada operated the site until July 1993, at which time ownership was transferred to Ross-Finlay who operated the mine until closure in August 1994. The mine closed in 1994 due to exhaustion of viable reserves. During this time period, it is estimated that a total of 939,237 tonnes of ore was milled to produce approximately 6988kg (246,500 oz) of gold (Puumala 2009). This estimate is based on grade and tonnage estimates obtained from The Northern Miner (article, May 30, 1994), Janes et al. (1994) and Jen and McCutcheon (1995). The first source summarizes production under the ownership of Placer Dome from 1989 to 1993, and the second and third sources summarize production under the ownership of Ross Finlay from 1993 to 1994. At the time of mine closure, it is estimated that reserves of approximately 40,000 tonnes grading 5.95g/t Au remained at depth (Chronicle-Journal, article, June 24, 1994). Responsibility for the tailings reclamation remained with Placer Dome Canada which became Goldcorp Canada on May 12, 2006.

The Dona Lake Deposit is predominantly BIF-hosted, geologically similar to the auriferous iron formation-hosted zones at the Central Patricia and Pickle Crow mines. The most comprehensive description was provided by Cohoon (1986):

"The Dona Lake property is south of the previous producers [i.e. Pickle Crow, Central Patricia, etc.] in a separate greenstone sequence that trends south and merges with the Osnaburgh-Pickle Lake belt [sic]. The main trend on the property is described by the nearly circular, 11km-long arc of high magnetics which wraps around the tongue of the Ochig Lake Pluton. The high magnetics are caused by a major, semi-continuous unit and numerous minor discontinuous units of oxide iron formation.

The iron formations occur within a package of tholeiitic, usually pillowed basalt and amphibolite with local tuffs and minor felsic volcanics and clastic sediments. These units dip away from the pluton at a very consistent 60° and also young away from the pluton, suggesting a pre-erosion domal structure over the intrusive. All of the volcanic and sedimentary units have been intruded by sodium-rich felsic dykes and albite porphyry with a composition similar to the Ochig Lake Pluton.

The entire assemblage has been metamorphosed to amphibolite grade, as indicated by the presence of garnet porphyroblasts, biotite, local amphibolites with blue-green hornblende, and the relative lack of chlorite.

The Dona Lake deposit is located in iron formation near the east-central portion of the property. The general geology in the immediate vicinity of the deposit, as derived from scattered outcrops, drilling and ground magnetic surveys, consists of tholeiitic basalt separated by several major units of iron formation, and intruded by felsic dykes and albite porphyry. The volcanics and sediments strike north-south to locally northwest-southeast and dip to the east and northeast at 60°. Tops, as determined from well-preserved pillows, are also to the east.

Several stages of deformation are evident in the area of the deposit:

- *The basalts, which are normally pillowed and massive, are very schistose and foliated in the vicinity of the iron formations. Some, but not all, of the felsic dykes are also affected by this foliation event.*
- *Virtually all of the iron formation has been isoclinally folded. The fold planes are parallel to overall stratigraphy and the fold axes plunge east down the dip of the iron formation. These folds have wavelengths of about 1m and amplitudes of up to 10m.*
- *Superimposed on the isoclinal folds with schistosity are low-amplitude cross folds with wavelengths of about 200m and amplitudes of 20m.*
- *A stratigraphically controlled shear zone has been identified over a distance of 1km in the footwall of the iron formation. It is composed almost entirely of chlorite and presumably post-dates the metamorphic event.*

It is within the fold axis of one of these broad-wavelength cross folds, in iron formation, that the Dona Lake gold deposit occurs. The spatial relationship is illustrated in [the Figure referred is not included in this guide; refer to Cohoon, 1986] which depicts the surface projection of the mineralization and the host iron formation. The other structural feature apparent in the diagram is a horizontal overlap of the iron formation of

approximately 150m, caused by a north-south sinistral fault at a low angle to the stratigraphy. Vertical movement on this fault is unknown but is likely to exceed 300m. This feature may be related to the chloritic shear mentioned above.

Gold mineralization occurs in both of the iron formations illustrated but the majority of the established reserves are in the one to the east. Mineralization has been defined over a strike length of 200m, but more than 80% of the reserves are in the central 100m in the core of the cross-fold axis. With width exceeding 25m in the core, the overall geometry is that of a flattened pod, which plunges east down the axis of the cross-fold, entirely within iron formation.

... The iron formations occur within the tholeiitic pillow basalt and amphibolite, which is strongly foliated in proximity to the mineralization. Intruding these units are numerous irregular albite-rich felsic dykes, albite porphyries and lamprophyre dykes.

The iron formations are usually classic oxide-facies iron formation, composed of finely bedded magnetite, chert and hornblende, with local grunerite, garnet, calcite and sulphides. A finely bedded chert-sulphide unit in the hanging wall has been genetically grouped with the iron-rich minerals other than sulphides and might be more properly termed a chert, since the sulphides may be secondary. Significantly, no carbonate iron formation, nor iron-rich carbonates, have been located on the property.

All of the gold occurs in oxide-facies iron formation. Mineralized sections display the following characteristics:

- *Between 5% and 15% pyrrhotite virtually always accompanies gold. Notably, this relationship does not apply to pyrite; even when pyrrhotite is abundant, if the pyrite content exceeds 3%-4%, gold values are usually low. The pyrrhotite is fine-grained and wispy, cross cutting bedding and apparently replacing or displacing other minerals.*
- *In most cases, evidence of original bedding in drill core has been partially or completely destroyed.*
- *There is some evidence to suggest that the magnetite content is considerably reduced in mineralized sections, perhaps having been altered to pyrrhotite and/or grunerite.*
- *Visible gold is common on the polished outer surface of core but has rarely been seen on broken surfaces. Visible gold occurrences usually correlate well with assay results.*
- *Gold mineralization is accompanied by traces of microscopic chalcopyrite and sphalerite. However, neither mineral was noted microscopically in drill core.*

Several features are notable by their absence:

- *There are virtually no quartz veins and the few which do occur seldom contain gold. There is also no visible or geochemically evident siliceous alteration, at least not within the basalts. Within the iron formation, variable quartz content and the possibility of remobilization of original chert makes identification of siliceous alteration difficult in drill core.*
- *There is no arsenopyrite and no evidence of geochemically anomalous arsenic. This situation should be contrasted with the other gold deposits in the Pickle Lake camp where vein quartz was usually the immediate host and arsenopyrite was often the main sulphide.*

Detailed studies concerning the genesis of the deposit are just beginning but, in general, it is assumed that the important factors relating to localization of mineralization are:

- *The iron formation which provided a competency contrast with the adjacent basalts and a chemically attractive site for the replacement of iron-rich minerals by iron sulphide. Limited polished section work on mineralized iron formation indicates that the magnetite beds are finely fractured and brecciated, leaving what would presumably be a very porous network for the movement of fluids.*
- *Cross-folds which induced the fracturing in the iron formation and provided a locus for the entry and deposition of mineralized solutions.*
- *The sodium-rich felsic dykes and albite porphyry, whose exact role is uncertain, but whose association with most gold deposits in the Canadian Shield empirically suggests that they are a necessary factor.*
- *Amphibolite-grade metamorphism, which*

may have resulted in ductile, as opposed to brittle, deformation. It is assumed that this is the reason for the amorphous zone of sulphide replacement rather than a distinct break or shear zone with quartz filling.

All of the above hypotheses assume that the deposit is epigenetic, that the pyrrhotite mineralization is secondary and partially or completely replaced original iron-rich minerals, and that the gold mineralization was penecontemporaneous with the pyrrhotite. However, the sequence and mechanisms of deformation, and even the degree and nature of sulphide replacement, are open to further study.

Outcrop is very sparse in the vicinity of the deposit, except for some of the hanging wall basalts and one small exposure of the unmineralized chert. [Exposures were subsequently created during mining and development activities.] Consequently, considerable reliance was placed on geophysics and geochemistry in the early stages of exploration, prior to detailed diamond drilling. Not surprisingly, magnetics were the most useful tool in defining the distribution and gross structural characteristics of the iron formation. However, very closely spaced readings on a 50m box grid were required to define the subtle variations in structure caused by the cross-fold hosting the gold mineralization.

Horizontal loop EM surveys with a 100m coil separation gave a weak but discernable response over the deposit. It is assumed that the response is weak due to the wispy and patchy nature of the sulphide mineralization, despite sulphide concentrations in excess of 15%.

Surface soil geochemistry, involving both C- and A-horizon soils, failed to reveal the deposit. This failure is attributed to the uniform blanket of till which rests directly on [bed]rock.

Rock geochemistry was somewhat more useful during initial stages of exploration prior to diamond drilling. Samples of basalt in the hanging wall returned up to 82ppb gold and more than half of the samples, in a radius of 200m, contain more than 10ppb gold. Background elsewhere on the property, including in iron formation, is in the order of 1ppb gold.

The Dona Lake gold deposit is intimately associated with a folded, oxide-facies iron formation. It is the iron formation which played a crucial role in providing a structural and chemical trap for mineralizing solutions."

Structural setting for gold mineralization

East of the Ochig Lake pluton, in the vicinity of the Dona Lake Mine, Stott and Corfu (1991) described shear zones with normal sense movement that are parallel and dip away from the margin of the pluton and interpreted these shear zones as related to pluton emplacement. East of the northeastern lobe of the Ochig Lake pluton, within a mapped contact strain domain, in the vicinity of the Dona Lake area, Stott (1996) documented margin-parallel shear zones dipping away from the intrusion, showing pluton-side-up kinematics.

A discussion of gold in high-strain zones associated with pluton emplacement was given in Smyk et al. (2011). Stott and Biczok (2010) had related the structural geology of Musselwhite Mine (125km north of Pickle Lake) to the emplacement of the crescent-shaped North Caribou pluton and revisited the idea (Stott et al., 1989) that gold mineralization there may also be related to the intrusion of this pluton. In this model, lateral compression imparted by the intrusion of the pluton produces shallowly plunging, isoclinal and locally transposed folds, and high-strain or shear zones in relatively incompetent lithologic layers that fold more tightly. These narrow high-strain/shear zones reflect coaxial strain and would not be related to any through-going, transcurrent, regional shear zone. Any non-coaxial shear features on folded limbs can be accounted for by subjecting rocks to the limit of flattening and by accommodating the extreme shortening by rotation and lateral shear. These zones, however, may focus hydrothermal fluid flow and host fault-fill veins (cf. Dubé and Gosselin, 2007). Many such zones are characterized by replacement and/or alteration zones, rather than discrete vein systems. The mineralized zones that result from such focussed fluid flow are localized and may only represent a very small proportion of a favourable host lithology (e.g. banded iron formation).

Gold mineralization at Dona Lake is manifested as a flattened, plunging pod, hosted by a folded, sulphidized banded iron formation, largely in the core of a cross-fold axis (Cohoon, 1986). There is a notable lack of brittle features, quartz veining and a mineralized shear zone or 'break", ascribed in part to the relatively high grade (amphibolite facies) of metamorphism. The deposit is situated in the amphibolite-facies contact

metamorphic and strain aureole surrounding the Ochig Lake pluton (Stott, 1996). This pluton (2741Ma) has post-dated and overprinted the regional penetrative deformation fabrics with its own contact strain fabric (cf. Young et al. 2006).

Stott (1996) and Stott and Smith (1988) listed several different settings for gold deposits directly attributed to felsic pluton emplacement:

- Type A: A set of shear or high-strain zones bordering an uplifted and rotated wedge of supracrustal rock;
- Type B: Shear or high-strain zone defining the outer margin of a pluton-induced strain aureole;
- Type C: Shear or high-strain zone focussed along a contrast in rock ductility (e.g., BIF-basalt; Dona Lake Mine, Musselwhite Mine);
- Type D: Shear or high-strain zones in conjugate sets at small angles to the schistosity; this strain environment may correspond to regional orogenic shortening or to a pluton-induced strain aureole; (e.g., Pickle Crow Mine); and
- Type E: Shear or high-strain zones, tangential to a strain aureole, which may have been initiated during regional orogenic shortening and locally reactivated.

Sub-stop Descriptions, Dona Lake Gold Mine (Fig. 21):

Stop 4a: Dona Lake Mine Portal area

UTM Coordinates: NAD83; 15U 0702099E / 5699732N

The rehabilitated site of the former Dona Lake Mine is now marked by a grassy field along the sides of the access road, south of Sika Pond. The mine portal, now sealed, lies just south of the road. Foliated and folded mafic metavolcanic and gabbroic rocks outcrop in the vicinity of the site and along shoreline exposures on Sika Pond. The exposures near the reclaimed mine site are dominated by gabbro and pillowed basalt of the lower sequence of the Pickle Crow Assemblage with local banded iron formation (Young 2003). Confederation assemblage mafic volcanic rocks occur east of the Dona Lake Mine area. Well-preserved pillowed flows east of the mine area indicate east-southeast younging (Young 2003). Young (2003) has noted that in the Dona Lake area, gabbro is common and has a weathered surface characterized by a 'knobby' texture caused by coarse-grained hornblende and anastomosing fractures superficially resembling pillowed basalt (Fig. 22).



Figure 21. Dona Lake Mine area with Field Trip Stop locations.



Figure 22. Coarse-grained, amphibolitized gabbro, south of Sika Pond (Stop 4a).

Stop 4b: Banded Iron Formation

UTM Coordinates: NAD83; 15U 0701767E / 5699990N; 0701708E / 5699991N, and 0701764E / 5699994N

Banded iron formation outcrops (Fig. 23) in a number of locations (see three sets of UTM coordinates above) along a mine access road that skirts the western shore of Sika Pond and accesses a flooded mine pit. A southeasterly trending foliation and M- and Z-folds are developed in these BIF units. A rusty BIF sample collected by OGS staff returned <0.01 z/ton Au and 0.3 oz/ton Ag (unpublished data, Resident Geologist's Files, Thunder Bay)

Stop 4c: Pillowed Basalt

UTM Coordinates: NAD83; 15U 0701686E / 5700056N

A small outcrop of relatively undeformed pillowed basalt (Fig. 24) is situated on the west side of the mine road, across from where a pit had been developed in BIF. Bun pillows and brecciated pillow fragments have thin, dark, amphibole-rich selvages.



Figure 23. Rusty, folded BIF near pit, west of Sika Pond (Stop 4b).



Figure 24. Pillowed basalt, west side of road, near pit, west of Sika Pond (Stop 4c).

Stop 5: Ochig Lake Pluton

UTM Coordinates: NAD83; 15U 0693228E / 5693898N.

One of the few exposures of the Ochig Lake Pluton occurs on the eastern side of Highway 599, south of Fault Lake. These low-lying outcrops expose grey, medium-grained, equigranular biotite granodiorite with local, lenticular quartz-filled gashes (Fig. 25). One of the internal granitoids in the Pickle Lake belt, the Ochig Lake Pluton is semi-circular in plan, with a domical internal structure defined by outward-dipping foliation (Stott 1996). A northeasterly trending, steeply southeast-dipping foliation was noted by Stott et al. (1989a) just northeast of this location. Most of the pluton consists of homogeneous, medium- to fine-grained granodiorite to trondhjemite. The Ochig Lake pluton yielded a U-Pb zircon age of 2741±2Ma (Corfu and Stott 1993a).



Figure 25. Quartz veins and lenses in equigranular granodiorite of the Ochig Lake Pluton, Highway 599 (Stop 5).

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Field Trip 9 - The Ghost Lake Batholith and Related Pegmatites

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Introduction

The Late Archean (2685 Ma) Ghost Lake Batholith (GLB) is a roughly 280km2 elongated intrusion which trends east to northeast, following regional structures (Fig. 1). The GLB is exposed from Eagle River, northeast to Ghost Lake, and is classified as a two mica granitoid (biotite and muscovite). Mineralogy of the peraluminous fertile S-type granitoid includes cordierite, sillimanite, Mg-garnet, tourmaline, beryl, and rare dumortierite (a fibrous borosilicate). The batholith shows trends of increasing geochemical fractionation, and as a result, is host to exotic rare element pegmatite occurrences, such as the Mavis Lake pegmatite group.

Identifying the initial sources and processes that concentrate lithophile metal enrichment in rare element pegmatites can be difficult when pegmatites are not found in association with the fertile primary parent granite. This is further hindered when the melts separate and mix with the crustal material during ascent and emplacement, producing hybrid geochemical and mineralogical signatures. In contrast, the Ghost Lake Batholith represents an intrusive complex where the rare element pegmatite facies exists within its consanguineous, primitive peraluminous granite parent (Breaks and Moore, 1992). This relationship shown in outcrop presents an opportunity to assess mechanisms that concentrate rare elements in pegmatites. For this reason, the Ghost Lake Batholith has been the subject of much past academic research, and likely will continue to be for years to come.

This ½ day field trip will examine granite and pegmatitic outcrop from the Ghost Lake Batholith,

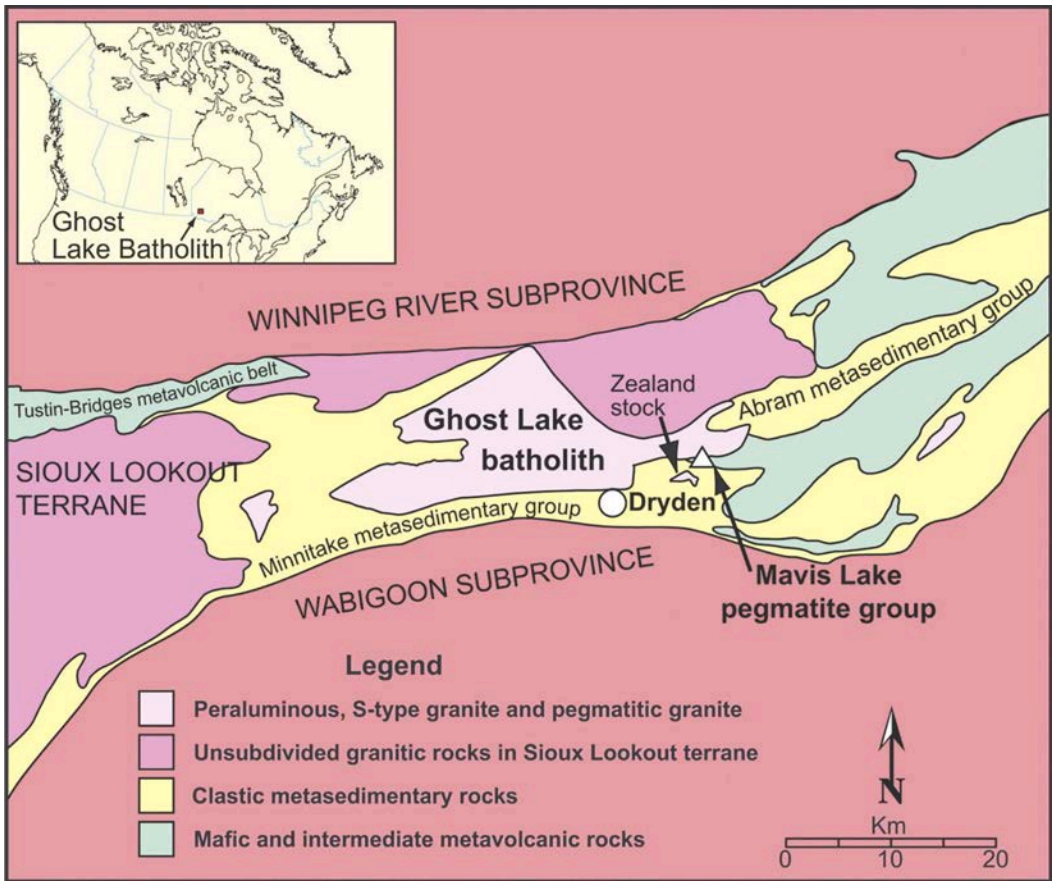


Figure 1. Generalized map showing the Sioux Lookout Terrane boundary and the location of the Ghost Lake Batholith and the Mavis Lake pegmatite group (from Brand et al., 2009).

and two associated pegmatites, both of the Mavis Lake Pegmatite Group. This field guide builds upon those previously written and compiled by Breaks (1982), Breaks (1985), Breaks and Janes (1991) and Beakhouse et al. (1995). One stop is a road cut, so caution must be exercised. Never stand on the paved portions of the road, and be aware of the traffic at all times.

Regional Geology

The GLB and related Mavis Lake Pegmatite group occur within the Winnipeg River–Wabigoon Subprovince boundary zone, referred to as the Sioux Lookout Terrane (SLT) (Beakhouse, 1989). The SLT is characterized by metasedimentary and metavolcanic assemblages exhibiting a wide range of metamorphic grade, including zones of migmatized metasedimentary rocks (Breaks and Moore, 1992). This terrane is host to about 150km of peraluminous granite plutons, with the GLB being the largest of the group. Geochemically, the plutons of the SLT exhibit enrichment in lithophile elements and rare-earth elements (REE's), including Cs, Be, Li, Rb, Nb, Ta, Ga, U, Th, Mo, W, and Sn.

The GLB is broadly concordant to the east-striking foliations and is weakly foliated. Evidence of the foliations is shown by preferred orientations of phyllosilicates, and biotite-cordierite-sillimanite segregations. Foliation diminishes towards the eastern segment of the batholith. Multiple events of ductile deformation in the GLB are described by Breaks and Moore (1982), and will be discussed at each field stop.

The GLB is subdivided into two portions comprising the Western GLB and the Eastern GLB. The Western GLB is also known as the lower intrusion, where the granitoids are less homogenous, and form transitional contacts with the migmatized sedimentary host. In the Eastern GLB, also known as the upper intrusion, the contacts with the metasedimentary rocks are abrupt and contain fewer sedimentary inclusions. Traversing from the lower intrusion through to the upper intrusion, there are marked trends of geochemical fractionation involving enrichment of B, Be, Ga, Li, Nb, and Rb; and depletion of Ba, Sr, Zr, and total REE.

Ghost Lake Batholith stops

Starting at the parking lot of the Best Western Hotel and Conference Center, Dryden, drive 13km west along the Trans-Canada Highway 17 to the village of Oxdrift. Park vehicles in the old Oxdrift School parking lot and walk to the road cut located just west of the Corner Road intersection.

Stop 1: GLB-1, Oxdrift School Stop, Muscovite-biotite granite, biotite-muscovite granite, rare granodiorite (± cordierite).

UTM Coordiantes: NAD 83 15U 0499697E / 5518078N

This road cut is located in the western part of the batholith and features different plutonic phases. Most of the outcrop at this location was termed GLB-1 by Breaks and Janes (1991). GLB-1 is one of the most common granitic units of the batholith. It is an inequigranular, coarse grained, massive to weakly foliated biotite and cordierite-biotite granite. Zones of inhomogenous biotite granite with inclusions of metasedimentary rocks and mafic segregations occur throughout GLB-1. Biotite and cordierite-biotite pegmatitic leucogranite segregations occur sporadically throughout the unit. Breaks and Janes (1991) document the pegmatitic masses as consisting of blocky, graphic K-feldspar-quartz masses up to 60cm wide, grading into smoky quartz segregations in association with blocky K-feldspar, biotite, and apatite. Cordierite can be seen occurring as square megacrysts, but it appears more often as dark masses that are up to 1.5cm in diameter. It can be replaced by chlorite, muscovite, and andalusite. Accessory minerals include garnet, apatite, zircon, monazite, and sillimanite. Secondary muscovite occurs after K-feldspar, plagioclase (An10-30), biotite and cordierite. Other plutonic phases at this location are dikes of fine-grained, grey, muscovite-biotite granite and coarse-grained, white biotite-muscovite leucogranite and pegmatite segregations.

Mavis Lake Group Pegmatites stops

Drive east from Stop 1 on Highway 17 back through Dryden for approximately 16.4km until you reach Airport Road. Turn left onto Airport Road and travel north for 4.8km to Ghost Lake Road. Turn right on Ghost Lake Road and follow the main road to the junction with a logging road at UTM coordinates 527090E, 5522510N, a distance of approximately 11.6km from Airport Road. Turn south and drive along this main road to an intersection with a secondary logging road at UTM coordinates 526970E, 5521410N, a distance of about 1.4km. Veer west along this secondary road and up the hill where several vehicles can park. Most of the better outcrops at this stop are located south of the logging road.

Beakhouse et al. (1995) describe the Mavis Lake

Pegmatite Group as an east-striking, 8km by 1.5km, concentration of rare-element pegmatites and related metasomatic zones. With increasing distance from the parent Ghost Lake Batholith, the pegmatite mineral assemblages exhibit well-defined zonations. More than 12 distinctive spodumene pegmatites are described from the Mavis Lake area and each ranges in size from 3 by 15m to 15 by 280m. Occurring parallel to the foliation of the host metavolcanic rocks, the pegmatites intrude as roughly lensoidal bodies. The rare-element pegmatites are classified as the albite-spodumene type (after Černy, 1982). Mavis Lake Group Pegmatites are structurally confined to the northern limb of the west-plunging Thunder Lake Syncline and show localized effects of late-tectonic deformation, for example: strained contacts; healed fractures involving tourmaline and spodumene buckling; and boudinage of pegmatitic granitic dykes near the contact zones.

STOP 2: Dryden Airport Pegmatite

UTM Coordinates: NAD 83 15U 0526720E / 5521360N

This stop shows pegmatitic-aplite dykes intruding metasedimentary rocks (Fig. 2). This dyke is described as a barren potassic pegmatite with a characteristic mineral assemblage including garnet, muscovite, biotite, abundant coarse tourmaline, albite, quartz, blocky microcline ($Or_{70-77}Ab_{23-30}$), and rare, large (up to 10cm in length) lime-green beryl. Remnant rock saw cuts represent poached rare beryl.

Return to the vehicles and drive back to Highway 17. Turn right (east) onto the highway and drive 3.7km until you reach Thunder Lake Road. Turn left onto Thunder Lake Road and travel 2.7km to Mavis Forest Road. Turn down Mavis Forest Road and travel 2.6km and park to your right at a small BMX trail entrance (just after the powerline). Follow the trail in and veer to your first left. Follow the trail until you reach a fork in the trail and then veer right and follow the intersection of the rutabaga trail and out onto a large ridge. Follow this around to the pegmatite clearing.

STOP 3: Fairservice Spodumene-Beryl-Tantalite Pegmatites

UTM Coordinates: NAD 83 15U 0523789E / 5518050N

The Fairservice pegmatite intrudes foliated and gneissic mafic metavolcanic rocks and fine-grained laminated metagreywackes. There is some vague internal zonation - in which this particular occurrence is representative of a quartz-rich core and spodumene-rich, albite-quartz pegmatite. This pegmatite hosts a randomly oriented, green primary spodumene, large coarse quartz pod-like segregations, thick yellow-green muscovite, albite, apatite, lesser white and blue beryl, large black tourmaline (Fig. 3), blue apatite, and orange garnet in a matrix of light grey massive quartz. A sharp contact with laminated metagreywackes is noted. Healed fractures of tourmaline are shown at this occurrence.

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Figure 2. Dryden Airport Pegmatite in contact with metasedimentary rocks.



Figure 3. Fractured tourmaline from the Fairservice Occurrence, Mavis Lake Pegmatite Group

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Field Trip 10 - Mattabi/Sturgeon Lake Historic VMS Camp

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Introduction

Detailed field, petrographic, and lithogeochemical studies performed since the mid-1980's have indicated that the south Sturgeon Lake region of northwestern Ontario is underlain by an extremely well-preserved, though partially eroded, Neoarchean subaerial to submarine volcanic caldera complex (Fig. 1: Morton et al., 1991; Hudak et al., 2003). This caldera complex, the Sturgeon Lake Caldera Complex (SLCC), hosted six massive sulphide orebodies which produced nearly 20 million tons of polymetallic volcanogenic massive sulfide (VMS) ore during mining operations between 1972 and 1991 (Table 1), as well as numerous sub-economic massive and semi-massive sulphide showings.

The combination of well-preserved volcanic and hydrothermal alteration textures, the variable 55° to 90° dip of a north-facing, essentially homoclinal volcanic sequence, and more than 600,000m of diamond drilling over an apparent 4,500 meter stratigraphic interval has enabled geologists the opportunity to examine the lithological, lithogeochemical, and metallogenic evolution of the SLCC. This includes the synvolcanic subvolcanic intrusions (Biedelman Bay Intrusive Complex), initial subaerial to shallow subaqueous pre-caldera volcanism (Pre-caldera Sequence, PCS), early subaerial to submarine explosive silicic volcanism (Early Caldera Sequence, ECS) that is associated

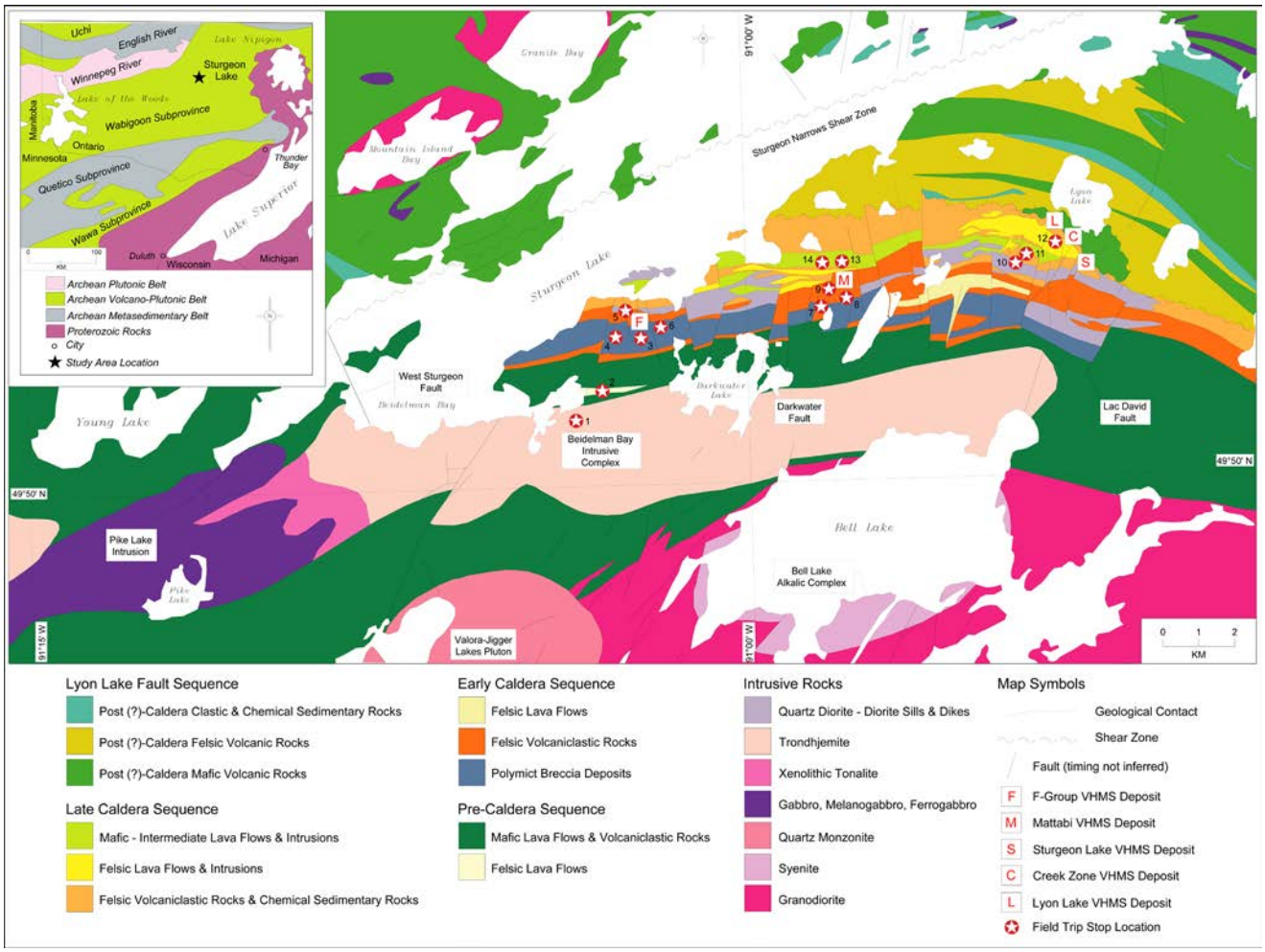


Figure 1. Location map (inset) and regional geological map of the south Sturgeon Lake region (modified after Trowell, 1983; Morton et al., 1991; Morton et al., 1999; Galley et al., 2000).

Table 1. Grade and tonnage statistics from the VMS ore deposits of the south Sturgeon Lake region (after Franklin, 1996). Caldera sequences include the Early Caldera Sequence (ECS) and the Late Caldera Sequence (LCS; Hudak, 1996; Morton et al., 1999; Hudak et al., 2003).

Deposit	Caldera Sequence	10^6 Tons	Cu %	Zn %	Pb %	Ag (g/t)	Ag (g/t)
F-Group	ECS	0.34	0.64	9.51	0.64	60.4	2.13
Mattabi	ECS/LCS	12.55	0.74	8.28	0.85	104.0	3.67
Sturgeon Lake	LCS	2.07	2.55	9.17	1.21	164.2	5.79
Creek Zone/Sub-Creek Zone*	LCS	0.91	1.66	8.80	0.76	141.5	4.99
Lyon Lake*	LCS	3.95	1.24	6.53	0.63	141.5	4.99
Total/*Average*		19.82	*1.06*	*8.50*	*0.91*	*119.7*	*3.85*
** VMS deposits interpreted to have originally formed as part of Sturgeon Lake deposit*							

with the development a multi-cyclic, piecemeal caldera complex up to 25km in strike length, and later intracaldera submarine mafic to felsic, dominantly effusive submarine volcanism and clastic and chemical sedimentation (Late Caldera Sequence, LCS). Post-volcanic structural deformation has not only led to the apparent transposition of non-caldera associated strata (Lyon Lake Fault Sequence, LLFS) up-section from the caldera-associated volcanic sequence, but has locally led to remobilization of massive sulphide mineralization along a major northwest-southeast-trending fault zone to form smaller, but locally economic, massive sulphide deposits (e.g., the Lyon Lake, Creek Zone, and Sub-Creek Zone deposits). The stratigraphic evolution in the SLCC represents one of the few examples of Neoarchean calderas which illustrate the modern "caldera cycle" (Smith and Bailey, 1968; Hudak et al., 2003; Mueller et al., 2004; Mueller et al., 2008).

This field trip has several purposes: 1) to illustrate the textures, lithologies, and geological structures resulting from various volcanological and sedimentological processes associated with various stages of caldera complex development; 2) to illustrate the hydrothermal alteration mineral assemblages within the caldera complex, and their spatial relationships to volcanogenic massive sulphide (VMS) mineralization; and 3) to illustrate methods by which exploration geologists can use physical volcanology, hydrothermal alteration mineral assemblages, and structural geology, along with other lithogeochemical and geophysical data, to effectively explore for VMS deposits in the Sturgeon Lake camp and elsewhere. This guidebook represents an updated version of previous field trip guidebooks for the Sturgeon Lake region that were associated with the Geological Association of Canada – Mineralogical Association of Canada meeting during May, 1996 (Morton et al., 1996), as well as the Precambrian Research Center Professional Workshop on VMS and lode gold deposits in Archean greenstone belts (Hudak et al., 2008).

In addition to this guidebook, the reader is referred to two papers which describe the physical volcanology and mineralization present within the SLCC. These papers provide detailed overviews of the regional geology as well as the literature related to subaerial and submarine volcanic processes and the genesis of VMS mineralization. Morton et al. (1991) presents an early interpretation of the stratigraphic sequence within the SLCC, and discusses the interrelationships between volcanological and mineralizing processes that formed the Mattabi VMS orebody. This classic paper is the first to discuss the development of a submarine caldera complex in the south Sturgeon Lake region, and how processes associated with caldera development led to conditions favourable for massive sulphide mineralization. Hudak et al. (2003) is a detailed discussion of submarine explosive silicic volcanological processes within the SLCC, and how these processes dictated the stratigraphic intervals, as well as the intracaldera locations, where economic VMS mineralization occurs within the SLCC. In addition, Hudak et al. (2003) includes the most up-to-date stratigraphic nomenclature and interpretations of the volcanological and ore-forming processes associated with the genesis of this exceptionally well-preserved Neoarchean subaerial to submarine caldera complex. In essence, Hudak et al. (2003) indicate that

larger VMS deposits correlate with larger explosive eruption events within the SLCC.

Regional Geologic Setting

The SLCC is located within the South Sturgeon Sequence of the Savant Lake-Sturgeon Lake Greenstone belt that occurs in the Wabigoon Greenstone Belt of the Superior Province (Fig. 1; Sanborn-Barrie and Skulski, 1999). The SLCC is up to 25 km in strike length, and contains an approximately 3000 meter stratigraphic thickness of north-facing, vertical to moderately north-dipping (55°) intracaldera fill (Morton et al., 1991; Morton et al., 1999; Hudak et al., in press) composed of greenschist to locally amphibolite facies (Trowell, 1974, 1983; Groves et al., 1988) metavolcanic, metasedimentary, and meta-intrusive rocks of Neoarchean age (Table 2). The eastern margin of the SLCC has been interpreted by Morton et al. (1991, 1999) to be the Lac David Fault. The western margin of the SLCC is poorly constrained by limited outcrop and diamond drilling, but based on the western limit of intracaldera strata, numerous dikes, and extensive hydrothermal alteration, is believed to be located beneath Biedelman Bay at the West Sturgeon Fault (Fig. 1). The caldera complex and associated ore deposits formed within an evolved, continental margin oceanic arc (Sanborn-Barrie et al., 2001; Galley, 2002) which contained magmas derived from back-arc basalts (Galley, 2003) that were not contaminated to any large extent by older 3.0 Ga Wabigoon Province continental crust (Bernier et al., 1999).

Two coeval intrusive complexes intrude into the pre-caldera supracrustal volcanic strata in the Sturgeon Lake region, and have been extensively studied by Galley et al. (2000), Galley (2002), and Galley (2003). The Pike Lake Layered Complex (PLLC) consists of massive to crudely layered ferrogabbro, melanogabbro, and gabbro that, combined, are up to 10km in strike length and up to 2500m thick. The PLLC is intruded along its eastern margin by the Beidelman Bay Intrusive Complex (BBIC), which is approximately 20km in strike length and up to 2000m thick (Trowell, 1983; Galley et al., 2000). The BBIC is composed of at least six separate intrusive phases, from oldest to youngest including xenolithic tonalite, quartz-porphyritic pre-main phase dikes, main phase leucotonalite, post-main-phase leucotonalite dikes, quartz-plagioclase-phyric porphyritic dikes, and late phase quartz monzonite and granodiorite stocks (Galley, 2002; Galley, 2003). Wide variations in geochemical signatures and age dates for these intrusive rocks indicate a complex magmatic history encompassing at least three separate magma sources over a time span of up to 20 my (Table 2; Galley, 2002). The pre-main phase dikes, main phase leucotonalite, and post-main phase leucotonalite dikes are interpreted to be syn-caldera magmatic phases based on similar U/Pb zircon

Table 2. Summary of geochronology in the south Sturgeon Lake region (modified from King et al., 2000).

Sample No.	Source	Rock Unit King et al., 2000	Rock Unit (this study)	Date (Ma)	Analytical Error (Ma)
PN76-13	Davis & Trowell, 1982	Post-caldera felsic volcaniclastic	Post-caldera felsic volcaniclastic	2717.9	+ 2.7 - 1.5
96-GIA-328	Galley et al., 2000: Galley, 2002	N/A	Biedelman Bay quartz-plagioclase porphyritic dike	2720	+3.5 - 3.0
PN76-14	Davis & Trowell, 1982	Lyon Lake Andesite and Rhyolite	Swamp Lake rhyolite	2736.0	+1.8 -1.8
JH82-2	Davis et al., 1985	Lyon Lake Andesite and Rhyolite	Swamp Lake rhyolite	2735.2	+6.9 -3.2
JH82-1	Davis et al., 1985	Lyon Lake Andesite and Rhyolite	Swamp Lake rhyolite	2734.8	+2.8 -2.5
JH82-5	Davis et al., 1985	Not Reported	Lyon Creek dacite lava	2735.0	+1.7 -1.7
JH82-4	Davis et al., 1985	Lyon Creek Lava Dome Breccias	Middle L tuff	2735.5	+3.0 -1.9
PN76-15	Davis et al., 1985	Mattabi Ash Flow	Middle L tuff	2734.7*	±1.6
JH82-3	Davis et al., 1985	Lyon Creek Lava Dome Breccias	Mattabi (?) tuff	2736.3	+9.3 -3.9
DD78-17	Davis & Trowell, 1982	Pike Lake Pluton Gabbro	Pike Lake Complex	2732.7	+3.6 -2.0
DD78-18	Davis & Trowell, 1982	Beidelman Bay biotite trondhjemite	Beidelman Bay biotite trondhjemite	2733.8	+1.4 -1.3
Not Reported	Galley, 2002	N/A	Beidelman Bay biotite leucotonalite	2734.0	+3 -3

* Davis et al. (1985) note this is a minimum age.

dates (2738.5-2732.5 Ma; Davis and Trowell, 1982; Davis et al., 1985; Galley, 2002) and trace element geochemical characteristics (Campbell et al., 1981; Galley et al., 2000; Galley, 2002) that correspond with SLCC intracaldera tuffs. These intrusive phases are believed, in part, to have provided thermal energy to drive regionally extensive hydrothermal systems which formed semi-conformable zones of sericite ± dolomite alteration that were subsequently cross-cut by diffuse, semi-conformable to disconformable alteration zones comprising iron carbonate (ferruginous dolomite, ankerite or siderite), iron-chlorite, chloritoid, and aluminum silicate (pyrophyllite, andalusite and/or kyanite) (Franklin et al., 1975; Campbell et al., 1981; Hudak, 1989; Jongewaard, 1989; Morton et al., 1991; Galley et al., 2000; Galley, 2002; Holk et al., 2002, Galley, 2003) that are genetically associated with VMS formation. Intrusive and hydrothermal breccias, and quartz-plagioclase-phyric dikes associated with porphyry-style Cu-Mo mineralization described by Poulsen and Franklin (1981) are approximately 15 my younger than the synvolcanic intrusive phases, indicating that porphyry mineralization in the south Sturgeon Lake area post-dates caldera-associated VMS mineralization (Galley et al., 2000; Galley, 2002).

Three distinctive types of faults have been recognized in the south Sturgeon Lake area, as well as at numerous other VMS deposits (Gibson et al., 1999). These include: a) synvolcanic faults; b) post-volcanic high-angle faults; and c) post-volcanic shear zones which may occur at a relatively low angles to the stratigraphy and may represent thrust faults. Synvolcanic faults are recognized using the following criteria: a) apparent offset of a layered unit, with subsequent units not offset; b) abrupt thickening or thinning of a volcanic, volcaniclastic, or sedimentary unit; c) rapid changes in alteration intensity or abrupt changes in alteration mineral assemblages; and d) the presence of apophyses or dikes associated with synvolcanic intrusions (Gibson et al., 1999; Hudak et al., 2003). Post-volcanic high angle faults have the following characteristics: a) offset of all stratigraphic units; b) abundance of brittle fracturing and/or zones of lost core; and c) abundance of quartz ± carbonate ± tourmaline veins filling fractures. Post-volcanic shear zones (thrust faults?) can be identified using a combination of the following criteria: a) intense shearing within adjacent units; b) displacement of older stratigraphic units into positions up-section from younger stratigraphic units; c) presence of "lamprophyre" and/or massive diorite dikes; and d) locally, the presence of graphite-rich breccia zones containing angular quartz-rich fragments (Hudak, 1996).

Several episodes of faulting and folding have taken place in the south Sturgeon Lake region. Numerous synvolcanic fault zones were identified by Morton et al. (1991, 1999) based on abrupt thickness changes in volcanic strata, terminations of fault zones by overlying volcanic strata, and proximity to intense hydrothermal alteration and/or VMS mineralization. Two episodes of post-volcanic faulting are preserved in the south Sturgeon Lake area. The earliest event is a low angle shear zone (possibly a thrust fault) which juxtaposed caldera-associated strata and non-caldera associated strata in the eastern and northeastern parts of the south Sturgeon Lake area (Hudak, 1996: Morton et al., 1999). The fault zone interpretation is supported by a) the presence of highly strained rocks along the contact between the two sequences (Dube et al., 1989; Koopman, 1993; Hudak, 1996); b) the lack of consistent stratigraphy along a 20-50 m thick zone adjacent to the contact in the vicinities of the Sub-Creek Zone, Creek Zone, and Lyon Lake VMS orebodies (Hudak, 1996); c) abrupt terminations of alteration mineral assemblages across the contact (Hudak, 1996); and d) sharp oxygen isotopic gradients across the contact (Moss, 1992; Holk et al., 2002). This fault zone has been successfully geophysically imaged by Nedmović and West (2002). A subsequent faulting event formed a series of NNE-trending faults that offset the intracaldera supracrustal strata and the early low angle fault (Figure 1: Koopman, 1993; Hudak, 1996; Morton et al., 1999). The major fold event in the region resulted from a ca 2.7 Ga north-south compression event associated with the collision of Neoarchean rocks in the south Sturgeon Lake region and a Mesoarchean volcanic rift sequence to the north (Sanborn-Barrie and Skulski, 1999). The north-facing and north-dipping stratigraphic sequence in the south Sturgeon Lake assemblage represents the southern limb of an E-SE-trending, shallow east-plunging F1 fold axis located in the Post-Lake – Barge Lake region (Sanborn-Barrie et al., 1998). A major 116°-trending, 16°E-SE plunging fold documented by Dube et al. (1989) and Koopman (1993) near the Lyon Lake and Creek Zone orebodies is consistent with the orientation of this F1 syncline.

Generalized Stratigraphy and Physical Volcanology of the SLCC

Thirteen supracrustal stratigraphic successions have been grouped into four stratigraphic sequences based on their temporal and genetic relationships to caldera

development, as well as their stratigraphic position relative to the Mattabi VMS orebody (after Hudak, 1996). Progressing stratigraphically up-section, these sequences are: a) the Pre-caldera Sequence (PCS); b) the Early Caldera Sequence (ECS); c) the Late Caldera Sequence (LCS); and d) the Lyon Lake Fault Sequence (LLFS). A major zone of structural deformation interpreted as either a shear zone (Koopman, 1993) or a thrust fault (Hudak, 1996) marks the contact between the PCS, ECS, and LCS in the south, and the LLFS to the north. Figures 2, 3, and 4 illustrate the geology in the western, central, and eastern parts of the SLCC, respectively. Figure 5 contains stratigraphic columns in various parts of the caldera complex.

The PCS (Figs. 6 and 7) comprises a 200-2100m thick succession of subaerial and shallow subaqueous basalt lava flows, scoria-rich volcaniclastic deposits, and minor associated rhyolite lava flows (Groves et al., 1988; Morton et al., 1991; Morton et al., 1999). Pillow lavas and hyaloclastite are conspicuously absent in this sequence, except locally in the easternmost regions of the south Sturgeon Lake area (Jongewaard, 1989). Groves et al. (1988) and Morton et al. (1999) have interpreted the pre-caldera volcanic environment as a subaerial to shallow subaqueous shield volcano with local fields of scoria cones and tuff cones.

The ECS (Figs. 6, 8, 9, and 10) contains a 650-1300m thick succession of volcanic and volcaniclastic strata. Up-section, these include: a) subaerially deposited ash fall tuff deposits (Jackpot Lake Succession); b) interstratified polymict breccias and subaerially and subaqueously deposited quartz-phyric lapilli tuff and tuff deposits (High Level Lake Succession); c) subaerial felsic lava flows, mafic-intermediate lapilli tuffs and volcaniclastic deposits (Bell River Succession); d) interstratified subaqueously deposited polymict breccias, volcanic sandstones and mudstones, and dacitic to andesitic lava flows and tuffs (Tailings Lake Succession); and e) subaqueous, massive to locally well-bedded, quartz-phyric lapilli tuff and tuff deposits (Mattabi Succession). Hudak (1996) interpreted this stratigraphic sequence as indicative of the early stages of caldera development (c.f. Smith and Bailey, 1968; Busby-Spera, 1984; Lipman, 1976; Lipman, 1997). The distribution of voluminous felsic volcaniclastic units and associated polymict breccias suggest that

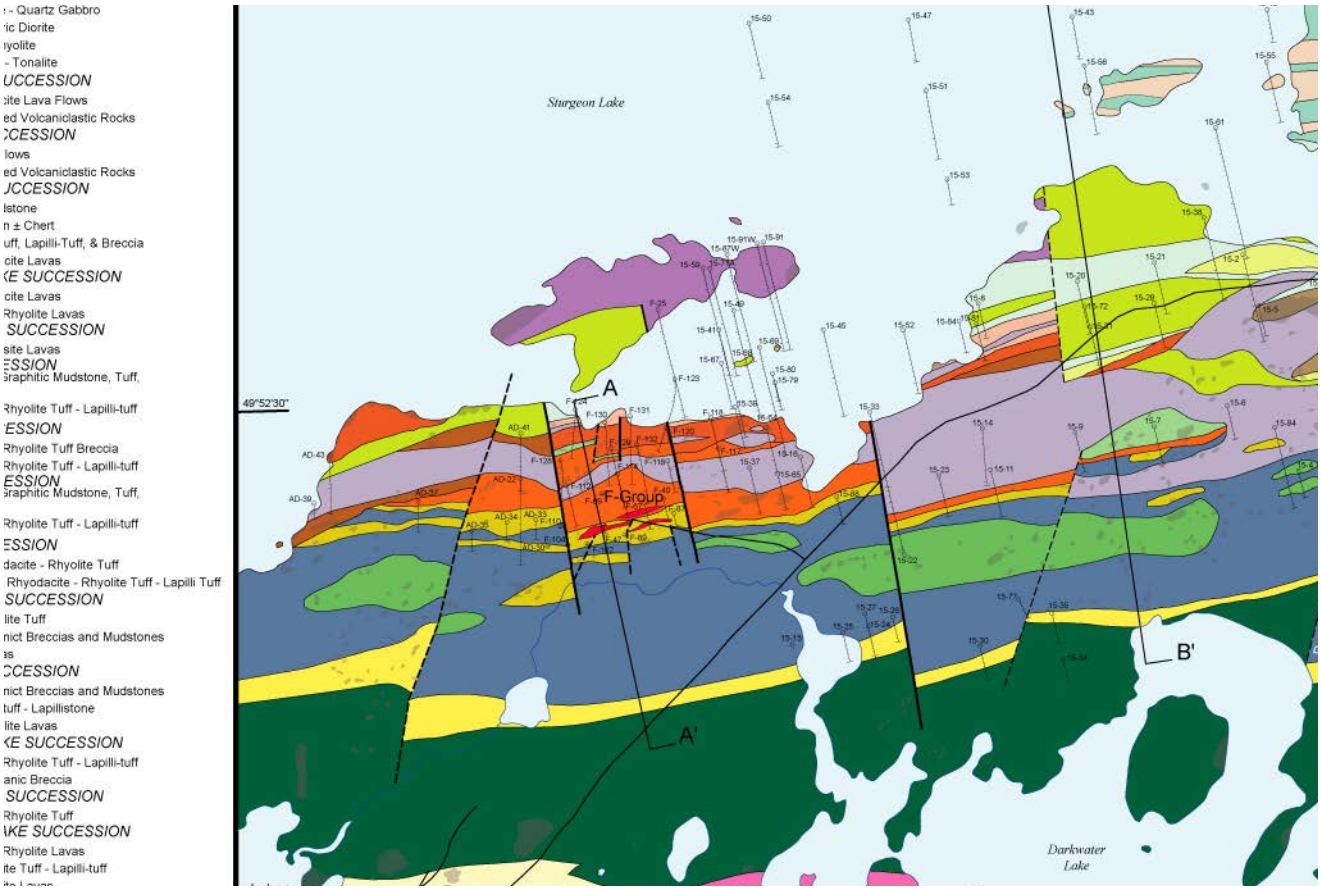


Figure 2. Geological map of the western one-third of the Sturgeon Lake Caldera Complex (modified after Morton et al., 1999). Lines A – A' and B – B' correlate to stratigraphic sections in Figure 5.

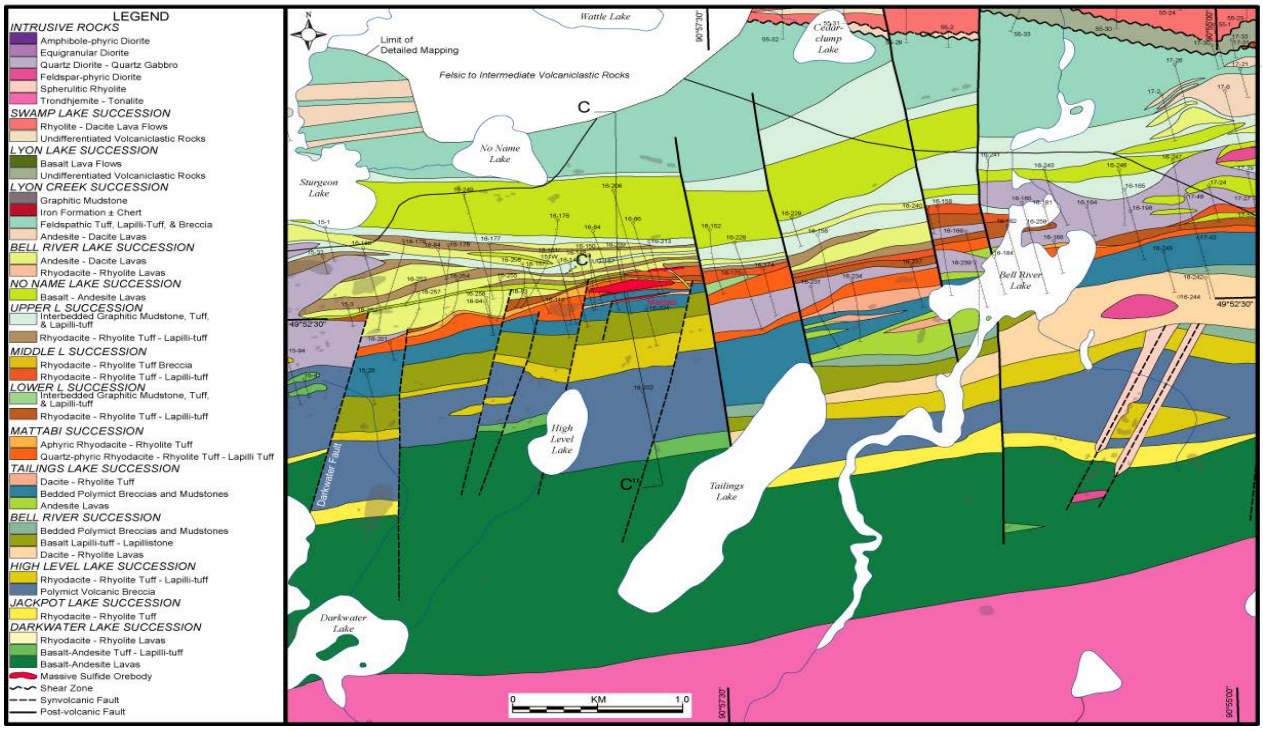


Figure 3. Geological map of the central one-third of the Sturgeon Lake Caldera Complex (modified after Morton et al., 1999). Line C – C' correlates to stratigraphic section in Figure 5.

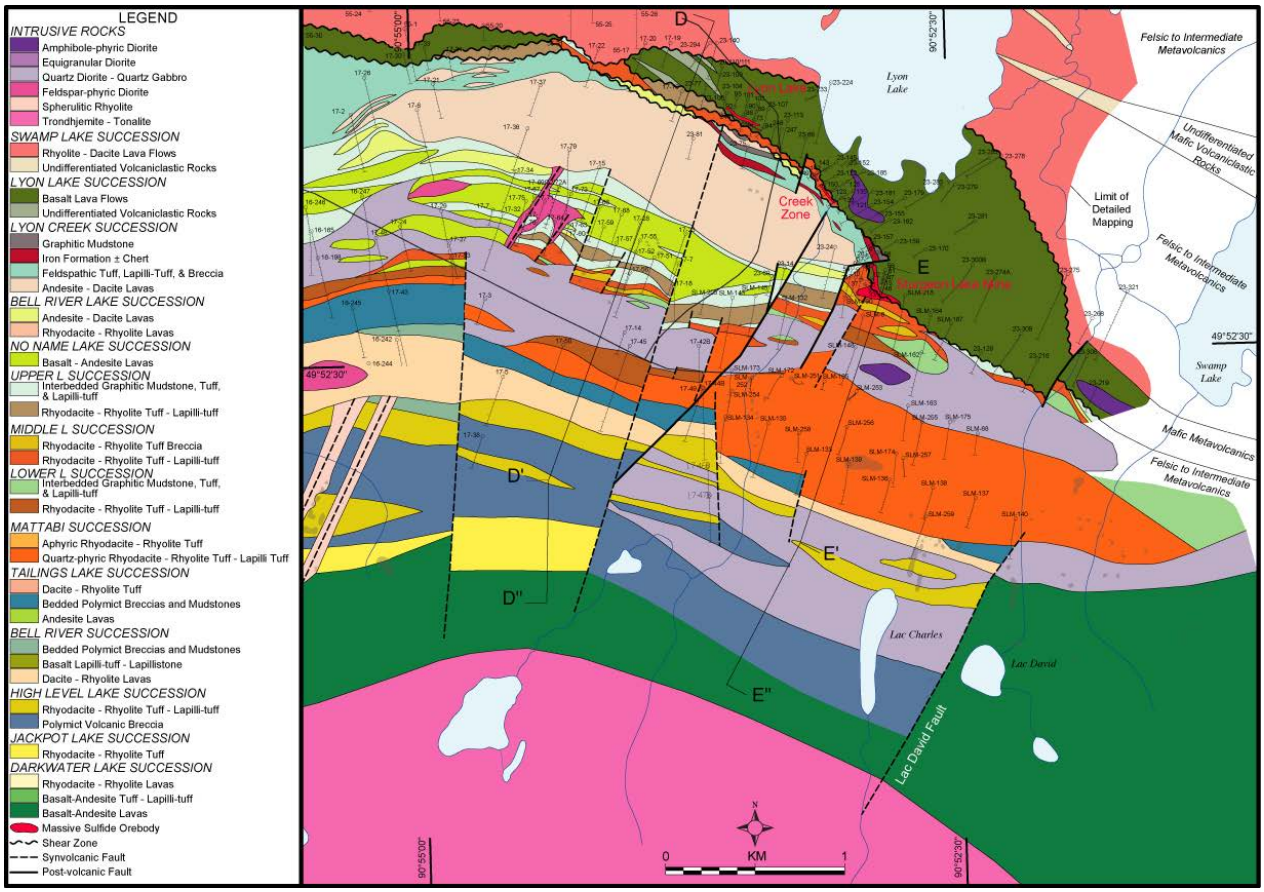


Figure 4. Geological map of the eastern one-third of the Sturgeon Lake Caldera Complex (modified after Morton et al., 1999). Lines D – D" and E-E" correlate to stratigraphic sections in Figure 5.

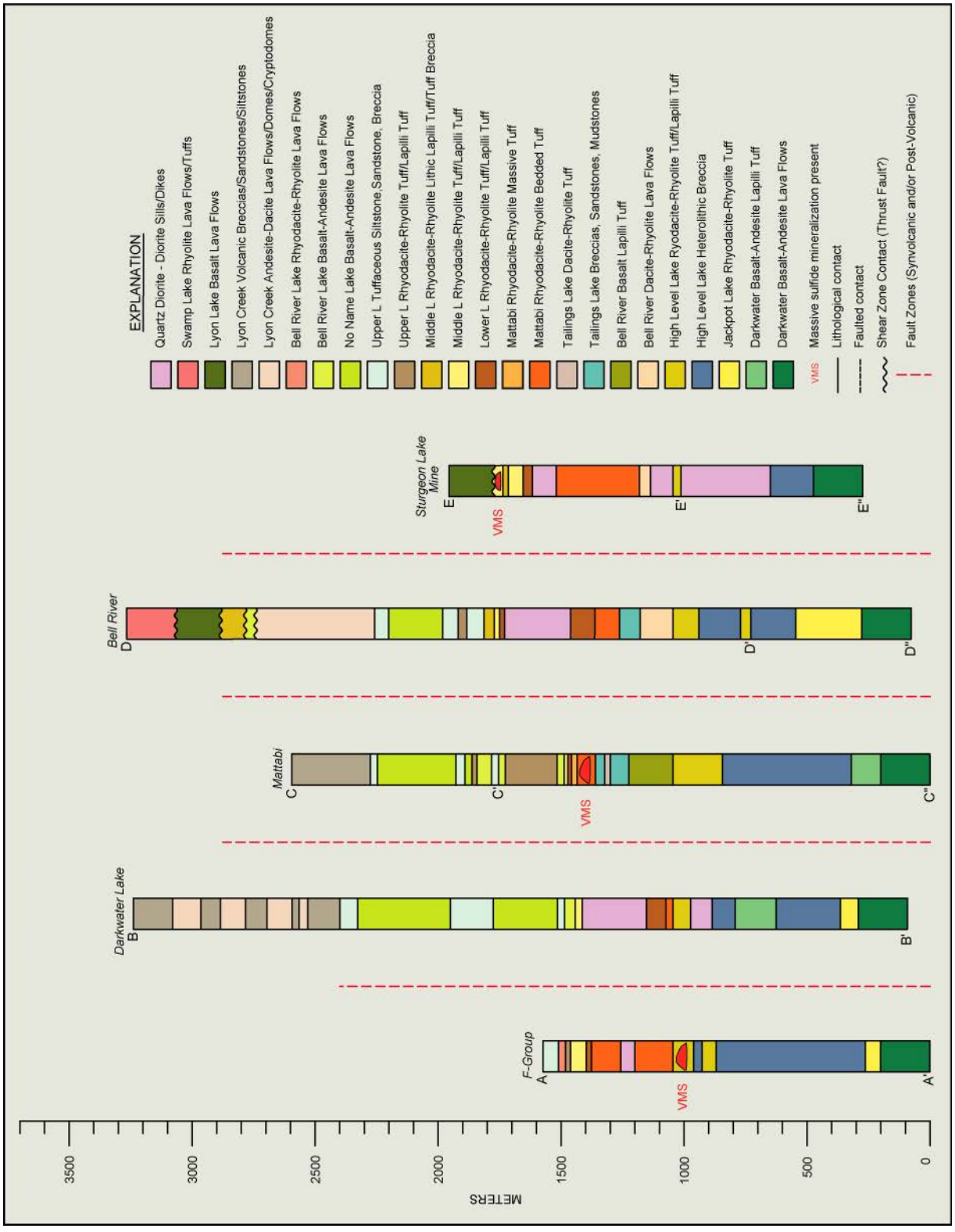


Figure 5. Stratigraphic sections across the Sturgeon Lake Caldera Complex (Hudak et al., in prep.). Section is hung on top of High Level Lake Rhyodacite-Rhyolite Tuff/Lapilli-tuff unit.

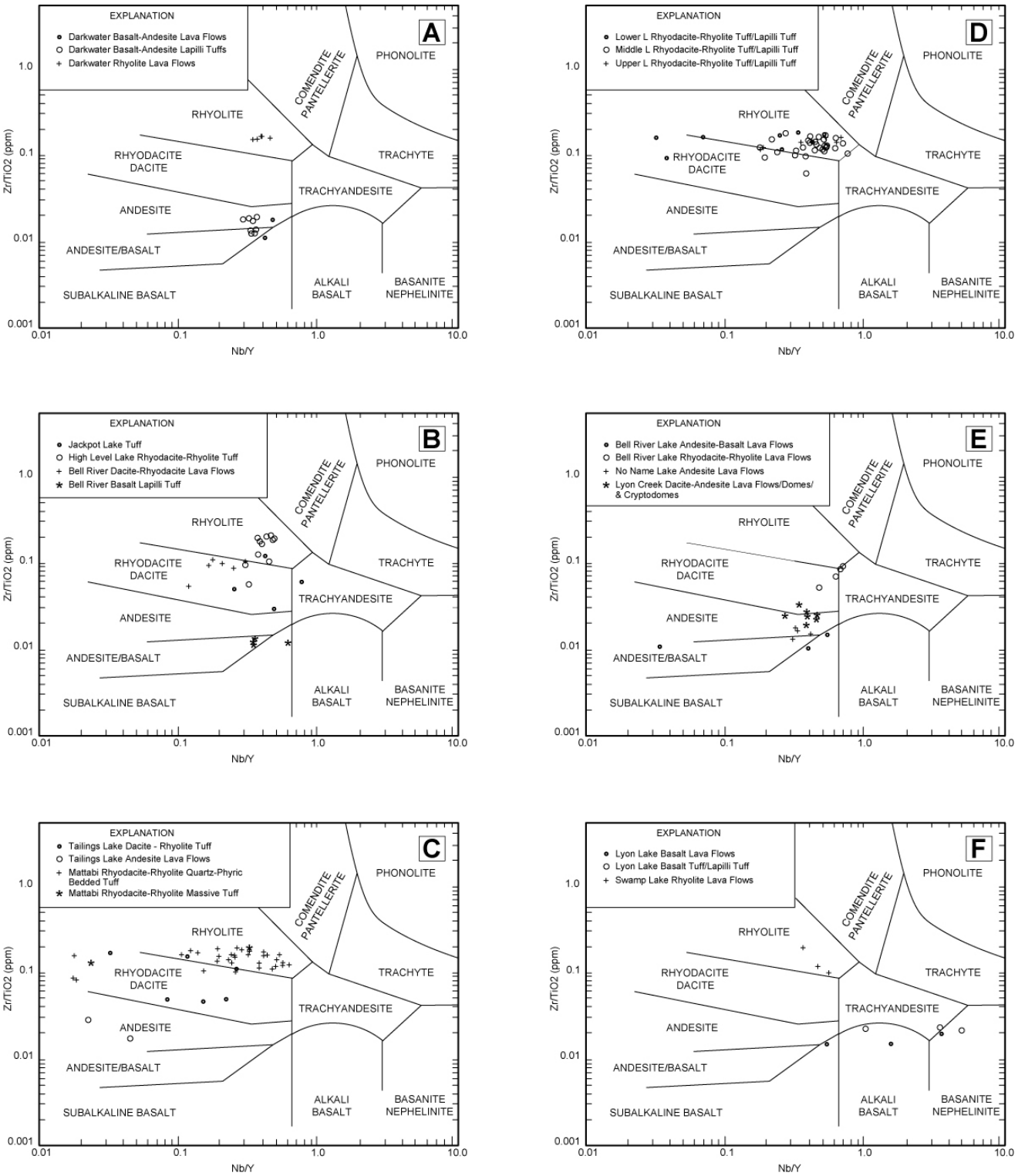


Figure 6. Immobile trace element Geochemical classification (after Winchester and Floyd, 1977) of least-altered volcanic and volcaniclastic rocks associated with the Sturgeon Lake Caldera Complex. Pre-caldera strata are illustrated in diagram A, early caldera strata are illustrated in diagrams B and C, Late-Caldera strata are illustrated in diagrams D and E, and Lyon Lake Fault Sequence strata are illustrated in diagram F. Data from Groves (1984), Hudak (1989, 1996), Jongewaard (1989), Walker (1993) and Franklin (unpublished data).

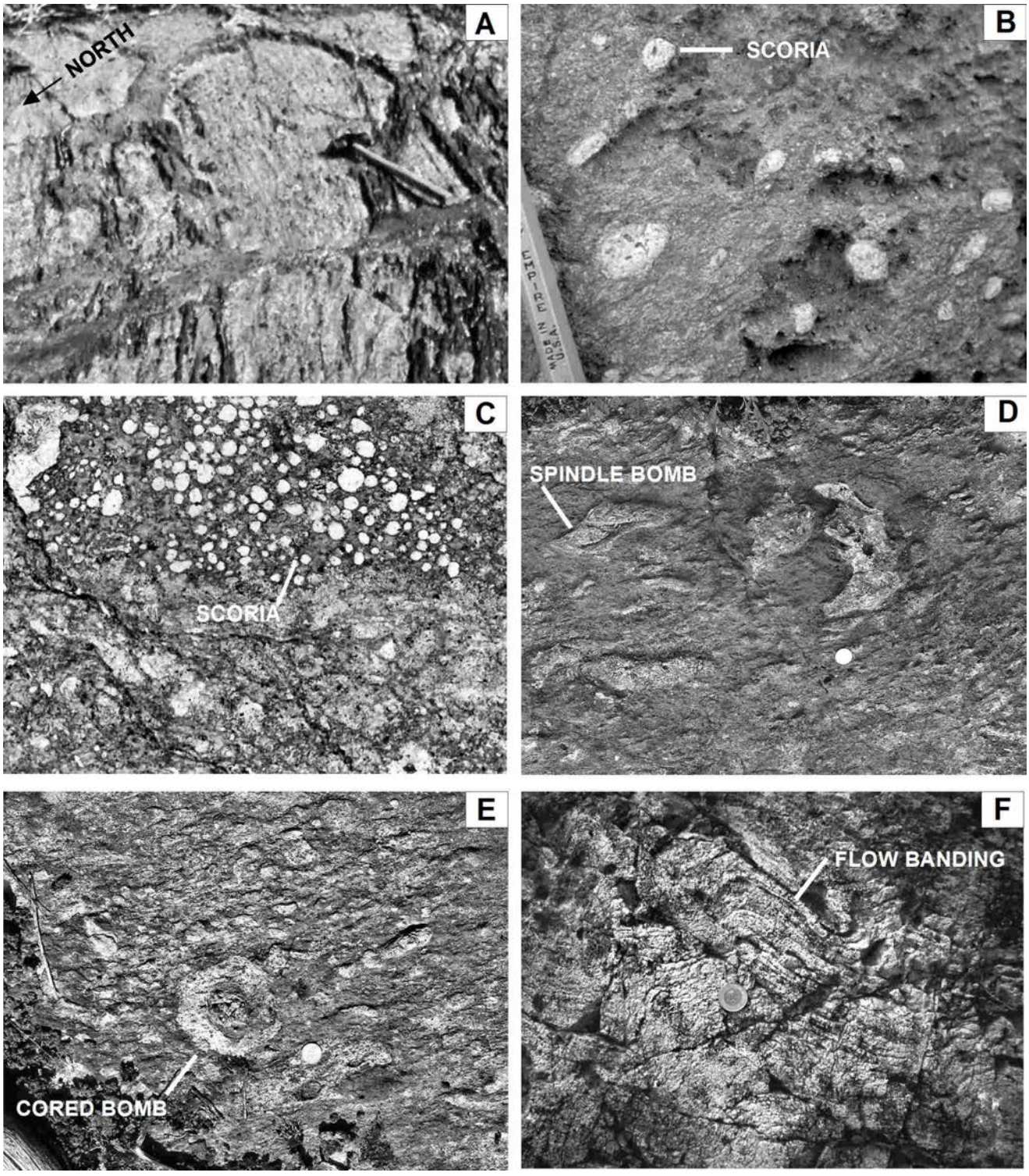


Figure 7. Pre-caldera (Darkwater Succession) strata associated with the SLCC. A) rare pillow lavas near Lac David; B) massive basalt-andesite tuff with carbonate-altered scoria lapilli; C) photomicrograph of scoria in basalt -andesite tuff (field of view 8mm); D) fusiform- and spindle-shaped bombs in basalt-andesite tuff; E) cored bomb in basalt-andesite tuff; and F) flow-banding in rhyodacite – rhyolite lava flow.

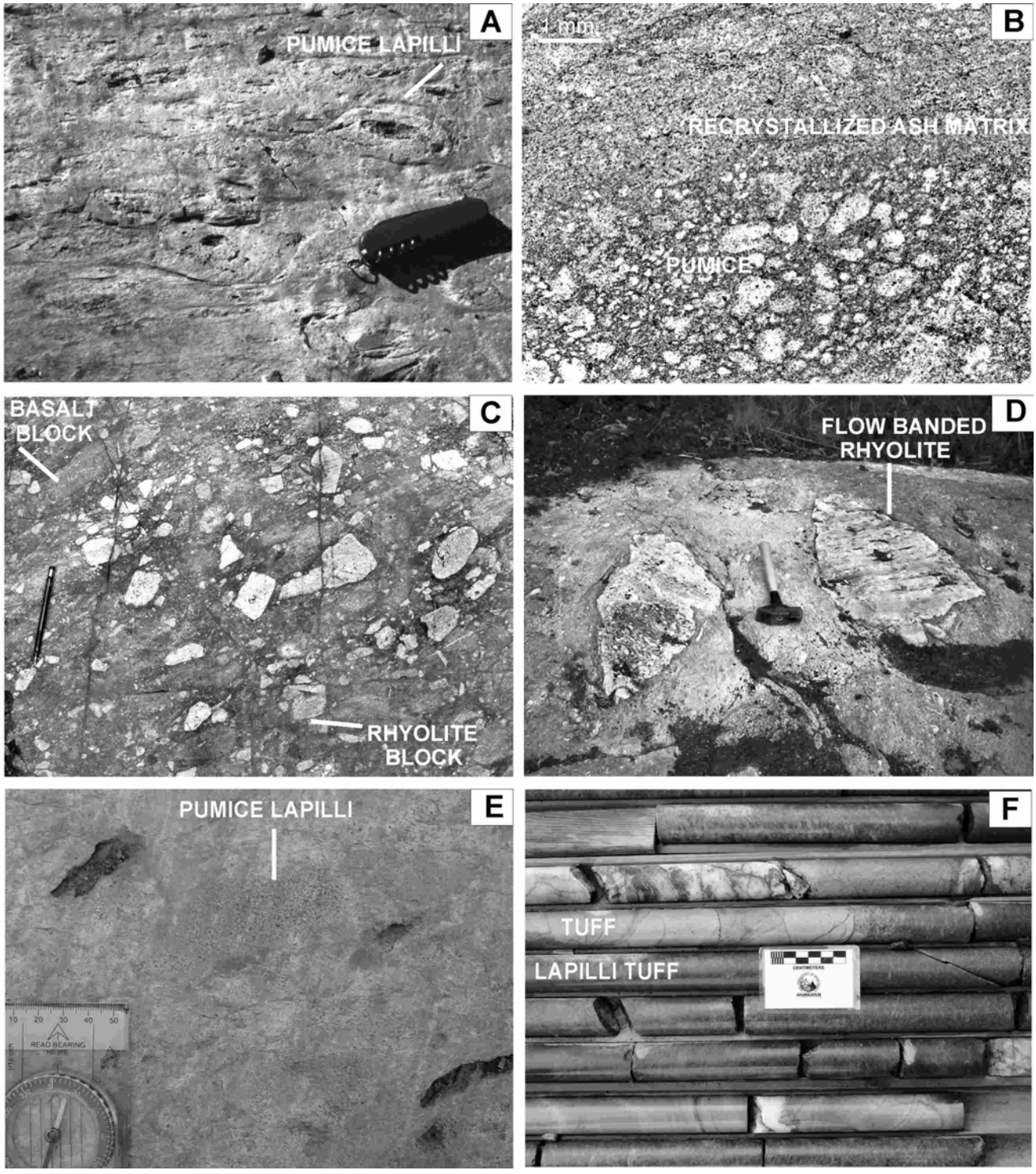


Figure 8. Strata from the Jackpot Lake and High Level Lake Successions. A) Jackpot Lake Succession lapilli tuff; B) photomicrograph of recrystallized ash matrix and pumice from Jackpot Lake Succession tuff (field of view 8mm); C) High Level Lake Succession polymict breccia (mesobreccia); D) High Level Lake Succession polymict breccia (megabreccia); E) pumice lapilli in massive High Level Lake Succession tuff south of the Mattabi orebody; F) interbedded High Level Lake Succession lapilli-tuffs and tuffs near the F-Group VMS deposit.

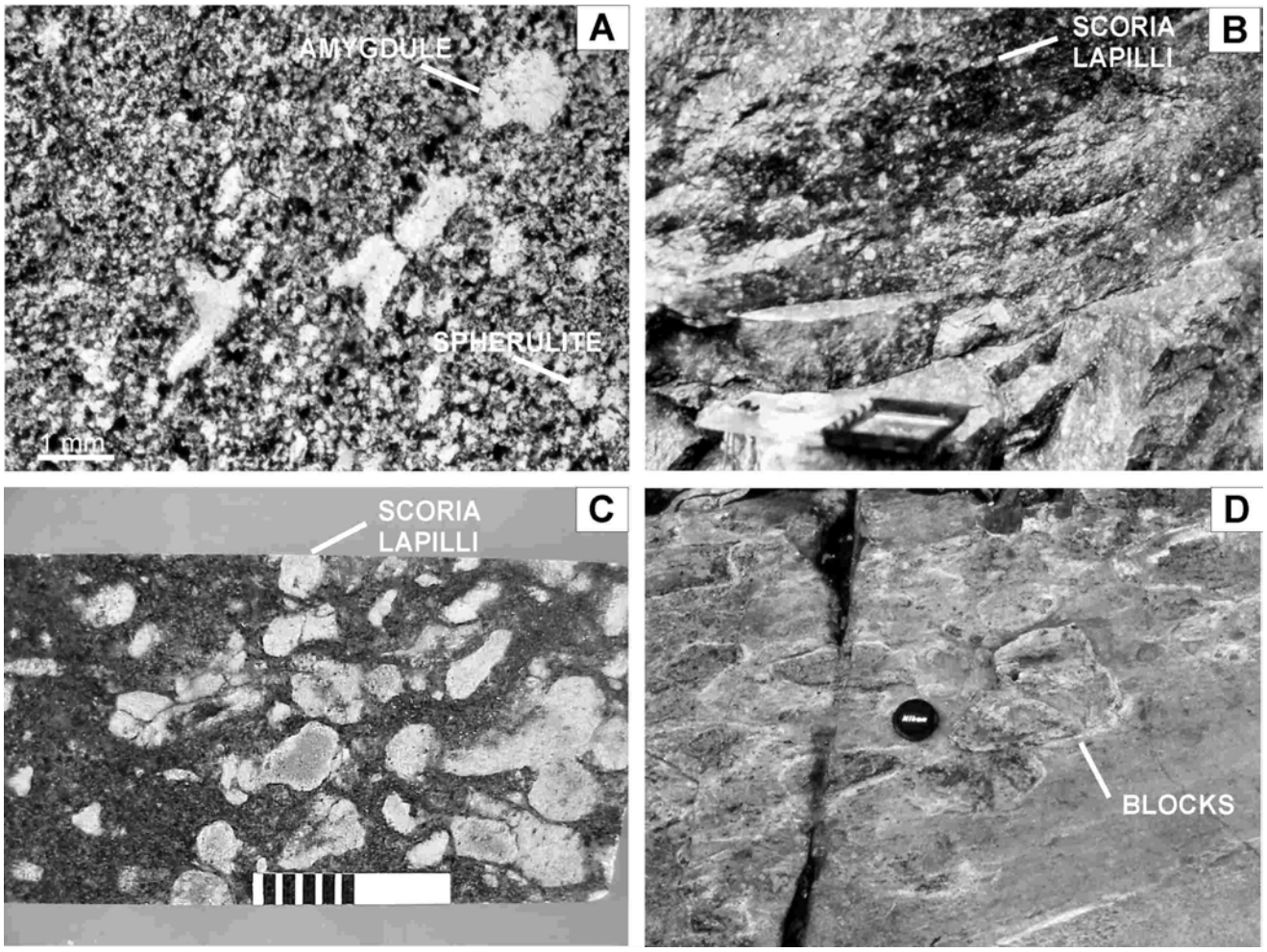


Figure 9. Strata from the Bell River and Tailings Lake Successions. A) photomicrograph of amygdaloidal Bell River Succession rhyodacite-rhyolite lava flow; B) massive Bell River basalt lapilli tuff with carbonate- and quartz-altered scoria; C) polished drill core sample of Bell River basalt lapilli-tuff (scale bar = 2cm); D) Tailings Lake Succession polymict breccia from south of the Mattabi orebody.

initial caldera development occurred simultaneously with the deposition of the High Level Lake Succession. A synvolcanic basin, bounded to the west and east by the Darkwater and Lac David Faults respectively (Fig. 1), appears to represent a nested caldera produced simultaneously with the eruption of the Mattabi tuffs (Hudak et al., 2003; Hudak et al., in prep).

The LCS (Figs. 6, 11, 12, 13, and 14) comprises a 500-1500m thick succession of quartz- and quartz + feldspar-phyric tuff and lapilli tuff deposits, volcaniclastic sedimentary rocks, andesitic to dacitic lava flows, domes, and cryptodomes, and Algoma-type banded iron formations (Koopman, 1993; Hudak, 1996). Hudak (1996) interpreted this sequence as characteristic of a maturing, late-stage caldera complex (c.f. Smith and Bailey, 1968; Lipman, 1997), and Hudak et al (in prep.) have utilized GIS analysis of the Sturgeon Lake geology that reflects relative percentages (by area and volume) of caldera collapse breccias, eruption-fed tuffs, lava flows, and sedimentary rocks that is consistent with this interpretation (Table 3). The most voluminous explosive eruptions in the LCS produced the Middle L lapilli tuffs and tuffs which are the host rocks for all the VMS orebodies in the LCS.

Several intra-caldera intrusive rocks have been identified and include: a) the Beidelman Bay Intrusive Complex (BBIC), a multiphase, dominantly trondhjemitic intrusive complex that petrochemical and lithogeochemical data indicate was, in part, the subvolcanic intrusion associated with the SLCC; b) massive to amygdaloidal rhyolite which occurs as feeder dikes to the Bell River Succession rhyolite lava flows; c) coarse-grained massive feldspar-phyric diorite which occurs as feeder dikes to the Lyon Creek Succession lava domes and cryptodomes; and d) fine-grained massive to amygdaloidal diorite and quartz

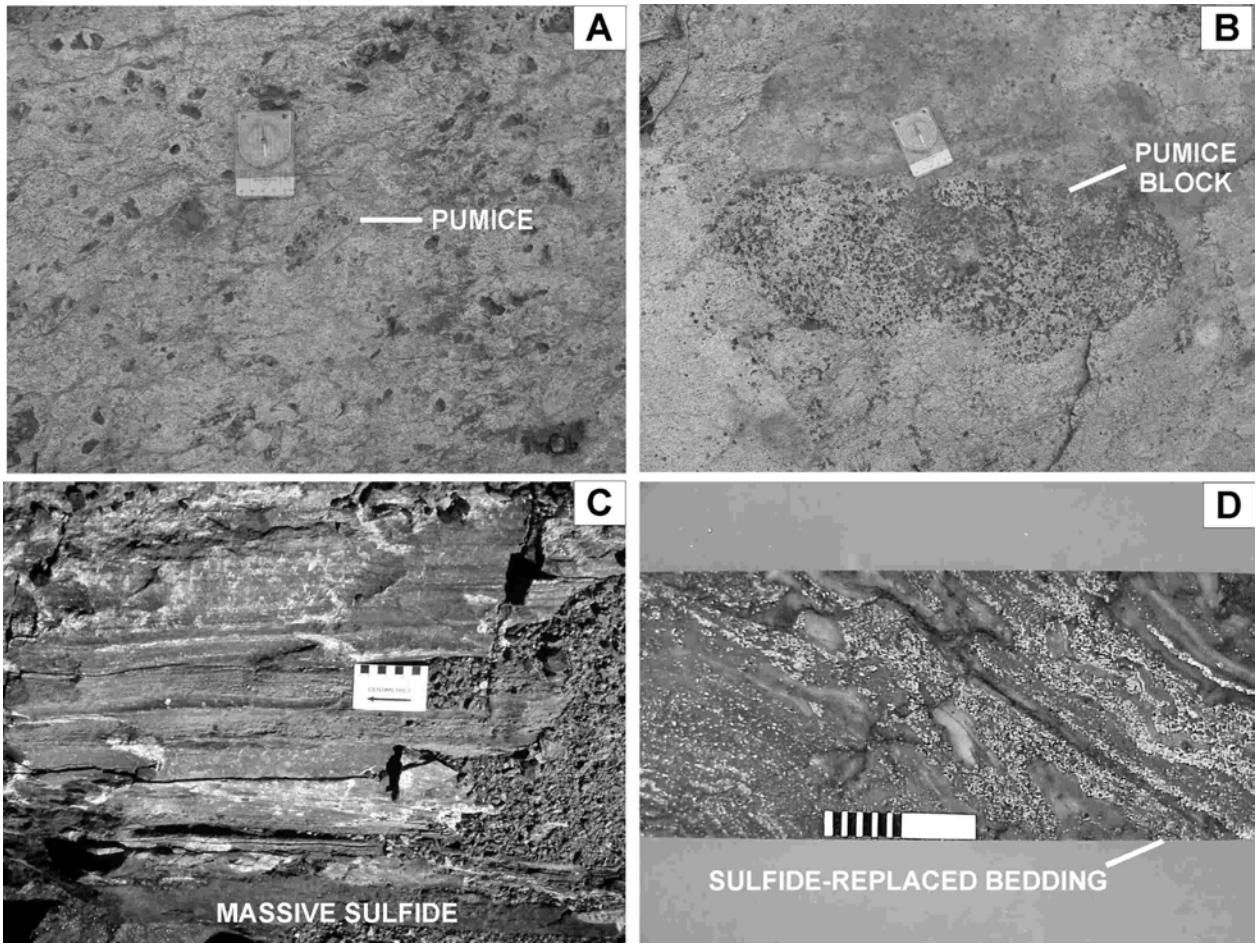


Figure 10. Mattabi Succession strata: A) massive lapilli tuff (compass is 55cm wide); B) pumice block in massive Mattabi Succession lapilli tuff from immediately southwest of the Mattabi VMS orebody; C) laminated to thinly-bedded tuff and subeconomic VMS horizon north of the F-Group VMS orebody (scale bar divided into centimeters); D) drill core appearance of bedding replaced by sulphides (mainly pyrite; scale bar is 2cm).

Table 3. Geographic information system (GIS) analysis of Pre-Caldera, Early Caldera, and Late Caldera sequences in the Sturgeon Lake Caldera Complex (Hudak et al., in prep.)

Distribution of Lithology Types in the Sturgeon Lake Caldera Complex by Area %			
Lithology Type	***Pre-Caldera %***	***Early Caldera %***	***Late Caldera %***
Caldera Collapse Breccia	0.0	49.6	0.0
Lava Flows	94.1	8.6	41.0
Eruption-Fed Tuffs	4.8	41.0	12.3
Sedimentary Rocks	1.1	0.8	46.7
Distribution of Lithology Types in the Sturgeon Lake Caldera Complex by Volume %*			
Lithology Type	***Pre-Caldera %***	***Early Caldera %***	***Late Caldera %***
Caldera Collapse Breccia	0.0	57.6	0.0
Lava Flows	98.4	3.5	42.1
Eruption-Fed Tuffs	1.6	38.7	6.3
Sedimentary Rocks	0.1	0.2	51.6

*Volume estimates of intracaldera strata completed by assuming that the Sturgeon Lake Caldera Complex was a rcular caldera structure similar to Cenozoic subaerial ash flow calderas such as Valles (Smith and Bailey, 1968), Santorini (Druitt and Francaviglia, 1992), and Crater Lake (Bacon and Druitt, 1988), and submarine ash flow calderas such as Healy (Wright et al., 2003) and Myojin Knoll (Fiske et al., 2001). Similar assumptions have been used to estimate eruption volumes in other ancient volcanic sequences (Busby-Spera, 1984; Kokelaar and Busby, 1992).

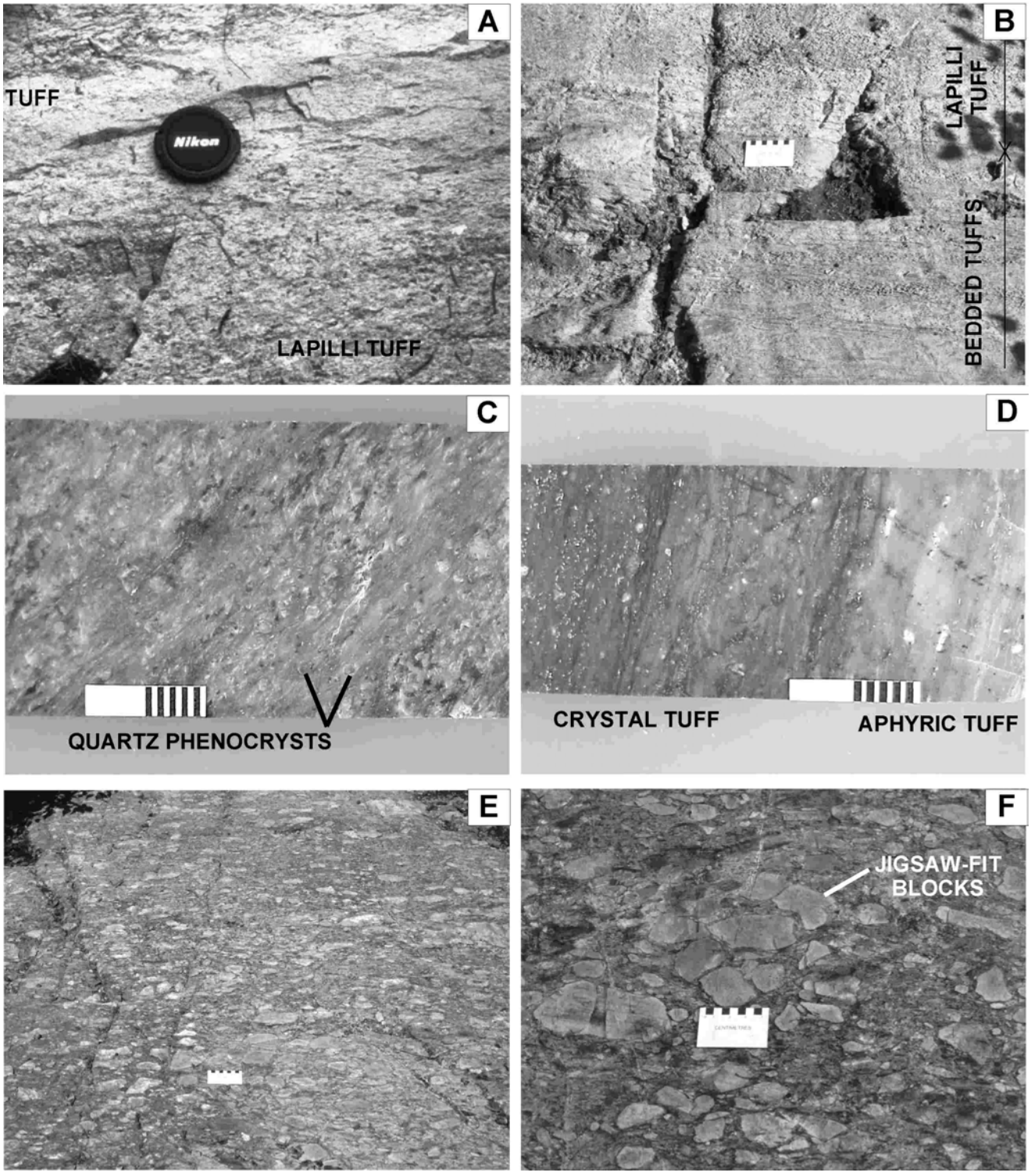


Figure 11. Lower L and Middle L strata within the SLCC: A) bedded Lower L rhyodacite-rhyolite tuff and lapilli tuff (lens cap is 55mm); B) Middle L Succession laminated to thinly bedded rhyo-dacite-rhyolite tuffs overlain by very thickly bedded lapilli tuff (scale bar divided into centimeters); C) massive Middle L tuff with 1-3 mm subhedral to euhedral quartz phenocrysts (scale bar is 2cm); D) normal graded Middle L tuff (up is to right of photo, scale bar is 2cm); E) outcrop appearance of Middle L rhyodacite-rhyolite tuff breccia (scale bar divided into centimeters); F) close-up view of Middle L rhyodacite-rhyolite tuff-breccia (note jigsaw puzzle-fit lapilli and bombs, scale bar divided into centimeters).

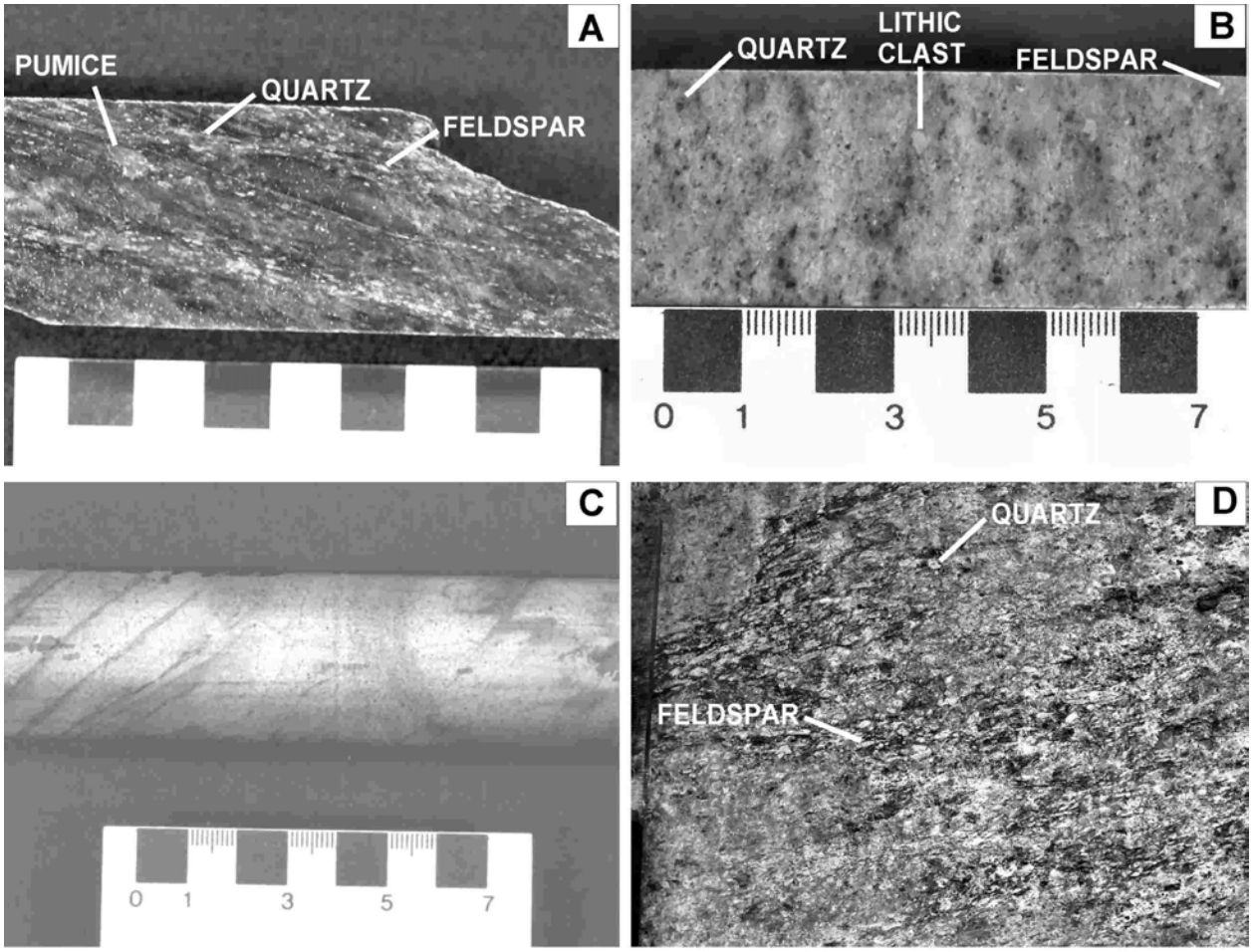


Figure 12. Upper L and Bell River Lake succession strata: A) Upper L Succession rhyodacite-rhyolite tuff and lapilli tuff (scale bar divided into centimeters); B) Upper L Succession crystal-rich reworked tuff (large divisions on scale bar are centimeters); C) massive, crudely graded, reworked Upper L tuff (scale bar divided into centimeters); D) Bell River Lake Succession quartz- and plagioclase-phyric rhyodacite – rhyolite lava flow (compass at left for scale).

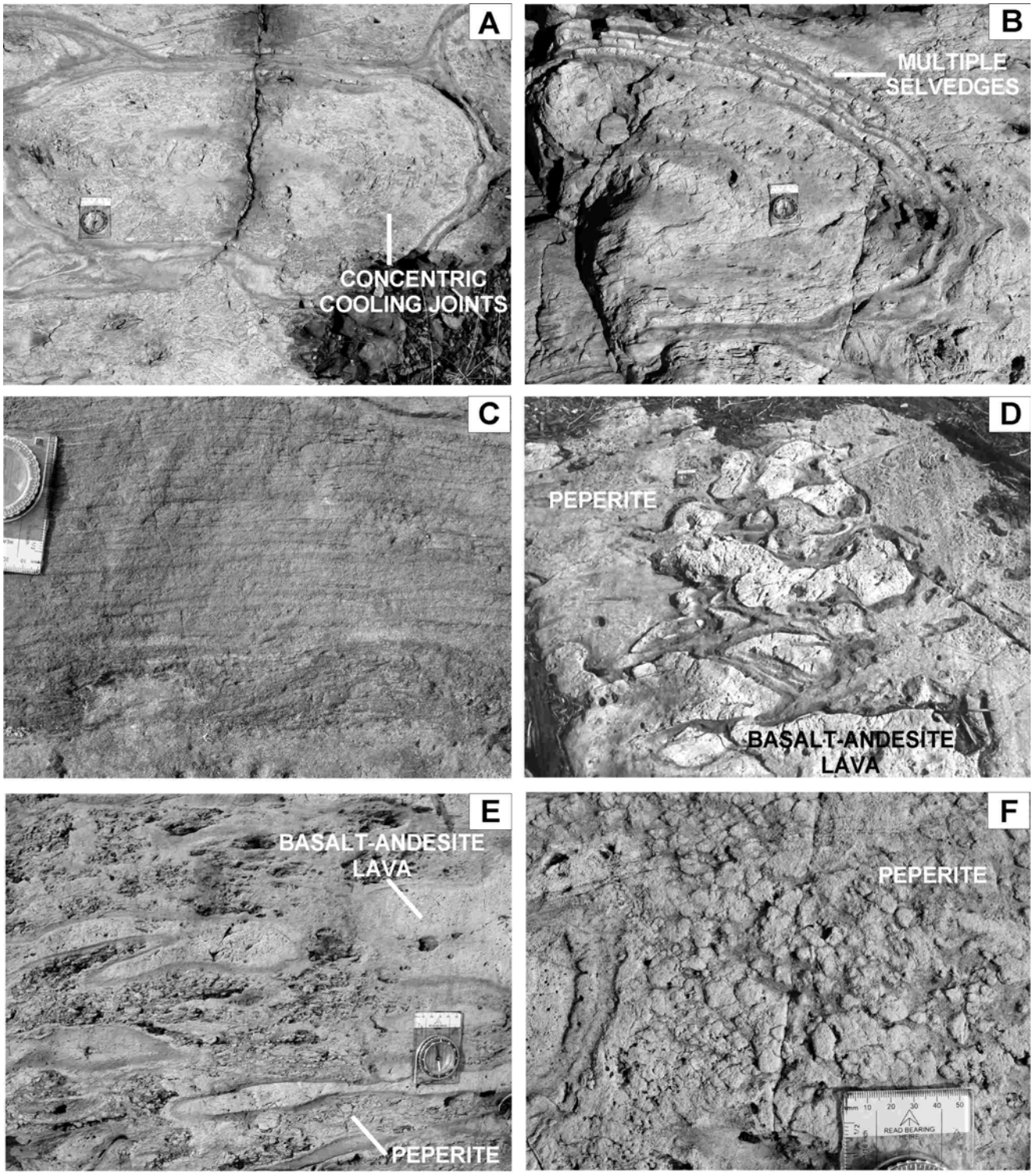


Figure 13. No Name Lake succession strata: A) pillow lava with concentric cooling joints; B) pillow lava with multiple selvedges (large divisions on scale bar are centimeters); C) laminated tuff (resedimented hyaloclastite; D) amoeboid basalt andesite dike with surrounding peperite and resedimented hyaloclastite; E) close-up of relationship between basalt-andesite dike and surrounding peperite; F) close-up of close-packed blocky to irregular peperite. Compass in all photos is 55 mm wide.

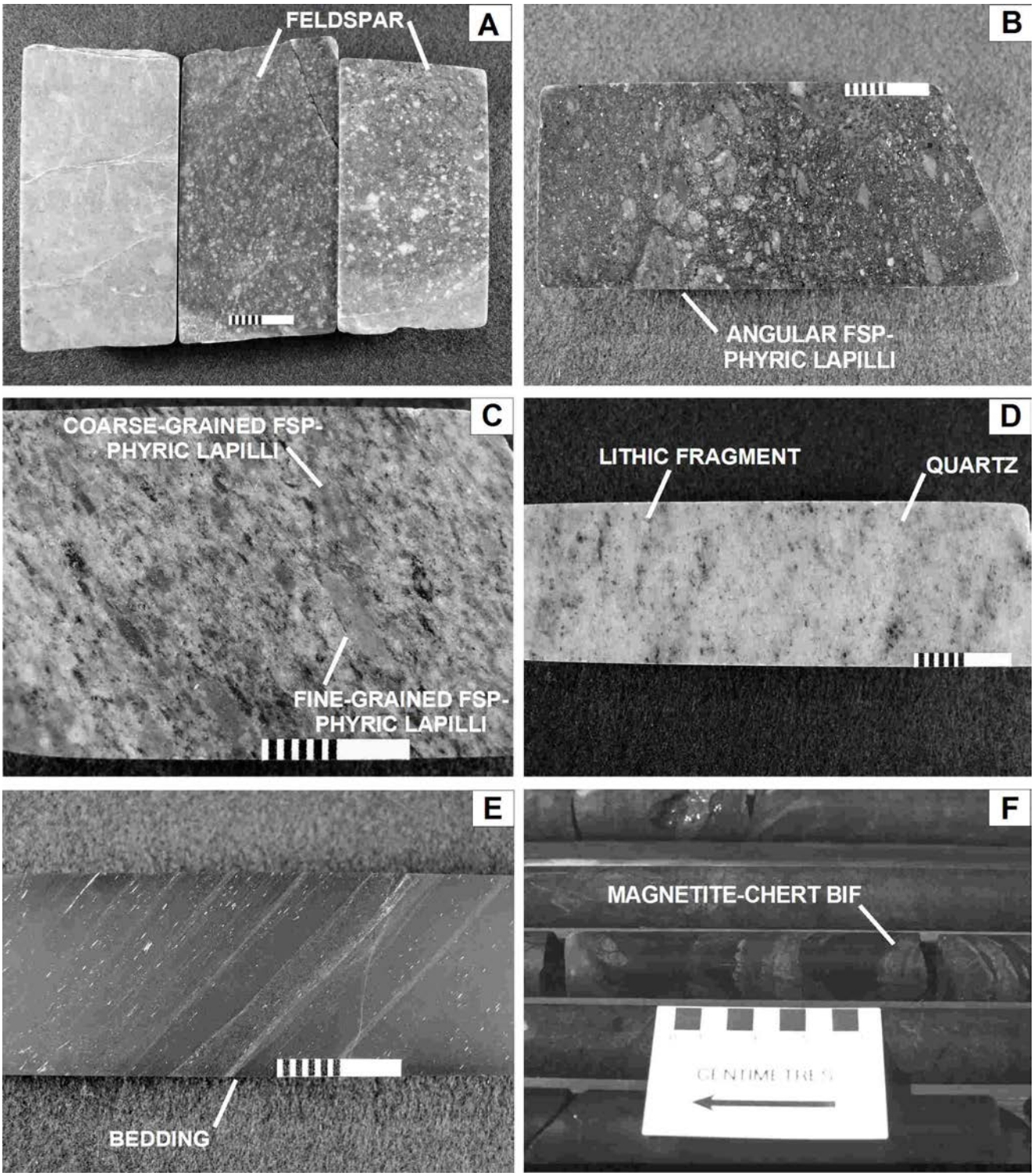


Figure 14. Lyon Creek Succession strata: A) vertical facies from margin (left) to center (right) of andesite-dacite cryptodome; B) andesite-dacite lithic tuff-breccia that occurs along margin of cryptodome; C) andesite-dacite lithic tuff breccia containing both fine- and coarse-grained feldspar phyric lava clasts; D) resedimented crystal-lithic tuff; E) laminated to very thinly bedded graphitic mudstone; F) folded magnetite-chert banded iron formation interbedded with chlorite-rich mudstones. Scale bar in photos 14A-14E is 2 centimeters. Scale bar in photo 14F is divided into centimeters.

diorite which dilate the stratigraphy across the entire caldera complex and may have been a subvolcanic sill complex which fed the No Name Lake Sequence basaltic and andesitic lava flows (Morton et al., 1999).

Post-caldera intrusive rocks also occur throughout the SLCC. These include: a) fine-grained, massive, locally feldspar-phyric diorite; b) coarse-grained amphibole-phyric diorite; and c) thin (<1-13m wide) "lamprophyre" dikes that occur within high strain zones associated with the structural deformation between caldera-associated strata and the non-caldera associated Lyon Lake Fault Sequence.

Hydrothermal Alteration Mineral Assemblages in the SLCC

Hydrothermal solutions, both ore-forming and non-ore forming, have altered the volcanic and intrusive rocks associated with the Sturgeon Lake Caldera Complex. Following alteration, rocks in the region were metamorphosed to greenschist and locally amphibolite facies. Therefore, the alteration minerals now present are, in part, metamorphosed equivalents of alteration minerals formed during the synvolcanic hydrothermal alteration events.

Hydrothermal alteration is widespread within the complex and in the uppermost parts of the Beidelman Bay Intrusive Complex (Franklin et al., 1975; Jongewaard, 1989; Hudak, 1989; Walker, 1993; Hudak, 1996; Galley et al., 2000; Galley, 2002; Galley, 2003). Discrete assemblages of metamorphosed alteration minerals form zones that are a) widespread and largely conformable to the volcanic stratigraphy (semi-conformable alteration); and b) locally lens-shaped or pod-like beneath massive sulphide occurrences and deposits (semi-conformable alteration); and c) narrow and elongate that cross-cut stratigraphy and are proximal to synvolcanic structures or synvolcanic faults (disconformable alteration; Franklin et al., 1975; Groves, 1984; Morton and Franklin, 1987; Jongewaard, 1989; Hudak, 1989; Walker, 1993; Hudak, 1996; Gibson et al., 1999).

Hydrothermal fluids formed five distinct, mapable massive sulphide ore-associated alteration mineral assemblages in the area (Fig. 15). From least- to most-altered, these assemblages are: a) widespread, semi-conformable carbonatization and silicification; b) widespread, semi-conformable iron carbonate ± iron-rich chlorite; c) widespread, semi-conformable chloritoid ± iron-carbonate and/or iron-rich chlorite; d) localized lens-shaped to pod-like, locally linear zones of aluminum silicate (pyrophyllite, andalusite, and/or kyanite) + chloritoid; and e) localized linear disconformable and semi-conformable, generally stratiform zones of aluminum silicate. Algoma-type iron formations associated with the LCS are associated with semi-conformable to disconformable veins, patches, and lenses of iron-carbonate + iron- rich chlorite + magnetite ± Mn-rich almandine garnet ± grunerite. Late sericite and/or magnesium-rich chlorite alteration locally overprints these five alteration mineral assemblages.

Iron-carbonate ± iron-rich chlorite assemblage rocks contain at least 10% iron-carbonate + iron-rich chlorite with less than 5% chloritoid or aluminum silicate minerals. Outcrops containing this alteration assemblage can generally be easily identified by their orange to orange-brown stained, commonly pitted surfaces. Staining varies from irregular patches up to 15cm in diameter, to veins and veinlets 1-15mm in width that are aligned parallel to the foliation. Pumice/scoria that has been replaced by iron-carbonate can be recognized as rounded to oval, orange-brown stained pits up to 5cm in diameter which commonly contain rounded- to lens-shaped quartz amygdules (10-60%). In thin section, this assemblage contains iron-carbonate ± iron-rich chlorite (10-60%), sericite (up to 30%), magnesium-rich chlorite (up to 50%), and locally, traces of chloritoid and/or aluminum silicate minerals.

Chloritoid ± iron carbonate and/or iron-rich chlorite assemblage rocks contain greater than 5% chloritoid, and are characterized by the presence of 1-3mm dark green to greenish-black chloritoid prisms and rosettes. The presence of chloritoid commonly gives the rocks a "salt and pepper" appearance. Locally, chloritoid porphyroblasts occur with sericite (10-55%) in 1-5mm wide grey green veins that vary from semi-conformable to disconformable in orientation. Other minerals present include iron-carbonate (up to 60%), iron-rich chlorite (2-20%, locally as a retrograde product of chloritoid), magnesium-rich chlorite (1-20%) and pyrite (up to 12%).

Aluminum silicate + chloritoid bearing rocks typically contain 1-3mm chloritoid porphyroblasts (up to 33%) in a grey to grey-pink matrix composed of massive pyrophyllite (5-20%), 1-3mm blocky pink andalusite (up to 10%), and/or blue tabular to bladed kyanite porphyroblasts (up to 8%). Chloritoid occurs as 1-3mm prisms or rosettes disseminated throughout the rock or in chloritoid + andalusite veins up to 1cm in width. In addition, iron-rich chlorite (up to 7%),

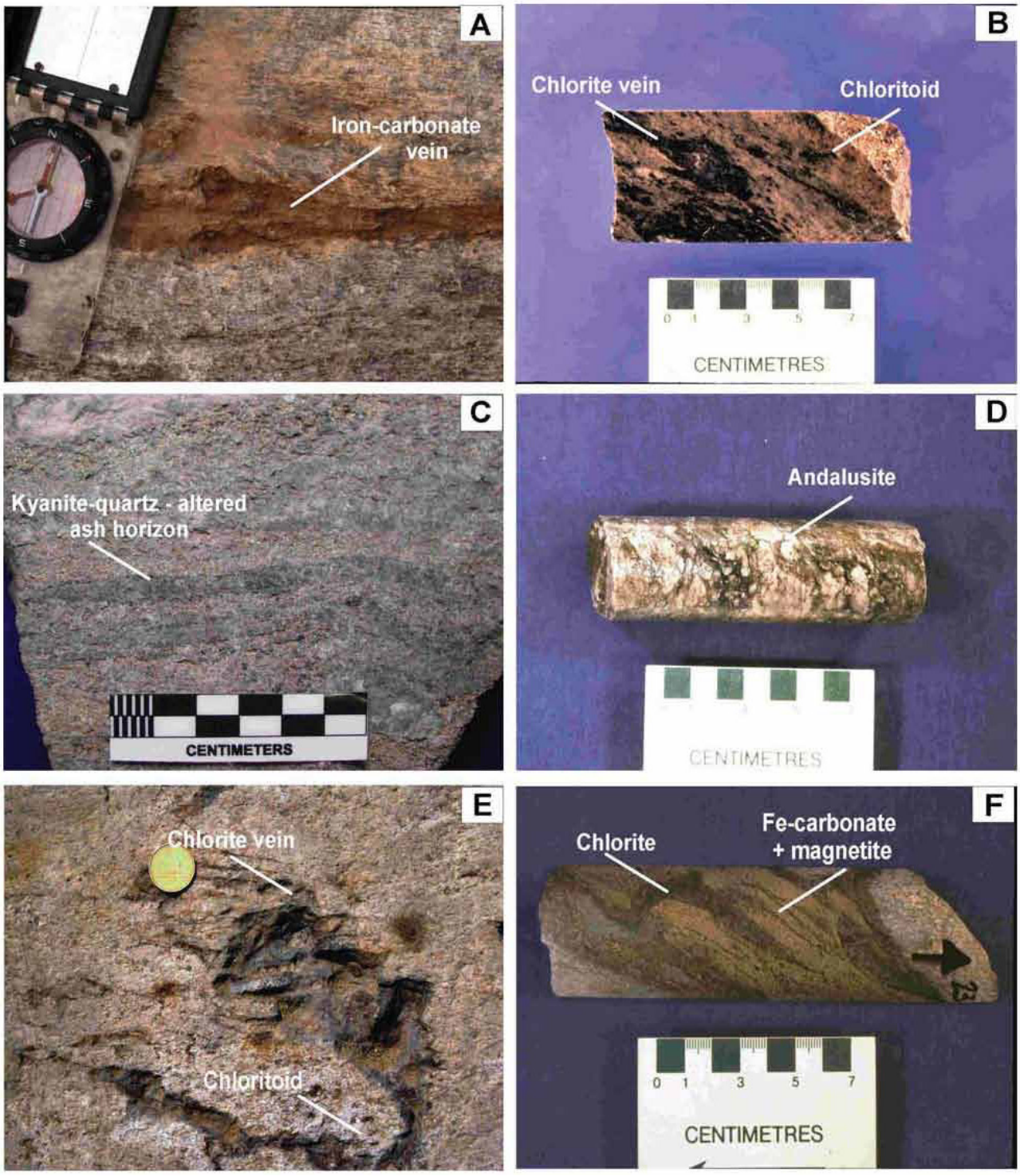


Figure 15. Field and drill core hydrothermal alteration mineral assemblages in the SLCC. A) Iron-carbonate assemblage in the F-Group area; B) chloritoid + chlorite alteration assemblage from Area 17; C) aluminum silicate alteration (kyanite + sulfides) from footwall to the Mattabi VMS deposit; D) patchy aluminum silicate (andalusite) alteration proximal to VMS mineralization in Area 17; E) iron-formation associated alteration (iron-chlorite + iron carbonate + chloritoid + magnetite) in Area 23; F) vein of iron formation-associated alteration (iron carbonate + magnetite + iron chlorite) in Area 23.

magnesium-rich chlorite (up to 35%), iron carbonate (3-35%), pyrite (up to 30%) and sphalerite (up to 5%) are also associated with this alteration assemblage.

Figure 16 illustrates the distribution of the VMS ore-associated alteration mineral assemblages in the vicinity of the F-Group orebody. Iron carbonate ± iron-rich chlorite assemblage rocks form a large, semi-conformable zone along the southern, eastern, and northern boundaries of the area. Locally, pod-like regions (up to 50m in diameter) of this assemblage occur within the chloritoid assemblage zone, which exists as a large, semi-conformable zone up to 100m thick in the hanging wall to the F-Group orebody, and is present as pipe-like alteration in the F-Group deposits footwall. More proximal to mineralization, semi-conformable and locally linear pipe-like zones containing the aluminum silicate ± chloritoid alteration assemblage are present. Aluminum silicate assemblage rocks are most closely associated with the mineralization at the F-Group deposit. These rocks are distributed in two distinct patterns: a) in disconconformable, pipe-like linear, 5-30m wide zones that trend NNE in proximity to synvolcanic fault zones; and b) in a broad semi-conformable zone (700m by 500m at surface) located both in the footwall and the hanging wall rocks to the F-Group orebody.

Figure 17 illustrates the distribution of the ore-associated alteration at the Mattabi deposit. Semi-conformable iron-carbonate (ankerite- and/or siderite-bearing) and silicified rocks form a broad zone in the lower footwall rocks. This zone is cross-cut by several westward-dipping tabular zones which contain an aluminum silicate-rich core and aluminum silicate ± chloritoid margin. These zones occur in close proximity to synvolcanic fault zones which lead upward to, and cross-cut, a broad semi-conformable zone of aluminum silicate + chloritoid altered rocks that crudely surrounds the Mattabi orebodies. The aluminum silicate-rich tabular zones, associated with the synvolcanic fault zones, spread out into a semi-conformable alteration zone directly stratigraphically below and lateral to the deposit. Stratigraphically overlying the deposit is a semi-conformable zone of chloritoid ± iron-rich chlorite ± iron-carbonate up to 150m thick (Walker, 1993).

Figure 18 illustrates the distribution of iron formation-associated alteration mineral assemblages that occur in Areas 17 and 23 southwest of the Lyon Lake and Creek Zone VMS ore deposits. It is important to keep in mind that based on stratigraphic and structural data, the iron formation-associated alteration assemblage has no genetic relationships to the Lyon Lake and Creek Zone deposits, as these deposits are believed to have been structurally remobilized into

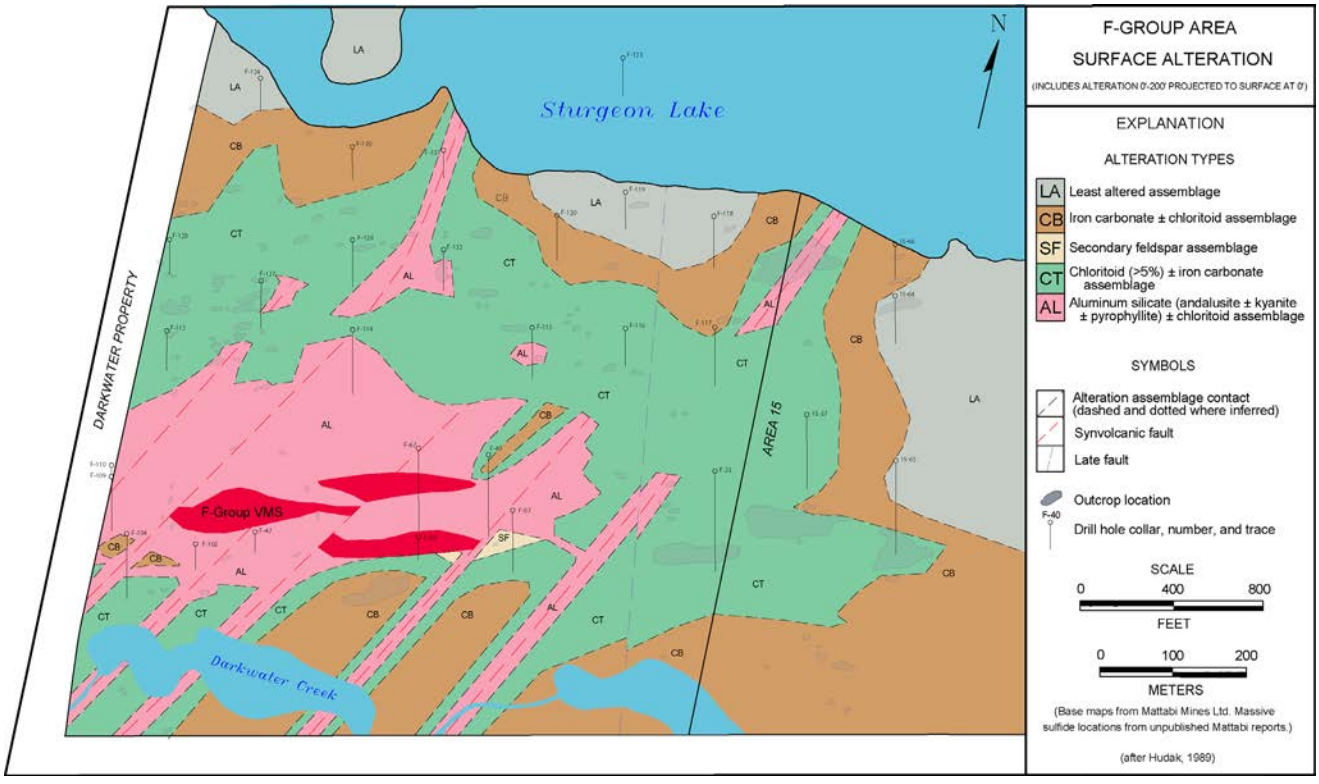


Figure 16. Distribution of hydrothermal alteration mineral assemblages associated with the F-Group VMS orebody.

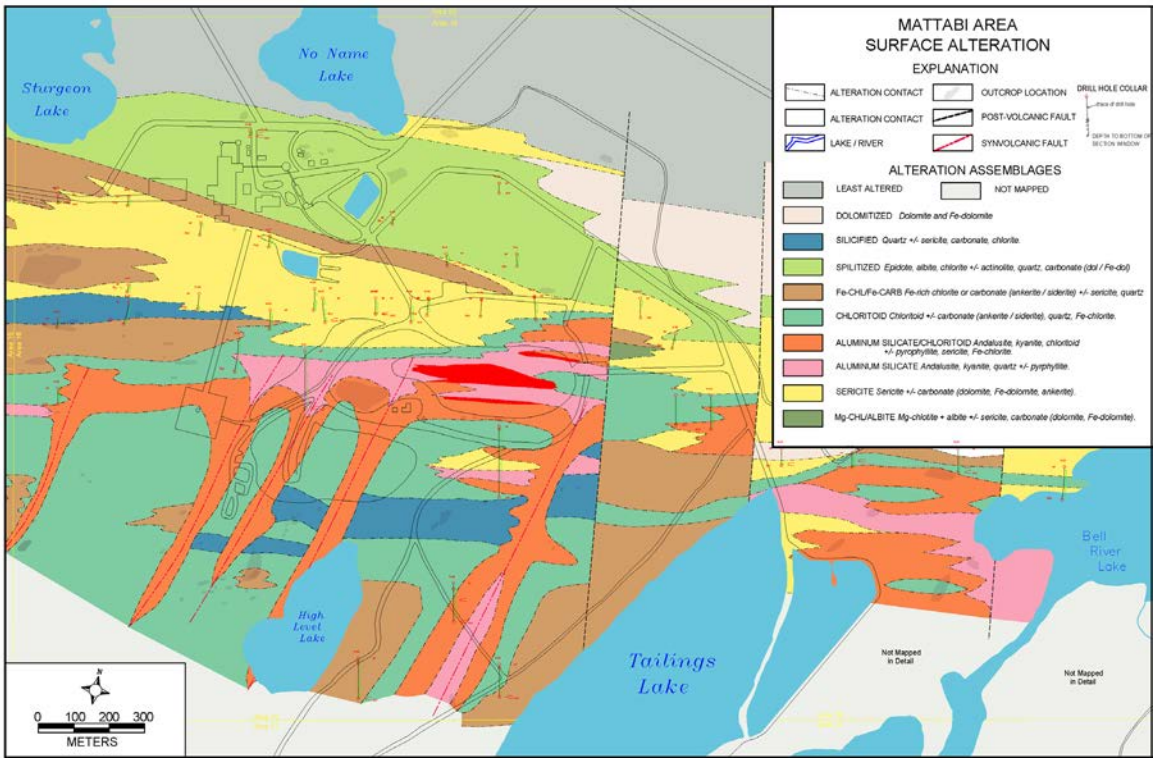


Figure 17. Distribution of hydrothermal alteration mineral assemblages associated with the Mattabi VMS orebody.

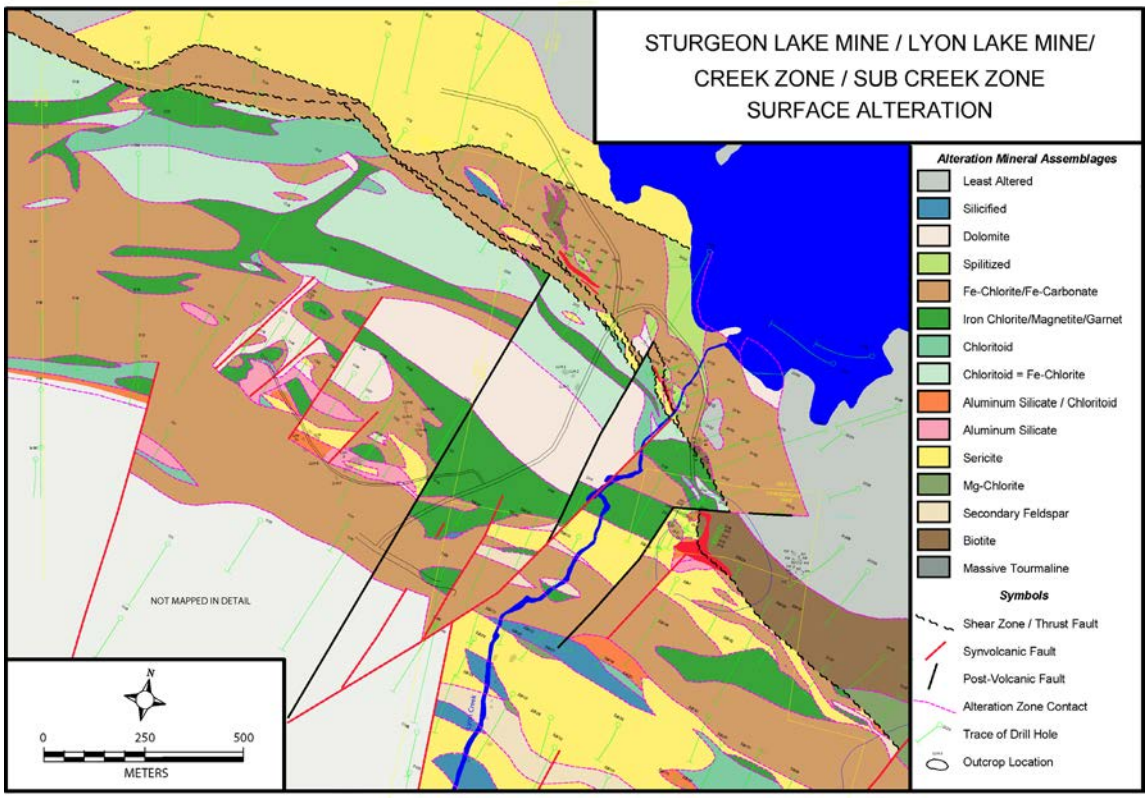


Figure 18. Distribution of hydrothermal alteration mineral assemblages associated with the Algoma-type iron formation and VMS mineralization in Areas 17 and 23.

their present locations (Koopman, 1993; Hudak, 1996; Morton et al., 1999).

Summary of the Geologic History of the SLCC

The following summary represents the temporal sequence of geological, volcanological, and ore-forming processes that occurred during the genesis of the Sturgeon Lake Caldera Complex.

Pre-Caldera Geological History

1. Subaerial basalt shield volcanism (Darkwater Succession basalt-andesite lava flows) with minor effusive felsic volcanic activity (Darkwater Succession rhyodacite-rhyolite lava flows and associated flow breccias).
2. Subaerial-shallow subaqueous scoria cone and tuff cone genesis (Darkwater Succession basalt-andesite tuffs, lapilli tuffs, and tuff-breccias) as the end stage in the development of a shield volcano – tuff-cone – scoria-cone complex.
3. Initial intrusion of the ancestral Beidelman Bay Intrusive Complex and the Pike Lake Layered Complex as a high-level magma chamber. This causes regional tumescence which results in the formation of pre-caldera structures that evolve into ring fractures.
4. Subaerial explosive felsic volcanism, probably erupting through vents proximal to pre-caldera structures caused by extension related to regional tumescence, deposits the Jackpot Lake Succession rhyodacite and rhyolite tuffs. This eruption can be interpreted as minor, pre-caldera explosive activity which commonly precedes caldera formation in the Smith and Bailey (1968) caldera cycle model. Further development of pre-caldera faults continues during this time.

Early Caldera Geological History

1. Formation of the ~25km strike length Sturgeon Lake Caldera Complex occurs as a result of voluminous subaerial explosive volcanism (at least 16km^3, possibly on the order of ~500-900km^3 based on observed caldera diameter and eruption volume observation (Cas and Wright, 1987; Hudak et al., 2003; Fig. 19) coupled with simultaneous caldera collapse. Explosive volcanism produces the High Level Lake rhyodacite-rhyolite lapilli tuffs which erupt simultaneously with caldera collapse that generates the High Level Lake Succession polymict breccia deposits (megabreccia and mesobreccia). Facies analyses suggest initial trap-door like caldera collapse where the floor of the caldera complex collapses into a subaqueous environment west of a synvolcanic fault located approximately at the boundary between the F-Group claims and Area 15 (refer back to Fig. 5). The eastern two-thirds of the caldera complex, from the Darkwater Fault to the Lac David Fault, remains in a subaerial depositional environment.
2. Intrusion of spherulitic rhyolite dikes in southern Area 16 - Area 17 which feed the eruption of Bell River Succession dacite-rhyolite lava dome in a subaerial environment in the eastern two-thirds

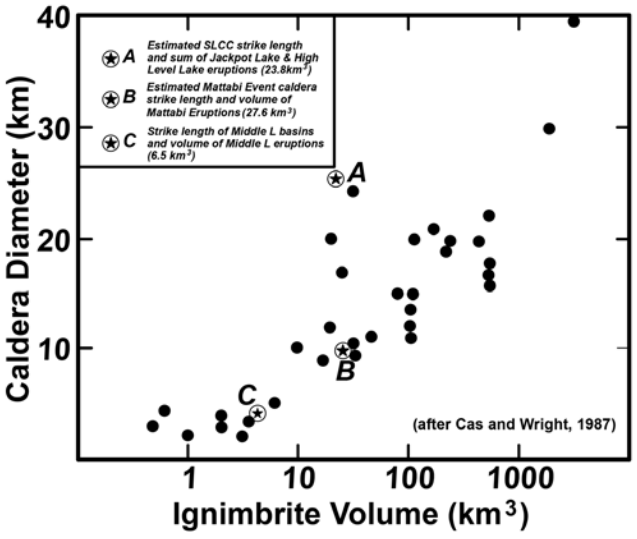


Figure 19. Comparison of estimated eruption volumes and caldera diameters for modern subaerial and subaqueous caldera eruptions, and the caldera-forming eruptions associated with the SLCC (Hudak et al., 2003, modified from Cas and Wright, 1987). Point A represents relationships for the initial SLCC event which resulted from the combined eruptions of the Jackpot Lake and High Level Lake succession rhyodacite-rhyolite lapilli tuffs and tuffs. Point B represents relationships for the Mattabi eruptive event, which formed the Mattabi Succession rhyodacite-rhyolite lapilli tuffs and tuffs, and a nested caldera between the Darkwater and Lac David faults. Point C represents the Middle L eruptive event, which formed the Middle L rhyodacite-rhyolite breccias, tuff-breccias, lapilli tuffs and tuffs, and possible two nested calderas of 1.5km and 3.1km in diameter (equivalent to a single caldera of ~3.4km diameter) in the eastern and western parts of the SLCC in the vicinities of the F-Group deposit and Areas 17 and 23.

of the SLCC. Post caldera-collapse submarine hydrothermal activity is centered in the F-Group and Darkwater regions of the SLCC, and forms the F-Group VMS orebodies. Based on observations of modern VMS mineralization in terms of tectonic setting, metal contents, physical volcanology and hydrothermal alteration mineral assemblages (Gibson et al., 1999; Morgan and Schulz, 2012; Monecke et al., 2014), it is likely that these VMS orebodies were formed as replacement-style VMS deposits (c.f. Doyle and Allen, 2003) at water depths less than 1500 meters (Hudak, 1996); Subaerial hydrothermal activity occurs in the eastern two-thirds of the caldera complex, and forms subaerial epithermal-like stringer mineralization in the High Level Lake lapilli tuffs and tuffs, as well as the Bell River Succession lava dome.

3. Eruption and deposition of the Bell River Succession basalt lapillistones and lapill tuffs from Area 16-Area 17 in the vicinity of the Bell River lava dome. These deposits pond to the west along the Darkwater fault, which marks the western limit of a paleo-basin that extends eastward to the Lac David Fault.
4. Intracaldera clastic sedimentation forms the Bell River Succession laminated to thickly bedded polymict tuffs and tuffs.
5. Continued subsidence of the basin between the Darkwater and Lac David faults changes the depositional environment from a subaerial to a shallow subaqueous setting. Scalloping of the basin margins leads to deposition of the Tailings Lake Succession massive to stratified polymict tuffs and lapilli tuffs. Periodic effusive eruption of andesitic (Tailings Lake andesite lava flows) and small volume explosive eruptions of dacite-rhyolite (Tailings Lake dacite-rhyolite tuff) also occurs.
6. High temperature hydrothermal activity forms the Mattabi "E" ore lens within the Tailings Lake dacite-rhyolite tuff.
7. Pulsating, voluminous (~30km^3: Hudak et al., 2003) subaqueous explosive eruptions form hot (?) high- and low-concentration eruption fed density currents within the basin between the Darkwater and Lac David faults, and cool high- and low-concentration, eruption-fed density currents as outflow sheets in the western one-third of the SLCC (Mattabi bedded quartz-phyric rhyodacite-rhyolite lapilli tuffs and tuffs). A nested caldera is formed during these eruptions between the Darkwater and Lac David faults, enabling the submarine environment to subside to depths in which VMS may form.
8. Regional low temperature submarine hydrothermal activity alters the volcaniclastic strata to regional sericite and carbonate alteration assemblages. This regional alteration is responsible for semi-conformable zone of Na-depletion that extends for 25km along strike within the Sturgeon Lake camp. The regional carbonate present is generally dolomite. Post-eruptive, high temperature synvolcanic hydrothermal activity in the vicinity of synvolcanic structures forms the Mattabi "B", "C", and "D" lenses, primarily as sheet-like replacement VMS deposits (c.f. Doyle and Allen, 2003) at water depths <1500 meters. Hydrothermal alteration associated with this mineralization leaches alkali elements and locally adds iron and manganese to form the pre-metamorphic precursors to the iron carbonate + iron-rich chlorite assemblage, the chloritoid ± iron-rich chlorite assemblage, the aluminum silicate + chloritoid assemblage, and the aluminum silicate assemblage. Regional dolomite reacts with the hydrothermal solutions to form ferrodolomite, ankerite, and siderite as one approaches VMS mineralization (Franklin et al., 1975). Downwelling of cool seawater deposits magnesium and potassium to form late magnesium-rich chlorite and sericite veins.
9. Subaqueous deposition and post hydrothermal reworking of Mattabi Succession massive rhyodacite-rhyolite tuffs. Continued regional submarine hydrothermal alteration produces regional semi-conformable alteration zones dominated by sericite.

Late Caldera Geological History

1. Subaqueous eruption, deposition, and post-eruptive reworking of the Lower L Succession rhyodacite-rhyolite tuffs and lapilli tuffs.
2. Continued erosion of caldera walls, subaqueous reworking of intracaldera deposits, and low temperature hydrothermal activity generates the Lower L Succession interbedded graphitic mudstones, tuffs, and lapilli tuffs).
3. Initial eruptions of No Name Lake Succession basalt-andesite lava flows east of the Bell River, and Bell River Lake basalt-andesite lava flows adjacent to the Darkwater fault.
4. Eruption of rhyodacite-rhyolite lava dome, and formation of VMS deposits on the dome, approximately 2km west of the present location of

the Sturgeon Lake VMS deposit (indirect evidence from rhyodacitic to rhyolitic lava lapilli and blocks in the Middle L breccia and tuff-breccia deposits).

5. Subaqueous disintegration of rhyodacite-rhyolite lava dome and associated VMS deposits, simultaneously with subaqueous rhyodacitic-rhyolitic plinean (phreato-plinean?) volcanism form high- and low-concentration eruption fed mass flows which deposit Middle L Succession rhyodacite breccia, tuff-breccia, lapilli tuffs, and tuffs within a nested caldera that has a well-defined western margin near the Bell River, and a poorly defined eastern margin (the location of the eastern margin is no longer able to be recognized at surface due to the structural deformation associated with the Lyon Lake Fault Zone). Simultaneous submarine plinean eruptions appear to have occurred north of the F-Group VMS orebody, and deposited relatively thick sequences of quartz-phyric rhyodacite-rhyolite lapilli tuffs and tuffs in a localized synvolcanic basin (Middle L Succession rhyodacite-rhyolite breccia, tuff-breccia, lapilli tuff, and tuff).
6. Post-eruptive high temperature hydrothermal activity forms the Mattabi "A" ore lens, the Sturgeon Lake VMS deposit, and subeconomic VMS deposits hosted in the Middle L Succession lapilli tuffs and tuffs in Area 17 and near the border between the F-Group claims and Area 15. Regional low temperature submarine alteration of the rocks yields semi-conformable sericite-rich and carbonate-rich alteration zones.
7. Intracaldera low temperature hydrothermal activity, sedimentation and reworking of intracaldera volcanic and volcaniclastic rocks (Upper L Succession interbedded graphitic mudstones, tuffs, lapilli tuffs).
8. Eruption, subaqueous deposition, and subaqueous reworking of plagioclase- + quartz-phyric volcaniclastic rocks (Upper L rhyodacite-rhyolite tuffs and lapilli tuffs).
9. Post-eruptive synvolcanic hydrothermal activity forms subeconomic VMS deposits in the Upper L Succession lapilli tuffs and tuffs in the eastern one-third of the SLCC.
10. Continued intracaldera sedimentation and submarine reworking of intracaldera deposits (Upper L Succession interbedded graphitic mudstones, tuffs, and lapilli tuffs).
11. Intermittent subaqueous mafic-intermediate and felsic volcanism (No Name Lake Succession and Bell River Lake Succession basalt-andesite lava flows, and Bell River Lake Succession rhyodacite-rhyolite lava flows).
12. Continued intracaldera sedimentation and reworking of intracaldera deposits (Upper L Succession interbedded graphitic mudstones, tuffs, lapilli tuffs).
13. Intrusion of plagioclase-phyric diorite-dacite dikes and sills, and the formation of the Lyon Creek Succession andesite-dacite lava flows, lava domes and cryptodome. Subsequent erosion of flows and domes yields sediment which lithifies into Lyon Creek Succession feldspathic tuffs, lapilli tuffs, and tuff breccias.
14. Development of a localized basin within the eastern part of the Lyon Creek Succession dome/cryptodome complex, and the deposition of volcaniclastic sediments with the basin (Lyon Creek Succession feldspathic tuffs, lapilli tuffs, and tuff breccias).
15. Low temperature hydrothermal activity within the Lyon Creek basin forms Lyon Creek Succession Algoma-type iron formation, chert, and graphite-rich mudstones.
16. Continued intracaldera sedimentation (Lyon Creek Succession feldspathic tuffs, lapilli tuffs, and tuff breccias).

Post-caldera Geological History

1. Regional compression, and formation of the Lyon Lake Fault Zone, possibly as a low-angle thrust fault; shearing of the Sturgeon Lake VMS orebody, remobilization of sulphides, and emplacement of Lyon Lake, Creek Zone, Sub-Creek Zone VMS orebodies within the high strain zone associated with the Lyon Lake Fault
2. 2.7Ga regional north-south compression yields north-facing homoclinal sequence, regional greenschist and lower amphibolite facies regional metamorphism.

Field Trip Stops

This field trip is designed to be completed in one to two days, depending upon the time spent, and the depth of discussions, at each field trip stop location. The field trip stops have been numbered so that the participants observe rocks from the base toward the top of stratigraphic sequence (older rocks to younger rocks) throughout the excursion. In addition to moving

more or less up-section, the field trip will successively investigate volcanic rocks, hydrothermal alteration, and mineral deposits in the western, central, and eastern parts of the SLCC.

N.B. All field trip stops are located on Glencore-Canada Property; therefore, permission must be obtained before attempting access to the field trip stops.

The first day of the field trip will concentrate on rocks that comprise the subvolcanic Beidelman Bay Intrusive Complex, the Darkwater Succession (pre-caldera rocks upon which the Sturgeon Lake Caldera Complex was developed), and the High Level Lake, Tailings Lake, and Mattabi Successions which comprise the Early Caldera Sequence, as well as host the majority of the VMS mineralization with the Sturgeon Lake camp. The second day of the field trip will focus on rocks that comprise the Late Caldera Sequence, including variably (and locally intensely) altered Middle L Succession tuffs and tuff-breccias (which host the VMS deposits at the Sturgeon Lake Mine about a kilometer east-southeast of our field trip stops), coherent dacites that comprise the Lyon Creek Succession cryptodome, and exceptionally well-preserved Neoarchean pillow lavas, volcaniclastic sediments, and locally, peperite deposits that make up the No Name Lake Succession.

Please note, there are no co-ordinates available for the stops described within this field trip guide. UTM Co-ordinates; however, will be supplied to participants at the beginning of the field trip.

Day 1 – Synvolcanic Intrusion, Precaldera Rocks, and Early Caldera Rocks Associated with the Sturgeon Lake Caldera Complex

The Beidelman Bay Intrusive Complex

Stop 1: Beidelman Bay Intrusive Complex

Two coeval intrusive complexes intrude the pre-caldera supracrustal strata in the Sturgeon Lake region (refer to Fig. 1), and have been extensively studied by Galley et al. (2000), Galley (2002) and Galley (2003). The Pike Lake Layered Complex (PLLC) is composed of massive to crudely layered ferrogabbro, melanogabbro, and gabbro, which combined have a strike length of approximately 10km and a composite thickness of approximately 2500m. The PLLC is intruded along its eastern margin by the Beidelman Bay Intrusive Complex (BBIC), which has a strike length of approximately 20km and a composite thickness of approximately 2000m (Trowell, 1983; Galley et al., 2000). The BBIC is composed of at least six separate intrusive phases. From oldest to youngest, these include xenolithic tonalite, quartz-porphyritic pre-main phase dikes, main phase leucotonalite, post-main phase leucotonalite dikes, quartz- and plagioclase-phyric dikes, and late-phase quartz monzonite and granodiorite stocks (Galley, 2002, 2003).Wide variations in geochemical signatures and age dates for these intrusive phases indicate a complex magmatic history encompassing at least three separate magma sources over a time span of up to 20 million years (refer to Table 2).

At this field trip stop, we will investigate the product of the middle intrusive event, the main phase biotite leucotonalite of the BBIC. According to Galley (2002), the main phase biotite leucotonalite makes up the bulk of the BBIC. It comprises a massive, medium-grained hypidiomorphic to seriate-textured rock that displays few internal variations in texture or grain size. Galley (2002) notes that this phase of the BBIC has lithogeochemical characteristics that matches favourably with those of the High Level Lake, Mattabi, and Middle L pyroclastic rocks within the SLCC, in agreement with earlier interpretations (Davis and Trowell, 1982; Trowell, 1983) that the BBIC was the subvolcanic magma chamber that erupted to form the intracaldera felsic pyroclastic rocks within the SLCC.

Precaldera Strata – The Darkwater Basalts and Darkwater Rhyolites

Stop 2: Darkwater Basalts and Darkwater Rhyolites

The Precaldera Sequence extends along strike across the entire south Sturgeon Lake region, and is composed of a 200-2100m thick succession of subaerial and shallow submarine basalt and andesite lava flows (Darkwater basalt-andesite lava flows), volcaniclastic deposits (Darkwater basalt-andesite tuffs and lapilli-tuffs), and minor rhyodacite-rhyolite lava flows (Darkwater rhyodacite-rhyolite lavas; Figs. 2, 3 and 4). At this field trip location, we will have the opportunity to investigate Darkwater basalt-andesite lava flows as well as Darkwater rhyodacite-rhyolite lavas.

The Darkwater basalt-andesite lava flows have been studied in detail by Groves (1984) and Groves et al. (1988). These lava flows comprise a 200-1800m thick sequence of aphyric to plagioclase-phyric, massive to amygdaloidal (2-25% amygdules) basalt – andesite lava flows. Groves (1984) and Groves et al. (1988) indicate that individual lava flows vary in

stratigraphic thickness from 3-40m, and are commonly characterized by billowy flow tops containing 45-70% amygdules and locally flow marginal autobreccias that contain 40-70% poorly sorted, massive to scoriaceous basalt-andesite lapilli and blocks. It is only on the far eastern end of the south Sturgeon Lake region that pillow lavas, sheet flows, and associated hyaloclastite deposits have been recognized (Jongewaard, 1989), suggesting that these pre-caldera strata were formed largely in a subaerial environment. At this location we will investigate the physical characteristics of Darkwater Succession basalt-andesite lava flows.

Moving to the north, we will also investigate aphyric to quartz-plagioclase-phyric, typically massive but locally spherulitic and/or flow banded rhyodacite-rhyolite lava flows that occur within the Darkwater Succession. Individual lava flows are up to 80m thick, and are separated by clast-supported volcanic breccias that have been interpreted by Groves (1984) and Groves et al. (1988) to be autobreccias. Similar felsic lava flows with stratigraphic thicknesses up to 10m locally overlie thin basalt-andesite lava flows in the eastern part of the south Sturgeon Lake region near Lac David (Jongewaard, 1989).

F-Group Region Intracaldera Strata

In the F-Group and Darkwater regions, participants will observe Early- and Late Caldera Succession strata which illustrate the three stratigraphic horizons which host VMS orebodies in the SLCC. These stops will include: a) interbedded polymict breccias (High Level Lake Succession polymict breccias) and rhyolite tuffs and lapilli tuffs (High Level Lake Succession rhyodacite-rhyolite lapilli tuffs and tuffs) that formed during simultaneous explosive felsic eruptions and foundering of the region above the shallow ancestral Beidelman Bay intrusion during formation of the Sturgeon Lake Caldera Complex; b) extreme aluminum silicate alteration within the High Level Lake Succession breccias and tuffs that occur down-section and along strike from the F-Group VMS deposit; and c) well-bedded quartz-phyric lapilli tuffs and tuffs that comprise the Mattabi VMS ore horizon (including a small replacement-type sphalerite-rich VMS deposit) in the western part of the caldera complex, and the hanging wall rocks to the Mattabi VMS deposit in this part of the caldera complex, the Middle L Succession rhyodacite-rhyolite lapilli tuffs and tuffs. The Middle L Succession lapilli tuffs and tuffs are the host rocks for the Sturgeon Lake VMS deposit in the eastern part of the SLCC.

The F-Group VMS deposit was discovered from airborne and ground geophysical surveys combined with exploration diamond drilling conducted by Mattagami Lake Mines in 1969. The orebody was mined by open pit methods from 1981-1984, and produced approximately 377,564 short tons of ore which contained 0.64% Cu, 9.51% Zn, 0.64% Pb, and 60.4g/ton Ag (M. Patterson, personal communication, 1990; Franklin, 1996).

Stop 3: High Level Lake Tuffs and Polymict Breccias (Mesobreccia)

At this location (Fig. 20), approximately 75m southeast of the F-Group pit, one can observe the contact between massive to sparsely graded polymict breccia deposits (the High Level Lake Succession polymict breccias) and overlying rhyolitic massive lapilli tuffs and tuffs (the High Level Lake Succession Tuffs). The green to green grey polymict breccia contain a fine-grained matrix compose of chlorite, sericite, and locally iron-rich carbonate (ferrodolomite and/or ankerite). Lapilli- to small block-sized clasts vary in abundance from 30-70%, and include: a) easily recognizable, light grey to pale white angular to subangular, locally flow-banded rhyolite lava flow fragments which have been

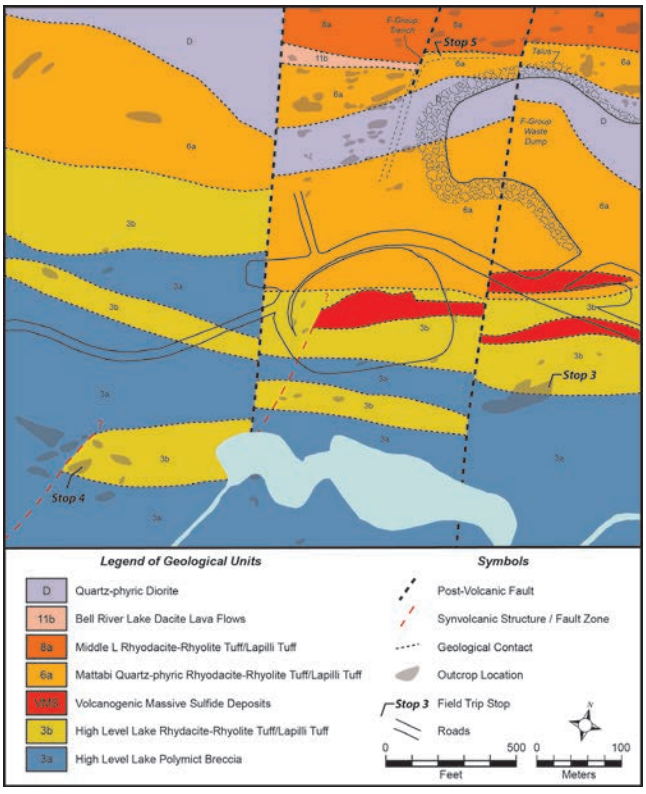


Figure 20. Geological sketch map of the F-Group area, with field trip stop locations (from Morton et al., 1996).

derived from the underlying Darkwater Succession rhyodacite to rhyolite lava flows; b) light grey to pale white, angular to subangular, locally silicified rhyolite tuff lapilli (presumably derived from the underlying Jackpot Lake Succession tuffs); c) green, commonly difficult to recognize, angular to rounded amygdaloidal basalt lapilli (derived from the underlying Darkwater Succession basalt-andesite lava flows); and d) green, commonly difficult to recognize, generally rounded to subrounded, locally pale-brown iron carbonate altered scoria lapilli (derived from the underlying Darkwater Succession andesite tuffs, lapilli tuffs, and tuff breccias).

As one moves from the southwestern part of the outcrop toward the northeast, the abundance of lapilli and blocks within the breccia deposits decreases, and the abundance of <1mm quartz phenocrysts increases to 1-2% over a zone which varies from 1-5m in width. This zone represents the gradational contact between the High Level Lake mesobreccia deposits and the overlying and intercalated High Level Lake quartz-phyric lapilli tuffs and tuffs. This gradational contact formed during mixing of the two units as they were deposited simultaneously (Hudak, 1989). Similar intercalations of felsic pyroclastic deposits and polymict breccia deposits have been documented in calderas within the San Juan Mountains in Colorado by Lipman (1976), and have been interpreted to represent deposits which result from simultaneous explosive volcanism and caldera collapse.

Continuing to move to the north on the outcrop, the gradational contact zone gives way to massive deposits of the High Level Lake Succession lapilli tuffs and tuffs. The light grey quartz- and sericite-rich, recrystallized ash matrix of these deposits contains 5-25% euhedral to subhedral, locally resorbed 1mm quartz phenocrysts and up to several percent, typically difficult to see, subangular to subrounded pumice lapilli. Irregular patches and lenses of red-brown iron carbonate alteration vary from 1-10cm in length, and locally comprise 10-15% of the outcrop. In thin section, many of the altered 1-3cm carbonate patches appear to be altered pumice lapilli.

The polymict breccia deposits at this outcrop, and numerous other outcrops in the Sturgeon Lake camp, are interpreted to be mesobreccias and megabreccias. Mesobreccias and megabreccias form from material that slumps off oversteepened walls of a caldera during and after caldera collapse. By definition (Lipman, 1976; Lipman, 1997; Lipman, 2000), megabreccia deposits contain blocks which are dominantly greater than 1m in diameter, whereas mesobreccia deposits contain lapilli and blocks which are dominantly less than 1m in diameter. Megabreccia deposits are generally formed proximal to caldera walls. Mesobreccia and megabreccia deposits which occur in the footwalls to the Mattabi and Sturgeon Lake Mine orebodies are stratigraphically equivalent to the polymict breccia deposits which are observed at this location.

Stop 4: Altered High Level Lake Polymict Breccias, Lapilli Tuffs, and Tuffs (optional)

Intensely aluminum silicate- and aluminum silicate + chloritoid-altered, intercalated High Level Lake Succession breccias and rhyolite lapilli tuffs / tuffs occur at this location, approximately 300m southwest of the F-Group pit (Fig. 20). Although difficult to recognize, these rocks comprise the same stratigraphic units exposed at the first field trip stop.

Here, the High Level Lake Succession polymict breccia deposits vary from green to grey-green to pale pinkish-grey, and contain up to 50% lapilli and blocks. The fragments are of three principal types: 1) 5% rounded, 3-10mm in diameter, intensely amygdaloidal quartz- and sericite-rich fragments which petrographic observations indicate are altered pumice; b) 5-10% light grey lapilli- to small block-sized felsic lava fragments (Darkwater Succession rhyodacite/ rhyolite lava flows); and c) up to 30% subround to oval, 3-10mm diameter chlorite-rich amygdaloidal fragments which petrographic observations suggest are scoria and amygdaloidal basalt. The matrix of this unit is generally composed of magnesium-rich chlorite, quartz, and sericite, but locally, where pale pinkish grey, andalusite and/or pyrophyllite also occur.

High Level Lake Succession rhyolite lapilli tuffs and tuffs overlie, and are locally intercalated with, the High Level Lake polymict breccia deposits in this area. The felsic lapilli tuffs and tuffs contain 1-20% 1mm diameter euhedral to subhedral quartz phenocrysts in a recrystallized ash matrix, and vary in colour from grey-green to greyish-pink depending upon the alteration mineral assemblage present. Grey-green regions contain an alteration assemblage of quartz, sericite, and locally magnesium- and/or iron-rich chlorite. Pinkish-grey regions are composed of an alteration mineral assemblage composed dominantly of quartz and up to 1mm diameter ragged anhedral to blocky subhedral andalusite. Light grey, subrounded to oval pumice lapilli vary from 3-20mm in diameter, and

are composed of recrystallized quartz. Petrographic observations indicate that the pumice lapilli contain 30-50% <1mm round quartz-filled vesicles.

Pervasive aluminum silicate alteration, greenschist facies metamorphism, and subsequent retrograde processes have led to the development of three different aluminum silicate phases within this group of outcrops. Andalusite is the most common aluminum silicate phase present (5-50%), and occurs as 1-6mm ragged anhedral to equant subhedral pink porphyroblasts. Thin section examinations indicate that the ragged andalusite porphyroblasts have locally undergone retrograde reactions and now contain inclusions and rims composed of sericite and/or pyrophyllite. Kyanite is present in two distinctive forms: a) as ragged tabular porphyroblasts up to 5mm in length within the altered matrix of the tuffs; and b) as pale blue blades ranging from 3-20mm in length within white to reddish-brown quartz-iron carbonate veins that are up to several centimeters in width. Pyrophyllite can commonly be found along the margins of both the andalusite and kyanite porphyroblasts, and may also occur in veins up to several centimeters in width as soft, pale greenish-white radiating micaceous aggregates. Pyrophyllite is commonly present where quartz veins intersect kyanite-rich veins. Minor amounts of chloritoid (generally <5% but locally up to 10%) are locally associated with these aluminum silicate minerals.

This series of outcrops is interpreted to be proximal to, and in part, within, a synvolcanic fault zone. These faults provided cross-stratal channel ways in which high temperature, acidic metalliferous hydrothermal fluids traveled upward through the subseafloor to the seafloor. The aluminum silicate alteration has been shown via mass balance analyses (Jongewaard, 1989; Hudak, 1989; Hudak, 1996) to have developed as the acidic fluids leached cations from the rocks (for example, during the alteration of feldspar or volcanic glass), leaving them rich in aluminum and silica (and presumable with a clay-rich pre-metamorphic alteration mineral assemblage). Andalusite and kyanite certainly formed during the greenschist facies metamorphism of the strata; however, studies of both modern and ancient hydrothermal alteration assemblages (White and Hedenquist, 1990; White and Hedenquist, 1995) associated with epithermal mineral deposits indicate that andalusite may also form as a primary, high temperature alteration mineral phase. Pyrophyllite may have formed as a primary mineral as well, but based on textural evidence, appears primarily to be due to retrograde metamorphism of kyanite and andalusite.

Stop 5: The F-Group Trench

Excavated in 1989, the F-Group reclamation trench was designed to channel runoff waters from the F-Group waste dump into the F-Group pit (Fig. 20). Four different lithologies are exposed in this trench: 1) a dark grey to green, locally amygdaloidal gabbro to quartz-diorite sill-like synvolcanic intrusion; 2) light grey to pink, aphyric to locally quartz-phyric, bedded to massive Mattabi Succession lapilli tuffs and tuffs; 3) semi-massive to massive, replacement-type lenses of pyrite ± sphalerite which occur at the equivalent stratigraphic horizon to the "B"-lens of the Mattabi VMS orebody; and 4) grey to grey-green, bedded to massive, quartz- ± feldspar-phyric lapilli tuff and tuff deposits of the Middle L Succession.

Several alteration mineral assemblages can also be recognized at this locality. These include: a) iron carbonate ± iron chlorite assemblage; b) the chloritoid assemblage; c) the chloritoid + aluminum silicate ± sericite assemblage; d) the aluminum silicate ± sericite assemblage; and e) locally, silicification. Note the cross-cutting relationships of the various alteration assemblages which can be observed by close examination of the trench wall rocks.

Structurally, two different generations of faults have been identified by Walker and Hudak (1989) within the F-Group trench. Synvolcanic structures, which locally led to minor differences in the thicknesses of the volcanic units within the trench, produced cross-stratal permeability that focused upwelling metalliferous fluids in pathways to the paleoseafloor. Metasomatism resulting from interactions between the volcaniclastic strata and these synvolcanic metalliferous fluids produced the extensive hydrothermal alteration in the area. Cooling and neutralization of these fluids by cooler seawater or lower temperature hydrothermal fluids within the tuffs within the shallow seafloor led to the development of replacement-style (Doyle and Allen, 2003) massive sulphide occurrence within the Mattabi tuffs. Locally, strongly sheared, commonly sericite-rich, east-northeast trending high strain zones represent post-volcanic structural deformation which is believed to be related to splays off the northeast-trending Sturgeon Narrows Shear Zone (Figure 1) that is located to the north and west of this location beneath Sturgeon Lake.

Stop 6: Bedded and Graded High Level Lake Mesobreccia Deposits (optional)

As indicated previously, it appears that the initial

development of the Sturgeon Lake Caldera Complex involved trap-door like caldera collapse in which the most significant displacement occurred in the western part of the caldera. Here, in the western one-third of the caldera complex (refer to Fig. 1), we can observe planar thin- to thick-bedded, matrix-supported, normal and locally reverse-graded polymict lapilli-tuffs and tuffs. The finer-grained deposits on this group of outcrops display Ta, Tb, and Te-type bedding units (c.f. Bouma, 1962), whereas coarser deposits display R2-R3 and S1-S3 bedding units (c.f. Lowe, 1982).

Mattabi Region (Area 16) Intracaldera Strata

In the vicinity of the Mattabi VMS deposit, field trip participants will observe: a) the High Level Lake Succession polymict breccias and rhyolite lapilli tuffs and tuffs in the central part of the SLCS: b) thick, massive, pumice-rich, quartz-phyric lapilli tuffs and tuffs that comprise the immediate footwall and host strata to the Mattabi VMS deposit (Mattabi Succession lapilli tuffs and tuffs); and c) hanging wall basalt to andesite pillow lavas, pillow breccias, and locally, bedded volcaniclastic sedimentary strata and peperite (the No Name Lake Succession lava flows and associated interflow sedimentary strata). Previous field trips to the Sturgeon Lake area also included a stop at an exceptional exposure of well-bedded polymict breccia deposits and associated normal graded volcaniclastic sandstones and mudstones which comprise the Tailings Lake Succession sedimentary strata; however, during reclamation, this exposure, which occurs immediately east of the former Mattabi headframe, was buried by approximately 3-5m of fill. Due to the importance of this exposure in terms of understanding the development of the SLCC, we have chosen to include its field trip description although we will not be able to observe the outcrop.

The Mattabi VMS deposit was discovered by Mattagami Lake Mines in 1969 from follow-up drilling of airborne geophysical anomalies. The orebodies were mined by open pit and underground mining methods, and comprised five stratiform lenses of massive sulphide ore separated by stringer base-metal mineralization or barren host rock which occur in three distinct stratigraphic successions (Tailings Lake, Mattabi, and Middle L successions, respectively). Massive sulphide lenses which cropped out and extended to approximately 250m below the surface were mined via open pit methods between 1972 and 1980. The deeper VMS deposits were mine using underground mining methods until reserves were depleted in 1988. Combined, the five lenses comprising the Mattabi VMS deposit produced approximately 12.55 million tons of VMS ore grading 8.28% Zn, 0.74% Cu, 0.85% Pb, and 104g/ton Ag (M. Patterson, personal communication, 1990; Franklin, 1996).

Stop 7: Mattabi Footwall - High Level Lake Polymict Breccias and Rhyolite Lapilli Tuffs/Tuffs

This series of outcrops is located approximately 500m stratigraphically below the lowermost lens of the Mattabi VMS orebody. The southern portion of these outcrops comprises coarse polymict breccias which are interpreted to be mesobreccia deposits formed during caldera collapse. The far northeastern outcrops comprise quartz-phyric rhyolite tuffs which overlie, and are intercalated with, the polymict breccias (the field relationship seen previously in the vicinity of the F-Group orebody). Figures 21 and 22 illustrate the locations of the outcrops described below.

Stop 7a: Polymict Breccia Deposits (High Level Lake Succession Mesobreccia)

These outcrops comprise coarse, polymict, breccia that contains up to 50% 1-25cm light-coloured subangular felsic lithic fragments (Darkwater Succession rhyolite lava flow lapilli), up to 10% lapilli- to block-sized pumice fragments, which commonly have silicified rims, and <5% amygdaloidal mafic lapilli, which are up to 5cm in diameter (Darkwater Succession amygdaloidal basalt lapilli). Petrographic observations indicate that the matrix is composed of a mixture of fine-grained recrystallized quartz (40%), chloritoid (12%), magnesium-rich chlorite (30%), white mica (sericite ± pyrophyllite, 15%), and opaque minerals (pyrite and/or magnetite, 3%). The northeastern section of the outcrop contains a bus-sized felsic block (>10m in diameter) with similar composition to the smaller felsic lapilli which occur throughout the breccia deposits (Walker, 1993).

Stop 7b: High Level Lake Succession Tuffs

High Level Lake Succession tuffs at this location are light tan to grey in colour and contain 2-5% 0.5-1.5mm diameter subhedral to euhedral, locally resorbed quartz phenocrysts. In thin section, only "ghosts" of 2-10mm diameter pumice lapilli can be observed within a matrix composed of recrystallized, inequigranular polygonal quartz (up to 65%), fine-grained sericite (25%), magnesium-rich chlorite (6%), 3% pyrite, and 1% magnetite and/or ilmenite. Further to the

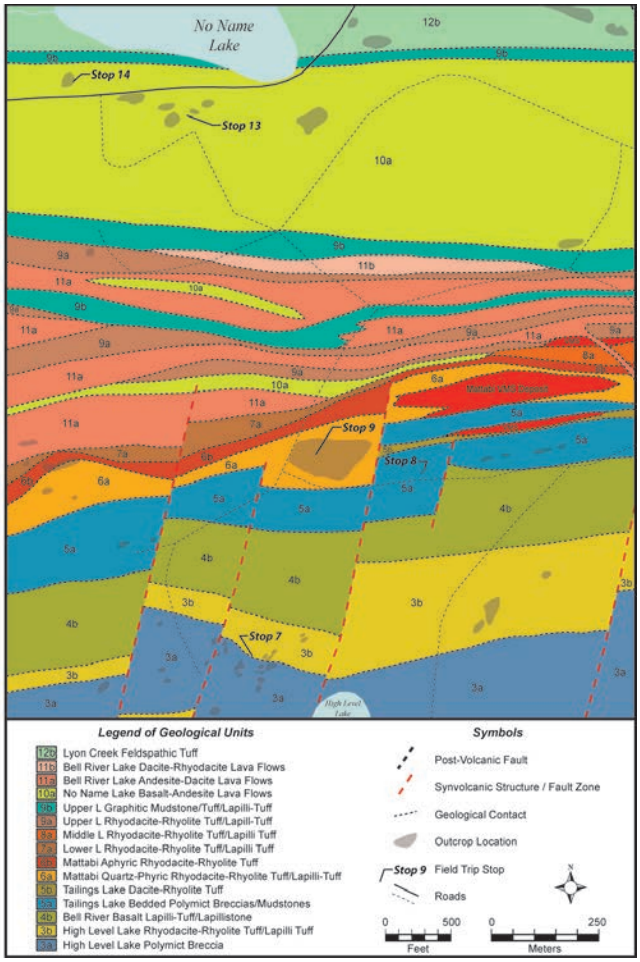


Figure 21. Geological plan map of the Mattabi area, with field trip stop locations (after Walker, 1993; Morton et al., 1996).

east, the unit contains a coarse, fragmental texture. Here, the rock contains 60-70% lapilli- to block-sized subangular to angular felsic lithic fragments in a felsic matrix. The texture has been interpreted by Walker (1993) to represent deposits formed by post-depositional slumpage of partially consolidated High Level Lake Succession tuffs. Only minor variations in the alteration mineralogy can be found between the matrix and the fragments present at this location.

Stop 7c: Chloritoid–Aluminum Silicate-Chlorite Altered High Level Lake Mesobreccia

This exposure is composed of High Level Lake polymict breccia deposits which contain 20-30% rounded, 2-30cm, highly amygdaloidal scoria lapilli and blocks, as well as up to 10% 1-15cm subangular felsic lapilli and blocks which are similar in composition to those observed in outcrop M-1a. In thin section, the matrix comprises 30% quartz, 20% magnesium-rich chlorite, 10% iron carbonate, 15% sericite ± pyrophyllite, 10% chloritoid, up to 10% ragged andalusite, and 5% opaque minerals. Chlorite alteration increases toward the center of the outcrop where massive chlorite veining up to 50cm in width occurs.

The chloritic veining at this location is interpreted to have resulted from recharge of cool, fresh seawater into a hot hydrothermal system. This appears to have resulted in magnesium-dumping and subsequent chlorite alteration (Walker, 1993; also see Seyfried et al., 1999). The quartz-filled tension fractures which

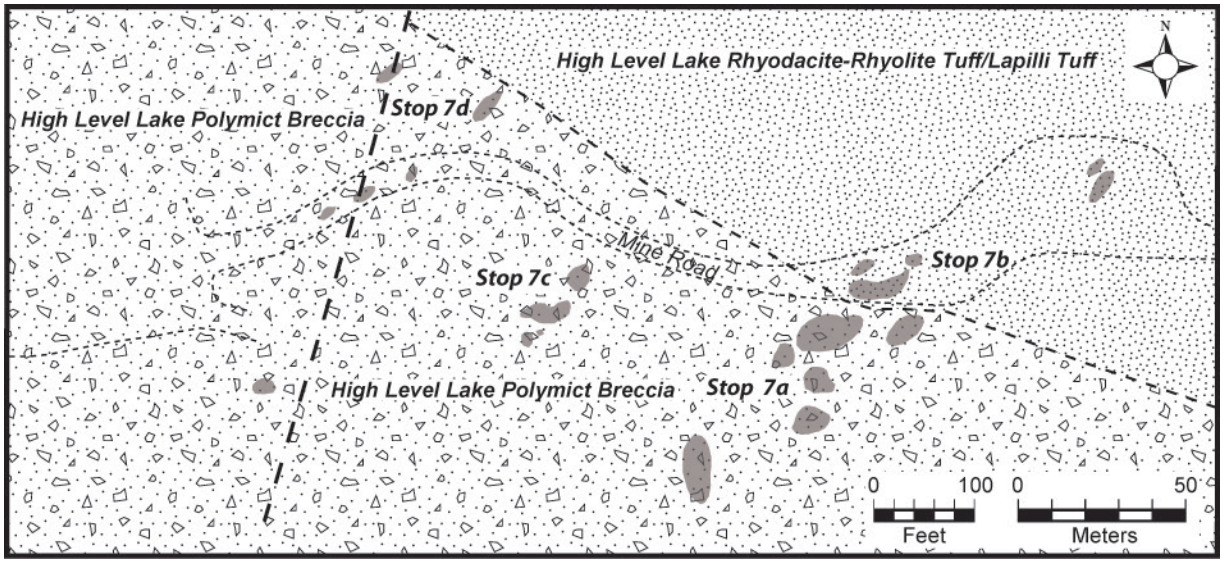


Figure 22. Geological sketch map of the High Level Lake Succession outcrops south of the Mattabi VMS orebody (after Walker, 1993; Morton et al., 1996).

occur at this location may be the result of volume changes due to hydrothermal alteration. Kyanite can locally be found in these fracture-filling veins on the southern part of the outcrop. A 10-20cm wide band of silicified rock, striking North-South, bisects the outcrop. Samples from this silicified rock contain 50% quartz, 15% sericite ± pyrophyllite, 8% iron-rich carbonate, 7% magnesium-rich chlorite, 2% andalusite, and 2% opaque minerals. This band of more intense alteration may represent a conduit responsible for upward, high-temperature, acidic metalliferous fluid movement which was later overprinted by lower temperature, more neutral hydrothermal fluids that produced sericite and chlorite alteration.

Stop 7d: Chloritoid – Aluminum Silicate - Fe-carbonate Altered Mesobreccia

This series of outcrops illustrates a definable, confined and symmetrically zoned increase in alteration intensity within a synvolcanic fault zone in the High Level Lake polymict breccia unit. Original volcanic textures within the breccia unit within this synvolcanic structure are strongly overprinted, but still recognizable when carefully inspected. In particular, one can still relatively easily recognize the abundance of relatively unaltered felsic lithic lapilli. Alteration in the small outcrops on the road and immediately north of the road consist of 1-4cm clots of iron-carbonate-rich material surrounded by anastomosing veinlets of quartz, chloritoid, and andalusite. The dominant change in rock mineralogy from the previous outcrop (Stop 7c) is an increase in the amount of Fe-carbonate and chloritoid.

Stop 8 (No Longer Available): Mattabi Footwall - Tailings Lake Succession Bedded Sediments

Note: Reclamation in the vicinity of the former Mattabi Mine headframe has unfortunately resulted in the burying of the classic outcrop of the Tailings Lake Succession. Although this outcrop can no longer be observed, I have included its description below, as the field relationships and textures observed in this former outcrop were extremely important for the development of the Sturgeon Lake Caldera Complex volcanological model described by Morton et al. (2001), Morton et al. (1999), Walker (1993) and Hudak et al. (2003).

The Tailings Lake Succession consists primarily of highly variable polymict breccias, sandstones, and mudstones, with minor intercalated felsic tuff horizons and intermediate to mafic lava flows. The polymict breccias vary in their clast composition, clast abundance, and bedding characteristics. Three clast types are most common: 1) mafic lithic clasts, which are commonly replaced by chlorite and/or iron-carbonate (up to 50%); 2) fined-grained cherty felsic lithic lapilli (up to 30%); and 3) rounded pumice lapilli (up to 20%). Bedding is uncommon, but where present, is usually defined by sorting of the clasts, as well as changes in the compositions of the clasts. The Tailings Lake polymict breccia deposits are lithogeochemically indistinguishable from the High Level Lake polymict breccia deposits, and suggests their provenance is similar (e.g., from infilling of a basin by clastic material derived primarily from Pre-caldera strata).

Many of the characteristics of the Tailings Lake polymict breccias are conspicuous in the exposure located beside the Mattabi Mine ventilation shaft. This exposure is atypical in its cross-sectional view, and because of the presence of well-defined bedding within the breccia unit. Here, the unit contains 5-30% 2-30mm diameter mafic lapilli (which contain 5-30% oval to rounded iron-carbonate- and quartz-filled amygdules or weathering pits), as well as 2-30mm felsic lithic or pumice lapilli (5-30%). In thin section, the matrix comprises quartz (35%), iron-carbonate(20%), and andalusite (10%), as well as late patches and veins of magnesium-rich chlorite (20%) and sericite/pyrophyllite (10%). Bedding in the unit is defined by various abundances of mafic and felsic fragments. It appears mafic fragments are generally normal graded and felsic pumice lapilli are reverse graded. Such reverse grading of pumice clasts is commonly attributed to the slow settling of cold, highly vesicular fragments as water infiltrates vesicles in an aqueous environment (Whitham and Sparks, 1986). Bedding trends approximately 100° and dips 60-70° to the north.

Stop 9: Mattabi Footwall – Aluminum Silicate-Altered Mattabi Lapilli Tuffs and Tuffs

This large outcrop on the southwestern side of the Mattabi open pit consists of moderately- to strongly-hydrothermally altered, massive Mattabi Succession quartz-phyric rhyolite lapilli tuffs and tuffs (Fig. 21). This exposure contains 10-50% subrounded to rounded juvenile felsic lapilli, 5-15% 5-30cm (although locally, up to 70-80cm diameter) delicate amoeboid to subrounded pumice, and 2-7% 0.5-1.5mm diameter subhedral to euhedral quartz phenocrysts. The recrystallized altered ash matrix consists of fine-grained polygonal quartz (40-50%), chloritoid (10-30%), sericite ± pyrophyllite (15-35%, after andalusite),

andalusite (up to 5%), and opaque minerals (generally pyrite, 1-5%). Lithic fragments consist of quartz ± sericite ± pyrophyllite and the pumice are replaced, and locally contain amygdules with, quartz ± sulphide minerals.

Bounding facies, as well as the presence of massive sulphide mineralization, indicate that these strata were deposited in a subaqueous environment. To the north (up-section), this unit grades into a series of bedded and locally normal graded aphyric tuffs and quartz-phyric tuffs. Petrographic studies indicate the presence of heat retention structures (lithophysae) and spherulites (indicative of the original glassy nature of the deposits) within the massive lapilli tuffs at this location (Walker, 1993: Hudak et al., 2003).

White (2000) has shown that massive lapilli tuff deposits, which contain delicate, amoeboid-shaped pumice as well as heat retention textures, which are overlain by bedded tuffs of similar composition represent primary, hot, eruption-fed high concentration mass flows which are essentially true submarine pyroclastic flow deposits (e.g. originally deposited from collapse of hot, gas charged flows of juvenile volcanic material). Hudak et al. (2003) have, based on textures at this outcrop as well as in several diamond drill core intersections, shown that the Mattabi tuffs were, at least locally in the vicinity of the Mattabi VMS orebody, deposited as submarine pyroclastic flows from voluminous submarine explosive rhyolitic volcanism.

End of Day 1 of Sturgeon Lake Field Trip

Day 2 – The Late Caldera Sequence

Lyon Lake and Sturgeon Lake Mine Regions (Areas 17 and 23)

In this part of the caldera complex, we will observe two important units within the Late Caldera Sequence: 1) the Middle L Succession tuff breccias, lapilli tuffs, and tuffs (which are the host rocks to the Sturgeon Lake VMS deposit approximately 1.5km to the east of the field trip stop location); and 2) the Lyon Creek Succession dacite cryptodome–lava dome complex, which are interpreted to comprise the final igneous products associated with the genesis of the Sturgeon Lake Caldera Complex.

Four VMS orebodies occur in the eastern part of the SLCC: 1) the Sturgeon Lake Mine, a 2.07 million ton ore deposit mined by open pit methods which contained 2.95% Cu, 9.17% Zn, 1.21% Pb, and 164g/ton Ag; 2) the Lyon Lake deposit, a 3.95 million ton ore deposit mined by underground methods which contained 1.24% Cu, 6.53% Zn, 0.63% Pb, and 142g/ton Ag; 3) the Creek Zone deposit; mined via open pit methods; and 4) the Sub-Creek Zone deposit, mined by underground methods. Combine, the Creek Zone and Sub-Creek Zone deposits contained 0.91 million tons of ore which graded 1.66% Cu, 8.80% Zn, 0.76% Pb, and 141g/ton Ag (Franklin, 1996).

The genesis of these four VMS deposits has historically been controversial in the Sturgeon Lake Camp. The Lyon Lake, Creek Zone, and Sub-Creek Zone deposits were originally known as the NBU ore deposits. Harvey and Hinzer (1981) interpreted abrupt facies changes, coarser volcaniclastic rocks, increased alteration intensity, and a greater MnO/FeO ratio in the Sturgeon Lake, Creek Zone, and Lyon Lake deposits to indicate formation along the same stratigraphic horizon at various distances from high temperature hydrothermal vents. Harvey and Hinzer (1981) suggested that these VMS orebodies occurred stratigraphically up-section from the Mattabi and F-Group VMS deposits. Severin (1981) postulated that the Sturgeon Lake deposit occurred on the same stratigraphic horizon as the Mattabi orebody, and that the Lyon Lake, Creek Zone, and Sub-Creek Zone deposits formed in topographic lows from hydrothermal activity which post-dated the formation of the Sturgeon Lake deposit. More recent detailed mapping (Dube et al., 1989: Koopman, 1993: Hudak, 1996; Morton et al., 1999), petrographic studies, and lithogeochemical evaluations now indicate that the Sturgeon Lake deposit is cut by a major post-volcanic fault zone, and that the Lyon Lake, Creek Zone, and Sub-Creek Zone deposits represent parts of the Sturgeon Lake deposit which were moved into their present locations by this structural deformation.

Stop 10. Aluminum Silicate Altered Quartz-Phyric Middle L Tuffs

The Middle L Succession comprises a sequence up to 150m thick composed of quartz-phyric rhyolite tuff breccias, lapilli tuffs, and tuffs which can be followed along strike for at least 15km across the SLCC. VMS orebodies occur within this sequence of rocks at both the Mattabi (Mattabi ore lens "A") and Sturgeon Lake Mine deposits. In addition, anomalous Cu and Zn concentrations occur in the Middle L tuffs under Sturgeon Lake near the F-Group – Area 15 property boundary.

This small outcrop (Fig. 23), located immediately south of a drill road which runs approximately east-west through Area 17, is one of the few exposures of the Middle L Succession in the eastern part of the caldera complex. At this location, the matrix varies from pale grey to pinkish-grey in colour and contains 1-2% <1-2mm subhedral to euhedral quartz phenocrysts. Pumice and felsic lithic lapilli are not obvious on this exposure, but occur in minor amounts (1-2%) in thin sections and from diamond drill core intersections of the unit. The colour of this outcrop is largely due to the presence of 5-15% 1-3mm blocky subhedral andalusite and fine-grained quartz. Immediately down-dip and up-section from this exposure, a thin (1m thick) massive sulphide horizon occurs within bedded ash deposits in diamond drill hole 17-64. Due to a lack of exposure, it is difficult to determine whether the aluminum silicate alteration at this location represents disconformable alteration within a synvolcanic structure, or semi-conformable aluminum silicate alteration along the stratigraphic horizon which hosts the Sturgeon Lake deposit to the east.

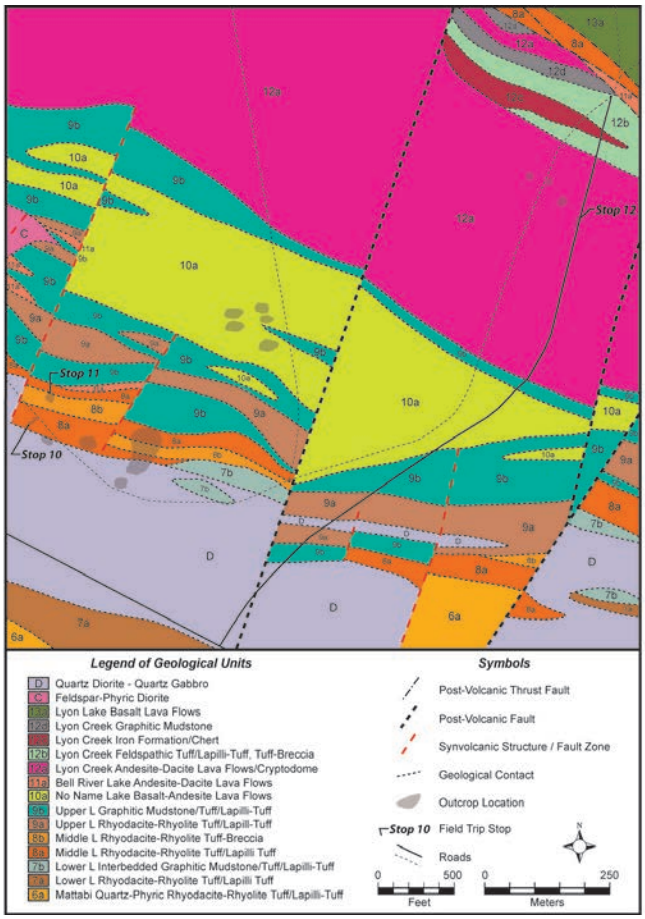


Figure 23. Geological plan map in Areas 17 and 23 (after Walker, 1993; Morton et al., 1996).

Stop 11: Middle L Succession Tuff Breccia

This stop is located immediately north of the Area 17 drill road approximately 30m north of the previous stop (Fig. 23). The spectacular volcanic breccia (tuff-breccia) is composed of a chlorite-, sericite-, iron carbonate-, and locally biotite-altered matrix which contains 30-60% subangular to angular, 1-35cm light grey felsic lava lapilli and blocks which contain 1-5% 1mm quartz phenocrysts, as well as rare massive sulphide lapilli and iron-carbonate-altered pumice lapilli. The felsic lava flow fragments are composed of spherulitic quartz- and K-spar-phyric rhyolite lava, are vaguely reverse graded, commonly have fine-grained (apparently chilled) rims, and often exhibit jigsaw puzzle-fit with adjacent fragments. The tuff-breccia deposits can be followed several hundred meters down dip in numerous diamond drill holes within Area 17. Bounding facies indicate that these deposits were formed in a submarine environment.

Hudak (1996) and Hudak et al. (2003) believe that these tuff-breccia deposits resulted from the collapse of a Middle L Succession submarine lava dome. This lava dome was likely located near a synvolcanic fault within a few hundred meters of this location. This tuff-breccia essentially represents deposits from block and ash flows that occurred in a submarine environment (Gibson et al., 1999). Massive sulphide lapilli within the tuff-breccias suggest that massive sulphides were being deposited on or within the lava dome prior to its collapse.

Stop 12: Lyon Creek Succession Cryptodome

The Lyon Creek Succession is composed of the youngest strata clearly associated with the development of the Sturgeon Lake Caldera Complex. As indicated above, these andesitic to dacitic lava flows, lava domes, cryptodomes and associated clastic and chemical sedimentary strata have been interpreted by Hudak (1996), Morton et al. (1999), and Hudak et al. (2003) to represent lava dome building and associated intracaldera clastic and hydrothermal sedimentation associated with the terminal stages of caldera development within a Valles-like caldera cycle (Smith and Bailey, 1968).

This stop (Fig. 23), located near the top of a small hill immediately west of the Lyon Lake mine road, is one of a handful of small exposures of the Lyon Creek dacite cryptodome. At this location we observe light grey massive plagioclase-phyric dacite lava which comprises the central part (and most

coarsely porphyritic) of the cryptodome. Hudak et al. (in prep.) have shown a systematic increase in the maximum size of plagioclase phenocrysts from the margins toward the center of the cryptodome. Tan to orange-brown, locally carbonate-altered tabular plagioclase phenocrysts (10-15%) generally vary from 1-3mm in diameter. Locally, one may observe plagioclase phenocrysts as large as 6mm in diameter. Hydrothermal alteration at this location comprises anastomosing 2-10mm wide veins containing iron-carbonate, chlorite, magnetite, and locally, burgundy-red Mn-rich almandine garnets. Locally, 1-2mm tabular deep green chloritoid porphyroblasts occur in the cryptodome immediately adjacent to the veins, and suggest hydrothermal processes which included the chemical breakdown of feldspar combined with iron metasomatism to form chloritoid. Alteration in this outcrop is genetically associated with the formation of Algoma-type banded iron formation which occurs up-section on the northeastern margin of the cryptodome–dome complex.

Stop 13: No Name Lake Andesite and Interflow Sediments and Peperite

The No Name Lake Succession comprises basaltic to andesitic sheet flows, pillow lavas, pillow breccias, interflow sedimentary rocks, and locally, peperites. Only the uppermost section of this succession is exposed at this location (Fig. 21); the lower sections can be observed only in diamond drill core and appear to consist primarily of thick, amygdaloidal sheet flows and pillow lavas.

The first outcrop (behind the core racks) consists of thin (30-70cm thick) sheet flows with 5-25% oval-shaped carbonate-filled amygdules (2-30mm in diameter) that are generally aligned parallel to strike and the dominant east-west-trending rock foliation. In thin section, these rocks are composed of 20-30% fine laths of plagioclase and 15% quartz in a secondary groundmass composed of chlorite (40%), biotite (10%), and epidote (2%).

Pillow breccia, hyaloclastite, interflow sedimentary strata, and peperite are exposed in the outcrop immediately east of the water tower. These rocks consist of approximately 25% amygdaloidal pillow lapilli and blocks (5-50cm) in a matrix comprising hyaloclastite. The pillow breccia fragments contain 10-20%, 1-4cm diameter carbonate-filled amygdules (these are commonly weathered-out to form small pits on the outcrop surface). The hyaloclastite portion of the matrix consist of 0.5-2cm angular andesite lapilli within a blocky, fine- to coarse-ash-sized matrix composed of delicately preserved hyaloclastite with convex fragment edges. Interflow sedimentary strata are finely bedded, and are locally intruded by amoeboid to relatively straight, locally discontinuous amygdaloidal andesite dikes which are up to 50cm in width. Look for blocky peperite where the wet sediments interacted with magma along the edges of the dikes.

Pillowed andesite flows are exposed in the outcrop north of the water tower. This rock consists of well-formed 1-4m long amygdaloidal pillows with 25-30% 1-2mm carbonate-filled amygdules. The amygdules illustrate a bimodal size distribution; most amygdules are 1-4mm, with another distinct group being larger and up to 30mm in diameter. Massive pillow selvedges vary from 5-15cm thick. Such thick selvedges may indicate proximity to an eruptive vent (Kennish and Lutz, 1998; Hudak et al., 2002).

Stop 14: No Name Lake Andesite Pillow Lavas

At this, the final stop of our field trip (Fig. 21), we will observe "classic" pillow lavas associated with the No Name Lake Succession. At this location, the extremely well preserved, moderately- to highly amygdaloidal "bun-" and "mattress-"shaped pillows (nomenclature of Dimroth et al., 1978) illustrate exception concentric cooling cracks and locally, what may be multiple pillow selvedges. Stratigraphic topping directions for these pillow lavas are consistently to the north. The tannish-green color of these submarine lava flows is indicative of moderate intensity iron carbonate ± iron chlorite alteration that has been observed petrographically.

End of Day 2 of Sturgeon Lake Field Trip

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