



# THE WINDY CRAGGY COPPER-COBALT-GOLD MASSIVE SULPHIDE DEPOSIT, NORTHWESTERN BRITISH COLUMBIA (114P)

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**KEYWORDS:** Economic geology, Windy Craggy, volcano-sedimentary host rocks, massive sulphide, stockwork and stringer mineralization, hydrothermal alteration, copper, cobalt, gold.

## INTRODUCTION

The Windy Craggy copper-cobalt-gold massive sulphide deposit is located at 59°44' north latitude and 137°44' west longitude in the Alesk-Tatshenshini River area of the the St. Elias Mountains in extreme northwestern British Columbia (Figure 2-12-1). The deposit is in extremely rugged and glaciated terrain and crops out on Windy Peak (Plates 2-12-1 and 2-12-2). Access is by charter fixed-wing aircraft or helicopter. The airstrip at Windy Craggy is located 192 kilometres from Whitehorse, 135 kilometres from Haines, or 62 kilometres from the Haines highway. A 13-kilometre road built on Tats Glacier leads from the airstrip and camp to the portal and underground workings (Plate 2-12-2).

The deposit was discovered during a regional reconnaissance program in 1958 by Frobisher Ltd., now Falconbridge Limited, under the direction of J.J. McDougall. Exploration work was conducted by Falconbridge and its predecessor companies until 1981 when it entered into an agreement with Geddes Resources Ltd. In late 1983 Falconbridge conveyed title to the property to Geddes Resources. In early 1987 Geddes Resources commenced development of a 1852-metre adit extending close to a gold-enriched part of the deposit. This, and drifting alongside and parallel to the strike of the deposit on its western margin, was completed in the spring of 1988. Exploration work since then (current to September 1988) has consisted of underground drilling with the intention of defining the extent of gold mineralization and outlining reserves of copper and cobalt.

As of September 1988, 11 277 metres of underground drilling have been completed and a crosscut was being driven into massive sulphide mineralization to obtain bulk samples for metallurgical testing (Report to Shareholders, September 7, 1988). Grades and tonnages have not yet been calculated as assays and geological continuity between sections are still being developed, and only 420 metres of strike length has been systematically drilled. Previous estimates of grade and tonnage have ranged from 90 million tonnes grading 2.8 per cent copper to 320 million tonnes grading 1.52 per cent copper and 0.08 per cent cobalt (for example, Northern Miner, January 13, 1983; Canadian Mining Journal, 1986).

This report describes the Windy Craggy deposit and presents new information on the geological setting obtained from detailed underground drilling, mapping and sampling. Addi-

tionally, it gives a preliminary description of the styles of mineralization and alteration and their spatial distribution within the deposit. The author spent a period of four months at Windy Craggy this past field season and during this time logged approximately 4270 metres of drill core and examined much more in less detail. Approximately two weeks were spent mapping underground. During the 1987 field season about two months were spent mapping and sampling on the Tats claims, which are located in the immediate vicinity of Windy Craggy; one week was also spent surface mapping at Windy Craggy. This project is part of a Ph.D. thesis in progress at the University of Toronto.

## GEOLOGICAL SETTING

The Windy Craggy area is situated within the allochthonous Alexander terrane of the Insular tectonic belt (Figure 2-12-2). Geological mapping by Campbell and Dodds (1979, 1983), MacIntyre (1983, 1984) and Prince (1983) indicates the area is within a broad belt of complexly deformed Paleozoic clastic and carbonate rocks of relatively low metamorphic grade. The area is underlain by intermediate to mafic submarine volcanic units with variable amounts of interbedded calcareous argillaceous sedimentary rocks. MacIntyre (1984) has presented a preliminary stratigraphic section for the Windy Craggy area. The age of the volcanic rocks has been established as early Norian (Upper Triassic) on the basis of conodonts collected from sedimentary interbeds (Orchard, 1986).

The deposit is within a sequence of interbedded graphitic and calcareous argillites and intermediate to mafic volcanic



Plate 2-12-1. View of north face of Windy Peak looking south-southwest. Sulphide mineralization crops out in the dark area immediately below the peak and also in the area of snow slides just below this dark area and above the break in slope near the centre of the photo.

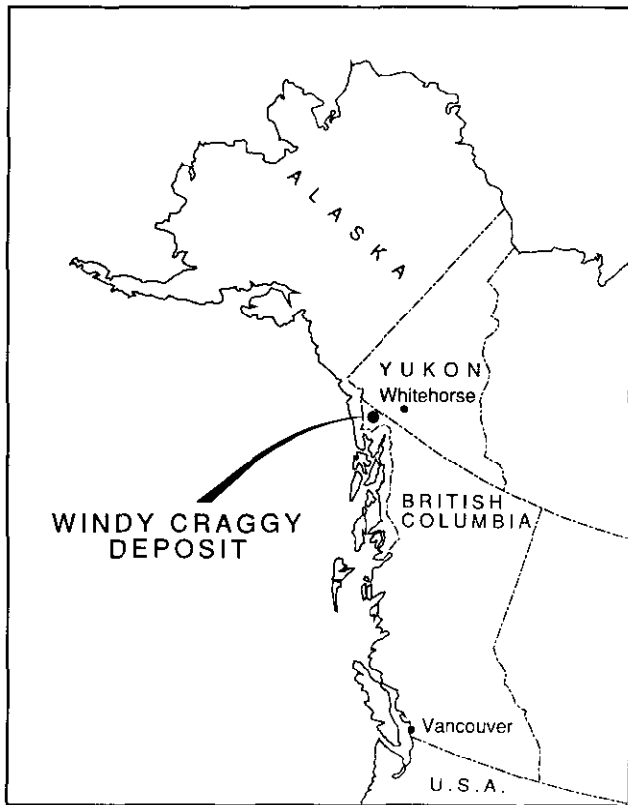


Figure 2-12-1: Location of the Windy Craggy deposit.

flows. These rocks have been intruded by subvolcanic dykes and sills. Up to the end of 1983, the deposit was thought to consist of two distinct sulphide bodies that have been isoclinally folded, crossfolded, faulted, and separated by a thick, altered pillow volcanic flow (Gammon and Chandler, 1986). Systematic underground drilling, which began in early 1988, generally supports these interpretations. Figure 2-12-3 is an isometric perspective view showing the position of the underground development (adit, North and South drifts), surface topography, location of underground drill holes, and positions of massive sulphide mineralization intersected in drill core on each drill section.

## LITHOLOGY

The host rocks to the Windy Craggy deposit are a volcano-sedimentary succession consisting of mixed graphitic argillites and intermediate to mafic pillowed and massive flows (Gammon and Chandler, 1986). A summary of rock types and mineralization in the immediate vicinity of the deposit, as identified in drill core and from underground and surface mapping is given below.

## FLOWS

Volcanic flows are fine grained and range in colour from medium grey to dark green. They are commonly amygdaloidal with spherical to amoeboid amygdules 1 to 5 millimetres in diameter composed of white, fine-grained calcite and, rarely, fine-grained pyrrhotite. In places amygdules

comprise up to 4 volume per cent of the rock. Less commonly, the flows are porphyritic, with euhedral phenocrysts of plagioclase 3 to 8 millimetres in diameter and/or a euhedral mafic mineral (probably hornblende) 0.5 to 3.0 millimetres in diameter and pseudomorphed by chlorite. Flows are pervasively chloritized and carbonatized in many places. Much of this alteration probably relates to a regional greenschist facies metamorphic event. Flows are generally only slightly foliated, and chlorite schist is a very rare occurrence.

Pillows are exposed on surface, however, convincing exposures of pillow structures are present in only a few places underground. Pillows vary from 10 to 70 centimetres in cross-sectional diameter and generally contain finer grained chloritized rims. Where present underground, pillows are invariably slightly sheared and pristine, undeformed examples are rare. Drill-core examination indicates individual flows are up to 100 metres thick and average 10 to 15 metres in thickness.

Field classifications (for example, andesite or basalt) have been made wherever possible, but these necessarily rely heavily on colour index, and regional and local alteration complicates determinations. However, on the basis of field mapping and previous studies of petrochemistry (MacIntyre, 1986), both andesites and basalts are present in the Windy Craggy area.

## TUFFS

Tuffs are common in the immediate vicinity of the deposit. They are predominantly dark green-black in colour, fine to very fine grained, and laminated to indistinctly bedded or massive. Individual units range from less than 1 metre to 35

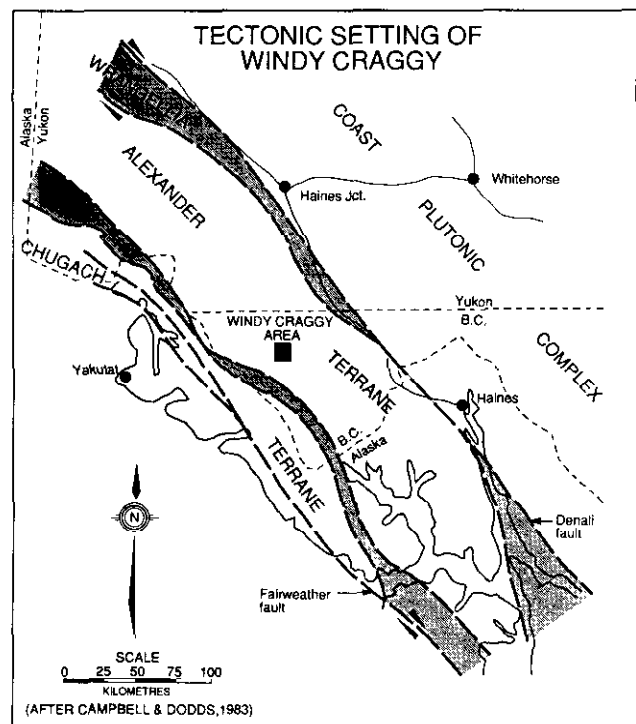


Figure 2-12-2: Tectonic setting of the Windy Craggy area (after Campbell and Dodds, 1983 and modified from Gammon and Chandler, 1986).

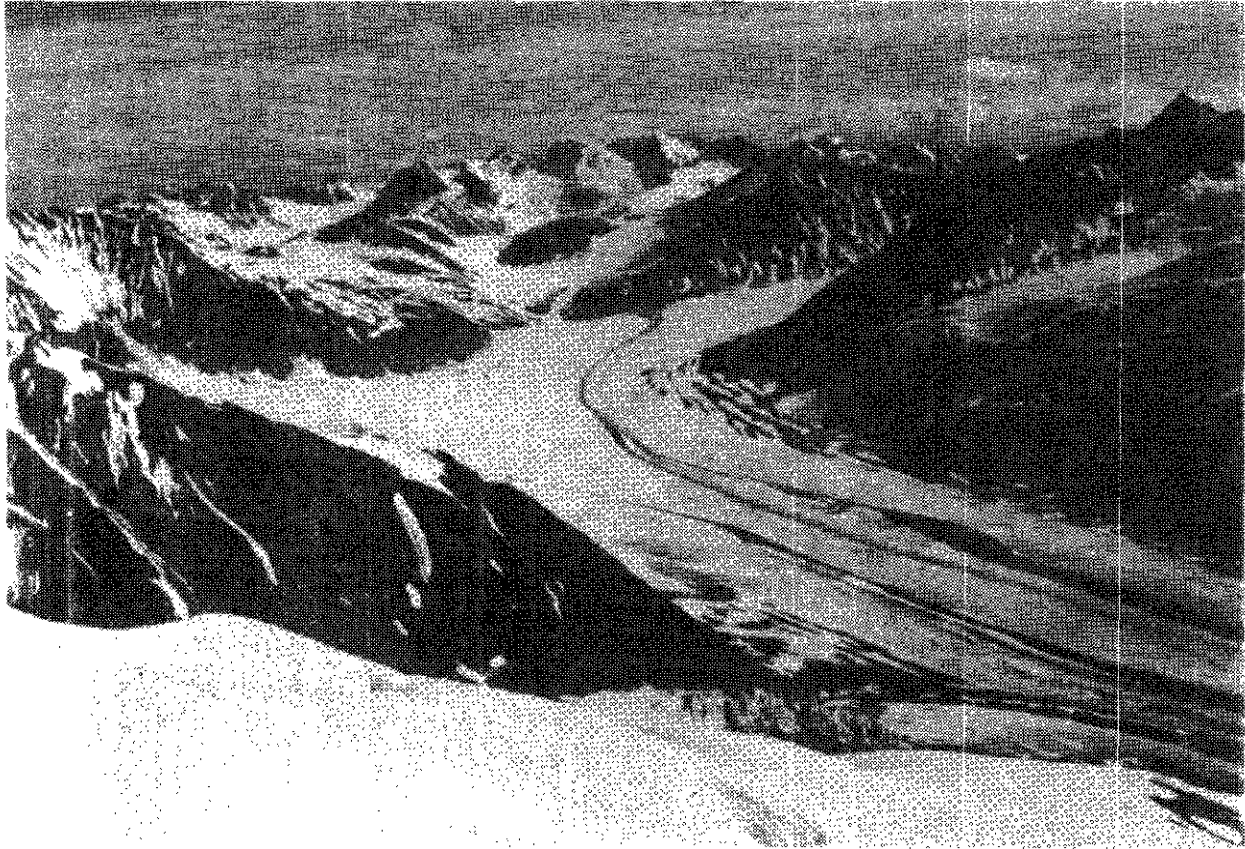


Plate 2-12-2. View of south face of Windy Peak and access road looking northeasterly up Tats Glacier. The portal is just above the snow where the road meets Windy Peak. Elevation of Windy Peak is 2000 metres. Access road built on Tats Glacier.

metres thick and average 10 to 15 metres thick. They are chloritic and often contain chlorite-rich interbeds. The tuffs commonly contain an appreciable component of interbedded argillite and in some places appear to grade laterally into argillite. Sedimentary structures such as graded and convoluted bedding (soft-sediment deformation), and sulphide-bearing nodules or concretions are common in drill core.

In places tuffs and argillites are mineralized and may contain up to 65 per cent pyrrhotite and 8 per cent chalcopyrite as fine disseminated grains, foliated bands and wisps, or beds ranging from less than a millimetre to 3 centimetres in thickness (Plate 2-12-3). In places, these sulphides have been deposited by chemical and/or clastic sedimentation. However, some of the sulphides may be diagenetic in origin, and epigenetic stockwork/stringer mineralization is also present within tuff.

### ARGILLITE

Argillites are dark grey-black to light grey-buff coloured and range from noncalcareous to calcareous. They are indistinctly to well laminated (less than 1 millimetre to 20 centimetres) and are dominantly fine to very fine grained, but minor thin, sandy lenses or beds containing lighter grey calcareous grains are also present. In places the argillites contain a significant tuffaceous component consisting of

chlorite-rich beds and laminae. Individual argillite units vary in thickness from less than a metre to 40 metres but on average are 10 to 15 metres thick. Boudins and sedimentary structures [normal graded bedding and lamination (Plate 2-12-4), soft-sediment deformation and slump structures (Plate 2-12-5), scours, pebble dents and concretions] occur within argillite.

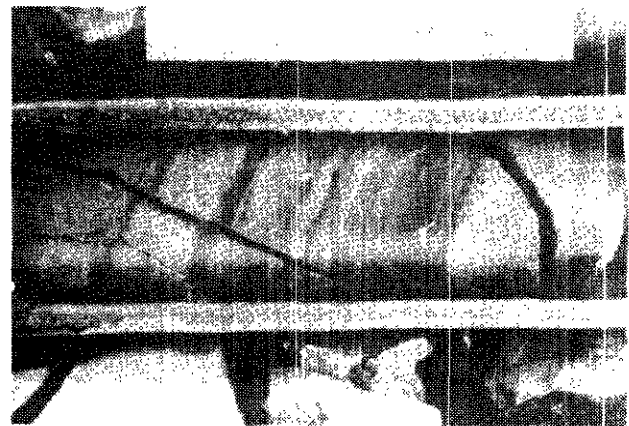


Plate 2-12-3. Mafic tuff with laminae of fine-grained pyrrhotite (sample 88-44; 35.0 m). White scale card is 9 cm long.

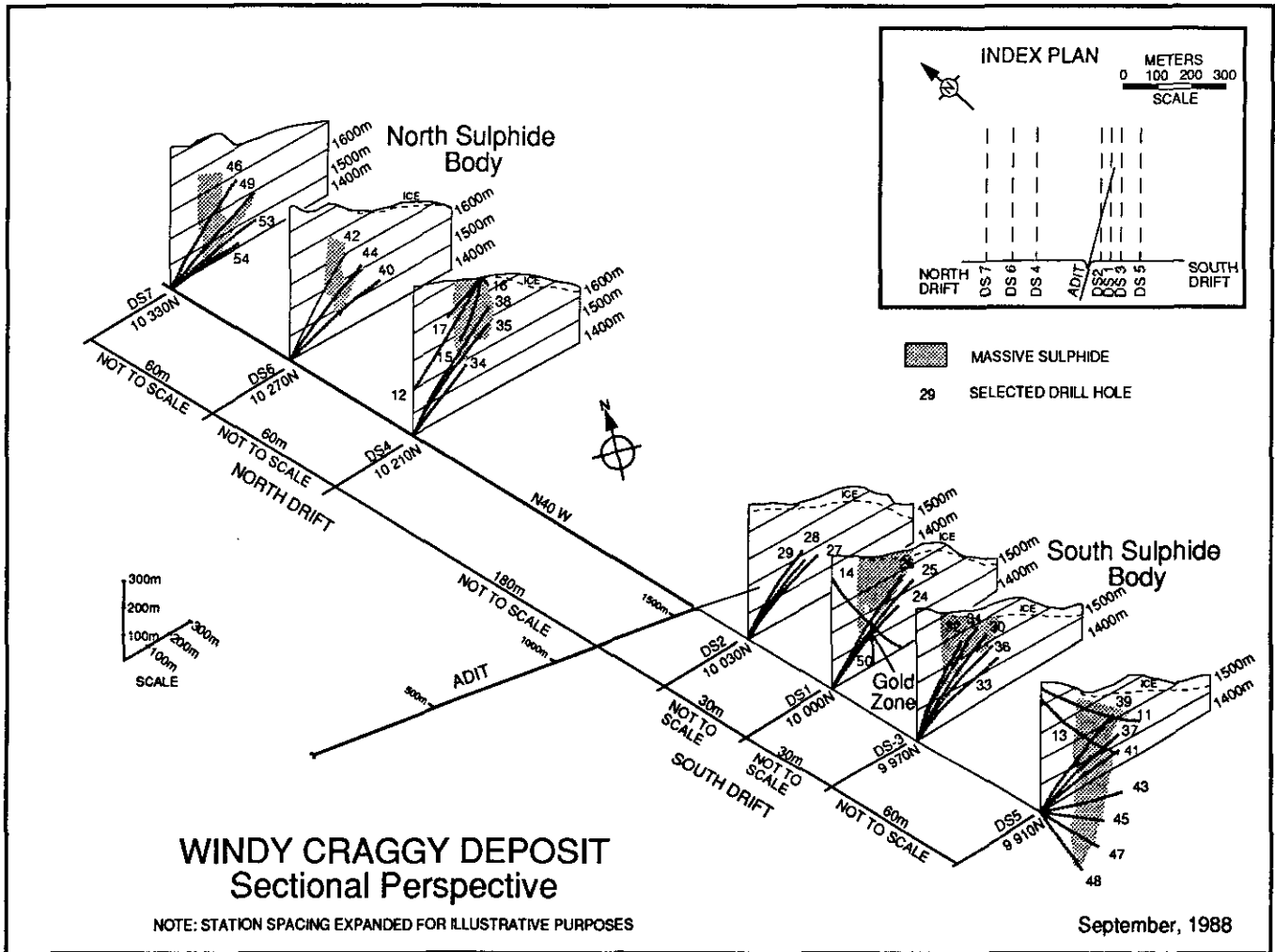


Figure 2-12-3: Isometric perspective view of underground development (adit, North and South drifts), location of underground drill holes, position of massive sulphide mineralization, and surface topography for each drill section. Spacing between sections is expanded and not to scale. See index plan (inset) for true scale (after an original diagram by Geddes Resources Ltd.).

“Nodular argillite” is a field term used to describe a locally important variant consisting of augen-shaped boudins of lighter grey calcareous siltstone, 5 millimetres to 3 centimetres in diameter in a darker, finer grained matrix (Plates 2-12-6 and 2-12-7). Plate 2-12-7 shows aligned, closely spaced boudins that have not been as strongly transposed and rotated as those in Plate 2-12-6. Concretions are also rarely present within argillite; they are round to ovoid, concentrically zoned, and comprise about 10 to 30 per cent of the rock. Concretions are 3 to 15 centimetres in diameter, with monomineralic layers of pyrrhotite, light grey calcite and rare blebs of chalcopyrite, 3 to 10 millimetres thick (Plate 2-12-8).

Mineralization within the argillites consists predominantly of occasional, very fine to coarse-grained (up to 8 millimetres diameter), euhedral cubes of pyrite and/or fine-grained disseminated pyrrhotite. These appear to be secondary, and probably formed by diagenetic growth. Sulphide-rich beds and laminae occur in a few intersections; textural evidence indicates that these are primary. In some places, epigenetic sulphides occur as discrete beds or bands that have selectively replaced certain beds.

Argillites may have a well-developed foliation which is defined by pyrrhotite plates that are aligned in an axial planar orientation. A slaty cleavage is variably developed within

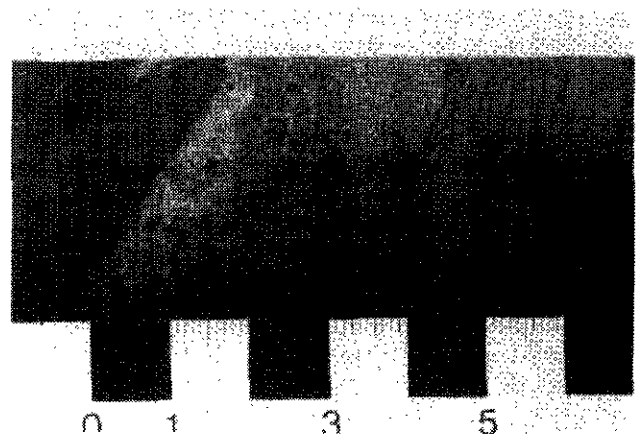


Plate 2-12-4. Normal graded bedding in argillite (sample 88-35; 115.5 m).

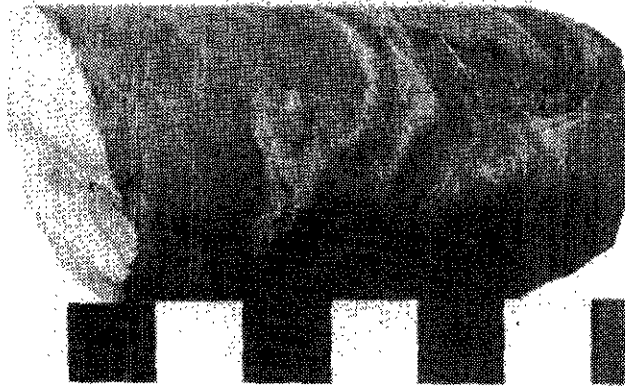


Plate 2-12-5. Soft-sediment deformation/slump structure in laminated, calcareous argillite (sample 88-36; 26.2 m).

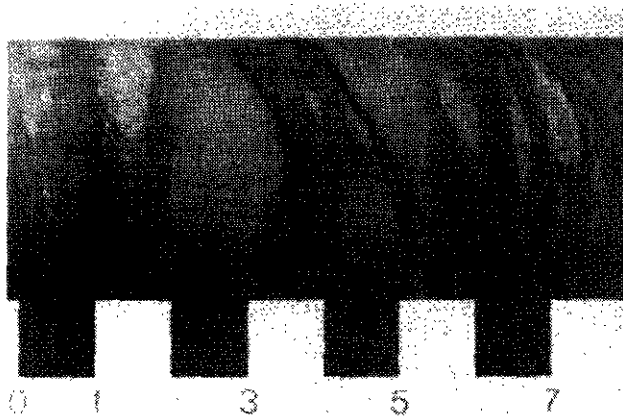


Plate 2-12-6. Light grey, calcareous boudins in finer grained, dark grey argillite groundmass (sample 88-44; 73.8 m).

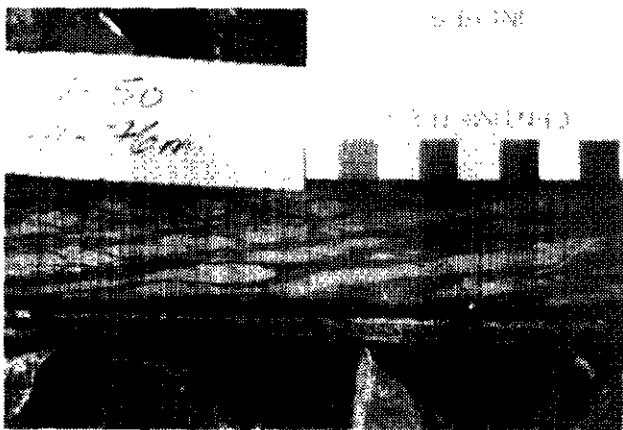


Plate 2-12-7. En-echelon augen-shaped light grey, calcareous boudins in dark grey argillite groundmass. Boudins are formed by breakup of lighter grey, calcareous beds (sample 88-50; 75.0 m).



Plate 2-12-8. Round to ovoid, concentrically zoned concretions in laminated to indistinctly bedded argillite. Concretions are 3 to 15 centimetres in diameter, with 3 to 10-millimetre-thick monomineralic layers of pyrrhotite, light grey calcite, and rare blebs of chalcocopyrite. Location is in south wall of the main adit at 1780 metres.

graphitic argillite, axial planar to  $F_1$  isoclinal folding (Gammon and Chandler, 1986).

### DYKES AND INTRUSIVES

Subvolcanic dykes range from less than 10 centimetres to 25 metres wide, are light grey-green to dark green in colour, fine to coarse grained, and generally possess a 1 to 20-centimetre-wide chloritic chilled margin (Plate 2-12-9). The dykes are predominantly equigranular but occasionally contain hornblende (or chlorite pseudomorphs), plagioclase, and, rarely, quartz phenocrysts. Sulphides are invariably absent. In some places, dykes appear to be conformable with the adjacent lithologies and may actually be sills, but many are discordant and were emplaced after deposition of some volcanic flows and lithification of tuffs and argillites.

Several textural and compositional types of dykes are recognized: (1) fine-grained dykes of intermediate to mafic composition; (2) medium to coarse-grained diorites; (3) medium to coarse-grained gabbros; and (4) biotite-bearing, intermediate to mafic dykes (lamprophyres?).

Dioritic and gabbroic or diabase bodies are of limited extent and occur spatially (and stratigraphically) beneath massive mineralization. Their thickness in drill-hole intersections ranges from 1 to 40 metres. They are green-black in colour and medium to coarse grained. They have homogeneous meshwork textures of intergrown plagioclase, amphibole and pyroxene, and in part display an ophitic texture (Harris, 1988). They are moderately to extremely altered and contain abundant talc with minor to moderate amounts of calcite, chlorite and epidote. In one drillhole, gabbro or diabase is a host to stockwork mineralization and, therefore, predates mineralization. Biotite-bearing dykes are extremely rare and of limited extent. They contain medium to coarse-grained, dark brown to black biotite flakes in a finer grained groundmass.

Most of the dykes are poorly to well foliated and therefore predate folding and tectonism of the deposit. Both the fine-grained and biotite-bearing dykes intrude the massive mineralization and thus postdate the emplacement of sulphides.



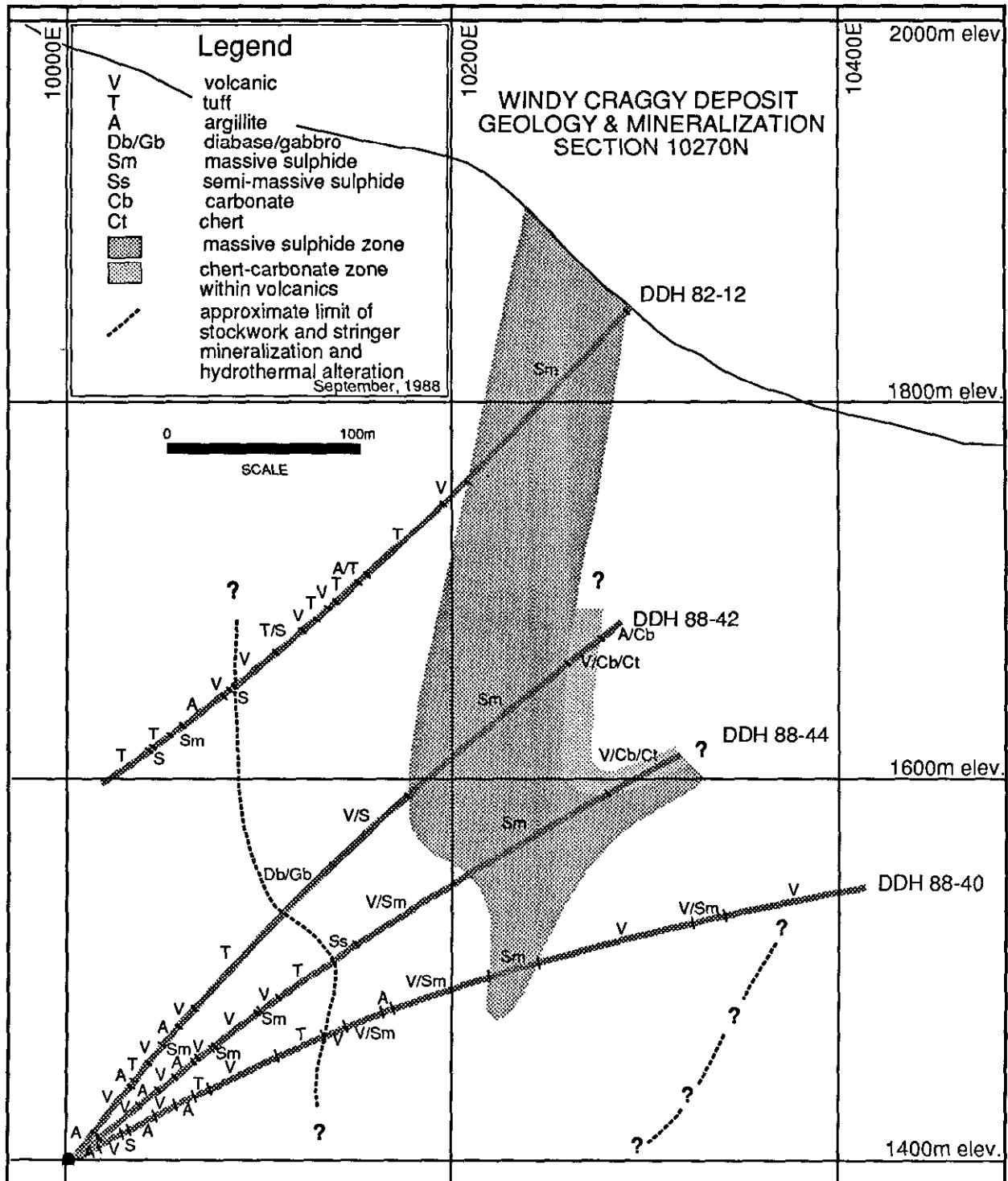


Figure 2-12-4. Section 10270N geology and mineralization showing location of adit, drill holes and lithologies noted in drill core. Also shown are boundaries of massive and stringer/stockwork mineralization, and chert-carbonate-sulphide unit, based on correlation between drill holes (after Geddes Resources Ltd. geological section).

## MINERALIZATION

Drilling has identified two main sulphide masses, the North and South sulphide bodies (Figure 2-12-3) which lie along a strike length of about 500 metres. Figure 2-12-4 depicts the geology and mineralization on section 10270N shown on Figure 2-12-3. This section is probably the least structurally complicated of the sections drilled and is typical of the dimensions of the massive sulphide mass intersected in other sections. It also contains a well-developed stockwork alteration zone in the footwall of the deposit.

The following table summarizes some typical assay results from underground diamond drilling (Shareholders Progress Report, September 7, 1988).

TABLE 2-12-1  
SELECTED ASSAY RESULTS, WINDY CRAGGY DEPOSIT

Hole	Intercept (m)	Interval (m)	Cu%	Au g/t	Ag g/t	Co%
<b>North Sulphide Body</b>						
88-46a	198-334	136	1.29	0.11	1.9	0.12
88-49b	180-332	142	2.02	0.08	3.9	0.10
88-49c	364-420	56	2.82	0.20	0.3	0.09
88-49	428-432	4	3.13	0.10	0.08	0.10
<b>South Sulphide Body</b>						
88-45d	156-304	148	2.00	0.09	0.1	0.11
88-47e	162-300	138	1.76	0.17	1.9	0.11
88-48f	272-314	42	1.22	0.05	0	0.12
88-43g, h	134-290	156	1.99	0.14	3.6	0.08
<b>Gold Zone</b>						
88-50	116-118	2	N/A	5.90	1.0	N/A
88-50i, j, k, l	128.85-147.40	18.55	0.62	4.47	3.6	N/A
88-52m	114.5-120.0	5.5	0.72	2.48	12.3	N/A

- a contains an interval of 24 metres averaging 2.30% copper  
 b contains an interval of 76 metres averaging 2.56% copper  
 c contains an interval of 22 metres averaging 3.48% copper  
 d contains an interval of 72 metres averaging 2.87% copper  
 e contains an interval of 28 metres averaging 2.84% copper  
 f contains an interval of 28 metres averaging 1.47% copper  
 g contains an interval of 16 metres averaging 3.05% copper  
 h contains an interval of 24 metres averaging 3.07% copper  
 i contains an interval of 5.5 metres averaging 11.56 g/t gold  
 j contains an interval of 0.35 metres averaging 27.60 g/t gold  
 k contains an interval of 0.5 metres averaging 38.00 g/t gold  
 l contains an interval of 0.5 metres averaging 25.30 g/t gold  
 m contains an interval of 3 metres averaging 3.58 g/t gold

## NORTH AND SOUTH SULPHIDE BODIES

### MASSIVE SULPHIDE MINERALIZATION

The massive sulphide mass varies in thickness from about 70 to about 150 metres (for example, Figure 2-12-4); however, folding and deformation may have modified its morphology and these may not be original stratigraphic thicknesses.

Three principal types of massive sulphide mineralization exist: massive pyrrhotite with lesser chalcopyrite, massive pyrite with lesser chalcopyrite, and massive pyrrhotite and pyrite with lesser chalcopyrite and magnetite. Current indications are that the massive sulphide mass is miner-

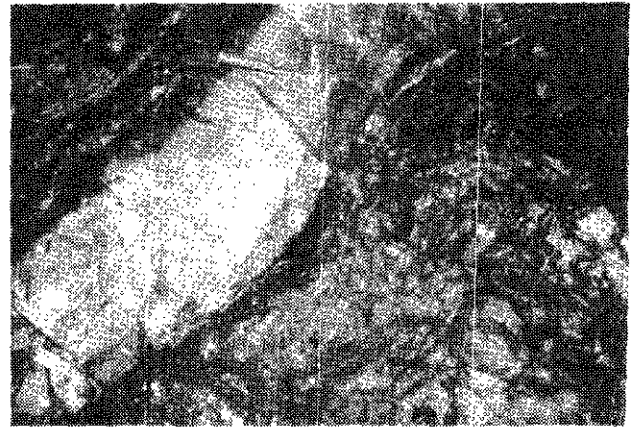


Plate 2-12-9. Mafic dyke, approximately 1 metre wide, with 10-centimetre-wide chloritized chilled margins; location is at end of North drift.

alogically zoned from massive pyrrhotite nearest the footwall to a massive pyrite zone at the stratigraphic top of the deposit. Magnetite occurs at the transition zone from pyrrhotite to pyrite, as fine-grained wisps, blebs, and patches. This zonation appears to be a primary feature unrelated to later metamorphism as only pyrrhotite-rich sulphides are associated with stockwork/stringer mineralization and pyrite-rich sulphides are absent. Figure 2-12-5 is a graphic log of drill-hole 88-44 showing the dominant lithologies intersected, the distribution of copper, cobalt, gold and silver, and estimates of pyrite and pyrrhotite abundances. Pyrrhotite occurs in the stringer/stockwork zone as well as within massive mineralization, but pyrite is not generally present within stockwork mineralization.

Previous preliminary investigations of the sulphide mineralogy (Harris, 1988; Buchan, 1983, 1984; Muir, 1980) have noted the presence of pyrrhotite, pyrite, chalcopyrite, with rare sphalerite, arsenopyrite, galena, vallerite, marcasite, cubanite and cobaltite. Gangue minerals include quartz, chlorite, calcite, ankerite, siderite, stilpnomelane, biotite and graphite.

There are a large variety of textures within the massive sulphide mass:

- fine-grained massive sulphides (pyrrhotite, pyrite, chalcopyrite, and magnetite) with minor chlorite along fractures.
- massive fine-grained sulphide (pyrrhotite, pyrite and chalcopyrite) with mottled, fine-grained carbonate (predominantly calcite with lesser ankerite and siderite) patches (Plate 2-12-10). Chalcopyrite occurs as discontinuous wisps, streaks and blebs associated with the carbonate.
- brecciated massive sulphides with angular, essentially monominerallic clasts of pyrite and/or pyrrhotite in a fine-grained sulphide matrix.
- foliated to gneissic sulphides with alternating, essentially monominerallic, discontinuous wisps, lenses and bands of chalcopyrite, pyrite, pyrrhotite, calcite and magnetite. This texture is relatively rare within massive mineralization and is probably due to recrystallization during folding and deformation.

- (e) recrystallized, "spongy" medium to coarse-grained pyrite. This texture may be primary and unrelated to metamorphism.
- (f) colloform-banded calcite, ankerite, and pyrite within fine-grained massive sulphides. This texture is indicative of open-space filling and suggests that cavities, pockets, and fractures were present within the sulphide mass.
- (g) primary sulphide banding consisting of finely laminated to bedded pyrrhotite, magnetite, pyrite and chalcopyrite.
- (h) soft-sediment deformation and slump structures within massive sulphide.

### STOCKWORK AND STRINGER MINERALIZATION

Stockwork and stringer mineralization consists of veinlets of fine-grained massive sulphide less than 1 millimetre to about 50 centimetres wide within brecciated host rock. Sulphides consist predominantly of pyrrhotite with lesser chal-



Plate 2-12-12. Stringer mineralization that has surrounded and, to a limited extent, brecciated pillowed mafic volcanics (basalt). Rims of pillows have been intensely chloritized. Mineralization consists of 70 per cent fine-grained pyrrhotite, 10 per cent chalcopyrite, and minor calcite and quartz. Location is approximately 150 metres north of adit in west wall of North drift. Pillow diameters are 30 to 50 centimetres.

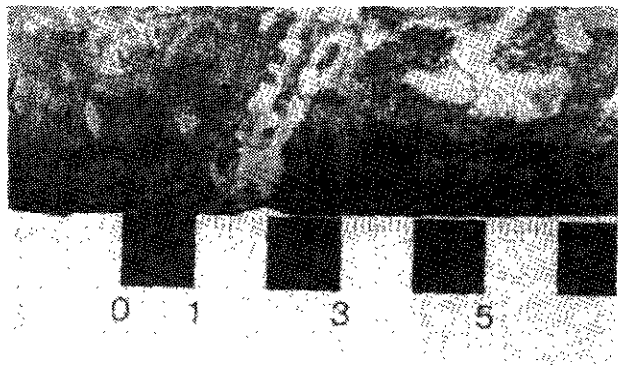


Plate 2-12-10. White calcite patches intergrown with massive pyrrhotite, pyrite and chalcopyrite (sample 88-49; 406.0 m).

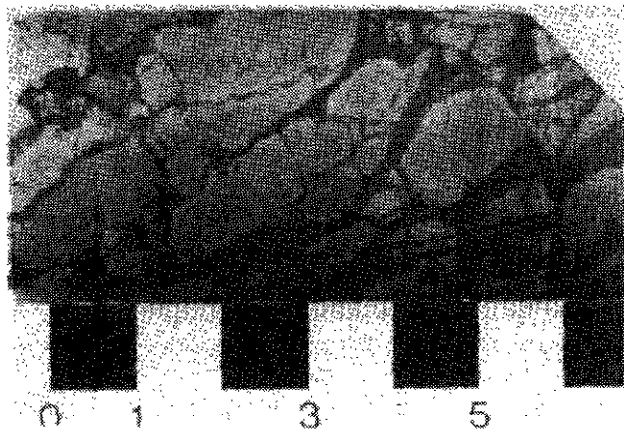


Plate 2-12-11. Stockwork or stringer mineralization. Clasts and fragments are bleached milky white in colour and strongly silicified. Dark veinlets and matrix are predominantly fine-grained pyrrhotite with lesser chalcopyrite (sample 88-32; 234.9 m).

copyrite and rare pyrite; gangue minerals include quartz and carbonate. This style of mineralization is not confined to any one particular lithology, although it appears to be most common within volcanic flows. The host rocks have been slightly to intensely chloritized and, in more extreme examples, have been strongly bleached and silicified. Host-rock breccia fragments are angular, 1 to 10 centimetres in diameter, and have been slightly to intensely chloritized and/or bleached and silicified (Plate 2-12-11). Silicified host-rock fragments are milky white, translucent, and resemble cryptocrystalline chert. The narrowest veinlets are generally associated with the most intense brecciation giving the overall appearance of a "crackle breccia".

Less intensely altered volcanic rock fragments are pervasively chloritized and medium to apple-green in colour, whereas moderately altered fragments are typically milky greenishwhite in colour. Plate 2-12-12 shows stockwork mineralization in brecciated pillow basalt in the North drift; sulphide veins are composed of 80 per cent pyrrhotite, 10 per cent chalcopyrite and 10 per cent each of calcite and quartz. Stockwork mineralization in argillite consists of light to dark grey fragments in a fine-grained sulphide matrix whereas similar mineralization in tuff generally contains dark grey-green fragments. Tuff fragments commonly contain more chlorite as a result of their original mineralogy. Intensely altered argillite and tuff fragments appear cryptocrystalline and milky white in colour. Pyrrhotite and chalcopyrite occur along select laminae and beds within individual fragments and as a breccia matrix between clasts. Relict lamination and bedding can be seen in both argillite and tuff (Plate 2-12-13). Sulphide laminae and beds are interconnected with matrix sulphides (Plate 2-12-14). It appears that sulphides have preferentially replaced coarser grained laminae and beds. In one place, stringer mineralization occurs within a diabase/gabbro intrusion.

Stockwork mineralization is localized within what is interpreted to be the stratigraphic footwall of the deposit and does



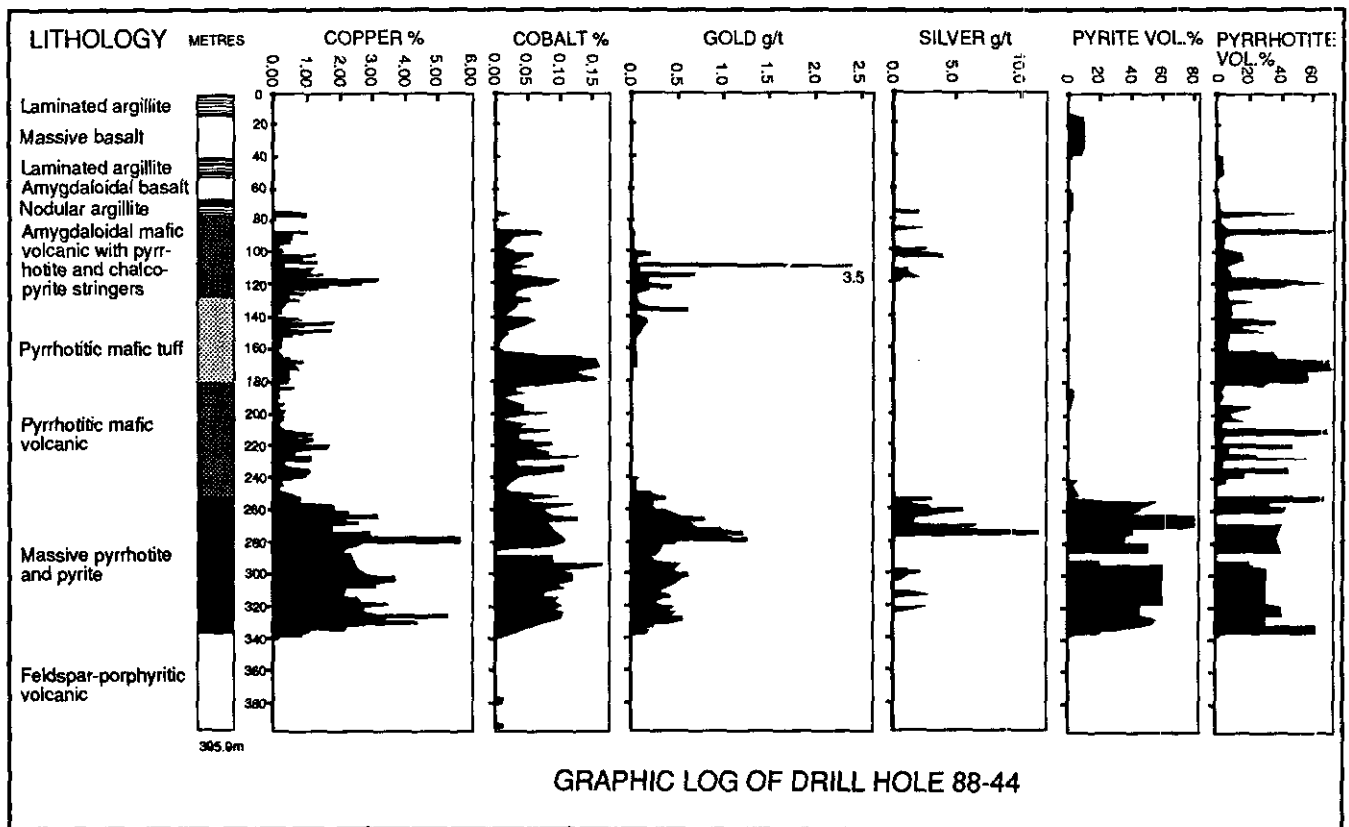


Figure 2-12-5. Graphic log of underground diamond-drill hole 88-44 shown on section 10270N in Figure 2-12-4. Shown are major lithologic units, copper, cobalt, gold and silver contents as well as estimates of pyrite and pyrrhotite abundances for adjacent 2-metre sample intervals (adapted from an original figure by R.J. Beckett and Geddes Resources Ltd. drill logs).

not appear to extend stratigraphically above massive mineralization. In the sections drilled to date (September, 1988), well-developed and recognizable stockwork and stringer mineralization extends about 100 metres beneath massive mineralization (Figure 2-12-4). However, as seen in Figure 2-12-5, significant copper (greater than 0.5 per cent), cobalt (greater than 0.05 per cent) (and even trace gold and silver) values occur well below this apparent boundary.

In many places stockwork/stringer mineralization is slightly to moderately foliated and individual clasts have been elongated and interstitial sulphide veinlets have been deformed to wisps and blebs.

### CHERT-CARBONATE-SULPHIDE

This unit consists of finely interlaminated to interbedded (less than 1 millimetre to 5 centimetres) calcite, siderite, ankerite, chert, chlorite, sericite, hematite, magnetite, pyrrhotite, pyrite, chalcopryite and, rarely, sphalerite (Plate 2-12-15). In places it contains a tuffaceous and/or argillaceous component. Individual units are generally narrow (0.1 to approximately 3 metres). In section 10270N (Figure 2-12-4) this unit consists of several thin carbonate-chert-sulphide bands within massive fine-grained mafic volcanic flows. Exhalite of similar appearance to the laminated chert-carbonate at Windy Craggy commonly overlies massive sulphide mineralization in a number of sulphide deposits. Possi-

ble analogues to this unit may be the "Tetsusekiei" of the Japanese Kuroko deposits (Kalogeropoulos and Scott, 1983), the Main Contact "C" tuff of the Noranda area (Gibson *et al.*, 1983) and the Key tuffite of Mattagami (Roberts, 1975). The chert-carbonate-sulphide unit at Windy Craggy does not typically carry gold, although in several places values between 1 and 3 grams per tonne were obtained.

### GOLD ZONE

The Gold zone was first indicated from surface by diamond-drill hole 83-14 which intersected 61.3 metres of "cherty carbonate material" that assayed 4.46 grams gold and 3.43 grams silver per tonne and 0.62 per cent copper. Within this section 5.5 metres assayed 11.66 grams gold and 3.09 grams silver per tonne and 0.98 per cent copper. This width may not be a true stratigraphic width. Underground drilling has confirmed the presence of this gold-bearing zone (see Table 2-12-1).

The gold-bearing unit contains fragments and patches and bands of milky white, very fine-grained cherty-looking rock. Less commonly, clasts of fine-grained green volcanic rock and rare laminated to banded argillite fragments are also present. Volcanic clasts commonly display a thin rim of darker green chlorite indicative of hydrothermal alteration. Clasts comprise about 40 per cent of the rock and are supported by a fine-grained, mottled sulphide and carbonate

matrix consisting of intergrown pyrite, pyrrhotite, chalcopyrite, magnetite, siderite, ankerite and calcite. Carbonate is fine grained and brownish grey (ankerite-siderite) to creamy white (calcite). Sulphides occur as fine-grained disseminations intergrown with carbonate. Rare visible gold occurs as discrete grains, 30 to 80 microns in diameter, associated with sulphides and carbonate. Electrum and native silver are present (Gasparrini, 1983; Buchan, 1984).

Original Falconbridge drill logs describe the Gold zone as containing abundant "siliceous intervals" and "stringer sulphides" implying an epigenetic origin. This zone was reinterpreted to be a stratiform, syngenetic, exhalative sediment in which the original carbonate-chert-sulphide bedding has been transposed and dislocated by tectonic brecciation and/or by soft-sediment deformation (Fox, 1986).

However, several features do not support an exhalative origin:

- There is a very good positive correlation between gold and copper values in this zone. The precipitation of copper from typical ore-forming hydrothermal fluids occurs at temperatures higher than those invoked for exhalative mineralization (Barnes, 1979).
- The presence of altered volcanic and argillite clasts within the unit.
- Elevated gold values (1 to 2 grams per tonne) occur in the massive sulphide mass immediately adjacent to the Gold zone.

A favoured preliminary interpretation is that gold and attendant sulphides and carbonates were introduced into bedded argillite and volcanics and possibly chert-carbonate-sulphide by later, high-temperature hydrothermal fluids. These fluids brecciated and altered (chloritized and/or silicified) the host rocks in part. This hypothesis is supported by the presence of clasts and fragments of volcanics and argillite that are rimmed by chlorite. As well, in some places, pyrrhotite and minor chalcopyrite bands occur in dark grey, fine-grained quartzose argillite. These bands are interconnected by narrow sulphide veinlets which crosscut the argillite. This texture, noted in drill hole 88-50, suggests that sulphides have selectively replaced pre-existing beds and laminae.

## STRUCTURE AND METAMORPHISM

Multiple phases of deformation of the deposit have been noted since 1982 by Falconbridge geologists who recognized folded  $S_1$  cleavage planes in drill core. Mapping of the north face of Windy Peak (Kelemen and Radford, 1983) verified the presence of two phases of folding within the deposit.  $F_1$  isoclinal folds trend northwest and west-northwest. These are deformed by  $F_2$  open folds which trend north to north-northeast.  $F_1$  folds are often overturned towards the southwest and plunge  $30^\circ$  to  $50^\circ$  towards the northwest. The plunge of the  $F_1$  axes varies due to the influence of the steeply north-plunging  $F_2$  folds.

The north sulphide body is folded into a large, upright syncline plunging steeply to the northwest. The western limb of the syncline dips steeply north whereas the eastern limb has a more gentle dip to the south (Figure 2-12-4). Stockwork and stringer mineralization are most prevalent near the hinge

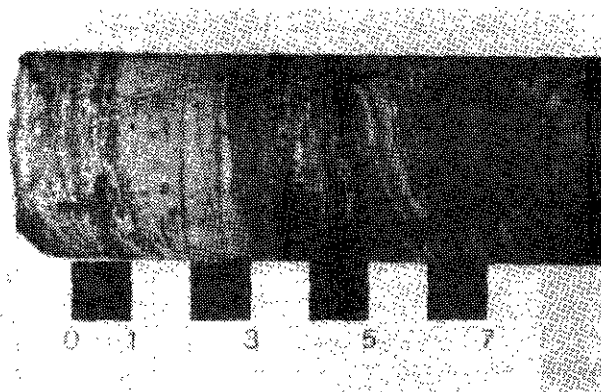


Plate 2-12-13. Extremely bleached and silicified, remnant argillite beds and laminae in massive pyrrhotite with minor chalcopyrite. Beds are broken and pulled apart slightly (sample 88-49; 181.4 m).

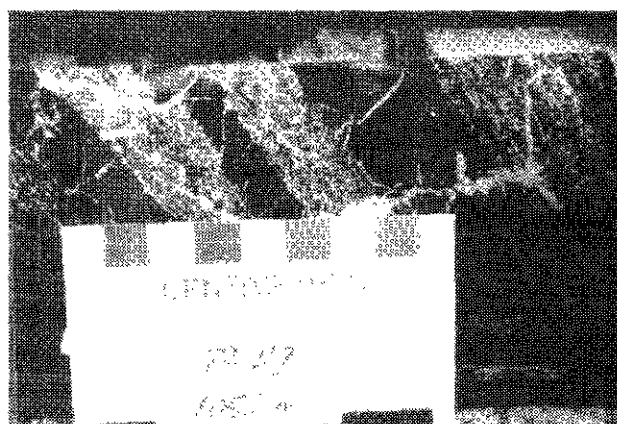


Plate 2-12-14. Beds of bleached and silicified tuffaceous argillite (black). Mixed white and black beds are pyrrhotite and minor chalcopyrite in coarser grained argillite. Sulphides appear to have replaced coarser grained beds. Note the veinlets of sulphide connecting the replaced beds (sample 88-49; 105.8 m).

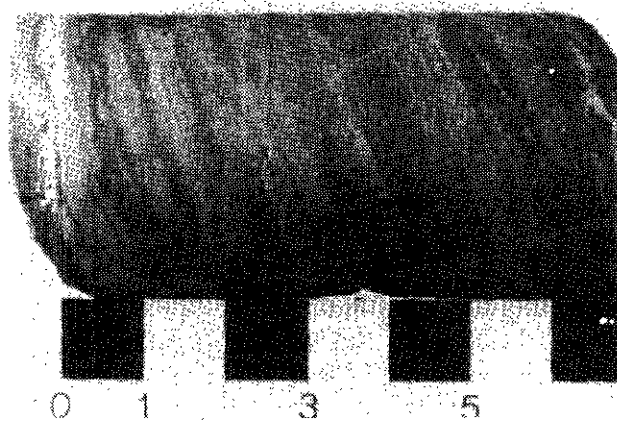


Plate 2-12-15. Chert-carbonate-sulphide unit consisting of finely interlaminated calcite, siderite, ankerite, chert, chlorite, sericite, hematite, magnetite, pyrrhotite, pyrite, chalcopyrite and rare sphalerite (sample 88-24; 305.7 m).

area of the syncline. Massive pyrrhotite is predominant in the western limb and massive pyrite is more common in the eastern limb.

The South sulphide body is monoclinical and plunges steeply southeast (Section 9910 on Figure 2-12-3). The monoclinical nature may be due to isoclinal folding as preliminary investigation indicates that stockwork mineralization occurs on either side of the massive sulphide mass. The two sulphide masses may in fact be part of a single, doubly-plunging structure.

Faulting is most prevalent within volcanic flows and gabbro/diabase units. Narrow zones of shearing and faulting with slickensided chlorite and/or talc and chloritic clay gouge are common in the diabase. All rock types contain narrow (1 to 3 millimetre) crosscutting veinlets of calcite and minor quartz. The orientation of these veinlets is generally random, but in several places they appear to be axial planar. Metamorphism of host rocks has not been intense, and primary textures and fabrics are preserved, except where the rocks have been affected by faulting or hydrothermal alteration. Host rocks are regionally metamorphosed to greenschist facies. All styles of mineralization bear some evidence of foliation.

## CONCLUSIONS

The Windy Craggy deposit is a major resource of copper and cobalt with at least one gold-rich zone. It may prove to be one of the largest massive sulphide bodies in North America. The deposit is hosted by a sequence of interbedded volcanic flows, tuffs and argillites that have been intruded by dykes and sills. Mineralization consists of one or two massive sulphide bodies comprised predominantly of pyrrhotite, pyrite, chalcopyrite and magnetite. Significant stockwork/stringer mineralization is confined to hydrothermal alteration zones that are interpreted to stratigraphically underlie massive mineralization. The abundant argillaceous sediments, combined with basalts and synvolcanic dykes, indicate a setting similar to the present day seafloor sulphide deposits of Guaymas Basin in the Gulf of California (Peter and Scott, 1988).

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