A REPORT ON A FIELD VISIT MADE TO THE
EMPIRE Cu – Au – Ag – (Zn) PROJECT, IDAHO, USA
7th to 12th March 2019 FOR PHOENIX GLOBAL MINING (UK: PGM)

A View North of the Aerial Tramway Headhouse – Empire Mine, Idaho

FRONTISPIECE

By

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EXECUTIVE SUMMARY

At the request of the Phoenix Global Mining (UK – AIM's: PGM) Board, the writer reviewed some of the drill core at the Mackay Core Storage Facility, Mackay, Idaho, between the 7th and the 12th March 2019. Review of the surface outcrops was not possible due to heavy snow cover. This report summarises the key technical findings and their implications for exploration and evaluation of this potentially major Cu – Au – Ag – (Zn) – (Pb) – (Mo) – (W) ore system.

Following recent drilling campaigns, designed by PGM to bring the oxide copper – gold – silver ore resources into NI43 – 101 "Measured and Indicated" category of resources and to expand the "inferred" resource base, the latest Ore Resources calculated by Hard Rock Consulting LLC, of Colorado, USA, stand at 11.485 million tonnes at average grade of 0.52% Cu, 0.14% Zn, 0.007 oz/t (0.22 g/t Au) and 0.31 oz /t (9.64 g/t) Ag, with additional "Inferred" category resources of 9.88 million tonnes at 0.41% Cu, 0.13% Zn, 0.009 oz / t (0.24 g/t) Au and 0.29 oz / t (9.5 g/t) Ag, as of November 11th 2017. It seems likely, that a substantial proportion of the near surface oxide ore resource has now been defined by PGM. Nonetheless, further oxide ore resource potential persists to the north along the geologic strike of the Empire granite porphyry breccia (GPB) and associated mineralized skarn for perhaps 3km further than the current limits of the oxide ore resource. This area now needs to be explored and evaluated.

The bulk of the core reviewed by the writer was drilled within the Cu – Au – Ag – (Zn) oxide ore resource with few economic ore intercepts being within the protolith sulfide zone beneath the base of surface oxidation (BOSO). Indeed, very little of the surface drilling undertaken on the Empire Project has been drilled below BOSO and the writer has had to rely upon a few deeper RC percussion holes drilled by PGM and the underground mapping of ASARCO (1923 – 1932) and the USGS (1943 – 1944) to elucidate the geologic controls to the mineralization and the likely geometry of the ore shoots. Given the full strike extent of the Empire GPB – Skarn mineralized structure of some 5 km to as much as 8 km in total (KRI latest information), it may be deduced that substantially less than 5% of the sulfide ore potential of the system has been systematically explored and evaluated. In other words, only the surficial oxide potential has been seriously explored and evaluated leaving the bulk of this potentially major ore system largely untested.

Examination of the geology, core and drill hole assay data for the entire Empire Project is strongly suggestive of the following important observations and facts. During the main base and precious metal forming episodes, of which there appear to be three recognizable events, mineralization was controlled by the interplay between the mainly SE dipping NE striking shear structures, and the moderately (in the AP pit area) dipping, N to NNW striking, contact between the GPB and the AKL sequence. These features controlled the localized development, dip and structural pitch of, especially the high-grade copper – gold ore shoots, in trans-tensional dilation sites.

The larger, and more extensive medium grade copper – gold – silver mineralized bodies with grades above the apparently arbitrary application of a 0.4% Cu cut off grade (based on a review of the drilling assay data) are developed over widths of a minimum of 5m up to more than 20m with mean grades between 0.8% Cu – 3% Cu, 0.3 – 2 g/t Au and 10 – 100 g/t Au. These ore shoots are, in plan, ovoid to pipe like ore bodies extending over many tens of meters and up to at least 100 m of strike with their greatest development being down their structural plunge or pitch, which can be from a hundred to several hundred meters. In resource terms, these ore shoots constitute anything from tens of thousands of tonnes to several hundred thousand tonnes, and maybe, at their largest dimensions, up to one million tonnes depending upon the economic cut off grades ultimately applied.

In the context of the overall Empire Ore System (EOS), which has been established over some 3.5 km (with recent geological work extending this to 5km) of geologic strike towards the NNW, the overall underground ore resource potential may be measured in tens of millions of tonnes at the grades as indicated from core intersections made to date; albeit, at this juncture, mainly in the oxide zone. Of this potential sulfide resource, PGM and its predecessors have tested well under 5% of the prospective strike and downdip geologic scope of the ore system.

The foregoing features of the copper + gold and silver ore bodies clearly indicate that the oxide open should be amenable to within pit selective mining above well-defined cut of grades as the grade fall off below 0.4% is quite marked. Indeed, two clear grade changes occur at around 0.4% Cu and 1% Cu which must be related to definable geologic features of the mineralization such as structural and lithologic / alteration / skarn facies controls.

If selective mining can be implemented, during open pit mining, it will reduce the tonnage of ore to be processed in the plant and increase the overall head grades for Cu, Au and Ag; with Zn being a minor contributor. These benefits will reduce CAPEX cost for the plant and overall operating costs adding to the projects IRR and NPV and, moreover, reduce the CAPEX payback period.

Another feature of the base and precious metal mineralization discussed in this report is the clear development of three ore shoot types as follows: 1) combined copper – gold and silver; 2) gold dominated, and 3) silver dominated. These ore types are developed over mineable widths of from 4 to 20 meters at grades of from 1.5 g/t to 98 g/t Au and 250 to 400 g/t Ag. However, it should be noted that both the highest-grade gold and silver dominated intercepts occur within 100m of the surface; i.e., well within the strongly weathered ore. Hence, the possible impact of supergene enrichment cannot be ruled out, and all such gold and silver dominated intercepts need to be carefully examined for the occurrence of fine-grained particles of native gold and silver, especially within limonite – goethite Fe oxyhydroxides. Furthermore, if gold and silver dominated economic mineralization is a feature of the protolith sulfide mineralization, then these mineralized bodies will almost certainly have been completely missed by the historic miners who were wholly focused on mining copper ore above a visual 2% Cu cut-off grade. If such a range of ore types persists below the BOSO, then some serious questions need to be addressed concerning their mineral paragenesis, metallurgy and economic potential. Clearly, the overall gold content of such intercepts could have important economic benefits and add to the projects already significant potential.

Finally, there remains the nature of the overall ore system at the Empire Mine which puts the overall economic potential into a geologic framework which makes sense of all the features of the mineralization and explains its geometry, mineral zonation, and scale / scope of possibilities / probabilities. The key to understanding the Empire Ore System (EOS) does not lie within the endo and exoskarn ore bodies but in the geochemistry, petrology and textures exhibited by the GPB intrusive, which is, without all doubt, the source of the mineralizing hydrothermal system. This 500 m to 600m wide complex felsic igneous porphyry / breccia body extends over at least 5 km N – S. It is in fact a dike like porphyry stock. Within the drilled oxide ore resource area, the GPB provides vital clues as the its parenthood of its associated hydrothermal system, such as:

a) Its unusually high fluorine content indicating its derivation from a highly fractionated alkali granitoid system at depth;

b) Its own texture being that of a crowded porphyry, matrix supported, igneous breccia containing abundant rounded / partially assimilated clasts of granophyre and aplite, with the former containing abundant miarolitic cavities bearing ubiquitous purple fluorite up to 50 vol% in the cavities;

c) The presence, throughout the GPB, of a host of diagnostic and unusual igneous textures such as: 1) ovoid grey quartz porphyroblasts all exhibiting very unusual vermicular texture due to the high activity of fluorine in the melt; 2) strong development of Unidirectional Solidification Textures (UST's) otherwise knowns as "brain rock"; 3) miarolitic cavities containing andradite – quartz and calcite; and 4) grey aphanitic silicification and K feldspar alteration of the GPB groundmass and development of stockwork quartz veining;

d) The presence of vein / veinlet hosted molybdenite deeper with the Empire Ore System (EOS) and of localized high grade scheelite mineralization on the 1000 level of the historic mine plus elevated tungsten geochemistry at deeper levels in the EOS; and,

e) Late intrusion of a quartz latite dike swarm along the 2nd order NE structures;

The foregoing collectively comprises the geologic / geochemical signature, and upper expression, of a porphyry Mo – W system or secondly, and considered less likely, a porphyry Cu – Mo system at depth. Furthermore, given the extensive strike of the GPB / Empire skarn Cu – Au – Ag – (Zn) – (Pb) – (Mo) and (W) ore system, it seems likely that such a porphyry is in detail a typical cluster system such as that exhibited at such major systems as Chuiqucamata, Chile (17 km with 7 deposits); El Teniente (12 km with 5 deposits), Chile; Oyu Tolgoi, Mongolia (18km with 5 deposits); and Grasberg – Ertzberg, Irian Jaya (10 km with 8 deposits).

The textures, geochemistry of the GPB are very similar to that documented for the Questa porphyry Mo deposit in New Mexico, USA, and the Henderson – Urad porphyry Mo – W system in Colorado, USA. Given the geology documented at Questa and Henderson, the textures and geochemistry of the GPB indicate that the Porphyry Mo – W system may lie at a depth below surface of between 400m to 600m.

In conclusion, the Empire Project Ore System is, in economic terms, multi-faceted, and appears, from all the evidence cited above, to comprise a major porphyry Mo – W & endoskarn system with significant geological and geochemical differences to the World Class 1 category porphyry copper related Antamina polymetallic skarn deposit in Ancash Province, Chile.

The first objective for PGM is complete the Bankable Feasibility Study (BFS) on the Empire Oxide Project and advance this through Decision to Mine, plant construction and project commissioning by 2021. Thereafter, the full scope of the much larger and higher-grade sulfide ore system needs to be fully explored, evaluated and developed. This may be most cost effectively achieved through rehabilitation of the historic underground workings providing wider access to the underground resources and most cost-effective drilling sites.

Finally, there remains the deeper tungsten and molybdenum ore potential, at some depth below the 1600 level. It is expected that tungsten (as scheelite in the skarn) and molybdenum grades will increase with depth. It is also expected that multiple intrusive bodies will be encountered at depth, as for the Mount Emmons, Rico, Questa, Henderson and Climax molybdenum – tungsten deposits of the Colorado Mineral Belt, USA. These are world class systems, with three of them now virtually mined out. Given the strike extent of the Empire system, of at least 5km, and the usual dimensions of porphyry Mo – W systems of less than 1.5 km across, the Empire system would almost certainly comprise a structurally controlled N - S striking cluster porphyry system.

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IMPORTANT ADVICE

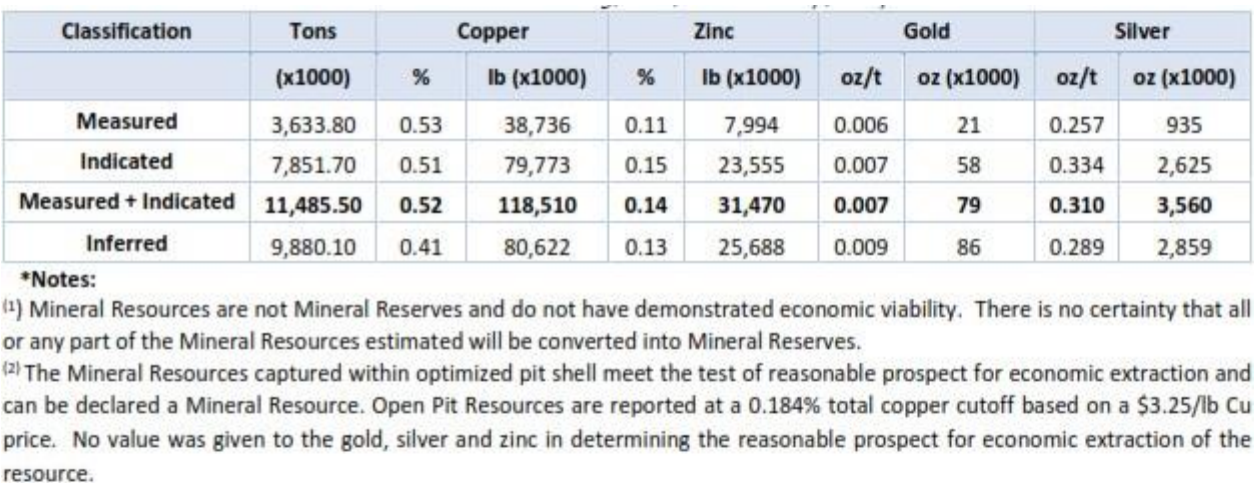
Please note than the writer, Nigel Maund, is a shareholder in Phoenix Global Mining Ltd

1.0 Introduction

The writer was asked to visit and review the drill core at the Mackay Core Storage Facility, Mackay, Idaho, between the 7th to 12th March 2019, by the Board of Phoenix Global Mining Ltd (UK – AIM's stock ticker PGM). Throughout his review of the core the writer was afforded the valuable assistance of PGM's 100% North American Subsidiary, KONNEX Resources Inc's (KRI) CEO Mr. Ryan McDermott and Chief Geologist, Mr. Nathan Bishop, and their exploration staff. It was not possible at this time of year to visit surface outcrops due to extensive snow cover. This report described the key findings from the writer's visit with their economic implications. The summary of his findings is described in the Executive Summary with interim conclusions and recommendations at the end of the report.

All previous reports to PGM, by the writer, written during 2014 and 2015 were based upon desktop review of the extensive PGM data base on this project. Since its successful IPO on the London AIM's market 29th June 2017, PGM has substantially expanded its land holding in Idaho around the original KRI mineral claims covering the historic Empire copper mine near Mackay, and, moreover, in 2017 had undertaken the drilling of 28 additional Reverse Circulation Percussion (RC) and core drilling focused on the open pit oxide copper resource thus advancing its ore resource statement on the proposed open pit copper oxide project with the latest updated Statement being released on November 11th 2017 by Hard Rock Consulting LLC of Lakewood, Colorado, USA. Summary ore resources are given on Table 1 below:

Table 1: A summary of the Ore Resources for the Empire Project estimated by Hard Rock Consulting LLC as at November 11th, 2017.



Classification	Tons	Copper		Zinc		Gold		Silver	
	(x1000)	%	lb (x1000)	%	lb (x1000)	oz/t	oz (x1000)	oz/t	oz (x1000)
Measured	3,633.80	0.53	38,736	0.11	7,994	0.006	21	0.257	935
Indicated	7,851.70	0.51	79,773	0.15	23,555	0.007	58	0.334	2,625
Measured + Indicated	**11,485.50**	**0.52**	**118,510**	**0.14**	**31,470**	**0.007**	**79**	**0.310**	**3,560**
Inferred	9,880.10	0.41	80,622	0.13	25,688	0.009	86	0.289	2,859

***Notes:**

(1) Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. There is no certainty that all or any part of the Mineral Resources estimated will be converted into Mineral Reserves.

(2) The Mineral Resources captured within optimized pit shell meet the test of reasonable prospect for economic extraction and can be declared a Mineral Resource. Open Pit Resources are reported at a 0.184% total copper cutoff based on a $3.25/lb Cu price. No value was given to the gold, silver and zinc in determining the reasonable prospect for economic extraction of the resource.

Since this release a further 8,600 meters of drilling in 93 holes again focused largely on the copper oxide target enabling the current preparation of a Bankable Feasibility Study (BFS). During the 2017 and 2018 Konnex drilling campaigns, a number of higher-grade sulphide intercepts were made and will hopefully provide a basis for future sulphide targeting.

2.0 Project Location and Access

The Empire Mine is located The Empire Mine is located in the Alder Creek mining division in Custer County, Central Idaho, approximately 5.5 km southwest of the town of Mackay (Figures 1, 2) at approximately 43° 55' North Latitude and 113° 39' West Longitude. Mackay is on Highway I-93 approximately 140 km west of Idaho Falls. The property package includes portions of Sections 1 and 2 in Township 6 North, Range 23 East; Sec 6, T6N, R24E; Sec35 and 36, T7N, R23E; and Sec31, T7N, R24E, Boise Meridian; Van Angeren 2014.

Figure 1: A summary map of Idaho showing the road infrastructure (access), cities and towns and the location of the town of Mackay and the Empire Mine Project

The property consists of one contiguous block of claims comprised of: Honolulu Copper group and Mackay group, consisting of 23 patented (private) claims, 215 unpatented claims and six unpatented mill site claims covering a contiguous 301 hectares (743.7 acres, Figure 2 below).

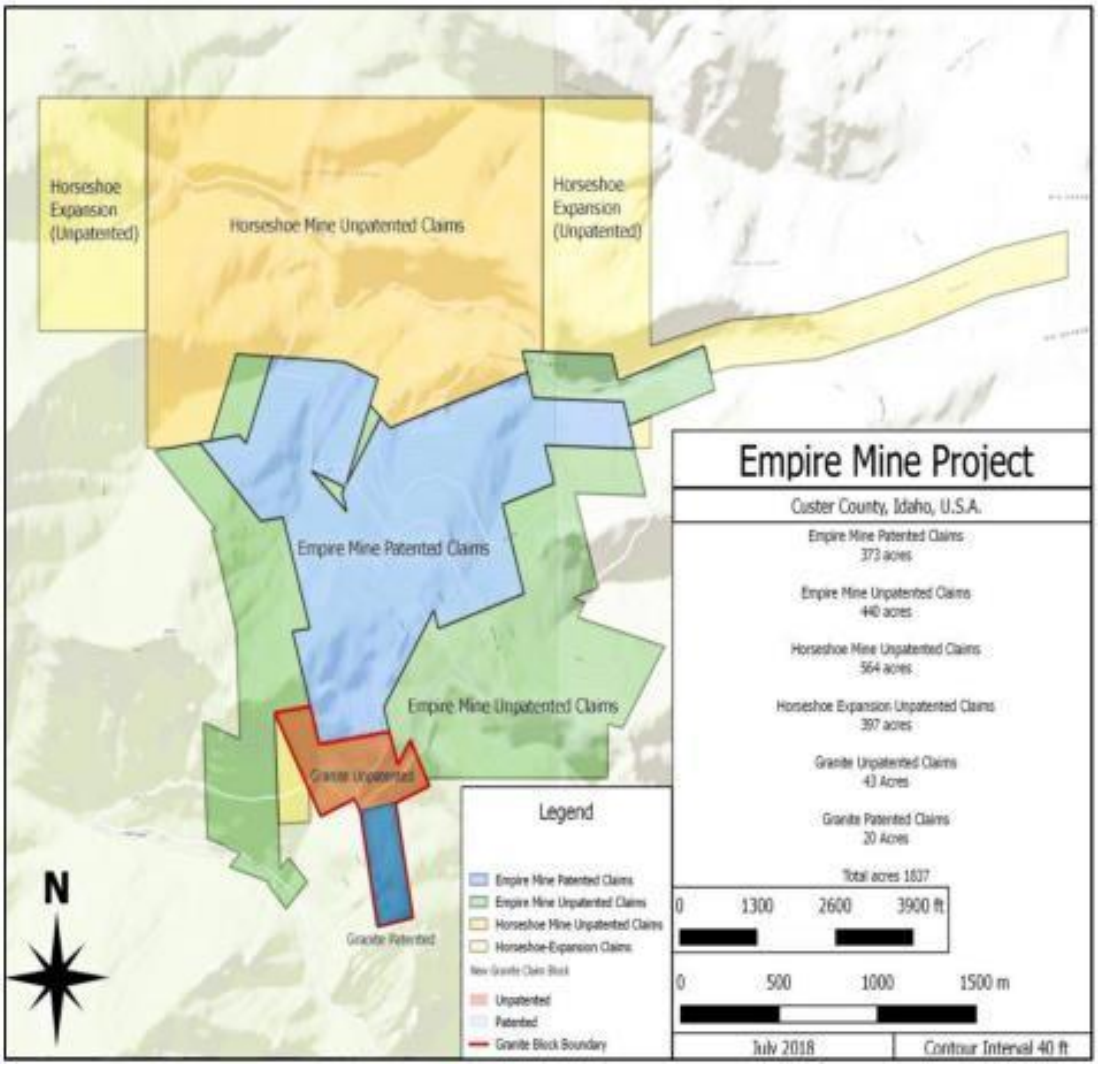


Figure 2: A summary map of the KRI claims centered on the historic Empire Copper Mine.

By February 2019, KRI had a total of 194 unpatented mineral claims covering some 3,880 acres at the Empire Copper Mine Project bringing its total mineral claim holdings in the district to 5,717 acres (Figure 3, below).

The Empire Mine property is accessible from Mackay, Idaho, via a well-maintained, 5.5 km long (3.3 miles), all-weather gravel road. Access to various portions of the claims, including old workings and drill pads, is provided by four-wheel-drive trails.

The region has a semi-arid climate and is typical of central Idaho, i.e., long, snowy winters, and short, cool, dry summers. Vegetation in the project area is sparsely distributed up to 2,000 meters, although timber is abundant on northerly slopes within the mountain range.

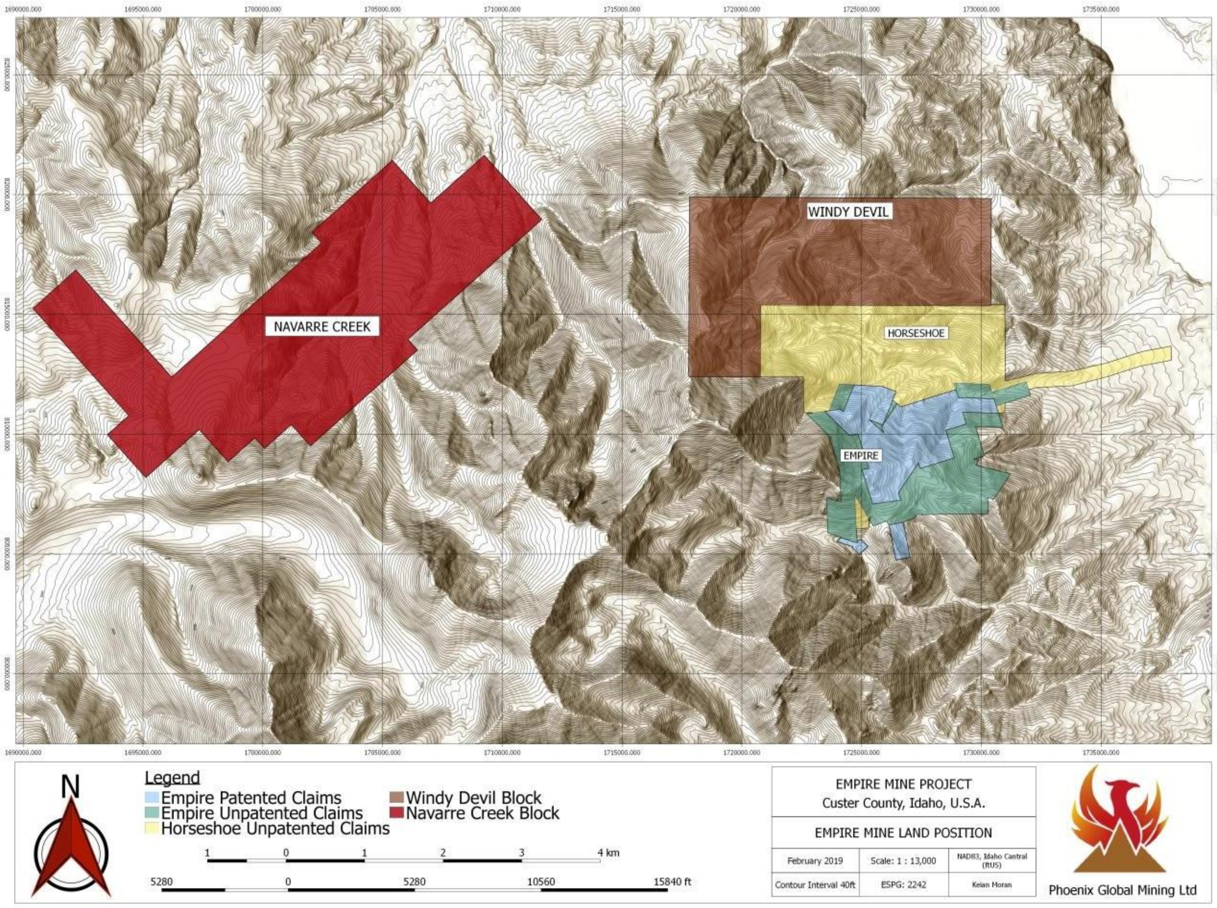


Figure 3: An overview summary map of all the KRI mineral claims in the vicinity of the Empire Copper Mine Project overlain on the topographic map of Custer County.

Mackay, with a population of approximately 550, is located 5.5 km to the northeast at an altitude of 5,900 feet (1,793m). Custer County as a whole has a population of 3,385. Mackay provides housing, services and basic amenities to support the employees of mines in the area. There is sufficient skilled and unskilled labor in and around the towns of Mackay and Challis (80 km to the northwest) to supply the employment needs for the future. Supplies may also be obtained from Idaho Falls which is serviced by regional airport, rail and major highways.

The project is located in the White Knob mountain range, at elevations of 2,050 to 2,750 meters above sea level. Local peaks reach 3,450m in elevation, whereas Mackay is at 1,800m altitude.

3.0 The Mining & Exploration History of the Empire Copper Mine

3.1 Mining History

The property of the Empire Copper Company, the largest producer of copper in the state of Idaho, is located on a steep mountain side 3.5 miles (5.6 km) southwest of the city of Mackay in Custer County. At the height of its production it consisted of 38 mining claims, a smelter capable of handling over 500 tons of ore daily, and a 7.75-mile (12.4 km) Shay railroad connecting the mines and smelter.

The mine, which was opened about 1884 and worked at various times, was originally organized under the laws of West Virginia as White Knob Mining Co. It was reorganized as White Knob Copper Company on April 24, 1900, under the laws of New Jersey by San Francisco millionaire John W. Mackay and engineer Wayne Darlington, who became president and general manager of the company respectively. They were responsible for a great deal of development work, the construction of a large smelter, and an electric railroad. In 1901 E.J. Mathews succeeded Mackay as president, and in 1902 Henry J. Luce succeeded him. Wayne Darlington and his staff resigned in the spring of 1902 after a dispute with Luce and Darlington was replaced by S.F. Boyd, who in turn was replaced by Percy L. Fearn.

In October 1904, after seven different managers had tried unsuccessfully to operate the property at a profit, the company was placed in the hands of a receiver. It was purchased by George W. Young of New York on March 18, 1905, for $1 million. He immediately transferred the property to a New York consortium which, in February 1905, had organized the White Knob Copper and Development Company.

A three-mile aerial tramway to replace the 7.5-mile Shay railroad was constructed in 1917 and 1918 at a cost of $125,000. Labor problems caused a reduction in ore output, and by 1919 the mine was operating exclusively on the leasing system.

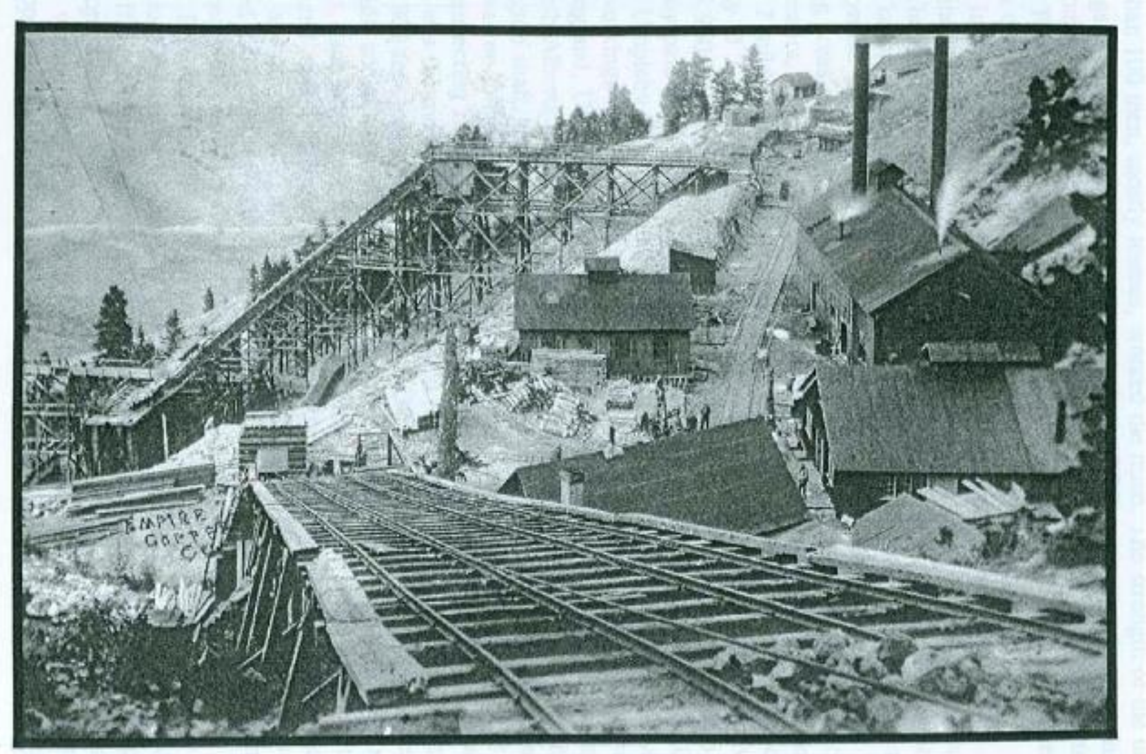


Plate 1: A view of the Empire Copper Mine Tramway & Engine House vicinity Alberta tunnel

Eccles and his Utah associates reincorporated the company under Idaho laws on October 8, 1921, renaming it Idaho Metals Company. The mine was operated exclusively by leasers until 1927. This system did not permit the necessary development of the Cossack Tunnel and in early 1928 the company was again placed in the hands of a receiver.

The holdings of the Idaho Metals Company passed out of the hands of the receivers in late May 1928 when the property was purchased by A.J. Anderson and W.E. Narkaus of Victoria, B.C., who immediately sold it to the newly formed Mackay Metals, Chase A. Clark, president. The mine and mill plants were entirely rebuilt, the mine rehabilitated, and an active development campaign started which resulted in the discovery of a large tonnage of new ore in the Cossack tunnel. Lack of money again plagued this new organization and the company suspended operations in August of 1930. Although the leasers continued to work, they stored all their ore. In 1931 the property was sold to the county for taxes.

In the early days of the Empire mine high-grade oxidized ores were mined from open cuts and treated locally in a small smelter. From 1899 to 1907 the mine passed through a period of over-capitalization and mismanagement. The Empire Copper Company acquired the property in 1907 and operated almost continuously until 1921, shipping crude ores- to Salt Lake smelters. The company paid handsome dividends but apparently toward the end of this period too little attention was directed to underground development and the maintenance of reserves. In October 1921, the Idaho Copper Company succeeded the Empire Copper Company and installed the present mill and tramway. Milling began in 1924, only the low-grade sulphide ores averaging about 2.8 percent copper being treated, and both concentrate’s and crude ores were shipped to Salt Lake smelters until operations ceased in 1930. From 1928 until August 1930, the mine was worked by Mackay Metals, Inc. which went into voluntary receivership in 1931, at which time the patented claims were taken over by Custer County. A small amount of crude ore was produced by lessees in 1935-1937. The Mackay Exploration Company, present operators of the mine, took over the property in 1939 under lease and bond agreements with Custer County and with Mackay Metals, Inc.

The workings of the Empire mine are distributed along a north-trending, arcuate zone for a distance of about 3,500 feet (1,064m) and over a maximum width of 400 feet (121.6m).

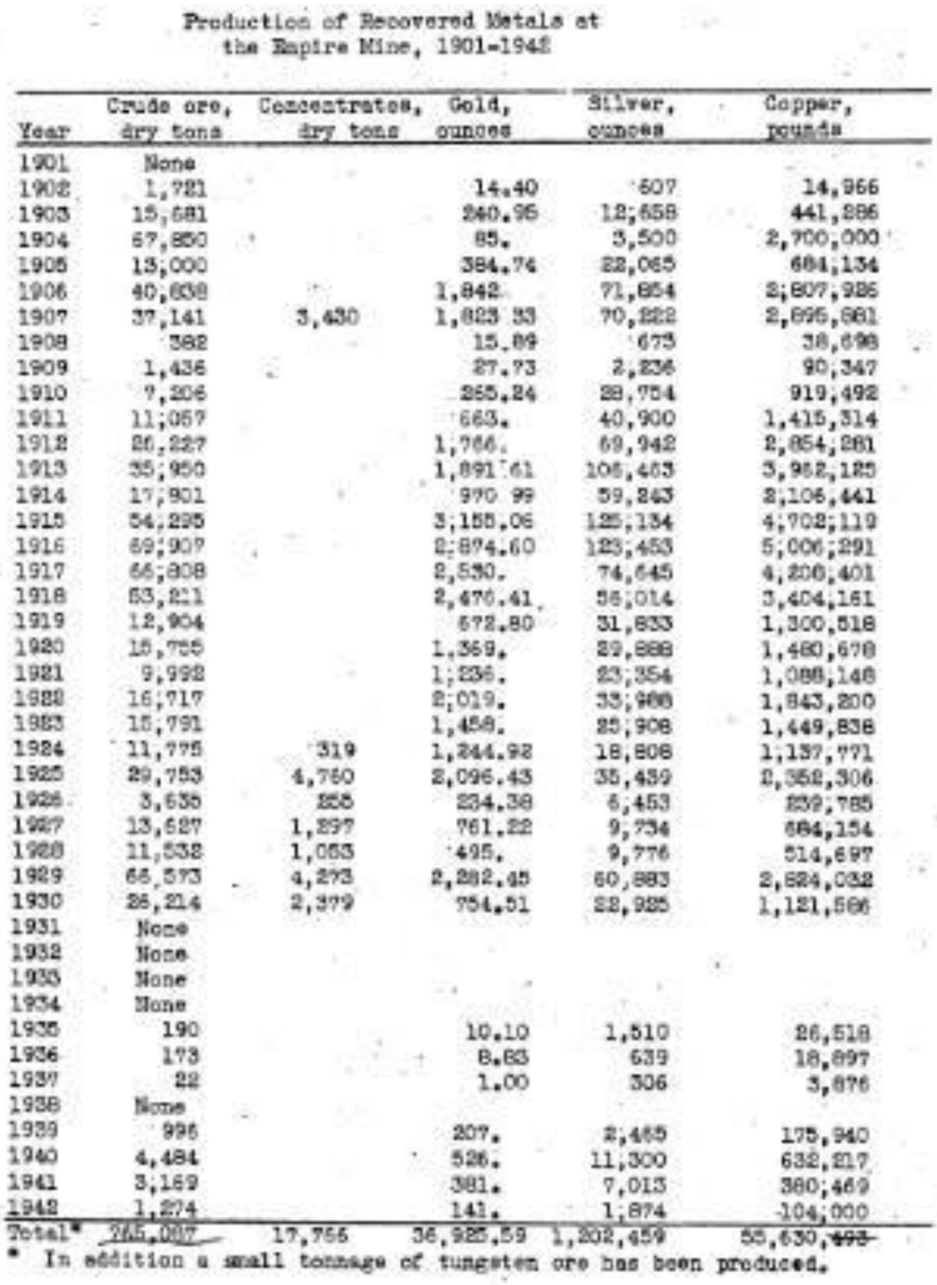
The large ore bodies near the southern end of the property were mined by surface methods in the early 1900’s as a “Glory Hole”. Because of the favorable local topography, underground development of the Empire deposits has been carried out chiefly from adits. The Clark and Darlington shafts at the south end of the property are the largest of several early shafts. The total length of all horizontal workings is well over 60,000 feet (18.24 km), of which some 35,000 feet (10.64 km) were accessible when mapped by the Geological Survey.

In 1944, six of the nine major levels are over considerable distances. The main portal of the mine is at the 700 level, the longest level, which serves as a tie between the older parts of the mine to the south, and the more recent, deeper development to the north. About sixty-five percent of the total mine output up to 1944 came from stopes above the 700 level. An interior vertical shaft extends 330 feet (100m) below the 700 level to connect with the 800, 900, and 1000 levels. The Cossack Tunnel, or 1600 level, lies 600 feet (182 m) beneath the 1000 level but has no connection with the upper workings; Farwell and Full, 1944.

Because of the irregular distribution and nature of the ore bodies, ore has been mined, almost as soon as it has been developed. The ground is generally hard and firm, requiring relatively little timbering except in some of the oxide stopes. Shrinkage stoping has been widely used although there are a few square-set stopes. The stopes range in size from enlarged raises to those with floor plans of about 8,000 square feet; Farwell & Full, 1944.

The Empire Mine produced 765,000 tons grading 3.64% copper, 0.048 oz/t (1.49 g/t) gold and 1.57 oz/t (48.83 g/t) Ag from 1901 to 1944. Mineralization was encountered over a strike length of 1,200 meters with a thickness of between 6 m to 73 m with persistence to a depth of more than 300 m.

Although the company remained in receivership until 1939, some leasers worked on the property. In 1937 G.M. Tomle of San Francisco held an option on the property with the Custer County Commissioners, but lack of funds prevented him from doing any work.



Production of Recovered Metals at
the Empire Mine, 1901-1942

Year	Crude ore, dry tons	Concentrates, dry tons	Gold, ounces	Silver, ounces	Copper, pounds
1901	None				
1902	1,721		14.40	607	14,966
1903	15,681		240.95	12,658	441,286
1904	67,850		85.	3,500	2,700,000
1905	13,000		384.74	22,065	684,134
1906	40,638		1,842	71,854	2,807,926
1907	37,141	3,430	1,823.33	70,222	2,895,881
1908	382		15.89	675	38,698
1909	1,436		27.73	2,236	90,347
1910	7,206		265.24	28,754	919,492
1911	11,057		663.	40,900	1,415,314
1912	26,227		1,766.	69,942	2,854,281
1913	35,950		1,891.61	106,463	3,962,125
1914	17,901		970.99	59,243	2,106,441
1915	54,295		3,155.06	125,134	4,702,119
1916	69,907		2,874.60	123,453	5,006,291
1917	66,808		2,530.	74,645	4,206,401
1918	63,211		2,476.41	56,014	3,404,161
1919	12,904		672.80	31,833	1,300,518
1920	15,755		1,369.	29,888	1,480,678
1921	9,992		1,236.	23,354	1,088,148
1922	16,717		2,019.	33,988	1,843,200
1923	15,791		1,458.	25,908	1,449,838
1924	11,775	319	1,244.92	18,808	1,137,771
1925	29,753	4,760	2,096.43	35,439	2,352,306
1926	3,635	258	234.38	6,453	239,785
1927	13,527	1,297	761.22	9,734	684,154
1928	11,532	1,053	495.	9,776	514,697
1929	66,573	4,273	2,282.45	60,883	2,624,032
1930	26,214	2,379	754.51	22,925	1,121,586
1931	None				
1932	None				
1933	None				
1934	None				
1935	190		10.10	1,510	26,518
1936	173		8.83	639	18,897
1937	22		1.00	306	3,876
1938	None				
1939	996		207.	2,465	175,940
1940	4,484		526.	11,300	632,217
1941	3,169		381.	7,013	380,469
1942	1,274		141.	1,874	104,000
Total*	765,007	17,766	36,925.59	1,202,459	55,630,~~498~~

* In addition a small tonnage of tungsten ore has been produced.

Table 2: The annual copper, gold and silver production from the Empire Mine between 1901 and 1942; Farwell & Full, US Dept of the Interior – Geological Survey Report 1944. Metal production is shown in US tons at 2,000 lbs. versus 2,204 lbs. to 1 metric tonne.

Plate 2: The entrance to the Cossack tunnel (Adit, 1,600-level), Empire Mine

3.2 1943 to 1944 USGS Mine Evaluation and Modern (1990's to Present) Exploration History

With the virtual collapse of copper mining operations following 1938, due to lack of funding and underground development / exploration, the USGS (then known as the US Department of the Interior – Geological Survey) was commissioned to undertake detailed geologic mapping and sampling (400 mine and dump samples) of the underground mine workings accompanied by selected core drilling from the underground mine levels comprising 21 diamond drill holes for a total 3,863 feet of drilling (1,174m).

The majority of the underground mine geologic mapping was undertaken by geologists of the International Smelting and Refining Company from 1923 to 1926 and latterly, in April 1942, geologic maps by geologists of the American Smelting and Refining Company (ASARCO) during January 1942 were made available. The present authors have drawn on these earlier maps for the geology of mine levels which are no longer accessible; F.W Farwell & R.P Full; USGS Open File Report, October 1944.

Sulphide ore resources, as of 1943, were small at 23,370 tonnes at an average copper grade of 2.67% Cu with unknown gold and silver grades. The successive mine operators had never undertaken systematic geologic work accompanied by sampling and operated the mine on a visual cut – off copper grade of 2%. Hence, prior to the ASARCO and latterly the USGS work the geology of the ore system had never been understood. To this day, the old underground mapping and sampling work remains the only detailed geologic mapping available of the Empire underground workings.

In their 1944 published report, Farwell and Full stated that their geologic studies *"indicate the possibilities of finding additional ore bodies at the Empire mine are very good, Thorough exploration of. known "tactite" (read skarn) bodies and search for new "tactite" masses are suggested. Specific recommendations for exploration are made and indicated on the level maps accompanying the report. It is recommended also that other mineralized areas around the granite stock be prospected and search made for possible undiscovered deposits".*

Post closure of the Empire Mine (officially 1944), the first modern surface exploration of the Empire Mine was undertaken between 1964 and 1972 when several companies drilled 141 mineral exploration holes in the AP Pit area.

The 141 surface holes were collectively drilled by the following companies: Cleveland Cliffs Iron Co. (CCDH 2 - 9; 8 holes, 1962); New Idria Mines (NI 1-20, 1967); Hile Exploration Co. (H 1-58, 1969); Capital Wire & Cable Co. (CW 114, 1970); and US Silver and Mining Corp (Behre Bolbear: BDH 1-41,1972). All holes were assayed for copper, and only nine were assayed for gold (NI series). During 1972 a flotation plant was constructed, and the ore developed by the USBM was exploited at the 1100 level. In 1975, Exxon Company explored for copper and molybdenum. Exxon drilled ten holes that were also assayed for gold. By 1975, a total of 173 holes had been drilled on the property; 134 of them in the AP pit.

Between 1995 to 1997, CAMBIOR Exploration USA Inc (CEI), a Canadian based international gold producer (TSX: CBJ) with operations in the America's (source Wikipedia), explored the property. Cambior was acquired by IAM Gold in 2006. Following intensively exploration and evaluation work around the old underground higher grade mine workings during 1997, CEI defined a drill-indicated, near-surface, oxide copper resource of 18.23 million short tons or 16.5 million metric tonnes grading 0.49 per cent Cu, 0.19 per cent Zn, 0.44 ounce per ton Ag (13.5 g/t) and 0.015 ounce per ton Au (0.48 g/t), beneath the old Atlantic – Pacific (AP) open pit, with an additional 9.65 million tons of material grading 0.29 per cent Cu and 0.31 per cent Zn. This resource is open ended at its northern, north-eastern and southern extensions.

Following CAMBIOR's work several, generally modestly funded, Canadian TSX – V junior companies undertook further modest drilling campaigns focused on the CEI defined oxide copper resource at the present historic "Atlantic – Pacific" (AP) shallow Open Pit. These campaigns were of short duration and largely directed towards earlier higher-grade copper – gold – silver zones with the objective of "ramping" up the stock price thus in the process also effectively reducing the "cost of capital" and enabling further capital raising. The Canadian junior companies involved during this period were as follows:

- In 2004, Trio Gold Corp. completed a ten-hole drill program in the AP Pit, together with a 2,100kg bulk sample for metallurgical testing in 2005.

- In 2006, Journey Resources Corp. completed 33 drill holes in the AP Pit area as part of a 65 hole "in-fill" drilling program proposed in 2005.

- In 2011, Musgrove Minerals Corp. completed 24 RC drill holes in the northern half of the deposit, as continuation of the 65-hole program proposed in 2005. This brings the total number of drill holes on the property to 287, of which 258 have useable data, and 196 are in the AP pit.

- In 2013, Boxxer Gold Corp. initiated follow-up work on Trio's 2005 metallurgical testing by extracting four small bulk samples from four test pits in the AP Pit.

However, detailed prospect scale (1:600) geology with attendant systematic rock chip and channel sampling was not undertaken. Furthermore, detailed structural geologic analysis was not undertaken.

4.0 Geology of the Empire Mine Project Area

The Empire Mine is within the Alder Creek mining district. Regionally, geologic events include the late Palaeozoic Antler orogeny, Mesozoic Cordilleran orogeny, Paleogene extension tectonism, and Neogene Basin and Range extension and the development of the Snake River Plain (Rodgers et al., 1995).

The Alder Creek mining district is to the east of the Idaho batholith and north of the Snake River Plain. It is within the Cordilleran thrust belt, and at the edge of the Basin and Range structural province. The thrust faults were emplaced from west to east during the Mesozoic Era. In this region, the Copper Basin thrust on the southwest and the Lost River thrust on the northeast define the White Knob Thrust Plate. The thrust faults probably formed in the Cretaceous Period. Within the White Knob Thrust Plate, two northeast-striking Eocene faults further define the White Knob horst on the northwest and southeast, respectively (Skipp and Harding, 1985). The Alder Creek mining district is located in the White Knob horst.

The sedimentary rocks exposed on the surface of the White Knob horst are mostly Mississippian. The oldest sedimentary rock is the Lower Mississippian Copper Basin Formation. It is an argillite sequence more than 4,000 feet thick composed of distal thin bedded turbidite and interlayered mudstone, siltstone, and limestone deposited as flysch in a foreland basin (Nilsen, 1977; Skipp and others, 1979, Wilson et al., 1995, and references therein). The color is usually medium grey to very dark grey on fresh surfaces. Much of the dark color of these rocks is due to disseminated carbon; and the brown color is caused by weathering and the introduction of Fe oxides (Nelson and Ross, 1968).

The Upper Mississippian White Knob Limestone (called Brazer before Ross, 1962) conformably overlies the Copper Basin Formation. This formation is 5,500 feet thick, composed of blue grey to black, thick bedded, locally dolomitic but mostly pure limestone. Abundant chert nodules and lenses occur in some beds. The upper 3000 feet contains conglomerate, sandstone, and mudstone interbeds.

Skarn deposits in this area are mostly formed within the White Knob Limestone. Locally, Tertiary Challis volcanic rocks are present. On the NW and SE sides the horst is bounded by Eocene Challis volcanic rocks. Along the NE bounding faults, jasperoid is present.

The Mackay stock was emplaced into the Mississippian sedimentary rocks. The exposed Mackay stock trends roughly northeast. Underneath the cover rocks, the stock extends to the southwest as revealed by regional aeromagnetic data (Worl and Johnson, 1989). In the horst there are also numerous NE-striking dikes that occur mainly in the stock but are also present in the sedimentary rocks.

Eocene Challis Volcanic Group rocks are rare in the horst and occur mostly as thin remnants of flows, indurated and welded tuff, and tuff breccia (Nelson and Ross, 1968). These rocks range from andesite to rhyolite but are dominantly of latite composition. The colors range from brown, reddish brown, greenish grey and grey to locally light tan, with brown and reddish- brown colors most common. Geologic evidence indicates that the extrusive and intrusive rocks in the area are about the same age (51-44 Ma, Moye et al., 1988) and composition, and may be genetically related (Nelson and Ross, 1968).

The Mississippian rocks are folded. Generally, the anticlines and synclines trend north-northwest, though locally the folds may vary. The limbs have moderate to steep dips to the northeast and southwest. The strikes and dips vary locally because of intense folding (Wilson et al., 1995, and references therein). The uplift of the horst and the pluton emplacement were thought to be synchronous (Nelson and Ross, 1968; Skipp and Harding, 1985), but recently it has been proposed that the uplift may be earlier than the intrusion (Wilson et al., 1995, and references therein).

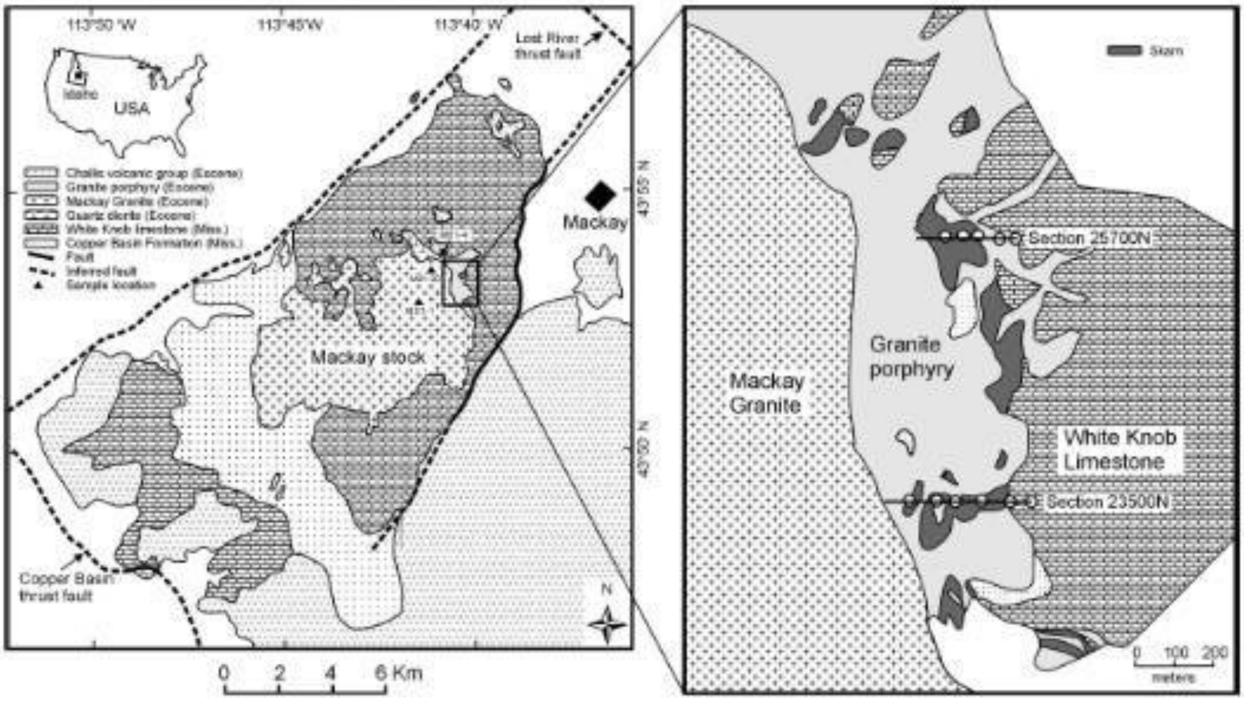


Figure 4: Summary Geology of the Mackay Granitic Complex with a zoom in to the Empire Mine Project Area. Geologic mapping based on Cambior's Geologic Map dated 1997.

Besides the dominant northeast-striking extensional structures including the horst, faults, intrusions and dike swarms, there are also northwest-striking Neogene structures related to Basin and Range extension. Numerous such faults are found in the Challis Volcanic Group on the NW and SE sides of the horst. Recently, a major fault was found to cut across the horst. The intersections of the northeast faults and the northwest faults are thought to be good locations for mineralization; the relationship between these structures is addressed later in this report.

Cu-Au-Ag-Zn deposits, mostly of skarn type, occur on the north-eastern border of the Mackay stock. Recent exploration also has focused on jasperoid-associated precious-metal deposits, gold skarns, and hot-spring type, volcanic-hosted gold deposits, especially where the NE and the NW faults intersect (Wilson et al., 1995).

The intrusive rocks in this area are mostly part of the composite Mackay stock with which the Empire Mine is spatially associated (Fig. 2-1). The outcrop of the stock is about 30 square kilometers in area and strikes roughly northeast, though it has many irregular contacts and apophysis into the surrounding sedimentary rocks. Regional aeromagnetic data indicate that the stock extends southwest of the exposed outcrop (Worl and others, 1989). Numerous wall rock xenoliths and roof pendants are present in the stock, especially near the border.

The intrusive rocks include, in time sequence, quartz monzodiorite, granophyre, granite porphyry, Mackay Granite (a porphyritic rapakivi granite with fine-grained groundmass), and numerous veins/dikes of latite porphyry, granodiorite porphyry, and quartz porphyry. Quartz monzodiorite is exposed in 3 small areas at the northern end of the stock and in some of the workings of the Empire Mine.

Granophyre is only found in drill core. It is not reported in previous studies (Umpleby, 1914, 1917; Farwell and Full, 1944; Nelson and Ross, 1968; Doyle, 1989, 1990; Wilson et al., 1995, Staff of Cambior, 1997). Granite porphyry is present only at the north-eastern corner of the Mackay stock. Mackay Granite is the major phase of the Mackay stock.

In the field, quartz monzodiorite can be distinguished from other rock types by its dark color and equigranular texture. The granophyre is recognized by a graphic texture that is barely visible to the eye but is recognizable with a hand lens. Granophyre contains few (less than 5%) or no phenocrysts. The granite porphyry is recognized by its porphyritic texture and very fine-grained groundmass. Individual grains in the groundmass are not visible with hand lens.

The Mackay Granite also is porphyritic, but the groundmass is coarser grained than the granite porphyry. With hand lens, individual grains are discernible. The Mackay Granite is distinguished from the granophyre by a higher phenocryst content (50-70%). Geologic evidence indicates that all phases formed in a short period, nearly at the same time as the Eocene Challis Volcanic Group

The petrology of the key igneous rocks types has been described as follows:

Quartz Monzodiorite

Quartz monzodiorite is exposed in 3 small areas at the northern end of the stock and in some of the workings of the Empire Mine. Typically, the color ranges from light grey to medium grey. A typical sample 17% quartz, 15% K-feldspar, 56% plagioclase, 6% clinopyroxene, 1% orthopyroxene, and minor amphibole and biotite. The plagioclase forms the framework of the rock, whereas quartz and K-feldspar fill the intersticies. The plagioclase is mainly andesine (An_{26}-An_{48}). Most plagioclase grains have oscillatory zonation. Generally, the core has a higher Ca concentration than the margin.

Pyroxene is euhedral to sub-euhedral and ranges from augite to clinoenstatite. The amphiboles are magnesio-hornblende or magnesio-hastingsite. The fluorine content of amphibole and biotite in quartz monzodiorite is 0.22 - 0.89% and 0.60 - 0.82%, respectively, which is low compared to these minerals in granite porphyry and Mackay Granite. The rock contains about 2% magnetite. Other accessory minerals include zircon, rutile, and apatite. About 2% of chlorite and sericite replace pyroxene, amphibole, and plagioclase.

Granophyre

Granophyre is only found in drill cores. It typically has extensive granophyric- micrographic intergrowth of quartz and K-feldspar in the groundmass. Sparse anhedral phenocrysts account for 0-5% of the total volume. The rock contains 2% phenocrysts and 98% groundmass. The phenocrysts are mainly K-feldspar (perthite with some showing micrographic texture), with minor plagioclase and trace clinopyroxene and amphibole. The groundmass contains 4% plagioclase (Oligoclase), 59% K-feldspar, and 35% quartz. Accessory minerals include about 0.4% fluorite, 0.2% magnetite, trace zircon, titanite, apatite, thorite, and monazite. Thorite and monzonite are very fine grained and were identified by backscatter analyses on an electron microprobe; Chang 1998. The Granophyre also frequently displays myrmekitic intergrowths between alkali feldspar and quartz and somewhat diffuse but unequivocal miarolitic cavities of quartz – purple fluorite indicative of this rock being highly charged in F rich volatiles and a high pH_2O which combined substantially depressed the quartz – feldspar solidus in the magma.

Granite Porphyry

Granite porphyry crops out on the NE margin of the Mackay stock, as intrusion or veins, which makes the shape of this part of the Mackay stock very irregular. According to Umpleby (1917) this rock is called granite porphyry and is interpreted as a border phase of the Mackay Granite. Nelson and Ross (1968) named this rock leucogranite porphyry.

Granite porphyry has a typical porphyritic texture with large phenocrysts set in an aphanitic groundmass, which distinguishes it from the Mackay Granite; as shown on Plate 3 below. The percentage, grain size, and mineral composition of the phenocrysts and groundmass vary greatly, even within a short distance. The groundmass makes up 31%-75% of the rock, as a mosaic of very fine-grained (0.007-0.15 mm), almost equidimensional grains. The phenocrysts include K-feldspar (10-35%, up to 20mm), quartz (8- 20%, up to 8 mm), oligoclase (8-15%, up to 4 mm), minor amphibole and/or biotite. the rock contains 61% volume percent phenocrysts, 37% groundmass, and 2% accessory and alteration minerals. The phenocrysts include 15% plagioclase, 33% K-feldspar, 9% quartz, 2% amphibole and 2% biotite. The K-feldspar, plagioclase, amphibole and biotite phenocrysts are euhedral, but the smoky quartz phenocrysts are rounded and have an unusual, extremely vermicular texture; as shown in the Plate below.

A photomicrograph of the vermicular quartz intergrowths is shown below on Plate 4. This texture is discussed in the text below.

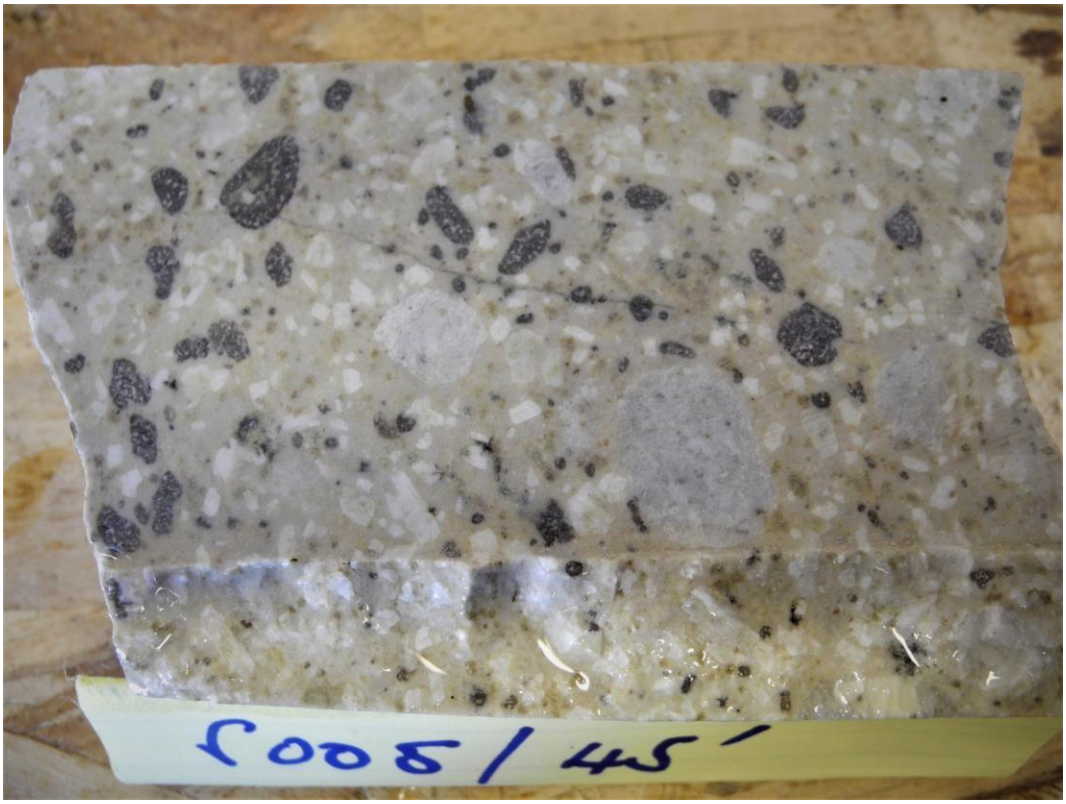


Plate 3: A macro view of bleached and hydrothermally altered “Granite Porphyry” from DDH S005 at a depth of 45 feet (13.68m) downhole. Note that the rock contains > 1 cm rounded clasts of the Granophyre with broken (cream colored) crystals of K feldspar and Oligoclase and dark grey rounded or orbicular quartz grains which display strong vermicular intergrowths with matrix minerals. The groundmass is aphanitic / glassy mix of quartz, K feldspar and plagioclase; photography by author.

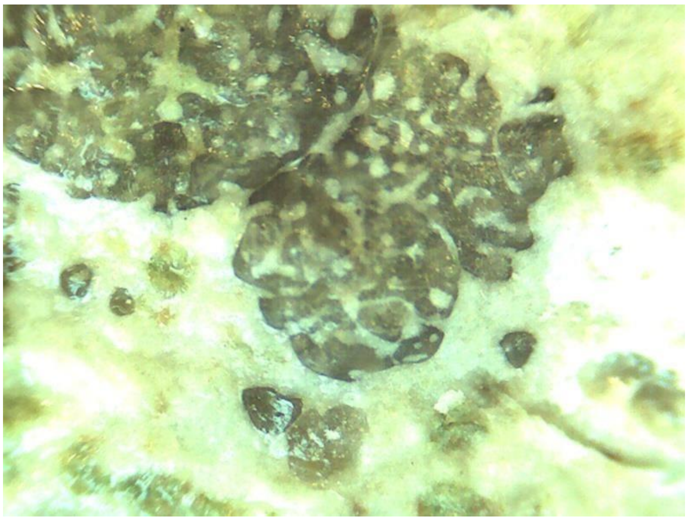


Plate 4: Vermicular grey quartz DDH S018 at 422 feet (128.28m) downhole; photography by Nathan Bishop

Further features of the "Granite Porphyry", within the mineralized porphyry main zone of endoskarn alteration, include the pronounced development of Unidirectional Solidification Textures (UST's) typically observed and documented in the upper cupola's of Porphyry Cu – Mo, Porphyry Mo – W (Questa, New Mexico and Henderson, Colorado) and Porphyry Sn deposits attended by pervasive grey fine grained to aphanitic silicification and development of garnet – quartz – calcite miarolitic cavities; as shown on Plates 5 and 6 below.

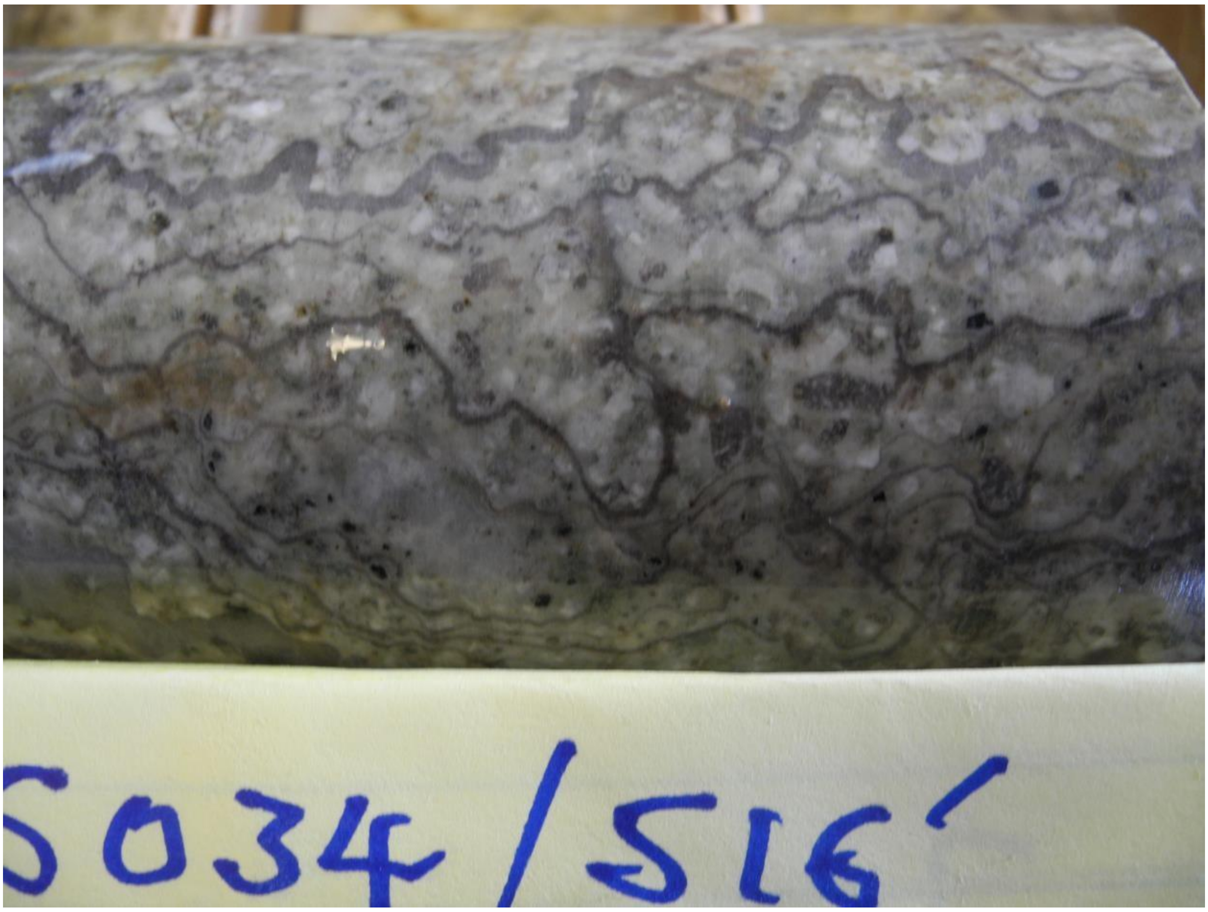


Plate 5: Intensely hydrothermally altered "Granite Porphyry" displaying strong development of Unidirectional Solidification Textures (UST's) over a 6m wide zone (20 feet) in DDH S034 at 516 feet (156.8m) downhole. The UST's occur as sinusoidal thin bands of grey quartz which point downwards towards the hydrothermal core of the system. Orbicular dark grey quartz grains displaying vermiform intergrowths with matrix minerals can be observed. The aphanitic matrix and feldspar porphyry phenocrysts of the Granite Porphyry are also strongly altered; photography by author.

The hydrothermal textures displayed by the Granite Porphyry intrusive at the Empire Mine are precisely those described in the uppermost portions of major porphyry deposits; especially porphyry molybdenum – tungsten deposits such as Climax, Henderson and Questa in the Colorado Mineral Belt, USA, and occurs as shown on Figure 5 below and bear direct comparison with the UST's displayed at the Seltai Porphyry Mo mineralized system shown on Plate 6 below; see Seedorf & Einaudi, 2004a & b, Gaynor et al, 2019.

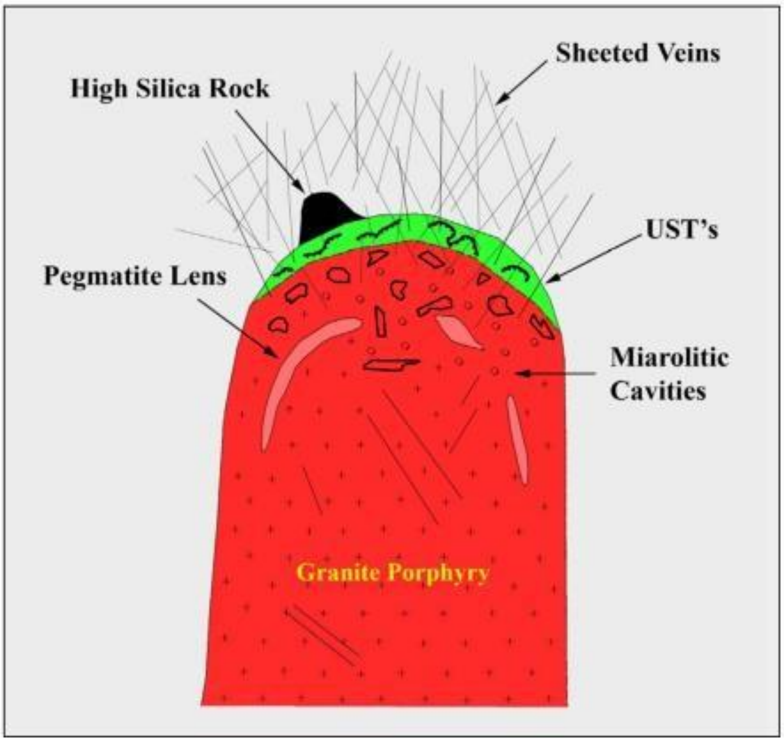


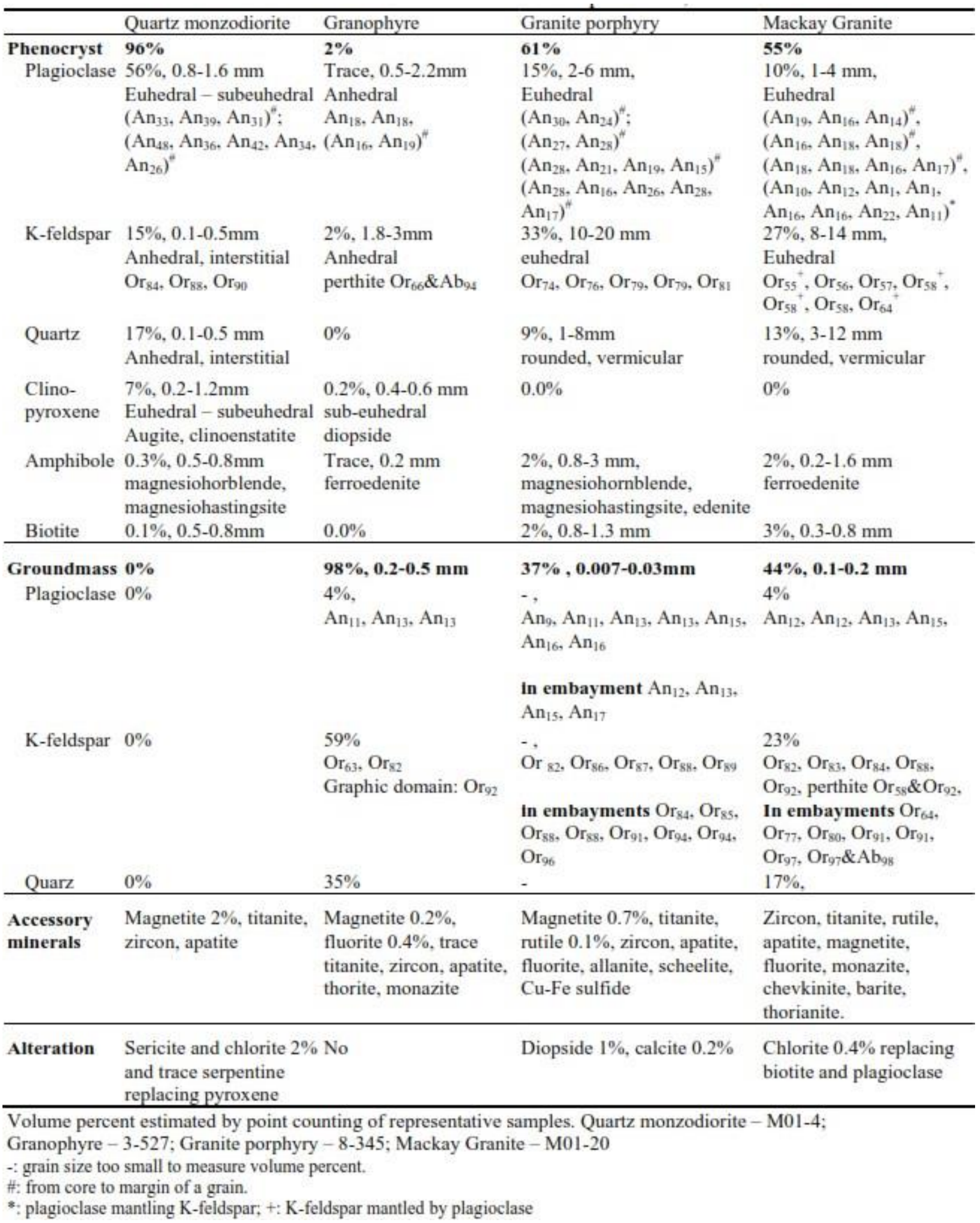
Figure 5: Volatile phase separation features & textures developed with the upper cupola of a granite porphyry stock typical of a porphyry Mo – W system; after D Kirwin, 2006.

Plate 6: UST's developed in the uppermost section of the Mineral Park porphyry Cu – Mo system, Arizona. Compare these textures with Plate 5 above; after D Kirwin, 2006.

The combination of the above textures in the Granite Porphyry at the Empire Mine testify, as Z Chang, 2003, points out, to these being developed at the magmatic – hydrothermal transition zone where boiling and phase separation of the water and other volatiles takes place. At the Empire Mine, especially in the Granite Porphyry and Granophyre intrusive bodies these volatiles were dominated by an unusually high content of fluorine, which amongst other textural / mineralogical phenomena has resulted in the widespread formation of large dark grey glassy vermicular quartz globules of the types illustrated on Plates 3 and 4 above, as a result of undercooling with resorption of quartz by the melt due to magma ascent and sudden decompression plus decreased F activity in the melt after some F partitions into the magmatic aqueous fluid.

Plate 7: This photograph shows the contrast between relatively unaltered and hydrothermally bleached "Granite Porphyry" displaying quartz – sericite alteration and destruction of the ferromagnesian minerals with textural preservation. Note the angular broken Granophyre clasts are clearer in the fresh Granite Porphyry; photography by author.

For the features observed at the Empire Mine, the embayments can be explained by a new hypothesis involving high fluorine activity. High F activity of both magma and hydrothermal fluid has been documented at Empire by high F content in igneous biotite and amphibole, and skarn vesuvianite; fluorite as an accessory mineral in igneous, endoskarn, and exoskarn rocks; and fluorite as daughter minerals in fluid inclusions.



	Quartz monzodiorite	Granophyre	Granite porphyry	Mackay Granite
Phenocryst	**96%**	**2%**	**61%**	**55%**
Plagioclase	56%, 0.8-1.6 mm Euhedral – subeuhedral $(\mathrm{An}_{33}, \mathrm{An}_{39}, \mathrm{An}_{31})^{\#}$; $(\mathrm{An}_{48}, \mathrm{An}_{36}, \mathrm{An}_{42}, \mathrm{An}_{34}, \mathrm{An}_{26})^{\#}$	Trace, 0.5-2.2mm Anhedral $\mathrm{An}_{18}, \mathrm{An}_{18}$, $(\mathrm{An}_{16}, \mathrm{An}_{19})^{\#}$	15%, 2-6 mm, Euhedral $(\mathrm{An}_{30}, \mathrm{An}_{24})^{\#}$; $(\mathrm{An}_{27}, \mathrm{An}_{28})^{\#}$ $(\mathrm{An}_{28}, \mathrm{An}_{21}, \mathrm{An}_{19}, \mathrm{An}_{15})^{\#}$ $(\mathrm{An}_{28}, \mathrm{An}_{16}, \mathrm{An}_{26}, \mathrm{An}_{28}, \mathrm{An}_{17})^{\#}$	10%, 1-4 mm, Euhedral $(\mathrm{An}_{19}, \mathrm{An}_{16}, \mathrm{An}_{14})^{\#}$, $(\mathrm{An}_{16}, \mathrm{An}_{18}, \mathrm{An}_{18})^{\#}$, $(\mathrm{An}_{18}, \mathrm{An}_{18}, \mathrm{An}_{16}, \mathrm{An}_{17})^{\#}$, $(\mathrm{An}_{10}, \mathrm{An}_{12}, \mathrm{An}_{1}, \mathrm{An}_{1}, \mathrm{An}_{16}, \mathrm{An}_{16}, \mathrm{An}_{22}, \mathrm{An}_{11})^{*}$
K-feldspar	15%, 0.1-0.5mm Anhedral, interstitial $\mathrm{Or}_{84}, \mathrm{Or}_{88}, \mathrm{Or}_{90}$	2%, 1.8-3mm Anhedral perthite Or_{66}&Ab_{94}	33%, 10-20 mm euhedral $\mathrm{Or}_{74}, \mathrm{Or}_{76}, \mathrm{Or}_{79}, \mathrm{Or}_{79}, \mathrm{Or}_{81}$	27%, 8-14 mm, Euhedral $\mathrm{Or}_{55}^{+}, \mathrm{Or}_{56}, \mathrm{Or}_{57}, \mathrm{Or}_{58}^{+}, \mathrm{Or}_{58}^{+}, \mathrm{Or}_{58}, \mathrm{Or}_{64}^{+}$
Quartz	17%, 0.1-0.5 mm Anhedral, interstitial	0%	9%, 1-8mm rounded, vermicular	13%, 3-12 mm rounded, vermicular
Clino-pyroxene	7%, 0.2-1.2mm Euhedral – subeuhedral Augite, clinoenstatite	0.2%, 0.4-0.6 mm sub-euhedral diopside	0.0%	0%
Amphibole	0.3%, 0.5-0.8mm magnesiohorblende, magnesiohastingsite	Trace, 0.2 mm ferroedenite	2%, 0.8-3 mm, magnesiohornblende, magnesiohastingsite, edenite	2%, 0.2-1.6 mm ferroedenite
Biotite	0.1%, 0.5-0.8mm	0.0%	2%, 0.8-1.3 mm	3%, 0.3-0.8 mm
Groundmass	**0%**	**98%, 0.2-0.5 mm**	**37% , 0.007-0.03mm**	**44%, 0.1-0.2 mm**
Plagioclase	0%	4%, $\mathrm{An}_{11}, \mathrm{An}_{13}, \mathrm{An}_{13}$	- , $\mathrm{An}_{9}, \mathrm{An}_{11}, \mathrm{An}_{13}, \mathrm{An}_{13}, \mathrm{An}_{15}, \mathrm{An}_{16}, \mathrm{An}_{16}$ **in embayment** $\mathrm{An}_{12}, \mathrm{An}_{13}, \mathrm{An}_{15}, \mathrm{An}_{17}$	4% $\mathrm{An}_{12}, \mathrm{An}_{12}, \mathrm{An}_{13}, \mathrm{An}_{15}$,
K-feldspar	0%	59% $\mathrm{Or}_{63}, \mathrm{Or}_{82}$ Graphic domain: Or_{92}	- , $\mathrm{Or}_{82}, \mathrm{Or}_{86}, \mathrm{Or}_{87}, \mathrm{Or}_{88}, \mathrm{Or}_{89}$ **in embayments** $\mathrm{Or}_{84}, \mathrm{Or}_{85}, \mathrm{Or}_{88}, \mathrm{Or}_{88}, \mathrm{Or}_{91}, \mathrm{Or}_{94}, \mathrm{Or}_{94}, \mathrm{Or}_{96}$	23% $\mathrm{Or}_{82}, \mathrm{Or}_{83}, \mathrm{Or}_{84}, \mathrm{Or}_{88}, \mathrm{Or}_{92}$, perthite Or_{58}&Or_{92}, **In embayments** $\mathrm{Or}_{64}, \mathrm{Or}_{77}, \mathrm{Or}_{80}, \mathrm{Or}_{91}, \mathrm{Or}_{91}, \mathrm{Or}_{97}, \mathrm{Or}_{97}$&$\mathrm{Ab}_{98}$
Quarz	0%	35%	-	17%,
Accessory minerals	Magnetite 2%, titanite, zircon, apatite	Magnetite 0.2%, fluorite 0.4%, trace titanite, zircon, apatite, thorite, monazite	Magnetite 0.7%, titanite, rutile 0.1%, zircon, apatite, fluorite, allanite, scheelite, Cu-Fe sulfide	Zircon, titanite, rutile, apatite, magnetite, fluorite, monazite, chevkinite, barite, thorianite.
Alteration	Sericite and chlorite 2% and trace serpentine replacing pyroxene	No	Diopside 1%, calcite 0.2%	Chlorite 0.4% replacing biotite and plagioclase

Volume percent estimated by point counting of representative samples. Quartz monzodiorite – M01-4; Granophyre – 3-527; Granite porphyry – 8-345; Mackay Granite – M01-20

-: grain size too small to measure volume percent.

#: from core to margin of a grain.

*: plagioclase mantling K-feldspar; +: K-feldspar mantled by plagioclase

Table 2: the mineralogy of the igneous rock types encountered at the Empire porphyry – skarn Cu – Zn – Au – Ag project; Z Chang, 2003.

High F activity is significant because it is known to lower melt viscosity and affect liquidus and solidus temperatures of a melt increase the partition coefficient of F between melt and aqueous magmatic fluid and increase the solubility of quartz in aqueous fluid and increase the solubility of melt in coexisting aqueous magmatic fluid.

The Mackay Granite

Mackay Granite occupies most of the outcrop area of the Mackay stock. It has both porphyritic and rapakivi textures with a fine-grained groundmass. The fine-grained groundmass and the rapakivi texture are the major criteria used in the field to distinguish it from the granite porphyry.

Point counting of a typical Mackay Granite shows that the rock contains 55% phenocrysts, 44% groundmass, and 1% accessory and alteration minerals. The groundmass contains 4% plagioclase (0.1 – 0.4 mm), 23% K-feldspar (0.05-0.4 mm), and 17% quartz (0.05-0.4 mm), locally with a mosaic or granophyric texture. The phenocryst population comprises 10% plagioclase, 17% K-feldspar, 13% quartz, 2% amphibole, and 3% biotite. The plagioclase and K-feldspar phenocrysts are euhedral, but the quartz phenocrysts (3-12 mm) are all rounded and extremely vermicular with a smoky grey color. K-feldspar phenocrysts (8-14 mm) are usually larger than plagioclase phenocrysts (1-4 mm). Some K- feldspar phenocrysts are mantled by plagioclase, resulting in a rapakivi texture, but a few plagioclase phenocrysts have anti-rapakivi texture; Chang, 2003.

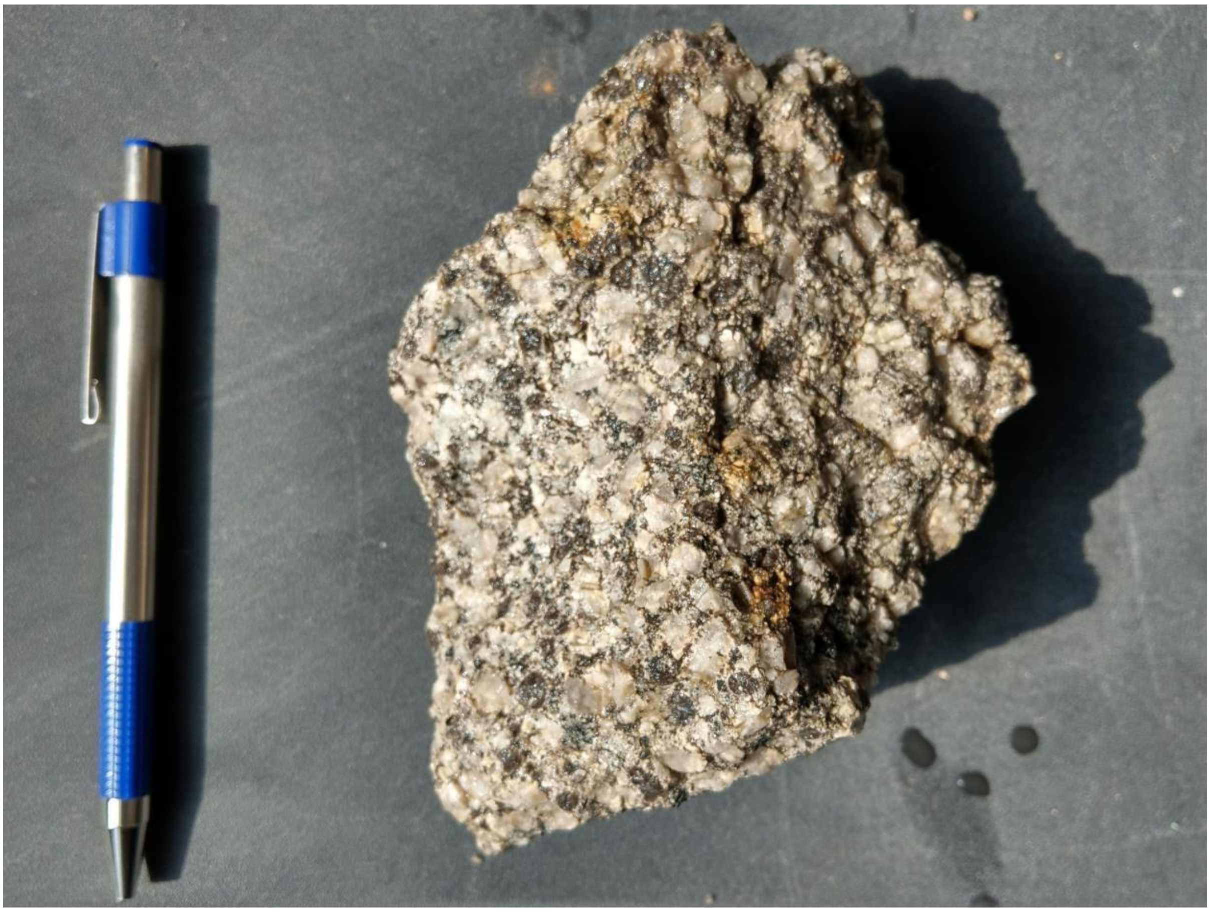


Plate 8: A hand specimen from surface outcrop of the Mackay Granite displaying its crowded porphyry coarse-grained texture dominated by feldspar (K feldspar and Oligoclase) and grey to smoky quartz; photograph taken by Mr. Keian Moran.

The Igneous Intrusive Sequence

The intrusive sequence has been deciphered from crosscutting relationships exposed in drill core. Exposed contacts between these rocks are scarce, and most are in mine workings. Based on the cross-cutting relationships, the sequence is: 1) quartz monzodiorite; 2) granophyre; 3) granite porphyry, 4) Mackay Granite, and 5) numerous dikes. The contact between quartz monzodiorite and other intrusive rocks is not exposed in either the surface or the drill cores. It is assumed that the quartz monzodiorite is the first intrusive phase because it is the most mafic rock.

At the contact between granophyre and granite porphyry, quartz veins in granophyre are truncated by granite porphyry. Also, granite porphyry veins cut across granophyre and contain breccias of granophyre. These observations prove that granite porphyry is later than granophyre. At the contact between granite porphyry and Mackay Granite, it is found that the marginal phase of the Mackay Granite intrudes into granite porphyry as veins. The marginal phase of the Mackay Granite is composed of coarse-grained smoky, vermicular quartz, and feldspars, without groundmass.

Mackay Granite is also later than alteration/skarn formation. Both granophyre and granite porphyry are altered and contain endoskarn veins, but the Mackay Granite is fresh. The emplacement depth of Mackay stock is shallow. This is supported by the fact that most of the intrusive rocks (granite porphyry, Mackay Granite, other vein rocks) have porphyritic textures and a fine grained to aphanitic groundmass, there is co-genetic volcanism, and the width of marble around the intrusion is narrow.

The granite porphyry and Mackay Granite have high-F contents, as indicted by the presence of fluorite as an accessory mineral and high-F biotite and amphibole compositions, whereas the F content in the quartz monzodiorite magma is low. The F concentrations of the amphiboles in granite porphyry and Mackay granite are high. In granite porphyry, the amphibole contains 1.63 - 2.46 wt.% F, and the amphibole in Mackay Granite contains 1.53% - 1.87 wt.% F. In contrast, the amphibole in quartz monzodiorite, a phase that does not host vermicular quartz, contains only 0.22 – 0.89 wt.% F. Similarly, the F concentrations of the biotite in granite porphyry and Mackay Granite also are moderately high, 1.43-3.87 wt.% F, and 2.24 – 2.42 wt.% F, respectively.

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Usually, the F content in amphibole of felsic igneous rocks is very low. For comparison, the compilation and review of fluorine in granitic rocks and melts by Bailey (1977) reports a mean value of about 0.2 wt.% for F in amphiboles. According to the compilation of Price et al. (1999), amphiboles in some A-type granites with moderate to high magmatic F contain 0.20 – 1.03 wt.% F.

5.0 Structural Geology of the Empire District and Mine Area

The writer has undertaken a review of the Empire Mine structural geologic setting at the regional, district and mine scales. These different scales show the relationship between major transcontinental features and their impact upon District and mine scale 2nd and 3rd order structures such as shears and faults.

At the semi – Continental scale, the major structure impacting on the location of the historic Empire Mine and project area become apparent. It has long been known that deeply seated major ENE striking transpressive shear structures have exerted a control on the disposition of world class minerals deposits in the Western USA. The most obvious example of this is the well-studied and economically prolific Colorado Mineral Belt (CMB) which is host to two of the world's two largest porphyry molybdenum producers of the past Century; i.e., Climax and Urad - Henderson. The CMB is also host to the substantial undeveloped porphyry molybdenum deposits of Mount Emmons and Rico. Besides mineral deposits the major ENE Snake River Plains structure has controlled the migration of the major long lived and very deeply seated (450 km deep) mantle plume responsible for the periodic eruptions of the Yellowstone super volcanic edifice.

The importance of the ENE structures was first recognized by E S T O'Driscoll in paper entitled "The Global Double Helix" published in Tectonophysics 1980. O'Driscoll termed the ENE structures as "the Laurasian Group" which typically are responsible for dextral transpressional shear corridors such as the CMB. Figure 6 below shows the location of the Empire Mine in relation to another ENE striking deeply seated basement structure known as "the Great Falls Tectonic Zone" abbreviated GFtz and the Mm structure immediately south of it. This structure is illustrated at a smaller scale on Figure 7 below.

The GFtz structure or one of its internal features appears to control the development of the Empire skarn – porphyry related ore system, as shown on Figure 6 below, where it is shown as a primary ENE striking structural feature related to NE striking 2nd order structures which exert a dominant structural control over the emplacement of the Cu – Au – Ag – (Zn) skarn mineralization at the Empire Project; see also Figure 8 below. The latter is illustrated in the old 1923 – 1926 and 1942 - 1944 underground geologic mapping of the 700' mine level of the Empire Mine, shown as Figure 9 below, where the control of the NE striking structures on the development of the high-grade Cu – Au – Ag ore shoots is apparent. Indeed, the structural interplay between the NE striking transpressional shears and the contact zone between the Granite Porphyry and White Knob Limestone / Marble forms the site of maximum skarn development and base & precious metal mineralization, with the ore bodies developed effectively developed "en echelon" at the endoskarn – exoskarn contact zone, mostly within the granite porphyry, where it is intersected by the NE striking shear zones

The bulk of the mineralization is developed at the contact between the wollastonite marbles / exoskarn contact zone which serve as an effective permeability wall and a reactive front against which the hydrothermal system has been effectively mechanically and chemically buffered, with the ore solutions ponded up against this front at the confluence between hydrothermal solution ingress structures and fluid escape zones. The larger stoped blocks of marbleized skarn (wollastonite – calcite) have been partially to wholly replaced by strong calc – silicate andradite (and grossular) garnet – pyroxene (diopside) skarn associated with scapolite and magnetite as a prograde skarn system developed in the range 650 – 700°C. However, as the system evolved with the widespread exsolution of the fluorine rich hydrous volatile phase within the granophyre and granite porphyry, the temperature of skarn alteration fell to around 450° to 550°C (Chang, 2003 and 2006). The development of retrograde skarn was relatively restricted to the major shear / contact zone structures and is more closely associated with the late development of the high-grade ore shoots with a lower temperature silicate assemblage comprising actinolite – chlorite and vesuvianite with temperatures of between 350 - 450°C

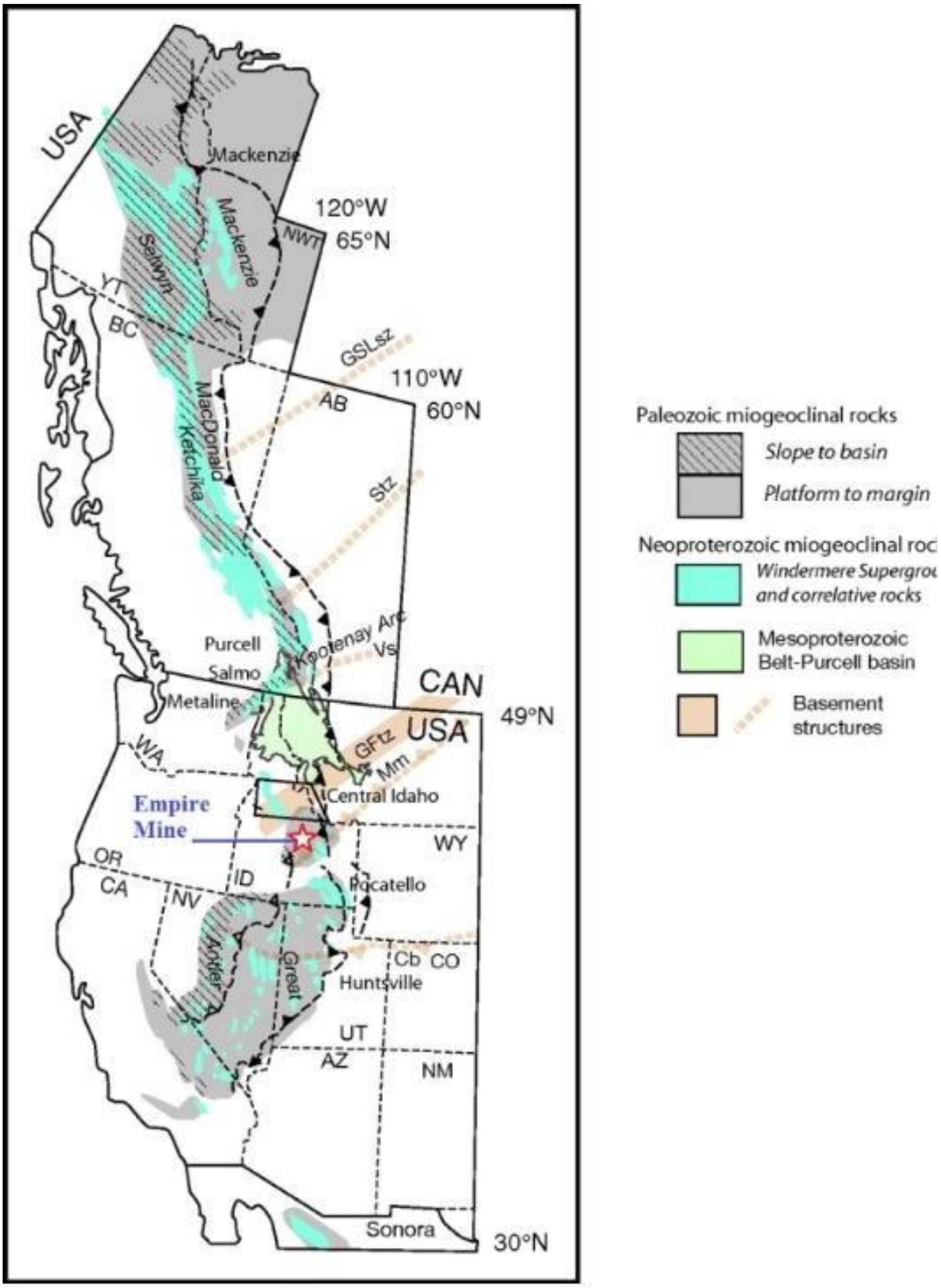

Figure 6: Major geologic rock formations and the location of major ENE (Laurasian) structures in the Western USA and Canada. The Empire Mine lies on a part of the Great Falls Tectonic Zone (GFtz)and Mm Zone at its southern boundary. This structure has controlled the emplacement of the Mackay Igneous Complex in a trans – tensional pull apart structure. Subsequent re – mobilization has resulted in the later emplacement of the fractionated Empire Rhyolite Porphyry dike and formation of the Empire skarn mineralization over the entire eastern margin of the porphyry with the enclosing Palaeozoic (Mississippian age) metasedimentary rocks;

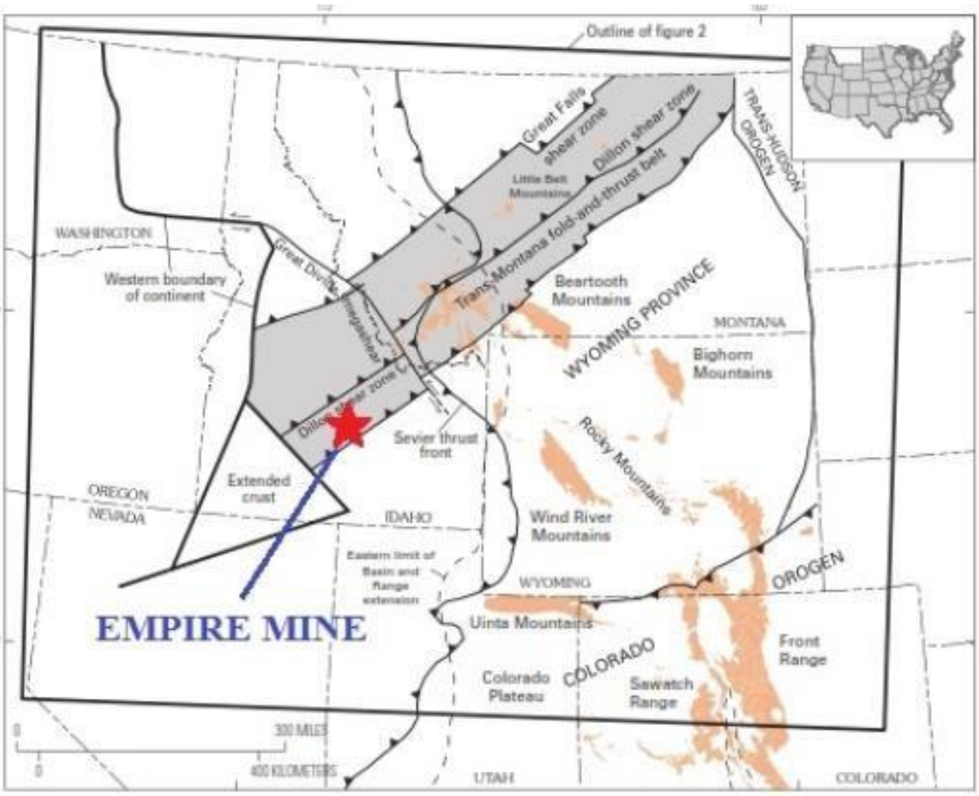

Figure 7: The Northern Rocky Mountains showing the location of the Great Falls Tectonic Zone (GFTZ = shaded) and the left lateral offset of the Dillon Shear Zone by the Great Divide Mega-shear (striking NW – WNW); Precambrian and basement uplifts are shaded in tan. The location of the Empire Mine within the GFTZ is shown.

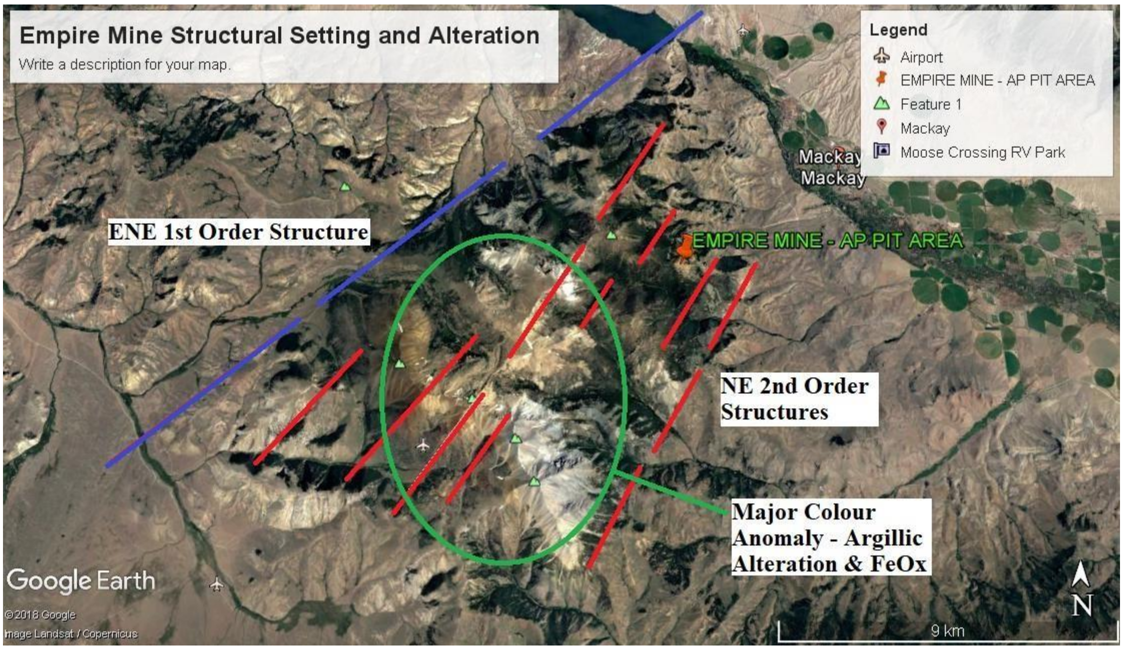

Figure 8: An interpreted Google Earth image showing the major geologic structures apparent in the rock formations as a 1st order ENE structure and 2nd order NE structures which have influences emplacement of post mineralization dykes and structures impacting on the morphology and displacement of the Empire skarn ore shoots.

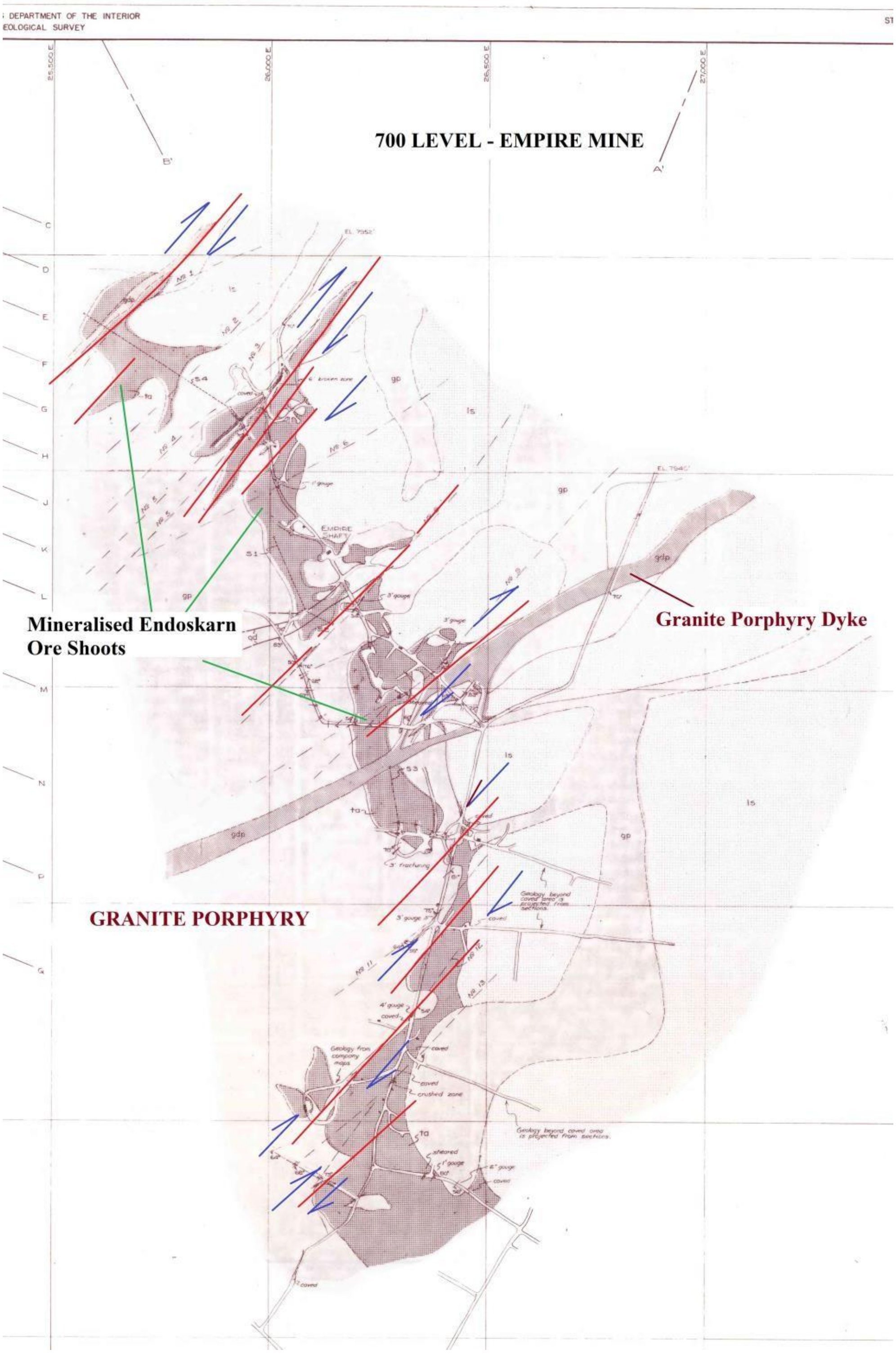

Figure 9: ASARCO & USGS geologic map of the skarn ore bodies on the 700 level of the Empire Mine, showing endo-skarn ore outline, interpreted NE structures and Granite Porphyry intrusive dykes. The contact between the Granite Porphyry and the White Knob limestone / marble and wollastonite exo-skarn is the 3rd order structure permitting dilation and hydrothermal replacement & mineralization in the endo – skarn; Farwell & Full, US Dept of the Interior – Geological Survey, 1944. Structures by the writer.

As Figure 8 amply illustrates, the control of the Cu – Au – Ag – (Zn) endo-skarn hosted ore bodies are dominated by the NE striking 2nd order transpressive shear structures which also have controlled the emplacement of the granite porphyry and late stage quartz latite porphyry dikes. As stated above, the interplay between the NE shear structures and the mechanically and chemically different White Knob limestone sequence to the east and the massive, mechanically competent, granite porphyry to the west provides the perfect physical / chemical (REDOX, pH) trap to deposit metals due to decompression on periodic seismic structural release at the contact zone during movement on the NE shears structures and a perfect chemical / permeability barrier trap at the contact marble – wollastonite ($CaSiO_3$) / calcic exoskarn with the garnet (grossular – andradite) – pyroxene (diopside) – actinolite – scapolite endoskarn bodies and the granite porphyry. The structural plunge of the higher-grade ore shoots appears to have been determined by the dip of the NE shears and their intersection with the moderately eastward dipping lithologic contact zone described above.

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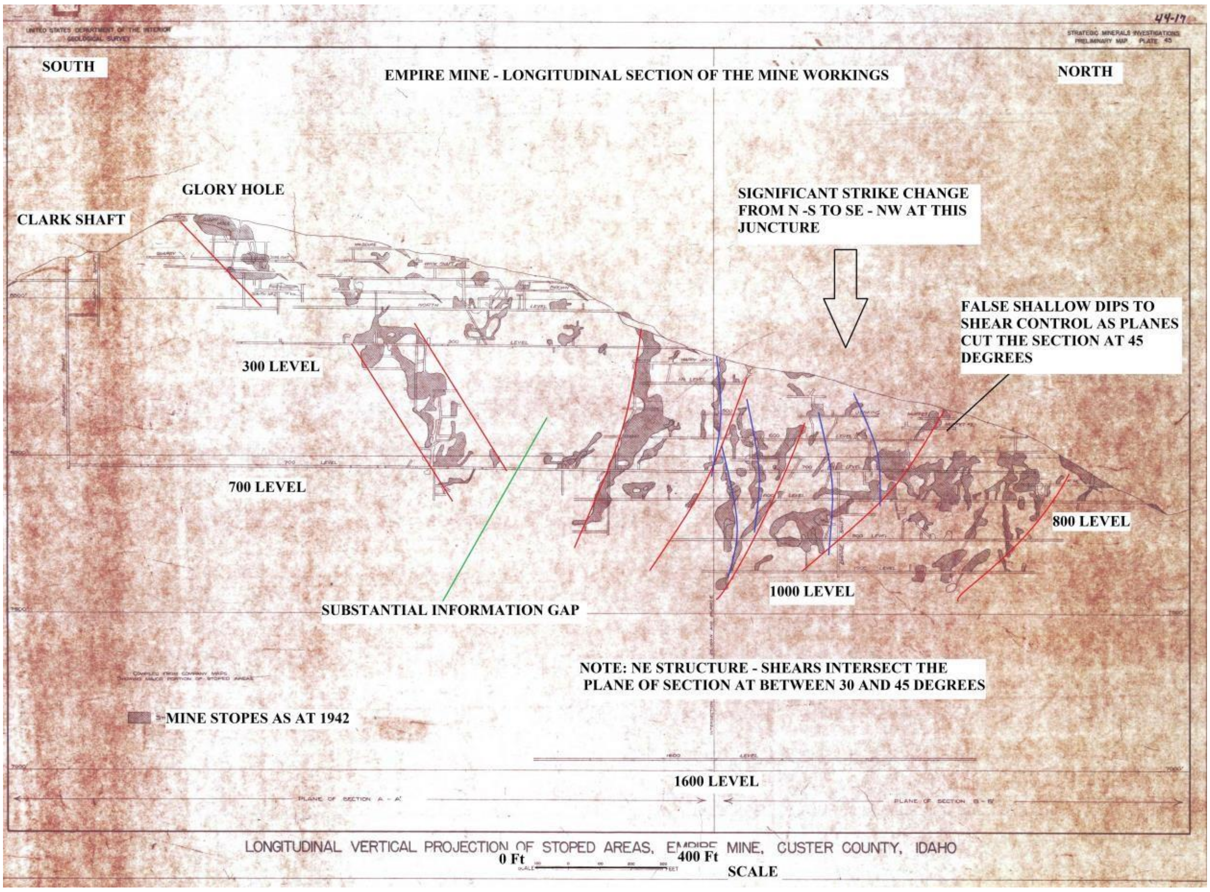

Figure 10: A Longitudinal Section of the Empire Mine workings showing the main working levels and stoped ore as at 1942. Suggested main NE striking shear zones (2nd order shears) controlling the major high-grade Cu – Au – Ag ore shoots are shown as red lines. 3rd order interconnecting shears also controlling the secondary ore shoots are shown as thin blue lines. These are curved representing the sigmoidal - dilational nature of their geometry. The differing direction of dip of the ore shoots reflects their control in a major shear structure. The "Glory Hole" ore shoots and its down plunge extension appears to suggest it was the footwall control shear; Farwell & Full; 1944

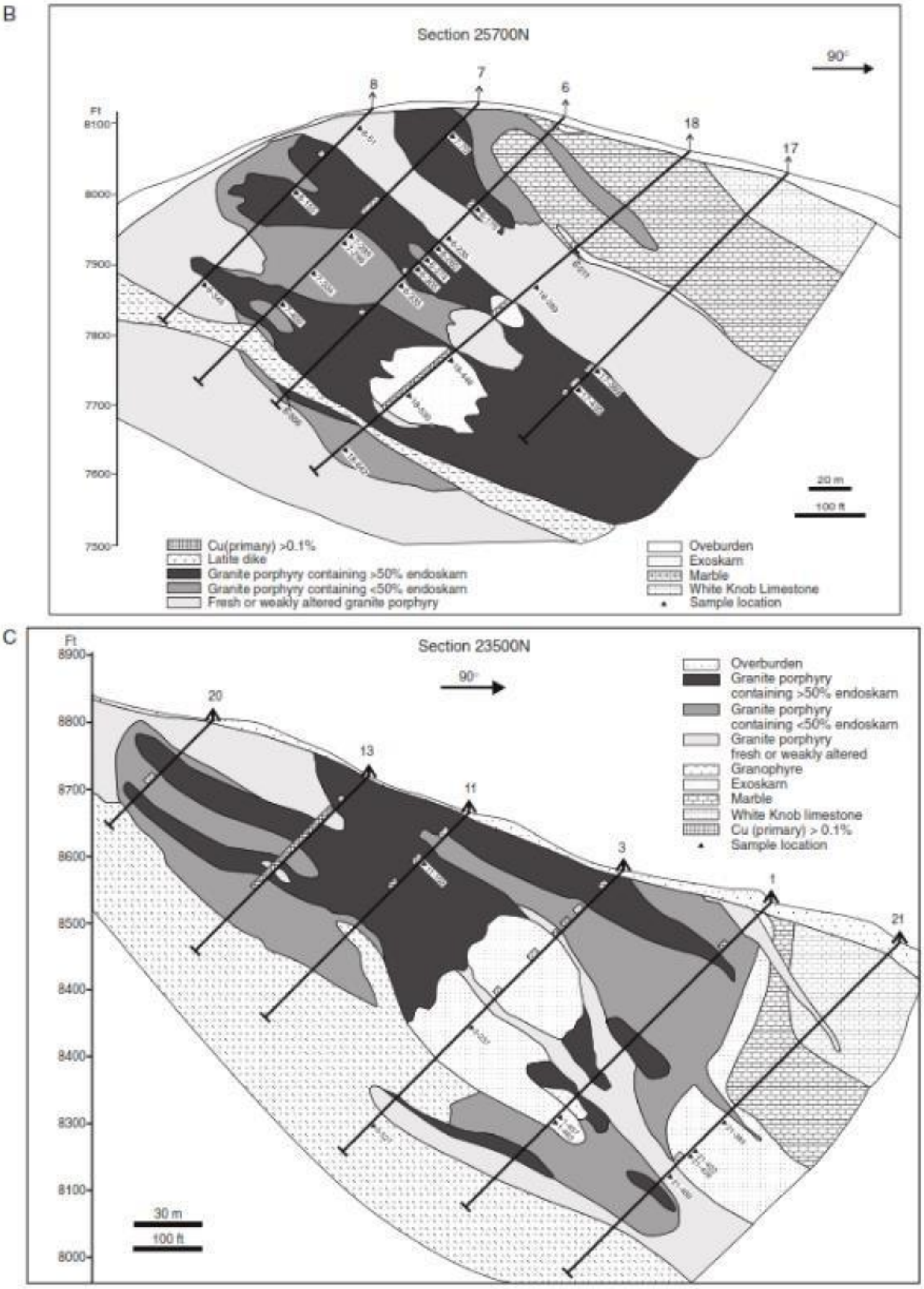

Figure 11: Two summary west – east geologic cross sections across the Empire Mine ore system with their locations given on the Summary Geologic Map shown on Figure 4 above. The main geologic elements of the Empire granite porphyry – endoskarn ore system is shown with the main rock types of the mine sequence and the location of core holes drilled by CAMBIOR Resources Inc between 1995 and 1998. The moderate easterly dip of the main lithologic units is clearly apparent; Chang; 2003.

From examination of the geologic mapping on the 700 and 800 level plans, and the Empire Mine longitudinal section showing the stoped ore bodies, it would appear that individual ore shoot geometry is also determined by 3rd order shear structures developed off the 2nd order shear structures resulting in lobate shaped ore shoots with apparently irregular overall geometry. The geometry of the ore shoots is, as already stated, also strongly influenced by the lithologic package as shown on Figure 9 above. Hence, as Figure 7 shows, in plan the ore shoots reflect the complex influence of structure and lithology in their development.

The high-grade ore bodies mined between 1901 and 1944 vary in size from a few thousand tonnes to tens of thousands of tonnes at the visual 2% Cu cut-off grade employed throughout the period of active mining. However, as discussed in the next section of this report, at 0.4% Cu cut-off grade the ore shoots are substantially larger with widths of mineralization between 5 to 15 meters and rarely slightly wider.

6.0 Formation of the Empire Skarn and Cu – Au – Ag – (Zn) Mineralization

The formation of the Empire skarn and associated Cu – Au – Ag – (Zn) ore bodies appears to be unequivocally associated with the intrusion of the so called “granite porphyry” which occurs as a large, up to 500 m wide dyke or lenticular stock like feature emplaced between the large composite Mackay granitoid complex (MGC) extending over a north – south strike of some 4 km emplaced on the contact between the Mackay Granitoid Complex and the White Knob limestone with chert nodules formation. Interestingly, the granite porphyry, which is less fractionated and fluorine rich than the granophyre, contains abundant clasts of the latter along with unusual globular vermiform quartz and a K feldspar porphyry texture in an aphanitic grey silica groundmass.

The major units hosting the skarn – mineralized sequence at the historic Empire Mine are from footwall (west) to hanging wall (east) as follows:

- The Mackay Granite
- Unmineralized Granophyre and Granite Porphyry
- Granite Porphyry with vein form endo-skarn development with variable development of Cu – Au – Ag mineralization;
- Granite Porphyry with strong semi - massive to massive endo-skarn development and the larger high-grade Cu – Au – Ag ore shoots;
- Calcic exo-skarn
- Wollastonite marble
- Marbleized White Knob Limestone sequence (Mississippian age)

An example of the White Knob limestone is given below on Plate 9. At the eastern margin of the Empire skarn system, this rock occurs as a massive to finely bedded slightly clastic to massive dark grey to black limestone containing fragments of Lower Mississippian shelly fauna and foraminifera deposited on a carbonate platform regime. The limestone contains zones of chert nodules which generally survive skarn formation. The formation and geometry of the skarn mineralized system is approached from the outer skarn facies to the innermost skarn development as a structurally controlled network of veins and metasomatic replacement bodies within the granite porphyry intrusive where the latter abuts against the MGC.

6.1 The Wollastonite Outer Exoskarn Front

At the outer contact of the Empire Skarn system, firstly nodular (Plate 10 below) and then massive white wollastonitic marble is formed where wollastonite is intergrown with Ca plagioclase ± andradite garnet and diopside pyroxene, which is essentially a prograde skarn hornfels. This effectively forms as an impervious, albeit reactive, block to the advance of skarn development and hydrothermal fluids to the east of the contact zone between the White Knob limestone sequence and the granite porphyry intrusive.

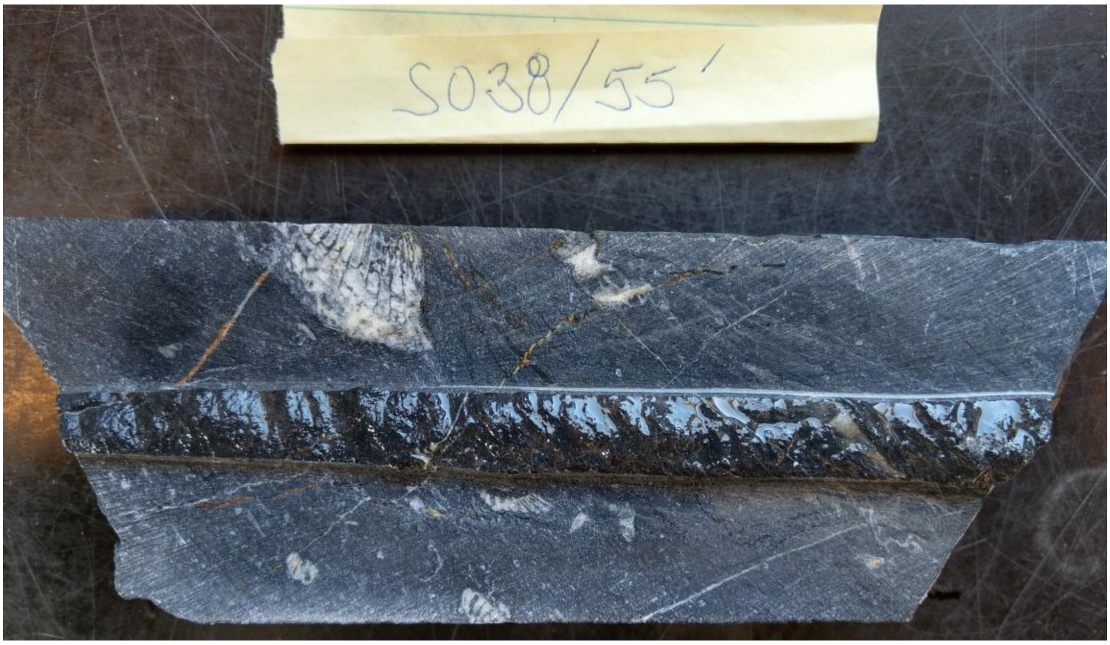

Plate 9: From DDH SO38 at 55 feet (16.7m) downhole, fossiliferous Upper Mississippian (Lower Carboniferous = between 348 to 360 million years) age "White Knob Limestone" (black variety containing finely divided carbon) formerly known as the "Brazer Limestone" was deposited as carbonate platform sediments at the eastern margin of the Antler turbidite basin; photograph by Nathan Bishop.

One of the most noteworthy features of the Empire Skarn System (ESS) is the myriad of textures this ore system exhibits and its sheer mineralogical and morphological complexity at the local scale, some of these textures / features are illustrated here. However, as pointed out in the previous section dealing with the structural controls to skarn formation and base and precious metal mineralization, the ore bodies do form within a structural – lithologic framework that is logical despite local complexity. As the sulphide ore system is systematically explored during the coming years, a viable model will emerge which not only enables more comprehensive understanding of ore body geometries but will be predictive in terms of the overall exploration / evaluation potential of the ESS to depth. As matters stand the model presented is in its infancy but nonetheless helps explain the manner in which the deposit has been mined to date and, moreover, ties together the geologic features of the deposit into an overall framework which makes geologic sense.

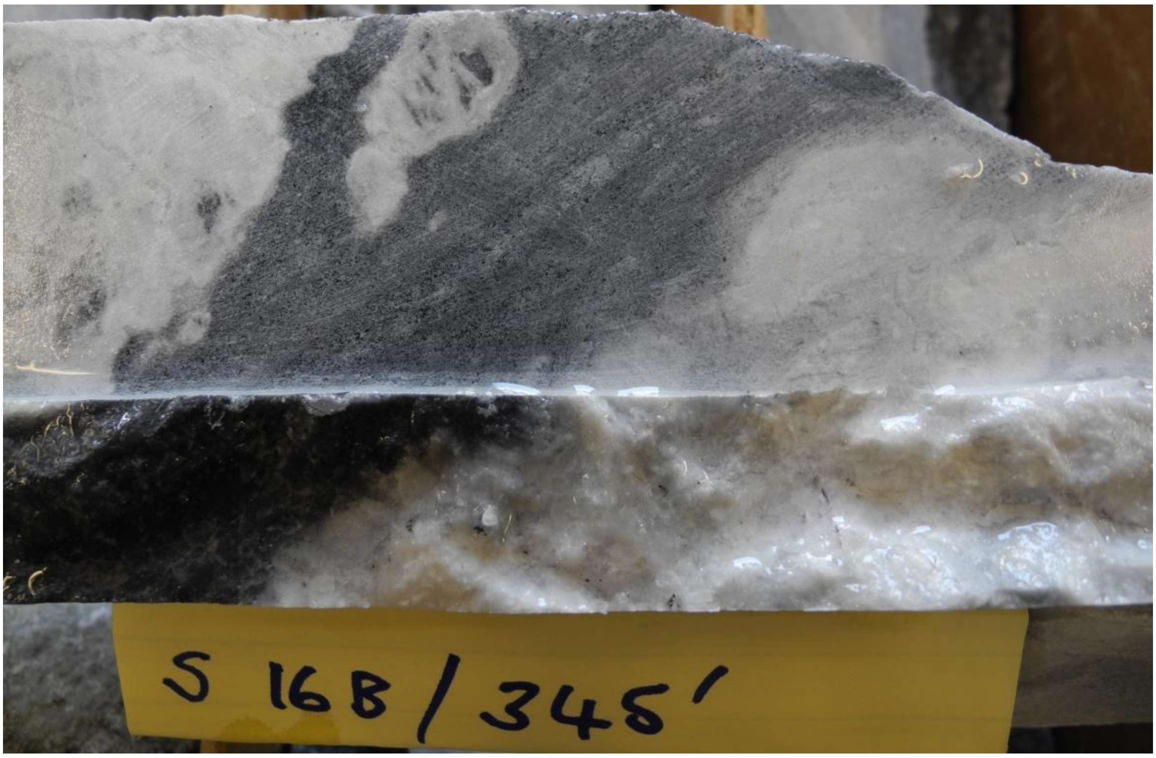

Plate 10: DDH S016B at 345 feet (104.88m) downhole with nodular development of wollastonite – calcite skarn after White Knob limestone at the outer (eastern) skarn contact.; photograph by author.

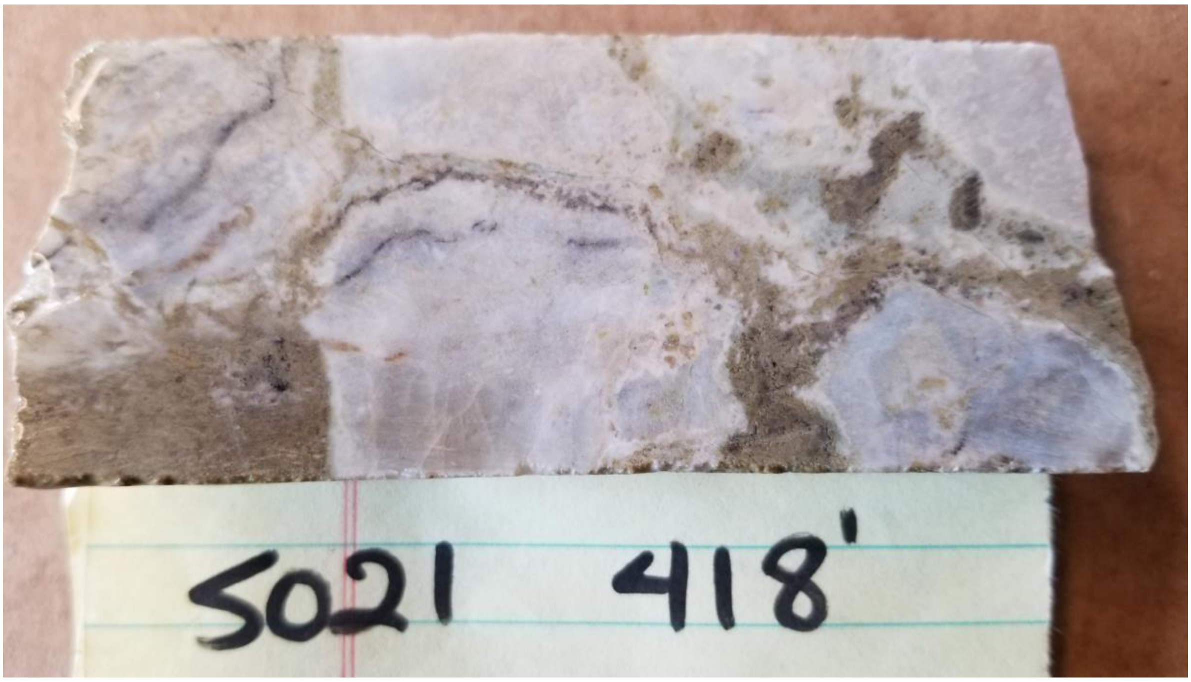

Plate 11: DDH S021 418 feet (127.07m) downhole. Garnet (andradite) wollastonite skarn formed at the contact zone between the wollastonite skarn and the calcic exoskarn. Note: no mineralization is apparent in this core.

Plate 11: DDH S016B at 356 feet downhole (108.22m). This core tray shows the contact zone between the wollastonite marble skarn to the left and the somewhat oxidized and limonite stained (iron sulphide mineralized) calcic exoskarn (garnet plus pyroxene) to the right; photograph by author.

6.2 The Calcic Exoskarn

The calcic exoskarn shown on Plate 11 above comprises massive fine-grained garnet (andradite lesser grossular, $Ca_3Fe^{3+}_2Si_3O_{12}$), diopside (pyroxene, $MgCaSi_2O_6$) and titanite ($CaTiSiO_5$ otherwise known as sphene) containing disseminated and veinlets of sulphides primarily pyrrhotite, pyrite and chalcopyrite. In the weathered supergene zone all the Fe sulphides are oxidised to limonite and goethite (α-$FeO(OH)$ = Fe oxyhydroxides) with copper minerals oxidised to chrysocolla ($(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$), malachite ($Cu_2CO_3(OH)$), azurite ($Cu_3(CO_3)_2(OH)_2$), antlerite ($Cu_3(SO_4)(OH)_4$), tenorite ($CuO$), cuprite ($Cu_2O$), minor native copper and grey high copper sulphide species: chalcocite (Cu_2S) and covellite (CuS).

The morphology of the exoskarn zone is that of an irregular zone of varying width from a few meters up to 5 meters in width. It effectively forms the hornfelsed and reactive skarn front developed along the entire eastern contact zone of the granite porphyry intrusive body.

Mineralisation in the exoskarn contains notable zinc mineralization as dark brown to black (Fe rich) sphalerite (Zn, Fe) S, where it often occurs a distinctive style of mineralization shown on Plate 12 below. At both the larger and smaller scales the Empire skarn deposit is zoned with zinc mineralization concentrated at the margins of the copper – gold – silver mineralization within both the endoskarn and exoskarn. Moreover, due to the impact of a high fluorine content in the hydrothermal fluids base metal mineralization has been effectively telescoped. The exoskarn also differs in its mineralogical assemblage with dominance of the prograde skarn mineral assemblage by andradite garnet with diopside pyroxene with little or no evidence of retrograde silicate mineral assemblages including scapolite, chlorite and epidote.

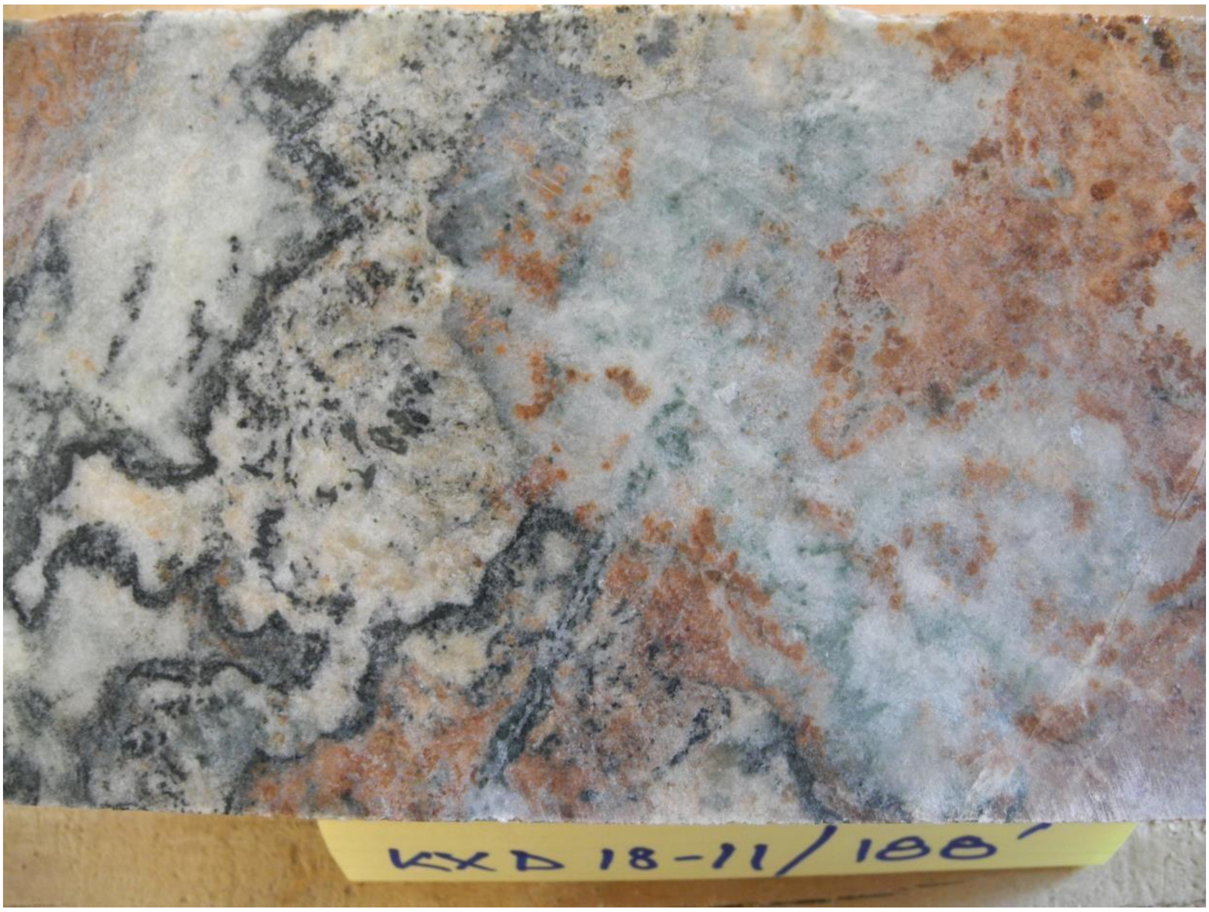

Plate 12: DDH KXD (Konnex) 18 – 11 at 188 feet downhole (57.15m). This example is developed in the contact zone between the endo and exoskarns with fine grained black sphalerite developed at pulsed collomorphic reaction fronts amidst andradite (orange brown) – diopside skarn with wollastonite – Ca plagioclase – calcite and quartz.

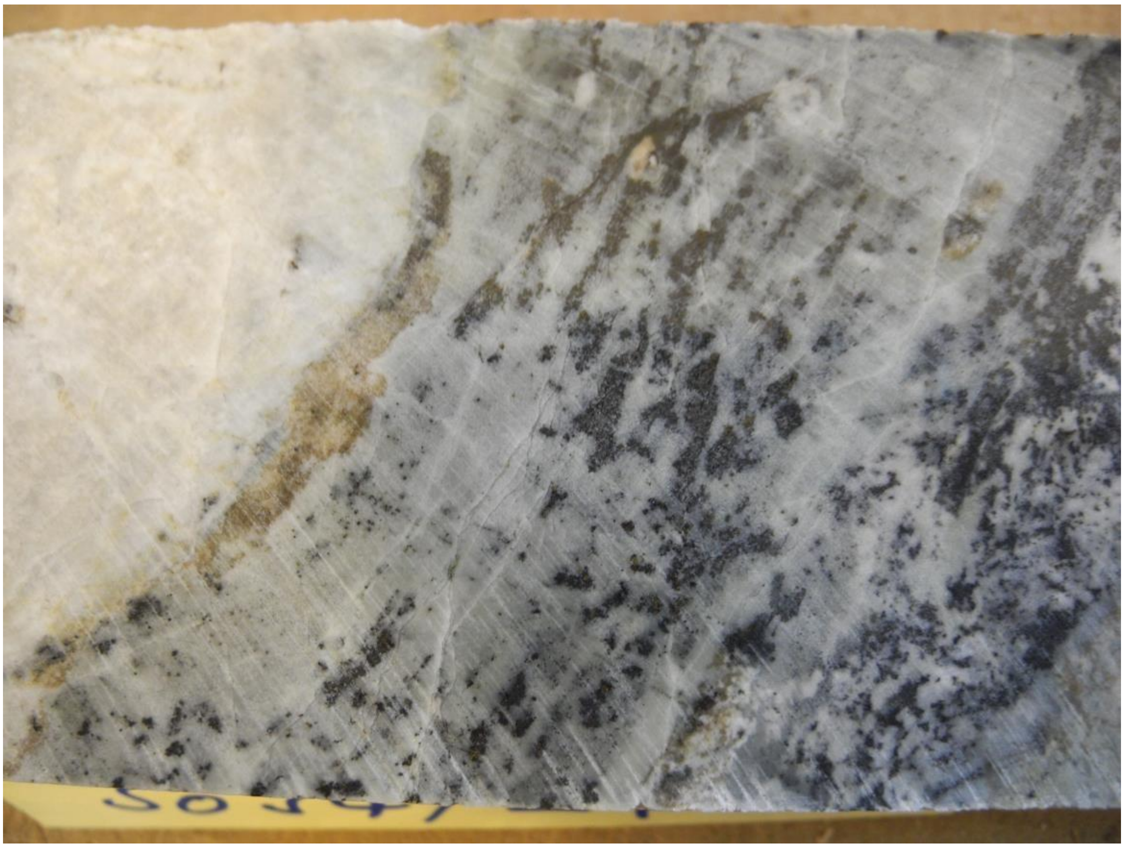

Plate 13: DDH S034 at 248 feet (75.39m) downhole. Strongly mineralized zinc exoskarn developed in close proximity to the wollastonite hornfels / skarn – exoskarn interface. Disseminated black (high Fe) sphalerite is hosted within wollastonite – calcite – garnet (andradite) skarn as a metasomatic reaction front.

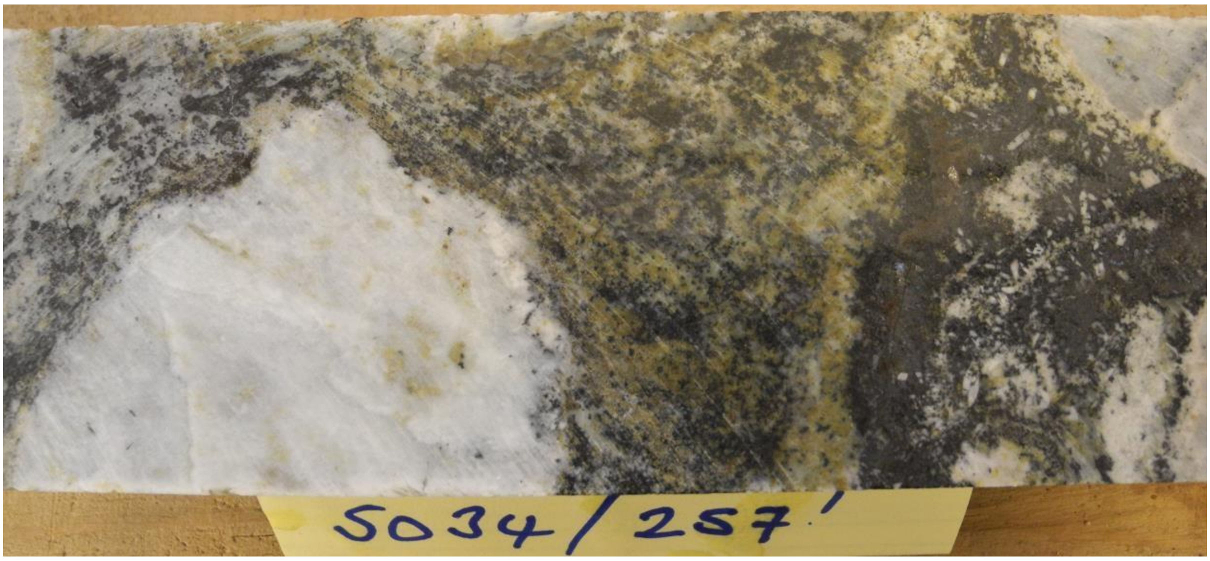

Plate 14: DDH S034 at 257 feet (78.13m) downhole. Strong metasomatic, replacement, sphalerite (dark brown) mineralization developed in exoskarn with wollastonite + Ca plagioclase + yellow andradite garnet + residual calcite.

Within the exoskarn the garnets change in color from yellowish (distal) through brown to dark brown (proximal to endoskarn). Work by Chang, 2003, has shown that all the garnets within the exoskarn are Fe rich. Coarser grained garnets display compositional zonation. Pyroxenes, however, do not show any apparent zonation.

Plate 14 above shows the development of locally intense Fe-rich brown sphalerite mineralization with yellow andradite garnet developed within the exoskarn overprinting the wollastonite + Ca plagioclase + calcite zone.

Plate 15 below illustrates further aspects of the complex granite porphyry dyke in contact with the exoskarn, including the development of anti – rapakivi texture and rimming of granophyre clasts and oligoclase (plagioclase) by K feldspar as potassic alteration with widespread potassic alteration and partial to complete destruction of ferromagnesian minerals.

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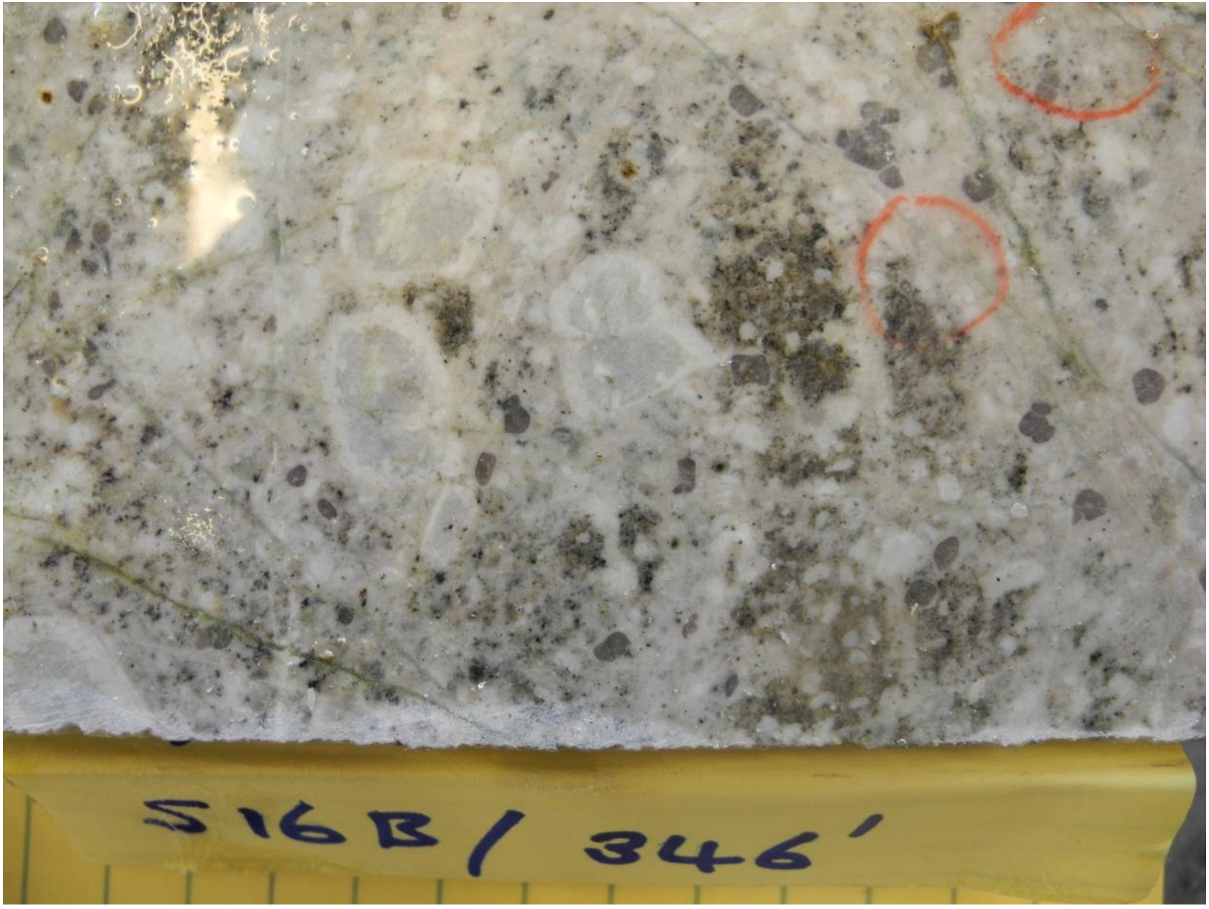

Plate 14: DDH S016B at 346 feet (105.18m). This plate illustrates a further facet of the complex granite porphyry intrusive body with K feldspar mantling granophyre clasts / inclusions and plagioclase phenocrysts (oligoclase in anti – rapakivi texture) with variable development of grey quartz exhibiting vermicular texture as described above. Residual nests of ferromagnesian minerals (biotite and hornblende) remain albeit surrounded by zones of bleaching and K feldspar with aphanitic silica replacement.

6.3 The Endoskarn & Cu – Au – Ag – (Zn) Mineralisation

The largest skarn bodies are developed at the immediate contact zone between the White Knob Limestone sequence and the Granite Porphyry intrusive dyke like stock. At this contact zone, the granite porphyry has stoped the hornfelsed and marbleized limestone sequence effectively ripping out blocks of varying size and tonnages. Furthermore, the interaction between the fractionated F rich volatiles of the granite porphyry and the partially assimilated and reactive blocks of hornfelsed wollastonite altered marbles has created a complex disseminated and metasomatic vein form skarn hosted base and precious metal mineralization which has been strongly influenced in its development by the previously discussed structural controls; especially 2nd and 3rd order shear planes and related zones of dilation. For the most part, prograde endo skarn mineral assemblages predominate with a substantially smaller overprint by later retrograde skarn minerals such as scapolite – chlorite – actinolite and epidote.

Plate 15: DDH S005 at 219 feet (66.57m) downhole. "Vein Form" metasomatic andradite (orange brown) – diopside (green) in the core of the "vein" margined by a wollastonite – Ca plagioclase and quartz selvedge, hosted within bleached and strongly silicified Granite Porphyry Breccia with polyphase stockwork quartz vein and veinlet development.

The prograde skarn mineralogy is in almost all cases dominated by the predominance of andradite garnet and diopside pyroxene with lesser hedenbergite. Grossular garnet, whilst significant in some areas of the deposit, is generally subordinate to andradite.

Chang noted that the disseminated type of skarn mineralization proceeded the vein style skarn mineralization. Whilst disseminated skarn alteration is widespread its development is generally weak, and the original igneous texture of the granite porphyry is preserved. The intensity of the disseminated skarn alteration does not diminish with distance from the veins. In contrast, the vein type alteration of the protolith is totally replaced by garnet + pyroxene or scapolite. Sometimes the garnet + pyroxene veins have wollastonite + pyroxene ± Ca rich plagioclase selvedges where the protolith is also totally replaced. Typically, these selvedges are narrow in relation to the width of the “veins”.

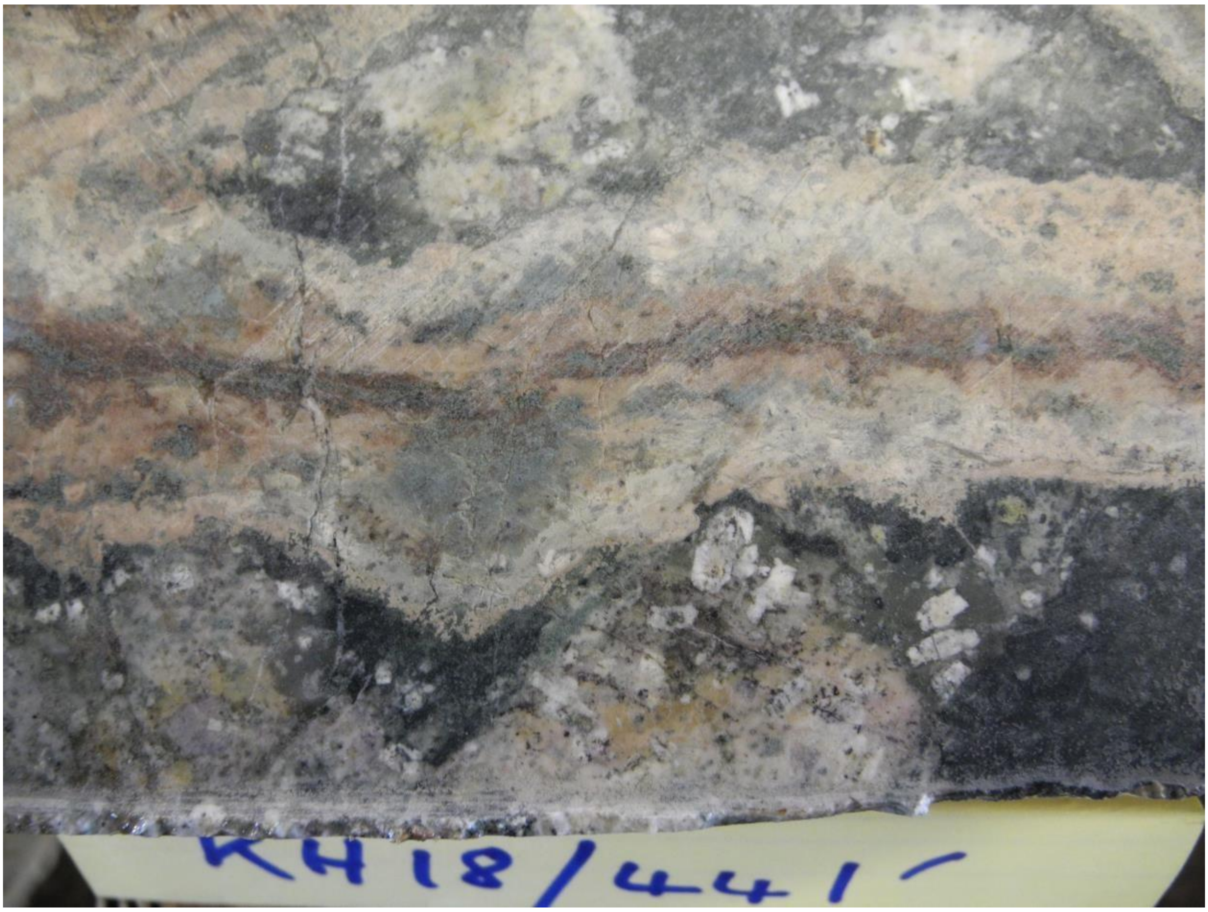

Plate 16: DDH KH 18 at 441 feet (134.06m) downhole. An irregular multi-phase skarn “vein” metasomatic replacement body hosted within the Granite Porphyry Breccia (GPB). Two generations of garnet skarn “vein” cut across each other with the darkest brown “vein” being the latest. The large selvedge to the vein comprises a replacement front of wollastonite + Ca Plagioclase and quartz with residual ferromagnesian minerals including scapolite and chlorite.

The disseminated skarn alteration in the Granite Porphyry is initially marked by alteration of the matrix groundmass to very fine-grained (diopsidic) pyroxene and titanite (sphene), whereas amphibole and biotite are slightly replaced by fine grained granular pyroxene and titanite. Plagioclase is slightly replaced by clay and minor very fine-grained pyroxene. Stronger disseminated skarn alteration occurs where fine grained actinolite appears in the assemblage (pyroxene + titanite) replacing the groundmass.

All primary amphibole in the granite porphyry is replaced by actinolite. With minor titanite and diopsidic pyroxene, K feldspar and plagioclase. Biotite is partially to wholly replaced pyroxene, titanite, K feldspar and plagioclase. Replacement of amphiboles and biotite is almost wholly pseudomorphic.

Prograde "vein" style endoskarn alteration is largely confined to the body of the granite porphyry. All of the granite porphyry exhibits disseminated skarn alteration / metasomatism whereas the granophyre is essentially fresh. Skarn "veins" cut all the different igneous textures inclusive of groundmass, phenocrysts and clasts. "Veins" vary in width form a few millimeters to centimeters. Occasionally "veins' can be very wide and enclose small blocks of residual granite porphyry which in some cases then resembles a matrix supported breccia.

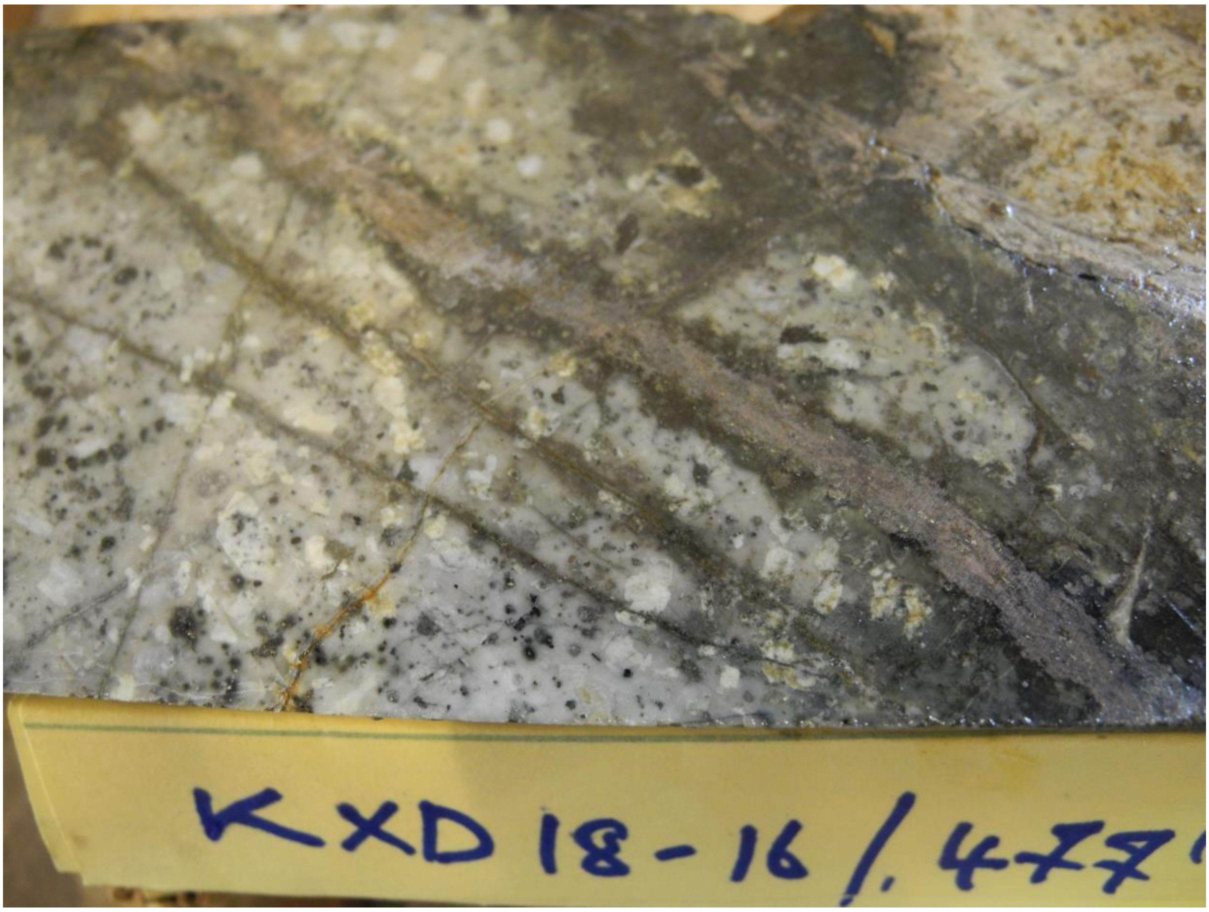

Plate 17: DDH KXD 18 – 16 at 477 feet (145m) downhole. A metasomatic endoskarn vein stockwork "vein" & "veinlet" system with the largest vein cored by pinkish brown andradite garnet. Note the irregular and embayed margins between the ore garnet and the yellowish green selvedge of scapolite which also has a ragged contact with the enclosing partially bleached and silicified GPB.

"Veins" typically have irregular shapes and ragged margins with some having branch "veinlets". The grain size within the veins varies from course at the center to fine at their margins. Many of the larger veins are zoned with an inner garnet dominated zone and a wollastonite dominated selvedge. Most of the veins exhibit alteration haloes; i.e. disseminated alteration minerals in the host rocks to the veins.

Maximum textural destruction occurs in the vein core with this diminishing towards the margins. Hence, the veins are clearly replacement features and not due to dilational fill.

The mineral assemblages observed in the endoskarn veins vary considerably but, nonetheless can be broadly categorized into three main types, as follows:

a) Scapolite ± pyroxene veins (cross cuts the whole rock);

b) Wollastonite + Ca-rich plagioclase + pyroxene veins;

c) Garnet and/or pyroxene veins and massive replacements:

    Garnet and/or pyroxene veins with wollastonite + Ca-rich plagioclase + pyroxene envelopes;

    Garnet and/or pyroxene veins without or with very narrow wollastonite + Ca rich plagioclase + pyroxene envelopes

Plate 18: DDH S016B at 372 feet (113.08m) downhole. Massive pinkish brown andradite endoskarn with residual ragged fragments of scapolite (?).

The most abundant veins are garnet and/or pyroxene veins, with the wollastonite + Ca-rich plagioclase + pyroxene veins as the second most abundant type. Scapolite veins are present in most of the rocks hosting vein-controlled alteration. However, the total volume is small because they are usually very narrow. The massive K-feldspar + pyroxene patches and quartz/fluorite veins with hedenbergitic halos are relatively rare. The quartz/fluorite veins are probably formed in the late retrograde stage.

Scapolite veins are the earliest. Wollastonite veins and garnet/pyroxene veins, with or without wollastonite envelopes, cut across scapolite veins. Although a few scapolite patches are present in the wollastonite envelopes of some garnet/pyroxene veins, they are probably remnants of the earlier scapolite alteration. Scapolite veinlets are present beyond rocks containing other veins, sometimes with dark green hedenbergite veinlets. Some of the scapolite veins are overprinted by green hedenbergitic pyroxene veinlets. These observations indicate that scapolite veins are the earliest vein type; Chang, 2003 and 2006.

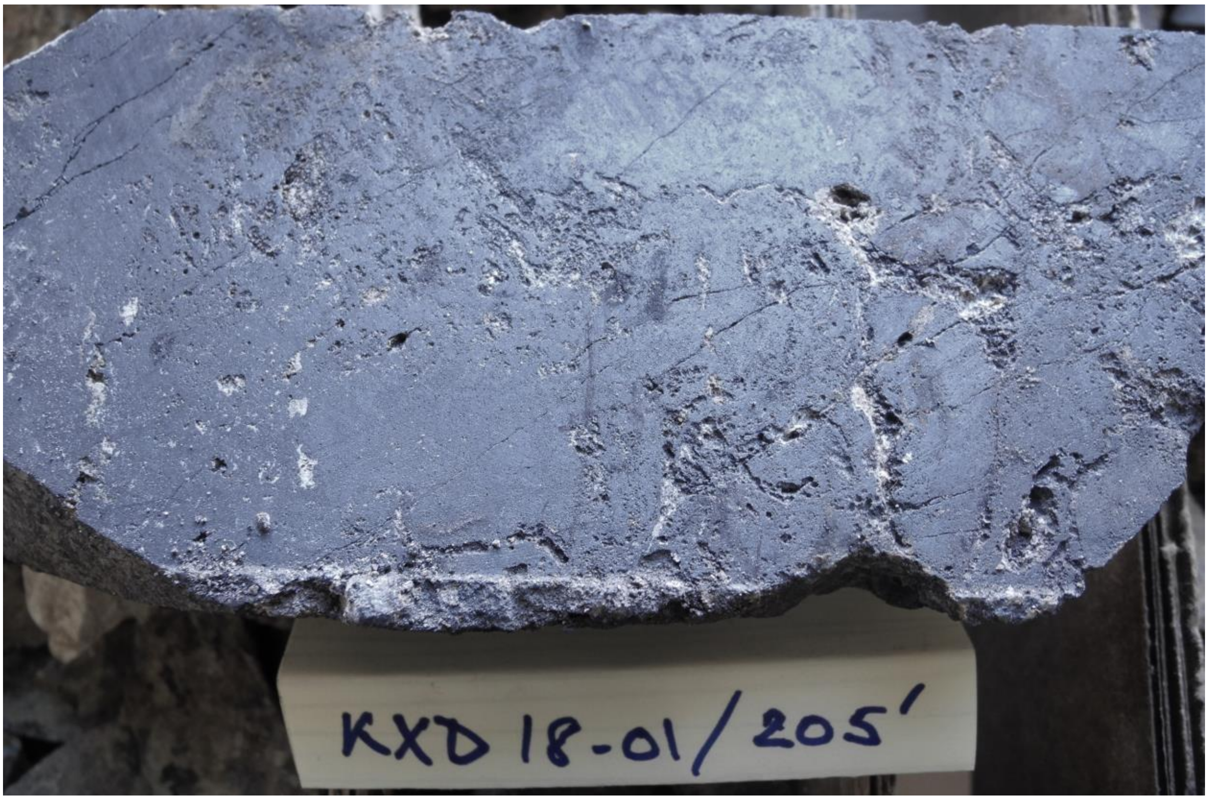

Plate 19: DDH KXD18 – 01 at 205 feet (62.32 m) Massive magnetite "skarn" replacement rock from a substantial body of this rock developed within the skarn system.

The mineral assemblage of wollastonite ± Ca-rich plagioclase ± pyroxene veins also occurs in the envelope of garnet/pyroxene veins and some wollastonite veinlets originate from the garnet/pyroxene vein envelopes. There are garnet/pyroxene veins crosscutting wollastonite-dominant veins, but the reverse has not been observed. These observations indicate that wollastonite-dominant veins, garnet/pyroxene veins, and the halos probably formed from the same fluid, with the wollastonite veins representing the distal front of the more proximal garnet/pyroxene veins; Chang, 2003.

All the garnet is pink-brown to dark brown in color and is of the andradite – grossular series. Regardless of vein width, garnet becomes more Fe-rich towards vein center, whereas towards vein margin the garnet becomes increasingly Al-rich. When the veins are narrow, the garnet is mostly Al-rich. In wider veins, Fe-rich garnet occurs in the vein center whereas garnet in the vein margin is still Al-rich. When endoskarn becomes massive, all the garnet is Fe-rich.

All the pyroxenes in endoskarns belong to the diopside-hedenbergite series. The content of the Mn end member, johannsenite, is 0.3%-7.6%, mostly <3%. The color changes from light greyish green to dark green.

6.4 Magnetite Skarns

Magnetite occurs as massive blocks, box works and veins in endoskarn and exoskarn, and sometimes as stripes/bands interlayering with skarn. This spatial relationship indicates that magnetite is later than skarn. Approximately three massive bodies of magnetite replacement skarn occur along the strike of the Empire skarn – granite porphyry system, with each extending over several hundred meters of strike and tens of meter in width. An example of this type of magnetite is shown on Plate 19 above

6.5 Retrograde Skarn

Retrograde skarn alteration is surprisingly limited at the Empire Mine with light yellow talc replacing diopsidic pyroxene and minor chlorite and epidote partially replacing garnet and pyroxene is scattered locations. The following personal communication from KRI Chief Geologist, Nathan Bishop, is regarded as significant in respect of retrograde skarn alteration: “It is my opinion that the oxidation of an exhumed sulfide system may be the most compelling reason why retrograde skarn alteration is poorly represented at this time in the Empire Ore System. The oxidation process produces intense textural destruction that is not present in other un-oxidized and un-exploited systems”, Furthermore, Mr. Bishop adds: “While relogging of core from the AP pit, the best explanation for some of the behaviors (mineralogy?) of rock was that it was retrograde altered from a garnet skarn to an amphibole dominated skarn with abundant sulfides. Subsequently, the sulfides were exposed to oxidizing meteoric waters. The oxidation of the rock destroyed the original mineralogical composition of the rock leaving little more than a mess of red, orange, brown, and black rock. This line of thinking helps me to understand the evolution of the term "Iron Oxide Breccia" here”.

7.0 Mineralisation

The mineralization has been split into three main groupings for the purpose of technical discussion. These three groupings are as follows:

- Oxide Ore
- Disseminated Sulphide Ore
- Semi Massive to Massive Sulphide Ore

Owing to the previous and current focus of exploration being the oxide ore, centered on the AP Open Pit area, geological knowledge of this ore type is the best studied and understood based on the density of information provided by core and RC percussion drilling together with surface geologic mapping and sampling in the shallow historic AP pit. Whilst much of the ore produced at the Empire Mine between 1901 and 1936, when mine production seriously declined, has been a mix of upper level high grade oxide ores with lower level sulphide ores, the accurate geological documentation of these ore types was never undertaken by the various operating companies. Indeed, the existing geological maps, of which Figure 7 above is an example, were mapped between 1923 and 1932 mainly by ASARCO with a small amount of additional underground mapping being undertaken between 1942 and 1944 by the US Dept of the Interior – Geological Survey; Farwell and Full; 1944.

Plate 20: PGM’s refurbishment of the first 50 meters of the historic 700 level in the Empire Mine during 2018

With PGM’s focus being the advancement of the surficial oxide ore body centered on the historic AP pit to early production by calendar 2021, the bulk of the exploration and evaluation drilling has, of necessity, focused on this area with the objective of completing a Bankable Feasibility Study (BFS) by 2020 and proceeding to a Decision to Mine (DTM) during the same year. The oxide ore this area is deeply weathered with oxide ores persisting to – 250 feet (- 80m) below surface. Hence, very little data has been gathered in the drilling of the subjacent sulphide ores as intersections are typically sporadic and relatively widely spaced. Only recently has PGM targeted selected sulphide targets on the larger Empire ore system beneath and immediately along the strike of the AP pit area. Nonetheless, as the following technical discussion will demonstrate, substantial sulphide ore potential exists within the overall Empire mineralized system below the Base of Surface Oxidation (BOSO).

PGM is fully aware of the longer-term sulphide ore potential at Empire and is currently refurbishing key historic adits to re – access the deeper level old mine workings on the 700 and 1100 levels, and ultimately the 1600 level; as shown on Plate 15 below. Once access at these levels has been achieved, PGM can undertake systematic geologic mapping, channel sampling and create drill cuddies designed to drill the sulphide ore bodies from the levels thus saving substantially on costs over and above the cost of surface drilling.

7.1 The Oxide Mineralisation

Oxide Cu – Au – Ag and Zn ores exist along the entire geologic strike of the Empire Skarn – Granite Porphyry Mineralized System of at least 5 kilometers of geologic strike and according to PGM this extends for 8 km. However, as stated above, the focus of the exploration effort since the 1980's until today has been centered on the historic AP open pit area, where the following NI 43 – 101 "Measured" and "Indicated" (M&I) ore resource of 11.485 million tonnes at average grade of 0.52% Cu, 0.14% Zn, 0.007 oz/t (0.22 g/t Au) and 0.31 oz /t (9.64 g/t) Ag, with additional "Inferred" category resources of 9.88 million tonnes at 0.41% Cu, 0.13% Zn, 0.009 oz / t (0.24 g/t) Au and 0.29 oz / t (9.5 g/t) Ag, was released on November 11th, 2017 by Hard Rock Consulting LLC, of Lakewood, Colorado, USA.

Oxide mineralization includes at and near surface widespread chrysocolla, a hydrated copper silicate which forms a footprint substantially larger than the actual mineralization due to the geochemical mobility of copper in the vadose oxide, and the main copper ore minerals malachite, azurite, antlerite, brochantite, cuprite with trace native copper.

The copper oxide mineralization, especially to the north of the historic AP pit, extends over some 1,200 m of strike along the granite porphyry – skarn – White Knob limestone sequence contact zone. The width of the oxide copper mineralized zone varies from a low 6m to as much as 73m and to a depth in the AP pit area of some 130 m below surface. The exposed width of the mineralized zone is to some degree a function of topography.

At surface the skarn is exposed along a steeply easterly inclined north trending ridge crest, with the northernmost outcrop being 255m lower in elevation than the southernmost exposure in the AP pit; i.e., 2,425m above mean sea level ("amsl"). The deepest mineralized drill hole intercept at the northern end of the skarn body in hole S039 lies at 2,319m asml or 126 m below surface.

Figure 11 above shows the depth of oxidation beneath the surface. However, this generalized does not reflect the detailed picture which is complicated by various structural and lithological features of the ore deposit. The most important of these are late faults with associated gouge affording deep ingress of meteoric waters into the ore system.

Other features which facilitate an increase in the depth of oxidation include the semi – massive to massive sulphide (including the very readily oxidised sulphide pyrrhotite) ore shoots where sulphide contents run as high as 70 – 80% over narrow zones of 1 to 2 meters and maybe more and mineralized shear zones developed within vein form skarns. In any case, in detail the base of surface oxidation is highly irregular with some oxidation penetrating deeply into the sulphide zone. Furthermore, residual high copper sulphide species comprising the assemblage chalcocite (djurleite – digenite), covellite and bornite are present as irregularly shaped “raisins and plumbs in oxide cake” increasing in number and size as the base of surface oxidation (BOSO) is approached. These residual sulphide zones occur as much as 20 m above the BOSO. The chalcocite – tenorite becomes difficult to see as it oxidizes to a deep red type of hematite which masks the sooty black tenorite and dull grey chalcocite.

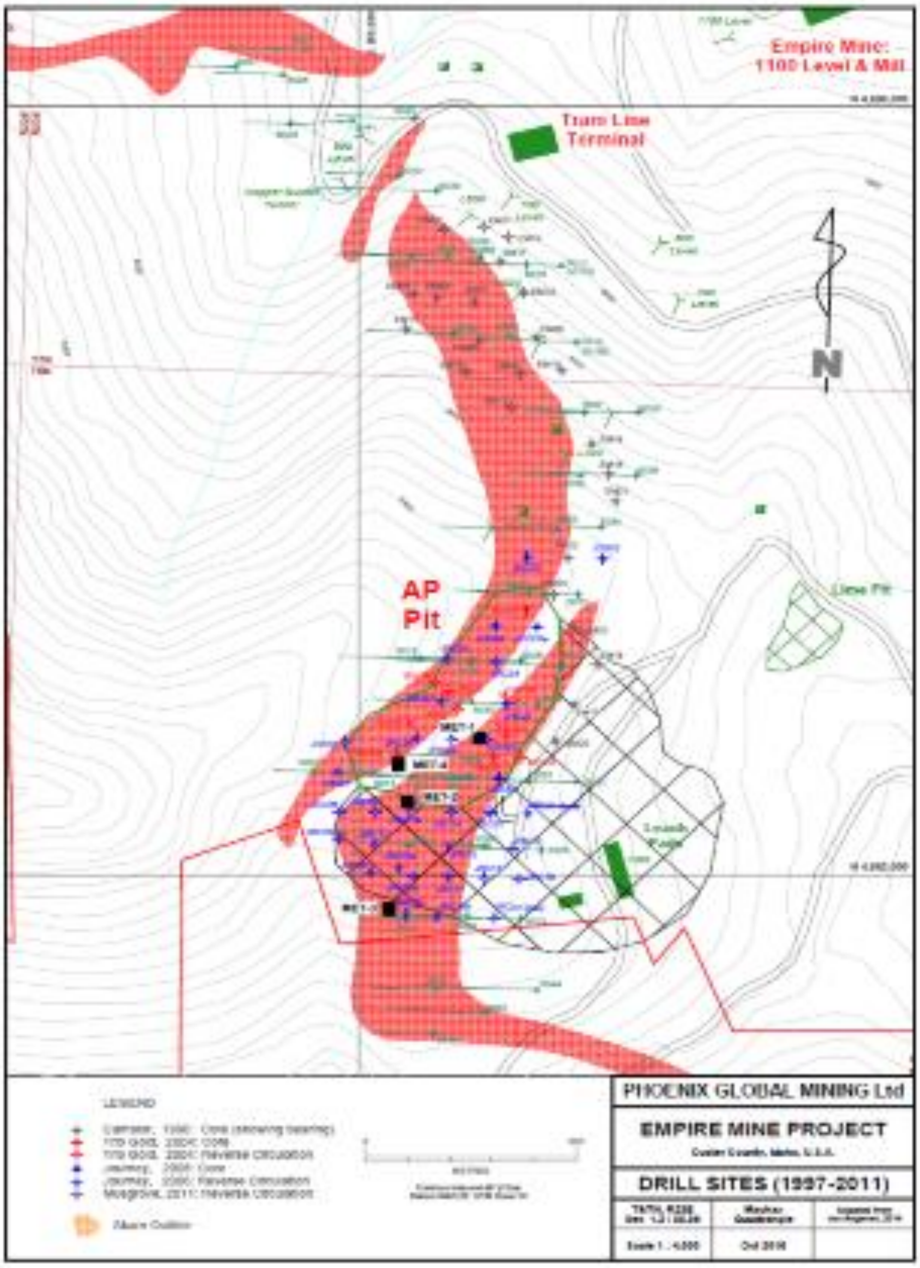

Figure 12: A Summary Map of the Location of Drill Sites over and in proximity to the AP open pit area which will comprise the initial oxide ore resource and proposed open pit mining project. It is worth comparing this map with that of the underground workings on Figure 7 above. The structural and lithologic control on the mineralization is clearly apparent.

Plate 21: DDH KXD 18 – 12 at downhole depth 272 – 284.5 feet (82.68 to 86.49m). Deep and thorough oxidation (FeOx plus clays) of endoskarn hosted copper ore showing the poor RQD and friable nature of the oxidised rock.

The writer feels sections showing the predominance of important secondary oxide copper minerals would be useful as well as documentation of the occurrence of residual copper sulphide mineral. Due the marked impact of tectonic features in the Empire Mine system, it seems highly likely that a well-defined supergene enriched chalcocite blanket was formed over a width of some 20 m but was subsequently faulted and fractured permitting deep ingress of oxidised ground waters and modification of the chalcocite blanket such that it effectively disaggregated into a zone of residual "islands" of semi – preserved sulphides mixed with oxide minerals. Hence, a mixed oxide – sulphide zone sitting above the unweathered protolith marks the former site a coherent chalcocite blanket. This probability needs to be addressed as its documentation will impact upon the manner in which the ore is mined for subsequent metallurgical treatment.

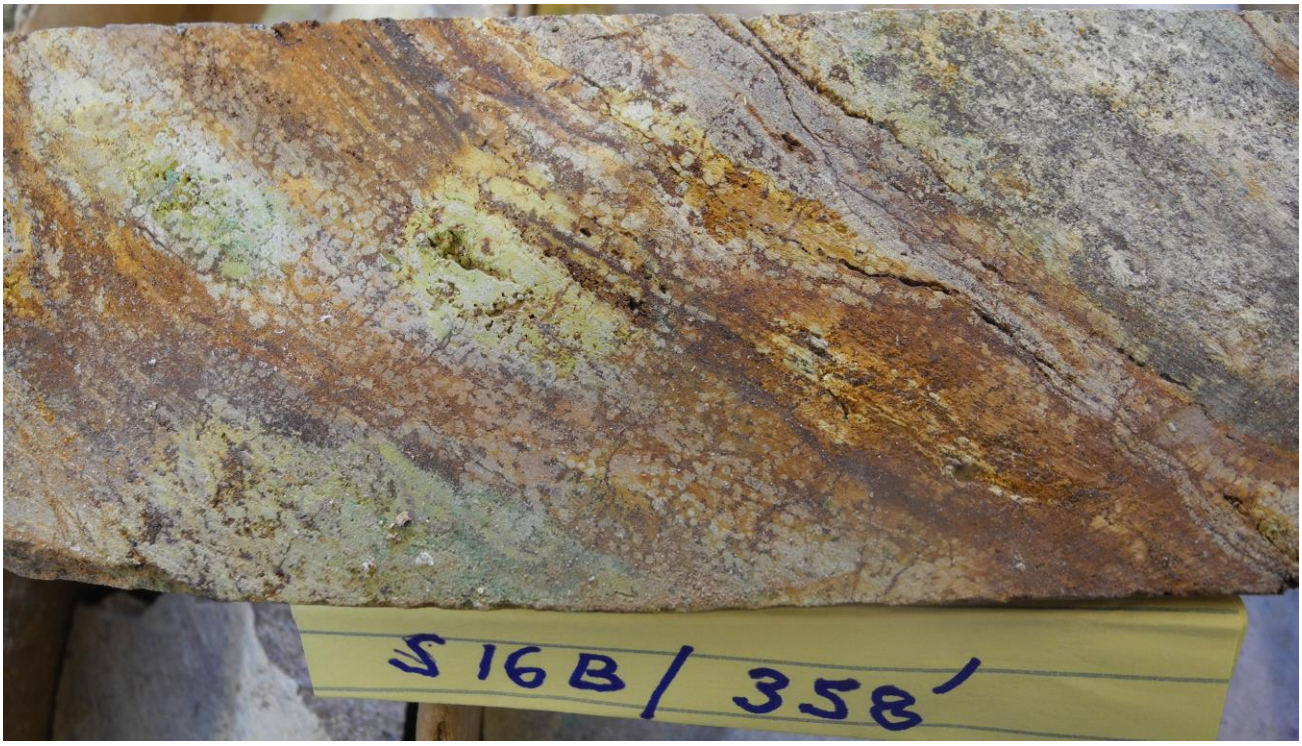

Plate 22: DDH S016B at 358 feet (108.83m) downhole. Partially to near completely oxidised "vein" type endoskarn hosted mineralization with thin semi – massive sulphide veinlets replaced by limonite – goethite oxyhydroxides.

7.2 Sulfide Mineralisation

The high-grade Cu – Au – Ag mineralization appears to occur as structurally controlled semi massive to massive sulphides replacement bodies associated with quartz – calcite vein / veinlet ± chlorite development attended by minor epidote and chlorite alteration of the prograde skarn assemblage. The typical sulphide mineral assemblage comprises magnetite, chalcopyrite, sphalerite, and minor molybdenite, native gold, pyrite, hematite, galena and arsenopyrite. From the various drill hole intercepts made in the sulphide ore, especially the most recent and better geologically documented drill holes completed by KRI, the mineralization can be seen to present in two economic and geologic distinct domains. However, these require further thorough documentation. The three main types of ore can be defined as follows:

a) The "**Broadly Disseminated Type"**: which is largely concentrated in the endoskarn either in massive or vein style skarn bodies. In economic terms, the writer has applied a simplistic cut off to examine the distribution of these bodies. However, this approach is hampered to a degree by the lack of surface drill hole data on the sulphide ore below the proposed AP open pit oxide ore resource. The bulk of the broadly disseminated mineralization developed throughout the partially skarn metasomatized granite porphyry can be regarded as uneconomic as overall copper grades lie below or significantly below 0.4 % Cu.

b) The **"Focused Disseminated Type":** The writer strongly suspects this ore type should take precedence as the main target of underground based and surface exploration once the BFS for the oxide open pit mine has been completed. Mineralisation in this ore type appears to be developed is close association with the highly focused high – grade ore bodies which were mined at the Empire Mine between 1901 and 1944 when the mine closed.

The key structural control appears to be the interplay between structural geology and lithology; i.e., the NE transpressive 2nd order shears and 3rd order dilational to transpressive structures developed within the otherwise mechanically competent but volatile enriched cooling Granite Porphyry Breccia intrusive (GPB).

Near the contact with the White Knob Limestone (WKL) sequence, the intrusion of the clast and crowded feldspar Granite Porphyry Breccia would have been as a highly viscous melt resulting is extensive "aggressive" stoping on its eastern flank against the mechanically weak highly reactive and brittle White Knob Limestone sequence, rather than on its western flank with the mechanically very strong and unreactive MGC. Xenoliths of varying size from tens to hundreds of thousands of tonnes of WKL rock would populate the immediate western contact zone of the GPB.

Subsequent high-level phase separation of the F enriched volatiles, marked by the widespread development of UST's, miarolitic cavities, development of grey globular quartz with ubiquitous vermiform texture, massive aphanitic quartz and stockwork quartz veins / veinlets, usually developed in an apical position within the intrusive stock, testify to the high level of emplacement of the GPB and to tectonically unstable seismicity triggered, and frequent, pulsed fluid boiling at this crustal level.

In response to the large scale and chemically virulent and highly reactive eutectic depressive nature of the late stage hydrothermal processes, dominated by F, the dissolution and redistribution of bulk chemistry within the GPB and its eastern contact zone would have been the major operating process. Hence endoskarn morphology was radically different in its development when one compares the Empire Mine to that of the world's largest polymetallic skarn deposit at Antamina, Ancash Province, Peru, which is directly associated with a substantial porphyry copper system;

In the Empire ore system, the larger xenoliths were metasomatically altered by prograde, massive, high temperature (700° - 750°C from fluid inclusion studies; Chang, 2003) andradite (garnet) – diopside (pyroxene) endoskarn with lesser remnant wollastonite and Ca plagioclase, calcite and quartz. Early pyrite – pyrrhotite – chalcopyrite – (sphalerite) and ((galena)) + precious metals mineralization would have been deposited in this phase. However, grades would have been modest with copper mineralization in the range 0.4 – 2.0% but averaging between 0.6 – 1.5% / tonne. However, mineralized widths vary from several up to at least 15 meters true width; as suggested downhole widths intersected in Table 1 below indicate. Hence, overall tonnages in these bodies could be cumulatively substantial.

Examination of the detailed intercepts that comprise the ore resource of the AP oxide ore bodies indicates that all the key economic elements, Cu, Zn, Au and Ag have an apparently confusing relationship with one another. Normally, for example, with their similar geochemistry gold and copper demonstrate a good correlation coefficient. However, as Table 2 demonstrates, this is only sometimes the case in the Empire skarn mineralized system. For example, hole EM 11 – 23 demonstrates an apparently good correlation between Cu, Au and Ag, but contrast this hole with KX 18 – 54.

Table 4: Mineralized intercepts largely from the AP Open Pit zone. Highlighted zones are above 2% Cu, 1 g/t Au and 60 g/t Ag in Yellow, and 3% Cu, 2 g/t Au and 100 g/t Ag in Orange, finally above 3% Cu, 3 g/t Au and 150 g/t Ag in Pink. Intersection from and to is given in Feet but intersection widths are also provided in feet and meters. The mix of Oxides and Sulphides indicates that remnant sulphides are present in the oxide mineralization above the base of surface oxidation.

Hole No	om – To Feet (m)	Width Feet Downhole (m)	Cu %	Au g/t	Ag g/t	Comment
I 11- 09	125 - 150	25 (7.6m)	1.22%	0.14	20.70	Oxide
I 11 - 16	220 - 235	15 (4.56m)	1.84%	0.76	33.77	Oxide (suls)
I 11 - 17	225 - 255	30 (9.12m)	1.14%	0.21	10.08	(Ox + suls)
I 11 - 23	280 - 320	40 (12.16m)	1.54%	1.11	46.90	(Ox + suls)
I 11 - 23	335 - 385	50 (15.20m)	1.20%	1.50	107.10	(Ox + suls)
D03	40 - 85	45 (13.68m)	1.34%	1.79	48.33	Oxide
D05a	100 - 140	40 (12.16m)	1.43%	0.41	31.00	Oxide
D05a	185 - 205	20 (6.08m)	1.09%	0.24	45.75	Oxide (suls)
C02a	75 - 155	30 (24.32m)	0.71%	0.50	12.00	Oxide
C11	80 - 210	30 (39.52m)	1.66%	0.08	37.18	Oxide (suls)
C14	40 - 75	35 (10.64m)	1.01%	1.12	21.69	Oxide
C15	60 - 135	75 (23.55m)	1.28%	0.06	35.53	Oxide
	135 - 235	00 (30.40m)	0.96%	0.30	30.12	Oxide
- 03	25 - 110	35 (25.84m)	0.35%	1.42	8.18	Oxide
- 06	55 - 135	30 (24.32m)	2.10%	Not Assayed	Not Assayed	Oxide
- 13	100 - 145	45 (13.68m)	1.21%	Not Assayed	Not Assayed	Oxide
- 19	175 - 210	35 (10.64m)	1.60%	Not Assayed	Not Assayed	Oxide (Suls)
02	11.5 – 261.5	50 (15.20m)	0.04%	1.22	1.45	Oxide (Suls)
05	82 - 150	68 (20.67m)	0.79%	0.30	18.37	Oxide
05	185 - 298	13 (34.35m)	1.45%	0.56	52.23	Oxide (Suls)
06B	172 - 185	13 (3.95m)	5.15%	1.15	69.50	Oxide (suls)
07	214 - 242	9.5 (5.93m)	2.51%	0.57	52.65	Oxide (suls)
12	326 - 341	15 (4.56m)	1.83%	1.89	102.97	(Oxide) Suls
12	360 - 400	40 (12.16m)	1.17%	1.16	48.26	(Oxide) Suls
12	504 - 516	12 (3.65m)	1.51%	5.91	48.37	Suls
13	212 - 232	20 (6.08m)	1.03%	0.11	19.18	Oxide
14	14 - 78	64 (19.46m)	1.06%	0.30	27.52	Oxide
18	437 - 502	65 (19.76m)	0.80%	0.98	11.62	Oxide + Suls
33	96 - 111	15 (4.56m)	0.35%	98.23	12.00	Oxide
34	255 - 304	49 (14.90m)	1.40%	1.21	60.75	Oxide + Suls
35	65 - 91	26 (7.90m)	1.33%	0.63	27.70	Oxide
C04 - 02	0 - 40	40 (12.16m)	0.96%	0.07	55.94	Oxide
C04 - 03	95 - 205	10 (33.44m)	0.33%	2.09	4.39	Oxide
C04 - 06	0 - 40	40 (12.16m)	3.67%	0.26	104.76	Oxide
C04 - 06	80 - 195	15 (34.96m)	1.41%	0.12	33.75	Oxide
17 - 2	45 – 95	50 (15.20m)	0.69%	0.24	10.22	Oxide
17 - 3	55 - 75	20 (6.08m)	1.65%	0.16	79.08	Oxide
17 - 7	95 - 115	20 (6.08m)	1.10%	0.07	30.04	Oxide
17 - 11	60 - 90	30 (9.12m)	1.57%	0.04	55.20	Oxide
17 - 16	145 - 165	20 (6.08m)	2.10%	3.83	132.03	Oxide
D17 - 2	25 - 130	05 (31.92m)	0.97%	0.18	29.47	Oxide
D 17 - 3	60 - 85	25 (7.60m)	0.76%	0.17	28.20	Oxide

D17 - 3	130 - 165	35 (10.64m)	1.30%	2.12	68.18	Oxide
D17 - 3	175 - 230	55 (16.72m)	1.74%	1.25	41.41	Oxide (Suls)
D17 - 4	0 - 50	50 (15.20m)	1.00%	0.06	9.73	Oxide
D 17 - 4	145 - 250	05 (31.92m)	0.75%	0.20	18.08	Oxide (Suls)
D17 - 5	5 - 30	25 (7.60m)	1.03%	0.73	55.30	Oxide
D17 - 5	55 - 97	22 (6.69m)	1.96%	0.28	95.30	Oxide
18 - 33	60 - 85	25 (7.60m)	1.32%	0.10	14.60	Oxide
18 - 34	155 - 175	20 (6.08m)	1.25%	0.46	13.90	Oxide
18 - 34	225 - 245	20 (6.08m)	1.82%	0.41	44.08	Oxide (suls)
18 - 39	20 - 45	25 (7.60m)	0.31%	1.10	20.02	Oxide
18 - 44	545 - 575	30 (9.12m)	3.62%	1.46	86.33	Suls
18 - 47	25 - 45	20 (6.08m)	0.85%	2.16	43.35	Oxide
18 - 47	195 - 240	45 (13.68m)	1.06%	1.08	31.67	Oxide (suls)
18 - 52	340 - 400	60 (18.24m)	1.25%	0.22	18.21	Oxide (suls)
18 - 54	35 - 105	70 (21.28m)	0.12%	5.24	5.99	Oxide
18 - 55	55 - 90	45 (13.68m)	0.19%	0.08	287.97	Oxide
D18 - 10	66.5 - 105	3.5 (11.70m)	2.61%	1.03	48.68	Oxide

Further examples such as KX 18 – 54 include the extreme example of S033 and a more normal S002. In all these examples, gold displays virtually no correlation with copper or silver whatsoever. Indeed, the realization that gold dominated intercepts in the Empire skarn system clearly exist raises the issue of significant gold bearing structures which would have been completely overlooked by the underground miners, between 1901 and 1944, who relied solely on visual grade estimates above a threshold of 2% for copper.

One of the most remarkable intercepts, besides that of S033, is KXD 18 – 55 which intersected 45 feet (13.68m) from 55 feet downhole of 287.97 g/t Ag with only 0.19% Cu and 0.08 g/t Au. This radical departure from correlation with Au and Cu suggests at least two or three different mineralizing events plus, perhaps, the influence of supergene processes in the upper oxide zone. Silver is more mobile than gold in the supergene zone and would been prone to remobilization and redeposition within the complex lower oxide profile where residual sulphides are preserved. However, the KXD 18 – 55 intercept is shallow, and this suggest that silver may be present as supergene native silver particles within certain suitable locations within the upper oxide profile. The intersection in S033 is also relatively high within the oxide profile and suggest supergene influence given the unusually high mean assay value of 98 g/t Au over 4.5m for this intercept, and it seems likely that secondary native gold have been deposited in within this zone as well.

Regardless of the possible effects of supergene processes, the distribution of Cu, Au and Ag show, at best, a modest to sometimes poor correlation with each other, with silver demonstrating the closer association. This suggest that the timing of peak mineralization for each element was different with gold being later than copper.

Most importantly, Table 2, which lists only some of the intersections made during the drilling in and around the historic AP pit oxide copper resource, illustrates the scope for mining higher grade ore bodies over widths of between 5 to 20 meters employing trackless mining and lower cost, mass mining, techniques such as long-hole stoping in exploitation of the combined medium and high grade ores. Although most of the intersections made lie within the current open pit oxide resource, some have been made in protolith sulphide ore underneath this resource; most recently by KRI (PGM).

All data is supportive of their being discrete bulk mineable ore shoots in the Empire system which should be developed along the entire 5 to 8 km strike of the known Granite Porphyry – Skarn contact zone. Given the evidence from the historic mine workings and drilling data these bodies are likely to vary in size from a few tens of thousands of tonnes to several hundred of thousand tonnes in the larger shoots. The ore grades are likely to fall within the ranges indicated by the intersections listed on Table 2.

Finally, a word on the high-grade ore shoots and their controls and characteristics as deduced from historic mine plans and recent RC percussion drilling by KRI during 2017 and 2018.

a) **"Structurally Focused High – Grade Ore Shoots"**: These were the prime target of mining between 1901 and 1944 and were mined, as already stated, on a visual 2% Cu cut off (6% chalcopyrite). Apart from the work undertaken by ASARCO and ISARCO (a related company) with a minor contribution by the US Dept of the Interior, Geological Survey, no systematic geologic mapping of the various rock types associated with the mineralization or, indeed, of the actual nature of the mineralization itself; i.e., did it comprise disseminated, semi massive sulphide ore or actual massive sulphide ore? What minerals comprised the high-grade ores? What was their actual morphology and geometry? Did they exhibit structural controls and what were these?

   So, all the above questions remain to be answered.

   The writer has drawn his conclusions based on ASARCO's maps in Farwell's and Full's 1944 Report, much of which has been addressed under the previous section dealing with structural geology. From this, the control over the morphology of the high-grade ore shoots appears to have been the interplay between the contact skarn development, which dips east at a moderate angle in the AP pit area, and the NE striking, moderately NW and SE dipping as shown on Figure 8 above. However, these two components only serve to explain the twisted shape of the ore shoots along NE striking contacts with granite porphyry dykes and NE structures devoid of late intrusive bodies and along the exoskarn / endoskarn-granite porphyry contact zone, but there are tertiary structures developed in response to the shearing along the NE structures. These cause the ore shoots to develop off into the hanging wall of the southward dipping structures, thus further complexing an already complex ore shoot geometry in which the high-grade ore body pitch is determined by the intersection of the shear / fault planes and the moderate eastward dip of the skarn – porphyry contact.

   Evidence from RC chips drilled into the high-grade sulphide ore by KRI suggests this occurs as semi – massive to massive sulphide veins and veinlets together with a grey and glassy vein quartz with possible calcite. The bulk of the sulphide comprises pyrrhotite > pyrite > chalcopyrite with minor quantities of sphalerite and arsenopyrite. Ore grades in this type of ore range from 3% - 15% Cu with a mined average over life of mine of between 6% and 7%, with overall grades dependent upon the proportion of massive sulphide to gangue within any ore shoot.

   From the large number of drill hole intercepts which have intersected high grade ore (mostly in the heavily oxidised zone), the contact between high grade and medium grade disseminated ore, described above, appears to have, in almost all cases, been very sharp and distinct permitting the historic miners to have readily defined the margins to the high-grade ore shoots. Indeed, if the RC chips are any indication, the ore types are visually very distinct from one another in terms of mineralogy, color and texture.

During 1942 – 1943, the mine encountered localized high grade tungsten in these high grade ores with grab samples with the high grade copper + gold + silver ore on the 1000' level of the underground mine, where 50 ton car assays returned values of WO_3 between 2.1% and a selection of grab samples averaging 4.3% WO_3, which is extraordinarily high for a skarn deposit and is more characteristic of tungsten skarn deposits such as: Pine Creek, California; Salau, in the French Central Pyrenees and CANTUNG in British Columbia, Canada.

At both Salau and CANTUNG, high grade scheelite mineralization occurs within massive pyrrhotite replacement veins containing medium grained to coarse grained Mo rich scheelite (powellite) with 1% Cu as chalcopyrite and subordinate arsenopyrite and minor disseminated boulangerite – jamesonite (bismuth sulfosalts); with the later closely associated with medium to high grade (5 to 20 g/t Au) gold mineralization. KRI have followed up this occurrence in the records and discovered that the occurrence appears to have been isolated. However, this is discussed in the overall conclusions in the context of the evidence, already discussed, that the granite porphyry as exposed in the drill core exhibits many of the characteristics and textures of the upper cupola of a porphyry molybdenum – tungsten system.

8 Conclusions

The writer re – iterates that he has relied upon KRI and PGM reports including Ore Resource studies by Hard Rock, relatively recent published technical work (from the internet) such as Dr Zhaoshan Chang's PhD Thesis (2003) and technical papers co – authored with Dr Lawrence Meinert and Dr Chang (2007 and 2008), and finally the USGS Report of 1944 by Farwell & Full. Other technical work has been cited in the Bibliography relevant to the mineralization of the Empire ore system. During his recent on-site 5-day core examination with the kind assistance of KRI Chief Geologist, Nathan Bishop, the writer was able to review key ore types and intercepts and review textures and structures in ore and host rocks.

As much of the exploration and evaluation drilling has been within the largely intensely oxidised oxide copper – gold – silver mineralization, some geologic features have been partially obliterated or masked, especially in sulphide mineralized material which when oxidised accelerates rock decomposition; as illustrated on Plate 21 above. Furthermore, as described above, the detailed geology of the Empire skarn – ore system is complex where interpreted geology is often equivocal and has to be based upon broader overall geologic features. Hence accurate geologic modelling in the oxide resource has been difficult and modelling of ore envelopes has relied upon interpretation of assay data and, moreover, geostatistical based analysis of this data rather than geology. Often the key to unlocking understanding of the oxidised ore geology comes through drilling within the subjacent protolith where key structures and textures are preserved and inter – relationships become more readily apparent.

From the core reviewed, and as stated in the Geologic Review Section above, there seems little doubt that the Empire Ore System (EOS) is related to fractionated and large porphyry scale events which have been structurally focused along the eastern margin of the Mackay Granitoid Complex (MGC) with the host Carboniferous, Lower Mississippian age, White Knob Limestone sequence. A major ENE striking, dextral, transpressional structural “corridor” brackets the Empire deposit. It seems probable that movements along this structure created a “pull apart” extensional zone orientated N – S exploiting the eastern margin of the MGC as a plane of profound lithologic contrast and weakness. This pull apart facilitated the intrusion of the granite porphyry breccia (GPB) along the entire eastern contact zone of the MGC extending over at least 8 to 10 km as a large dyke like stock up to 500 – 600 m in width. Sequential opening along this structure during the Eocene period facilitated fractionation via pulsed seismicity within the parent subjacent magma chamber which is source for the GPB. Within the upper 300 m of the exposed GPB the latter exhibits many key geologic and geochemical features, which in combination comprise the signature of the high structural level porphyry Mo – W system. Despite these being described in the foregoing geologic section, these facts seem worth re- iterating here, as follows:

a) unusually high fluorine content of both the granophyre and GPB intrusive’s. In the latter, as documented by Chang (2003), there is widespread development of highly unusual globular dark grey glassy quartz varying between 5mm to 1cm in diameter exhibiting ubiquitous vermiform intergrowths with ground mass plagioclase and K feldspar. These unusual quartz crystals with their vermiform intergrowths testify to the phase separation in the GPB melt of a F rich volatile phase;

b) ubiquitous presence of miarolitic purple fluorite filled cavities in the granophyre;
c) miarolitic garnet – quartz – carbonate filled cavities in the GPB;

d) strong development over 6 to 7 m wide zones of UST’s in the GPB in a texture and granitic porphyry almost identical to the Questa molybdenum porphyry deposit in New Mexico, USA; Gaynor, Rosera and Coleman; GEOSPHERE, January 2019;

e) strong K- feldspar alteration and highly siliceous aphanitic groundmass texture in the GPB;

f) presence of vein / veinlet hosted molybdenite especially lower within the EOS / GPB and localized high grade scheelite mineralization on the historic mine’s 1000 level;

g) elevated tungsten geochemistry in the deeper drill holes; and,

h) intrusion of a swarm of late quartz latite dykes along the NE structures.

Furthermore, the fact that the GPB contains abundant granophyre clasts supports the view that these two intrusive bodies were very closely related in both time and space.

All of the above unusual textures are typically developed in the cupola of porphyry stocks in Cu – Au, Cu – Mo, Mo – W and Sn porphyry mineralized systems. Given the overall geochemistry of the EOS and the texture and geochemistry of the GPB, the writer favors a porphyry Mo – W type system with a Cu – Mo system as a second possibility. Furthermore, given the unusual strike extent of the EOS, the subjacent porphyry deposit would most likely comprise a cluster system developed over the N – S geologic strike. Examples of structurally controlled porphyry cluster systems include: Chuquicamata, Chile developed over 17 km of geologic strike (N – S) with 7 porphyry ore systems; Oyu Tolgoi, Mongolia developed over 18 km of strike (NE) with five porphyry ore systems; El Teniente, Chile developed over 12 km of strike (N – S) with six porphyry ore systems. Therefore, the EOS would not comprise anything unusual in this regard. Nigel – I would like to see a summary of the key porphyry elements presented in the Executive summary.

The development of the GPB – skarn ore system at Empire was further facilitated by a close spaced system of 2nd order, NE striking and largely moderately SE dipping, shears. As previously stated, the interplay between these structures and the GPB – White Knob Limestone sequence contact zone controlled the emplacement of the mineralized skarn and the geometry of the ore shoots. The development 4th order localized shears off the 3rd order structures added an extra element of ore control and complexity to the geometry of ore shoots.

The intrusion of the crowded GBP containing 40 – 50 vol% plagioclase crystals and granophyre clasts in a silica dominated viscous melt would have resulted in aggressive stoping of the brittle and highly reactive marbleized White Knob Limestone sequence on the eastern flank of the GPB, with varying sized blocks spalling off into the GPB melt. Away from the zone of country rock spalling, stoping and partial to complete assimilation / metasomatism, a rear zone of remobilized material driven by abnormally high Ca^{2+} and high P^{CO2} plus F rich volatiles created a veritable stockwork of grandite – pyroxene – Ca plagioclase – scapolite skarnoid replacement veins and veinlets effectively forming a type of unusual "crackle reaction breccia" behind the main endoskarn front into which later copper – iron dominated sulphide mineralization was superimposed with subordinate precious metals mineralization, and with base metals, primarily zinc, focused in the periphery of the structurally and lithologically focused main fluid ingress zones; i.e., in the exoskarns and peripheral endoskarn.

The development of the wollastonite hornfels metamorphic / metasomatic front on the eastern flank of the GPB served to seal the flow of ore fluids forming an effective "dam wall" against which ore fluids were ponded, except along NE shears which permitted penetration to a limited degree. The development of the calcic andradite – pyroxene exoskarn further chemically buffered the ore solutions completing the combined physical and chemical (REDOX) trap for deposition of the ore shoots. The main ore shoots are developed in this main endoskarn zone with more disseminated and less focused ore shoots developed in its immediate footwall to the west.

The entire Cu – Au – Ag – (Zn) mineralized system varies from 30 – 70m in width but can be traced at surface and in drill holes for several kilometers north of the AP pit, and to the south of it for an unknown distance. From the historic mine workings, the mineralization continues with little apparent change, other than the appearance of molybdenite and scheelite, to at least 400m below the highest altitude on the property. It may be reasonably assumed that this mineralization continues for several hundred meters below level. However, with the mining of localized high grade scheelite on the 1000 level, which has never been encountered in significant grades above this level, it would appear that the ore mineralization is zoned above the anticipated subjacent porphyry Mo – W ± Cu system, with the perched tungsten shell sitting above the subjacent molybdenite shell which should appear at between 500 – 700m below surface.

Finally, in view of the fact that the oxide deposit, evaluated to date, around the historic AP open pit and mine workings comprises but a small part of the total mineralized system, it may be reasonably assumed that, to date, only a small proportion of the overall prospective strike of the Empire GPB (porphyry) – skarn system has ever been systematically explored; probably around 5%. In terms of exploitation of the bulk tonnage low to medium grade (> 0.4% - 2% Cu) Cu – Au – Ag ore potential in the protolith sulphide ores, this figure falls to < 1%. Hence, the long-term economic potential of the entire Empire ore system is large and unknown in any detail both along a confirmed strike over at least 3.5 km (now extended by KRI to 5 km) and at depth to at least 600 – 700m underground. Furthermore, the metal zonation in the deposit is both lateral and vertical. Recent drilling at the Red Star prospect 330 m north along strike intersected 9.1m of 9.92% Pb with 360 g/t Ag in argentiferous galena including a 1.5m intercept of 20% Pb and 1,111 g/t Ag which is regarded as a high-level expression of the overall ore system. This may be explained by the ore zones being juxtaposed by late stage "basin and range" type block faulting along the strike of the Empire GPB – skarn zone, with the AP Pit area representing a stratigraphically lower portion of the overall ore system.

Interestingly, the historic Horseshoe Mine located 1,200 m to the northwest of Red Star within the 1,837-acre property, operated from 1916 to 1928 with reported grades of 20% lead and over 100 ounces ("oz") of silver per tonne (Source: U.S. Bureau Of Mines Open-File Report MLA 6-91; and Mitchell Victoria E., 1997, History of Selected Mines in the Alder Creek District, Custer County, Idaho, Idaho Geological Survey.) This would suggest that the entire copper – gold zone of the ore system would lie at some depth below the lead – bonanza silver veins.

Signed Electronically

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BIBLIOGRAPHY

Black Z J, 2017: "Summary of the Updated Resources for the Empire Mine Project" to Konnex Resources Inc. November 11th, 2017; HARD ROCK CONSULTING LLC, Lakewood, Colorado, USA

Chang Z, 2003; "Magmatic – Hydrothermal Transition, Skarn Formation and Mineralization at the Empire Mine, Idaho", PhD Thesis, Washington State University, USA;

Farwell F W & Full R P, 1944; "The Geology of the Empire Mine near Mackay, Idaho", Open File Report of the US Department of the Interior – Geological Survey, 22pp and 29 Figures;

Gaynor S P, Rosera J M and Coleman D.S; "Intrusive History of the Oligocene Questa Porphyry Molybdenum Deposit, New Mexico", GEOSPHERE 2019, Vol 15 No 2, pp 548 – 575;

Kwak, T.A.P., 1994; “Hydrothermal alteration in carbonate replacement deposits; ore skarns and distal equivalents, *in* Lentz, D.R., ed., Alteration and alteration processes associated with ore-forming systems”: Geological Association of Canada Short Course Notes, v. 11, p. 381 – 402.

Love, D. A., Clark, A.H., and Glover, J.K., 2004; “The lithologic, stratigraphic, and structural setting of the giant Antamina copper-zinc skarn deposit, Ancash, Peru”: ECONOMIC GEOLOGY, v. 99, p. 887 –916.

Maund N, 2015; “A Summary Review of the Empire Skarn Cu + Au + Ag + (W) + (Zn) Deposit, Central Idaho, USA; Consultants Report to Phoenix Global Mining Pty Ltd, 7th July 2015;

Meinert, L. D., Dipple, G.M., and Nicolescu, S., 2005; World Skarn Deposits: ECONOMIC GEOLOGY 100 ANNIVERSARY VOLUME, p. 299 – 336;

Phoenix Global Mining Ltd (https://www.pgmining.com/) Investor Presentations and News Releases;

Redwood, S. D., 1999; “The geology of the Antamina copper-zinc skarn deposit, Peru”: Gangue, v. 60, p. 1–7;

Redwood, S. D, 2004; “Geology and development history of the Antamina copper - zinc skarn deposit, Peru”: Society of Economic Geologists Special Publication 11, p. 259 – 278;

Seedorf, E., and Einaudi, M.T., 2004a; “Henderson porphyry molybdenum system, Colorado. I. Sequence and abundance of hydrothermal mineral assemblages, flow paths of evolving fluids”: Economic Geology, v. 99, p. 3–38.

Seedorf, E., and Einaudi, M.T., 2004b; “Henderson porphyry molybdenum system, Colorado. II. Decoupling of introduction and deposition of metals during geochemical evolution of hydrothermal fluids”: Economic Geology, v. 99, p. 39–72;

Shannon, J.R., Walker, B.M., Carten, R.B., and Geraghty, E.P., 1982, Unidirectional solidification textures and their significance in determining relative age of intrusions at the Henderson Mine, Colorado: Geology, v. 10, p. 293–297, https://doi.org/10.1130/0091-7613(1982)102.0.CO;2

Wallace, S.R., Muncaster, N.K., Jonson, D.C., MacKenzie, W.B., Bookstrom, A.A., and Surface, V.E., 1968, Multiple intrusion and mineralization at Climax, Colorado, in Ridge, J.D., ed., Ore Deposits of the United States, 1933–1967: New York, American Institute of Mining Metallurgy and Petroleum Engineers, p. 605–640;

White, W.H., Bookstrom, A.A., Kamilli, R.J., Ganster, M.W., Smith, R.P., Ranta, D.E., and Steininger, R.C., 1981, Character and origin of Climax-type molybdenum deposits: Economic Geology 75th Anniversary Volume, p. 270–316;

Van Angeren P, 2014; “Geologic Assessment and Exploration Potential (2014 /2015) for the Empire Mine Project” for Boxxer Gold Corp internal report, 3rd January 2014.