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A MINERALOGRAPHIC STUDY OF SURFACE AND DRILL CORE SPECIMENS FROM THE SOUP GROUP OF CLAIMS, AND ITS IMPORTANCE TO BENEFICIATION

94D/8E

Omineca Mining Division

(Latitude 56° 27'N Longitude 126° 03' W)

94D/8E

by

Dr. A. J. Sinclair, P. Eng.

August 7, 1975

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A MINERALOGRAPHIC STUDY OF SURFACE AND DRILL CORE SPECIMENS FROM THE SOUP GROUP OF CLAIMS, AND ITS IMPORTANCE TO BENEFICIATION

SUMMARY AND CONCLUSIONS

1. A thick, conformable magnetite skarn occurs in upper Takla rocks on the Soup claims. The skarn is continuous for more than 6000 feet, varies from 20 to 100 feet thick and has a tonnage potential of about 27,000 tons per vertical foot. It strikes roughly northerly and dips 30° easterly. The skarn appears to have interesting grade potential for iron, copper and gold.
2. Opaque minerals in the skarn are magnetite, pyrite and chalcopyrite. On and near the surface and along fractures limonite and malachite have formed.
3. Oxidation is intensified in exposures rich in pyrite. Limonite has formed more-or-less in situ whereas malachite is concentrated in the lower part of the skarn and the immediately adjacent footwall, indicating a greater mobility for copper than iron during weathering.
4. Sulphides occur almost exclusively in separate grains distinct from magnetite. Pyrite grains are large with relatively smooth boundaries and clean breaks are to be expected during crushing and grinding. Grain size is commonly 0.5 mm. or more and liberated grains should be produced efficiently.
5. Chalcopyrite occurs in two dominant grain sizes (i) 0.1 to 0.5 mm. diameter (and rarely larger), and (ii) about 0.01 mm. diameter as inclusions in pyrite or gangue. Chalcopyrite is almost never seen enclosed in magnetite but is associated with gangue. Liberation

of the coarse-grained chalcopyrite which appears to form about 99 percent of the copper in the rocks examined will require finer grinding than is necessary to liberate pyrite.

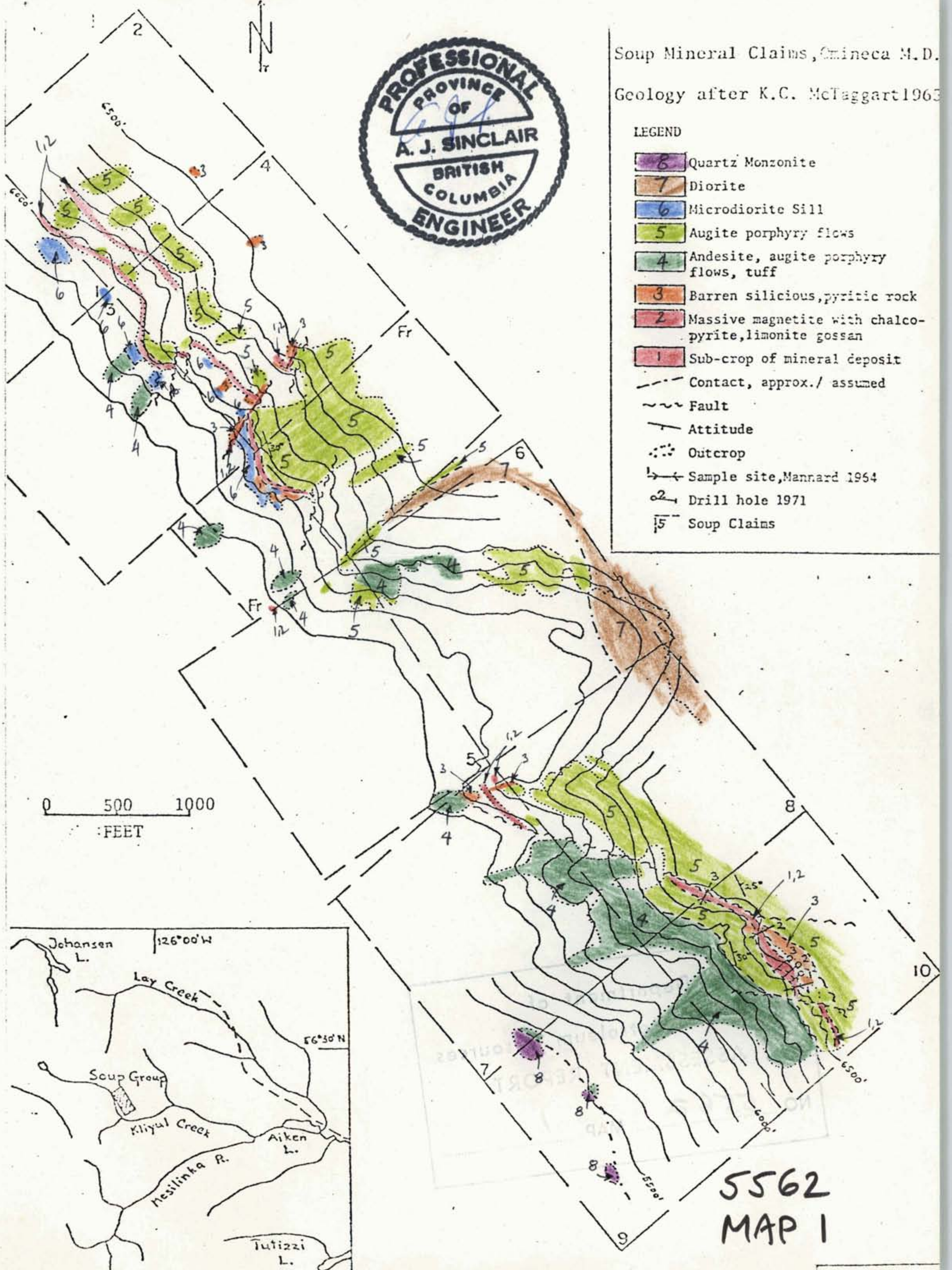
6. Gold has not been observed but assay data suggest that it correlates positively with copper values and is therefore incorporated in chalcopyrite and recoverable in copper concentrate.

INTRODUCTION

Soup Group of claims is about 12 miles northwest of Aiken Lake, Omineca Mining Division in central British Columbia (figure 1, inset), and covers much of the northeast valley wall of Kliyul Creek. Elevations range from about 4000 feet to 7000 feet a.m.s.l. The property is accessible via a pack trail from Aiken Lake. Helicopter landing sites on the property are not good.

The 10 Soup claims are part of what was known formerly as the Shell Group, staked originally for Leitch Gold Mines. These claims lapsed and were staked as the Soup Group in 1964 by Dr. W.H. White. Work on the property since that time includes detailed plane table mapping (McTaggart, 1965) and limited X-ray diamond drilling (3 holes totalling 70 feet) by Falconbridge Nickel Mines Ltd. (Gyr, 1972). Apart from this several exploration groups have visited the property.

The presence of an extensive zone of Cu-Au-Fe skarn is established on the property by work described above. Surface weathering, however, is extensive and meaningful evaluation of surface and near surface assays is difficult and ambiguous. Future work on the property should involve, among other things, quality grade estimations and some insight into the amenibility of the mineralized rock to beneficiation. Work reported here deals with the practical aspects of mineralography as they relate to recovery of economically important commodities from the mineralized rock.



Soup Mineral Claims, Omineca M.D.
Geology after K.C. McTaggart 1963
LEGEND
8 Quartz Monzonite
7 Diorite
6 Microdiorite Sill
5 Augite porphyry flows
4 Andesite, augite porphyry flows, tuff
3 Barren silicious, pyritic rock
2 Massive magnetite with chalcopyrite, limonite gossan
1 Sub-crop of mineral deposit
Contact, approx./ assumed
Fault
Attitude
Outcrop
Sample site, Mannard 1964
Drill hole 1971
Soup Claims
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A. J. SINCLAIR
0 500 1000
FEET
Johansen L.
126°00'W
Lay Creek
56°30'N
Soup Group
Kliyul Creek
Aiken L.
Mesilinka R.
Tutizzi L.
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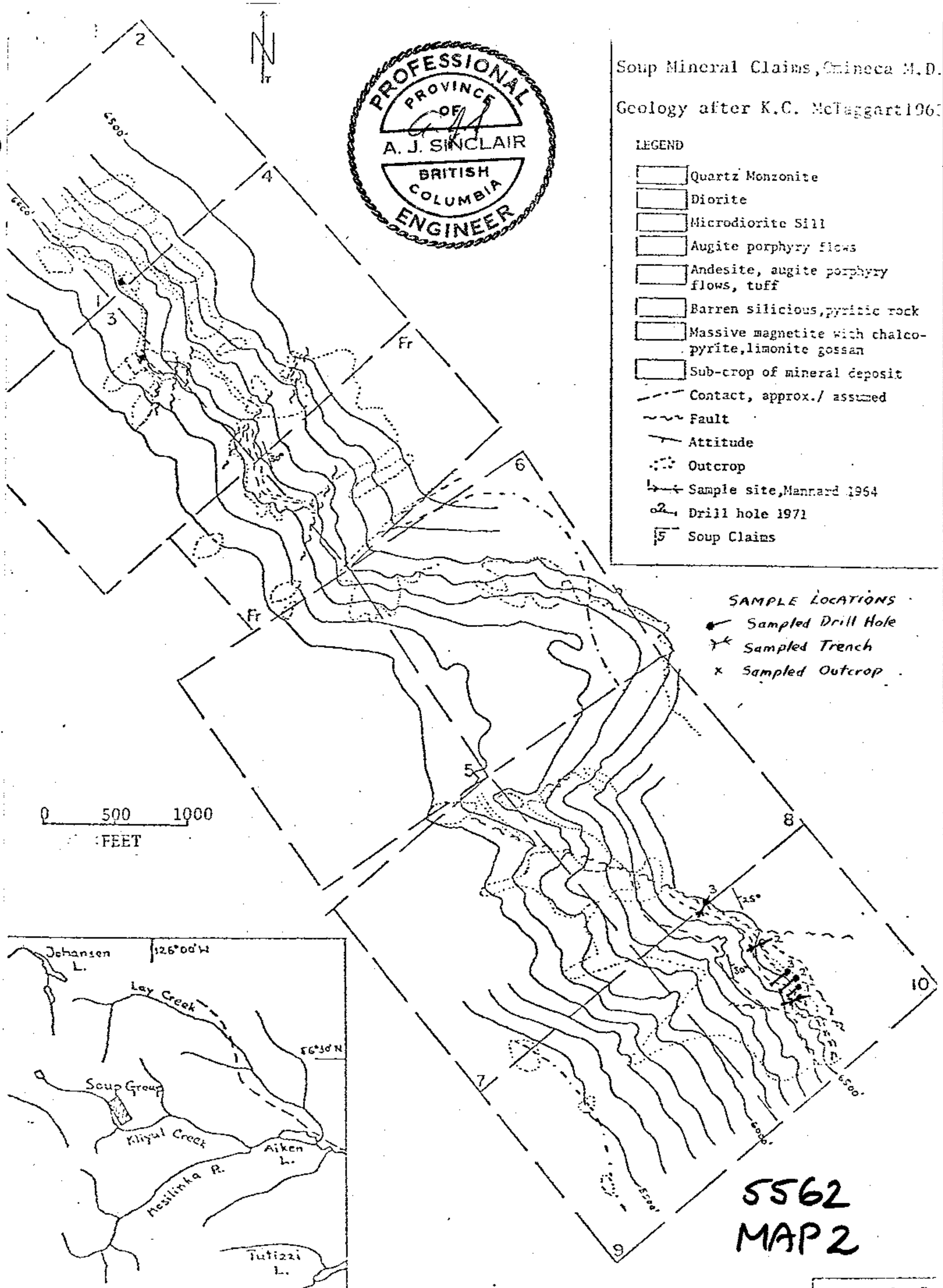
MAP 1



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Fault
Attitude
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Sample site, Mannard 1964
Drill hole 1971
Soup Claims
SAMPLE LOCATIONS
Sampled Drill Hole
Sampled Trench
Sampled Outcrop
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
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FEET
Johansen L.
126°00'W
Lay Creek
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Kliyul Creek
Aiken L.
Mesilinka R.
Tutizzi L.
6500'
6000'
5500'
25°
50°
Fr
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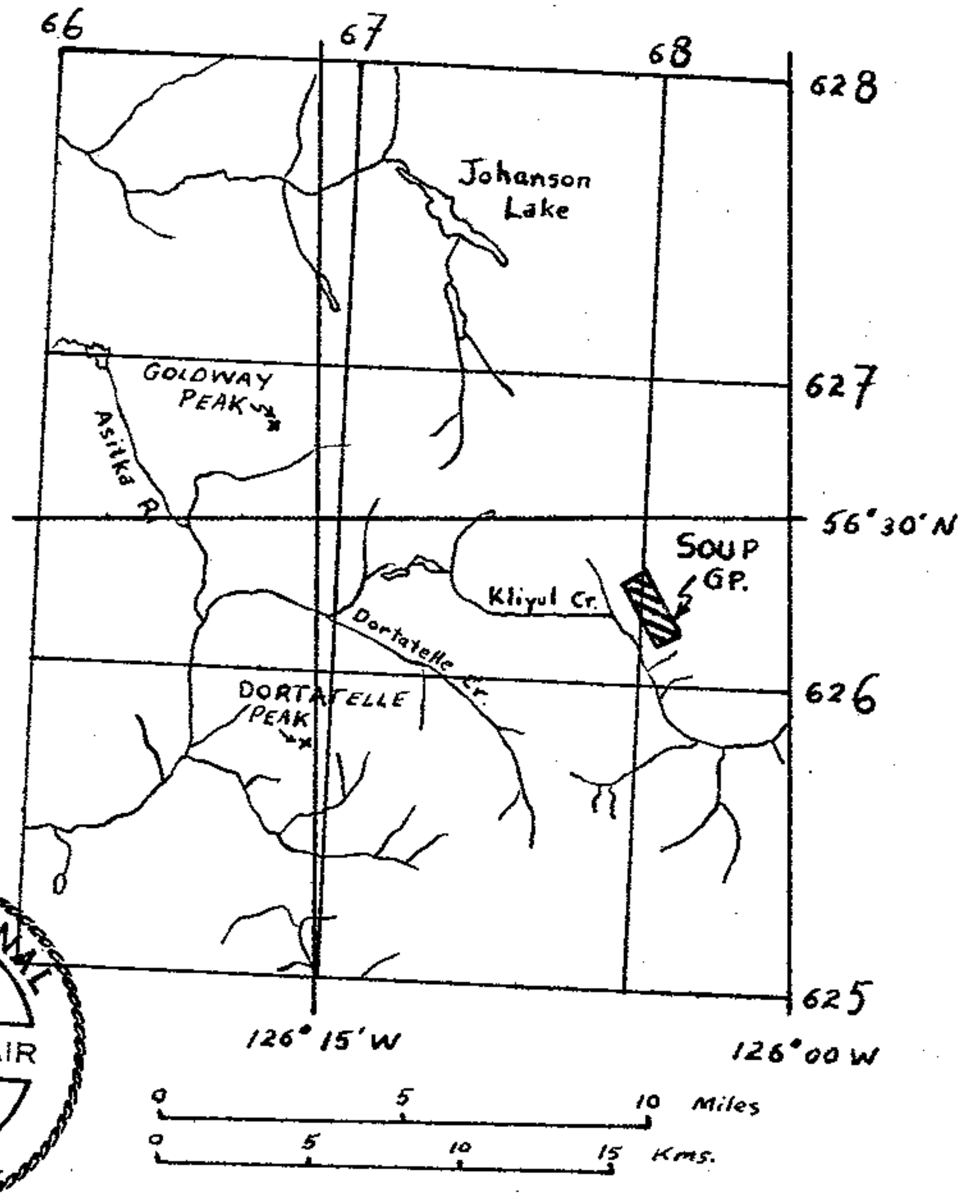
MAP 2



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LOCATION OF SOUP GROUP

Base map: McConnell Creek map sheet, National Topographic Series, 1: 250,000, 94 D. Location is shown relative to both a metric grid (UTM coordinates) and longitudes and latitudes.

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MAP 3

To accompany report by
Dr. A. J. Sinclair, P. Eng.

GENERAL GEOLOGY

The Soup Group of claims is underlain mainly by intermediate volcanic rocks of the Upper Triassic Takla Group. These rocks have been intruded by dioritic and quartz monzonitic bodies of Jurassic Omineca Intrusions. A magnetite-bearing skarn layer with interesting copper and gold values is contained within the upper part of the Takla Group exposed on the property.

Takla Group rocks strike slightly west of north and dip about 30 degrees to the northeast. The rocks consist of a lower unit of grey to green lavas containing a small amount of feldspar phenocrysts. An upper group consists mainly of augite porphyry flows and flow breccias. All rocks are cut by veinlets containing calcite and/or quartz and/or epidote.

A roughly tabular copper-gold-iron skarn zone appears to be conformable with, and to occur within, the upper group of Takla rocks. Wallrock are slightly silicified and pyritized augite porphyry (Gyr, 1972). The skarn itself is more-or-less massive magnetite commonly with forty percent or less non-opaque gangue, and containing variable amounts of pyrite and chalcopyrite. Pyrite is generally much more abundant than is chalcopyrite although both are commonly visible in hand specimens. Assay values are recorded in Table I and II. Surface of the magnetite skarn is extremely weathered (limonitized) to give a porous, rusty rock with malachite stain. Copper has been relatively more mobile than iron during weathering and the greatest concentrations of malachite are in the structurally lower part of the skarn and in the foot wall. Effects of surface weathering extend twenty feet or more below the surface, in some cases at least. Even the three drill holes referred to above did not penetrate the weathering zone.

Thickness of the skarn unit is variable but ranges from 20 to 100 feet (McTaggart, 1965). Total length is substantially more than 6000 feet, about one quarter of which is inferred to exist beneath a large rock glacier on the claims. Non-opaque minerals in and near the skarn include tremolite, garnet, epidote and clacite. At the southern part of the group where most work to date has been done, the magnetite skarn extends continuously for more than 1500 feet. On the north side the layer is offset by about 1200 feet along a near vertical fault striking N 70^{o} W. On claims Soup #2 and Soup #4 at the north end of the group two such layers are present, separated stratigraphically by about 100 feet.

McTaggart has estimated that tonnage potential is about 27,000 tons per vertical foot. Grade has not been investigated adequately because of extensive weathering but representative assay by two independent companies are listed in Tables I and II.

TABLE I

SURFACE ASSAYS, SOUP GROUP
(After Mannard, 1964)

	Outcrop Width	Au.	Cu.
Site 1	20'	$0.09 oz/t.	0.91%
Site 2 (500 ft. north of site 1)	35'	$0.06 oz/t.	0.46%
Site 3 (1000 ft. north of site 1)	30'	$0.10 oz/t.	0.44%

TABLE II

DRILL HOLE ASSAYS, SOUP GROUP
(After Gyr, 1972)

	Footage	Au.oz/t	Cu.%	
DDH #1	0-5'	tr.	0.07	Average 5-15':
	5-10	0.02	0.32	10' - 0.37% Cu.
	10-15	0.03	0.43	
DDH #2	0-5'	0.03	0.26	
	5-10	0.01	0.15	Average 0-20':
	10-15	0.01	0.09	20' - 0.16% Cu.
	15-20	0.01	0.13	
	20-15	tr	0.05	
DDH #3	0-5'	0.02	0.33	
	5-10	0.02	0.52	Average 0-25':
	10-15	0.02	0.10	25' - 0.28% Cu.
	15-20	0.01	0.26	
	20-25	tr.	0.18	

Soluble iron assays showed an average of 35% Fe.

MINERALOGRAPHY

A mineralographic investigation was made of numerous surface and drill hole specimens from the Soup Group. Polished surfaces were prepared using standarized techniques, hand specimens were examined thoroughly using a binocular microscope, and a detailed ore microscopic analysis was done for opaque minerals, these being the minerals with economic potential. Non-opaque gangue was studied only superficially with the exception that products of weathering were investigated with emphasis on their relationship to primary minerals.

The primary opaque minerals recognized are, in order of decreasing abundance, magnetite, pyrite and chalcopyrite. Secondary minerals apparent megascopically are limonite and malachite, both of which can be recognized in polished section as well.

Magnetite

Magnetite occurs mainly as anhedral grains either distributed as individuals or as small groups of individuals in gangue, or, where more abundant, as patches of essentially pure magnetite. Boundaries with gangue are commonly simple. Grain size varies over an order of magnitude, most grains being in the range 0.05 to 0.2 mm. diameter. Virtually all grains are roughly equidimensional.

Magnetite content is variable, from about 20 percent by volume to nearly 100 percent in specimens examined. With increasing magnetite content the effective size of pure magnetite patches increases indicating that the efficiency of liberation of gangue from magnetite by crushing and grinding will increase correspondingly. Where magnetite forms only about 20 percent (volume) of a specimen the effective grains size for beneficiation is approximately the true grain size, i.e. small, and extensive grinding will be necessary liberation of a high proportion of magnetite.

In all specimens examined there is a small proportion of magnetite present as very small inclusions in gangue. This would have the effect of introducing considerable gangue into a magnetic concentrate if such a technique were employed either in the making of an iron concentrate or to remove magnetic waste.

Magnetite is, in general, unaltered. Locally where intense limonitization has occurred such as on surface and along rusty fractures cut by drill holes, magnetite is replaced to varying degrees by limonite. The zones of intense limonitization, however, appear to owe their origin in large part to oxidation of pyrite. The effect is almost certainly one of near surface oxidation that in all probability will persist to depth only along deep fractures and/or shear zones.

Pyrite

Pyrite, the most abundant sulphide in the skarn deposit, is scattered somewhat erratically throughout. Most specimens on close examination show at least a trace pyrite content; other hand-sized specimens contain as much as 30 percent (volume) pyrite.

The pyrite is largely in the form of anhedral grains that are elongate and crudely rectangular in cross section. The long dimension of these pyrite grains is commonly one and one-half to two time the width. Pyrite virtually never forms close clusters but occurs as individual grains surrounded by gangue and/or magnetite.

Rare examples of pyrite occur as small grains, perhaps crystals, with straight boundaries, within magnetite grains. These are not common and would not in themselves give a high sulphur content to an iron concentrate. They are important because they suggest contemporaneous crystallization of the two iron minerals.

Inclusions in pyrite are not abundant. The commonest type of inclusions are minute grains of chalcopyrite within large single grains of pyrite i.e. the chalcopyrite in this form is <u>not</u> interstitial but is included within pyrite crystals. In the local samples where such a texture was observed any number from one to eight individual chalcopyrite inclusions were observed in a single pyrite grain. Less common are the very rare inclusions of magnetite and gangue within pyrite.

Boundaries of pyrite with gangue are such that clean breaks are to be expected during crushing and grinding. The majority of composite pyrite fragments to be expected therefore will be of the complex type in which very small inclusions of gangue, magnetite and chalcopyrite are present. If the amount of chalcopyrite lost to a pyrite concentrate or to tailing were significant it might be important to test for recovery of such copper by combination of roasting and leaching of pyrite concentrate. If roasting becomes necessary one should also consider the economics of sulphur recovery. However, the present indication is that a negligible proportion of the total copper is present as inclusions in pyrite.

Chalcopyrite

Chalcopyrite occurs in two principal forms in skarn rocks from the Soup group. By far the greatest proportion occurs as monomin-erallic masses of chalcopyrite nearly entirely surrounded by gangue. A lesser amount occurs intimately associated with pyrite either as minute inclusions or less commonly as small grains along the margins of pyrite grains, even locally extending into pryite grains. There is a possibility that pyrite is slightly replaced by chalcopyrite but the textures are not conclusive. Regardless, there is a rough correlation between the presence of pyrite and the presence of chalcopyrite in the same specimen (with the exception of highly weathered specimens) whether the two minerals are in close contact or not. It would appear that this correlation stems from the necessity of sulphur for formation of both minerals. Such a relationship could be important for crude evaluation of hand specimens because pyrite is considerably coarser grained and thus more visible magascopically than is chalcopyrite.

From the point of view of recovery, the large grains of chalcopyrite are by far the most important. They are large in places even exceeding one or two mm. in diameter. In the bulk of specimens examined, however, the size is more commonly in the order of 0.1 mm. diameter to 0.5 mm. diameter. A small proportion of chalcopyrite in gangue occurs in grains as small as 0.01 mm. diameter, about the same size as chalcopyrite included in pyrite.

Grain boundaries of the large grains of chalcopyrite are irregular but not highly so, and production of middlings fragments during crushing and grinding should not be too serious. It must be remembered, however, that for liberation of most of the chalcopyrite, particles must be crushed to substantially less than one quarter the grain size.

The inclusions of chalcopyrite in pyrite cannot be recovered easily but they appear to represent a very small amount of the total copper in the skarn. This is indicated by the relative grains size, most commonly of the order of 0.01 mm. diameter. The volume ratio of large grains to small grains is $\pi r_1^3/\pi r_2^3 = (0.1)^3/(0.01)^3 = 1000$. In other words about 1000 chalcopyrite inclusions are required to produce the same volume as <u>one</u> of the common-sized chalcopyrite grains in gangue. The calculation is highly idealized but is presented to emphasize the minor importance of chalcopyrite contained within pyrite.

If additional work shows that the chalocpyrite content of pyrite grains is significant it might be advantageous to make a pyrite concentrate and recover copper by a combination of roasting and leaching. The possibility of recovering sulphur during such a scheme might also be considered because of the potential local market in the pulp and paper industry.

Limonite

Limonite is a common weathering product on the Soup claims. The main deduction of the microscope work confirms an observation by Gyr (1972) who found that limonitization is most extensive in pyrite-bearing skarn. The relict centres of pyrite remaining in many limonite patches are adequate evidence of this fact. Limonite is the most obvious sign of weathering, and development of the mineral seems to be largely in situ, that is, limonite formed by alteration of pyrite and to a much lesser extent magnetite, has for the most part not moved far from the site of derivation of its contained iron. That some limonite is transported locally is evidenced by the stain on gangue, particularly in some of the drill core. It is interesting to note that the short X-ray drill holes put down in 1971 did not actually penetrate the zone of weathering, although weathering of drill core has not been as intense as surface weathering and is concentrated along fractures and/or shears.

Two forms of limonite occur, a compact "metallic" massive variety that forms distinct veinlets, forms cellular structure (boxwork) and forms pseudomorphs after pyrite. The second variety is a "dusting", staining or development of earthy or disseminated limonite. Both types are closely related spatially with the disseminated variety commonly forming a halo or envelope about the massive variety although the two varieties need not occur together. Both types are certainly relatively near surface features and one would not expect them to extend to depth. Consequently, limonite should not present serious problems to beneficiation procedures.

Malachite

Malachite has developed as an oxidation of chalcopyrite by the action of CO_2-bearing water. Copper has been notably more mobile during weathering than has been iron. Gyr (1972) notes that malachite stain is concentrated on the structurally low side of the magnetite skarn layer and in the adjoining footwall. The implication of this observation is that surface assays for copper are apt to be low because (i) copper has demonstrably moved out from surface rocks to form malachite, and (ii) no copper has yet been found fixed as supergene minerals.

In some cases small amounts of malachite have formed around chalcopyrite grains as a thin skin and the total is encased in a mass of limonite. In such cases it would seem that the central core of chalcopyrite was shielded from oxidation and removal by the enclosing limonite.

Because of the mobility shown by copper in the oxidizing environment it is encouraging to note that interesting copper grades found on surface persists in less weathered rock from drill core.

Gold

No gold has been observed megascopically or microscopically. More extensive sampling and assaying is required as are futher laboratory studies, particularly microprobe analyses. Examination of existing assay data in Tables I and II suggests that gold correlates somewhat with copper. One might therefore expect the gold to occur predominantly in chalcopyrite and to be recoverable from a copper concentrate.

ASPECTS RELATING DIRECTLY TO BENEFICIATION

1. All but negligible copper occurs in grains surrounded by gangue. Most of this copper is in relatively large grains 0.1 to 0.4 mm. diameter from which reasonably good liberation is to be expected during crushing and grinding.

2. Gold was not observed but assay data indicate a correlation with copper, and in all liklihood gold will be recovered from a copper concentrate.
3. A relatively pure magnetite concentrate seems feasible. The principal impuritywould be calc silicates. Chalcopyrite and pyrite should be easily and efficiently separable from magnetite and/or gangue after comminution.
4. Pyrite should not present a problem as a serious contaminant in a magnetite concentrate. Particle liberation should be achieved readily and, if necessary, a pyrite concentrate could be made.
5. Oxidation effects are surficial or nearly so, or are concentrated along local fractures or shears and should present no recovery problems of quantitative significance in the deposit as a whole.

REFERENCES

Gyr, T., 1972, Report for 1971 on Soup Group, Kliyul Creek; private for Falconbridge Nickel Mines Limited, Vancouver.

Mannard, G.W., 1964, Report on Soup Group of Claims; private report for Southwest Potash Corp. Ltd., Vancouver.

McTaggart, K.C., 1965, Geology of the Soup Mineral Claims Nos. 1 to 10 Inclusive, and Soup Fraction; Private report and map submitted as assessment work to the B.C. Dept. of Mines and Petroleum Resources.

PROFESSIONAL ENGINEER
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A. J. SINCLAIR

....
Dr. A.J. Sinclair, P.Eng.
August 7, 1975

CERTIFICATE

I, Alastair J. Sinclair, of the city of Vancouver, province of British Columbia, hereby testify:

1. That I am a Geological Engineer residing at 5869 Dunbar St., Vancouver 13, B.C.

2. That I obtained a B.A.Sc. degree in Applide Geology from the University of Toronto in 1957, an M.A.Sc. degree in Geological Engineering from the University of Toronto in 1958, and a Ph.D. in Economic Geology from the University of British Columbia in 1964.

3. That I am a registered Professional Engineer in the Province of Ontario in the Mining Division, and in the Province of British Columbia in the Geology Branch.

4. That I have practiced my profession for fourteen years.

5. That the accompanying report is based entirely on work by me.

Dated at Vancouver in the Province of British Columbia this 7th day of August, 1975.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. J. SINCLAIR

....
Dr. A.J. Sinclair, P. Eng.

PERSONNEL AND DAYS WORKED

Dr. A.J. Sinclair, P. Eng.	July 3, 10, 11, 25, 26, 28, 29, 30; August 1, 3, 4, 5, 1975.

Work done includes binocular microscope examination of samples, preparation of polished surfaces, ore microscopy and report preparation.

9 days total @ $250.00 per day	$2250.00

This work is to be disbursed as indicated on 'Mining Receipt' No. 100892 and 'Affidavit on Application to Record Work' dated August 5, 1975 and filed in Vancouver. In brief, one years work is to be applied to each of Soup 1-9 inclusive (Record Nos. 26941 to 26949 inclusive) and two years to Soup 10 (Record No. 26950).