Tungsten Mineralization in the Carbonate Rocks of the George River Group, Cape Breton Island, Nova Scotia

by A K Chatterjee

Nova Scotia Department of Mines

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TUNGSTEN MINERALIZATION IN THE CARBONATE ROCKS OF THE GEORGE RIVER GROUP, CAPE BRETON ISLAND, NOVA SCOTIA

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HALIFAX, NOVA SCOTIA

1977

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Mineral Resources

PREFACE

This paper documents the recognition of an important geological environment for tungsten mineralization in Cape Breton Island, Nova Scotia.

At present approximately 48 per cent of world resources and 55 per cent of tungsten production is obtained from skarns. The importance of skarns as a source of tungsten and their development in the rocks of the George River Group suggests that they should be purposefully explored for the discovery of productive tungsten deposits.

Funding for this investigation was provided by the Department of Regional Economic Expansion and the Nova Scotia Department of Mines.

F. S. Shea, Director
Mineral Resources

Halifax, Nova Scotia
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TUNGSTEN MINERALIZATION IN THE CARBONATE ROCKS OF THE GEORGE RIVER GROUP, CAPE BRETON ISLAND, NOVA SCOTIA

A. K. Chatterjee

ABSTRACT

This paper documents the presence of tungsten mineralization in the calcareous rocks of the George River Group, Cape Breton Island.

In the Boisdale Hills, scheelite mineralization is restricted to a well defined metamorphic zone characterized by wollastonite and diopside-wollastonite associations. This metamorphic zone cross-cuts all the metasedimentary units and extends for approximately 4.5 kilometers along strike. Tungsten content of 0.55 per cent WO_3 is the highest established in one sample.

At Lime Hill, the favourable host rocks for tungsten mineralization are calcareous skarns while the known zinc mineralization is generally restricted to diopside-forsterite skarns. The tungsten minerals are scheelite, hydrotungstite and sanmartinite. Both the tungsten and zinc mineralization are accompanied by an alteration halo, the former with lizardite (1-layer orthosilicate) and the latter with antigorite [6(2)-layer orthosilicate]. Tungsten content of 2.80 per cent WO_3 is the highest established in one sample.

At Whycocomagh scheelite mineralization is associated with the chalcopyrite-magnetite mineralization in an altered diopside-forsterite-monticellite skarn. Tungsten content of 1.97 per cent WO_3 is the highest established in one sample.

INTRODUCTION

The presence of scheelite in siliceous limestone and siliceous dolomitic limestone of the George River Group was first detected with the massive sulphides in the magnesian skarn at McMillan Brook by Chatterjee (1977). Since the initial findings, tungsten mineralization has been recognized in association with the diopside-wollastonite skarn in parts of the Boisdale Hills, with the calcareous skarn at Lime Hill, and with the magnesian skarn at Whycocomagh Mountain (Fig. 1). The host rocks and the nature of tungsten mineralization are briefly described in the following pages, and it is hoped that this will assist future exploration for tungsten in the rocks of the George River Group.

BOISDALE HILLS

The geology of the Boisdale Hills has been mapped in detail by Milligan (1970). A portion of this map has been reproduced here as Figure 2 showing the location of samples containing scheelite. The scheelite content in these samples never exceeds more than one per cent (visual estimate) of the total. Tungsten content of 0.55 per cent WO_3 is

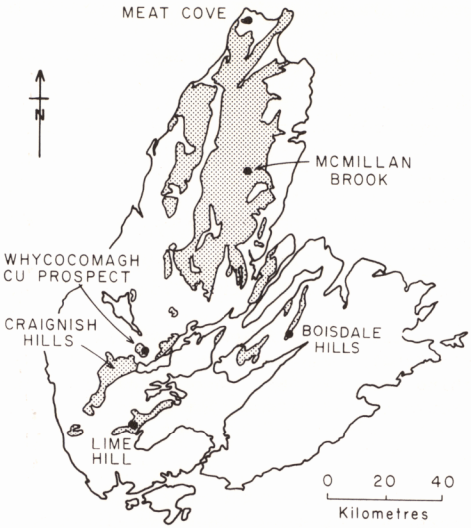

Figure 1

Map showing the distribution of the George River Group in Cape Breton Island and also the localities mentioned in the text.

the highest established in one sample (see Appendix I for analytical methods).

Host Rock for Tungsten Mineralization

The region is characterized by an interbedded sequence of calcareous, argillaceous and magnesian skarns* together with biotite, amphibole-garnet-biotite schists, garnetiferous quartzites, and minor amphibolite containing quartz. A summary of mineral assemblages in metamorphosed carbonate rocks of the Boisdale Hills has already been given by Chatterjee (1970).

Magnesian skarns are recrystallized carbonate rocks containing high temperature magnesian minerals. Typical minerals are merwinite, chondrodite, monticellite, forsterite and diopside. Depending on the availability of alumina, minerals such as spinel and anorthite may also develop.

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* The term "skarn" is here applied to recrystallized carbonate rocks containing calcium, magnesium, iron and aluminum silicates, and found in high temperature zones of the contact halos of intrusions.

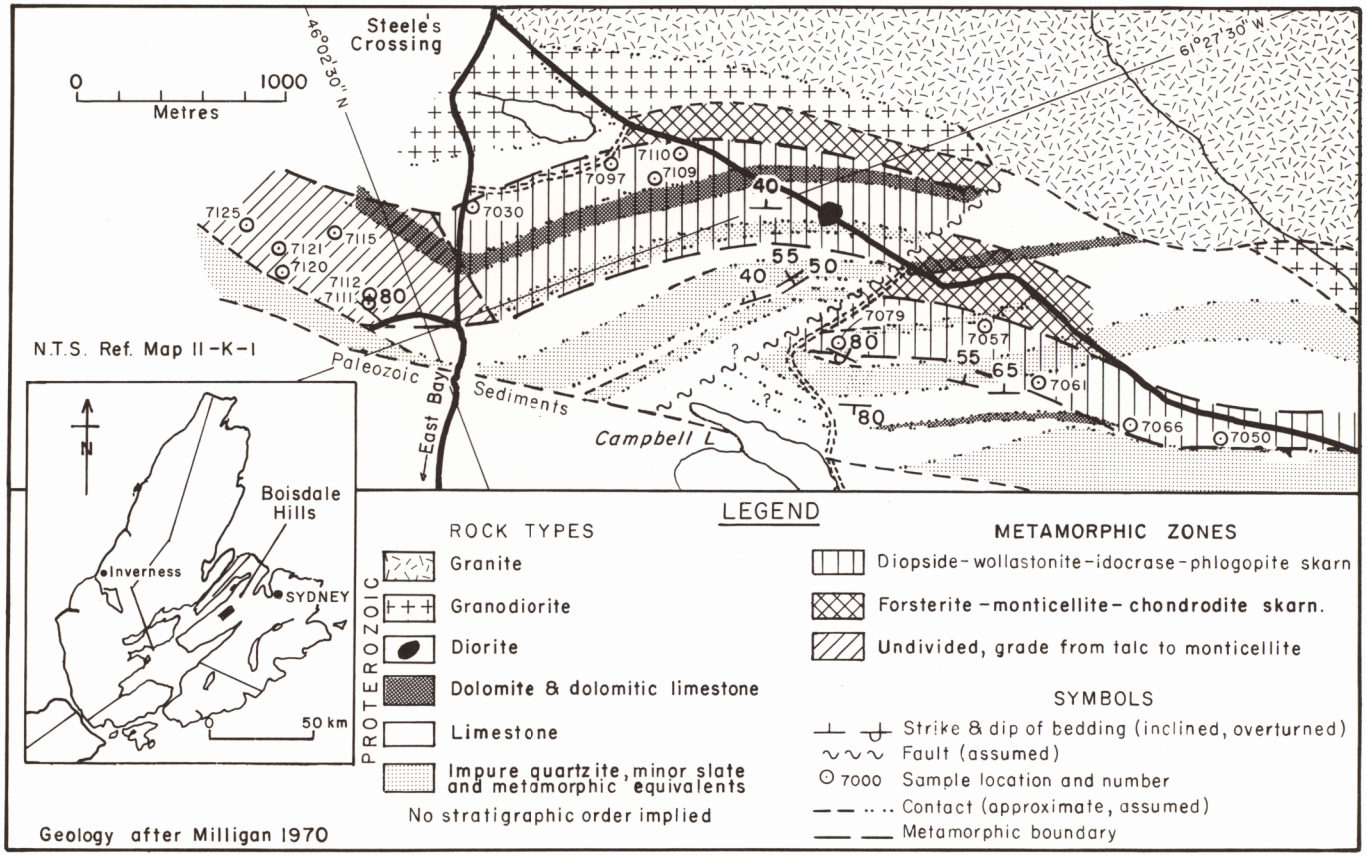

Figure 2 - Geological Map: Boisdale Hills

Calcareous skarns are recrystallized rocks containing high temperature lime-magnesia-iron silicates and alumino-silicates. The typical minerals are akermanite, idocrase, wollastonite and scapolite.

Argillaceous skarns are also recrystallized rocks containing high temperature lime-magnesia-potassium-iron silicates and alumino-silicates. Typical minerals in this group are scapolite, K-feldspar, calcic-plagioclase, zoisite, phlogopite and quartz. Minerals such as diopside and tremolite may also appear in this type under certain pressure-temperature conditions.

Marbles forming continuous beds of varying thickness are regularly changed to skarn through granitoid magmatism. Visible contacts with the intrusive rocks have not been found. Distinct mineral zones are absent in the carbonate rocks and monomineralic, bimineralic and poly-mineralic skarns are all typical.

Preliminary data on the distribution of scheelite, based on hand specimens in the Nova Scotia Department of Mines' collection, indicate that the tungsten mineralization is confined to impure siliceous and magnesian limestone units and is restricted to a metamorphic zone within these units (see Fig. 2). This metamorphic zone is characterized by wollastonite, diopside, diopside-wollastonite, and clinozoisite-idocrase-phlogopite mineral assemblages. This zone has been traced for approximately 4.5 kilometers, clearly cross-cutting the strike of the lithological units and paralleling the contact between the metasediments and the intrusive rocks.

Within the boundaries of the magnesian skarns, a hydrothermal calcite-sulphide mineralization is superimposed. This type of mineralization is seen as irregular and discontinuous veins consisting of magnetite, pyrite, pyrrhotite, chalcopyrite, bornite, sphalerite and calcite. These veins have a distinct alteration halo characterized by talc and antigorite. Microscopic examination of more than 50 thin sections and X-ray diffraction analyses of 15 antigorite samples indicate that in every case the antigorite is derived from pre-existing minerals such as forsterite, diopside, tremolite and dolomite. Some of the pertinent data concerning the relationship between antigorite and the pre-existing minerals are described below:

(a) Mesh Serpentine: It is generally fine-grained and forms an approximate prismatic arrangement of cross fibre veinlets cutting through the earlier mineral. Different stages of alteration may be seen in Plate 1, Figure A. When dolomite is completely altered, the end products are antigorite and calcite. The X-ray diffraction data are shown in Table 1A.

(b) Fibrolamellar Serpentine: It occurs as a tightly compacted matte of elongate fibrolamellar flakes of antigorite. This variety of antigorite has developed from tremolite (Plate 1, Figure B) and diopside (Table 1B). In four X-ray analyses, all the lines could only be accounted for by a mixture of diopside and antigorite.

(c) Antigorite as a poikilitic pseudomorph: This variety of antigorite occurs as elongated sub-rectangular flakes, and exhibits rather ragged and feathery terminations (Plate 1, Figure C and D). This type of antigorite is derived from forsterite.

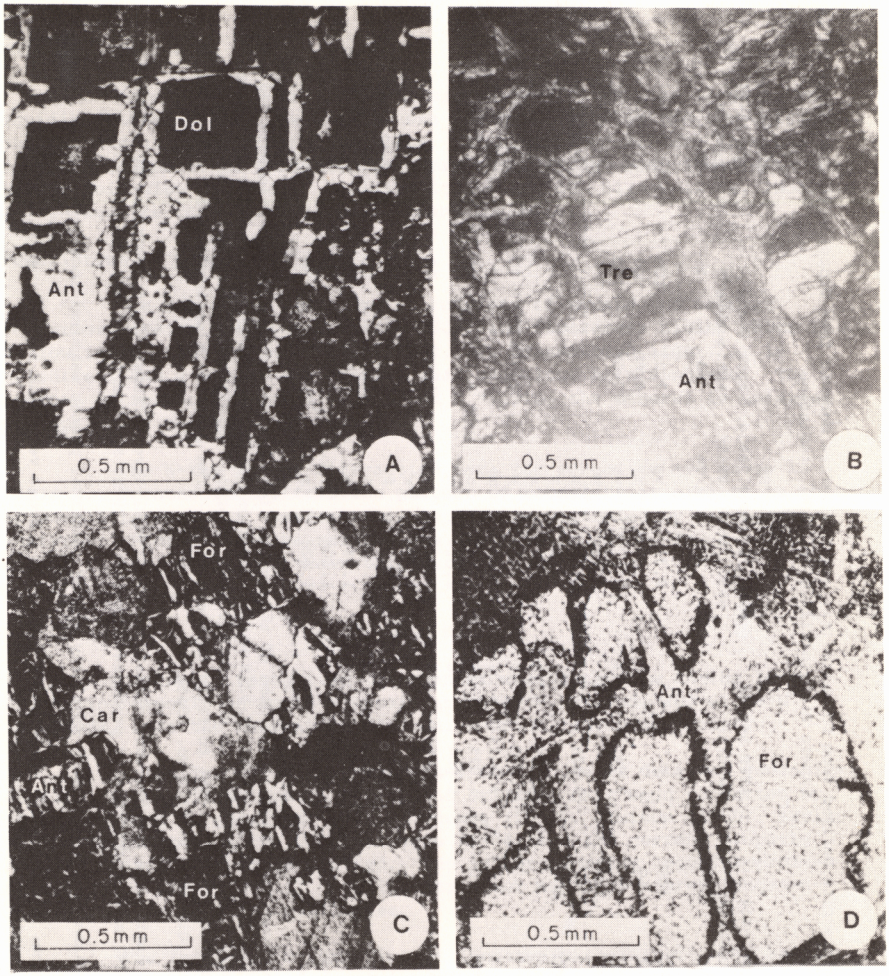

Plate 1

Photomicrographs showing the textural patterns of antigorite. A, Mesh Serpentine showing the pseudo-rectangular arrangement of Cross fibre veinlets. This variety of antigorite has been derived from dolomite. B, elongated fibrolamellar flakes of antigorite developed from tremolite and diopside. C and D, Poikilitic pseudomorphs of antigorite after forsterite. Ant, antigorite; Dol, dolomite; For, forsterite; Tre, tremolite; Car, carbonates.

TABLE 1

Powder X-ray Data for Antigorite Derived from Dolomite (A), and Antigorite Derived from Diopside (B), Boisdale Hills
Camera Diameter 114.6 mm, $CuK\alpha_1$ radiation

		A				B				ASTM 24-705	
NSDM Film Nos. 8931, 8932, 8934		ASTM 9-444 Antigorite**		ASTM 5-0586 Calcite		NSDM Film Nos. 8934, 8935, 8936, 8945*		ASTM 9-444 Antigorite**		ASTM 11-654 Diopside	
d	I/Io	d	I	d	I	d	I/Io	d	I	d	I
7.37	vs	7.33	100	-	-	7.31	vs	7.33	100		
4.60	m	4.60	60	-	-	4.60	m	4.60	60		
3.86	w	-	-	3.86	12	3.62	vs	3.66	100		
3.63	s	3.66	100	-	-	3.21	m			3.25	50
3.04	vs	-	-	3.035	100	3.01	s			2.99	80
2.50	s	2.502	100			2.91	s			2.90	70
2.28	m	-	-	2.285	18	2.521	s			2.53	60
2.09	m	-	-	2.095	18	2.309	s	2.335	70		
1.911	s	-	-	3 Refl.	22	2.227	m			2.22	30
1.86	s	1.791	10	1.875	17	2.127	s	2.149	60	2.11	
1.603	m	-	-	1.604	8	2.014	m				
1.521	m	1.53	80	3 Refl.	12	1.827	w	1.791	10		
1.469	w	-	-	1.473	2	1.756	w	1.739	10		
1.443	m	-	-	1.440	5	1.669	f				
1.420	w	1.41	20	1.422	3	1.623	s	1.626	40	1.62	40
						1.535	s	1.535	80		
						1.508	vs	1.501	70	1.51	70
						1.428	m	1.415	20		

* These four films are visually identical, but some of the weaker lines are not measurable for film 8936 and 8945. Distinctive are the two lines d = 3.01A and 2.521A which appear on each film with equal intensity. It must, therefore, be concluded that they belong to one and the same mineral. Only the calcium-magnesium silicate (diopside) of ASTM No. 24-705 and 11-654 fulfills this condition. The diopside also accounts for the splitting of the 2.91 from the 3.01A line in film No. 8935.

** The X-ray pattern of antigorite matches very closely with the 6(2)-layer orthosilicate described by Brindley and van Knorring (1954) and experimentally produced hydrothermally by Roy and Roy (1956).

d = the interplanar spacing between regularly spaced identical planes measured in Angstrom units
I = intensity
vs = very strong; s = strong; m = medium; w = weak; f = broad very weak reflection
I/Io = visual estimate of intensities

Nature of Tungsten Mineralization

Mode of Occurrence

Scheelite occurs as fine disseminated (<1 mm), as large rather equidimensional grains, as thin layers (<2 mm) following the compositional banding and as cross cutting veinlets. It never exceeds more than one per cent of the total content. In every case, it has been found with one of the following minerals: wollastonite, diopside, clinozoisite, idocrase and phlogopite together with calcite and dolomite.

Description of Scheelite

The scheelite investigated consists of square and tabular colourless grains (Sample No. 11K1-7050); and fluoresces bluish white to yellow in short-wave ultraviolet light. In transmitted light, it is colourless and a few grains exhibit weak anomalous birefringence. The indices of refraction are $N_e \approx 1.935$ and $N_w \approx 1.910$; the mineral is uniaxial and optically positive.

The X-ray powder diffraction data for scheelite are given in Table 2. Because the diffraction pattern of scheelite is similar to that of powellite ($CaMoO_4$), confirmatory tests were performed by microprobe analysis. Microprobe data showing the distribution of W, Ca, Si, Mo, Cu and Fe in the sample are shown in Figure 3.

LIME HILL

The newly recognized tungsten mineralization is in the long-known zinc deposit on North Mountain at 45°47'N latitude and 61°09'W longitude, near the headwaters of McCuish Brook, Inverness County.

Extensive exploration programs consisting of detailed geological mapping, geophysical survey and diamond drilling have been conducted by Belcher Mining Corporation (1955), Conwest (1959), Cominco (1960), Patino Mining Corporation (1968), Silvermaque (1974) and the current property holders Brascan Resources Limited. The author recently logged approximately 3,500 feet of drill core (Silvermaque) and encountered tungsten mineralization in a few drillholes.

The following description of tungsten mineralization is based solely on samples obtained from diamond-drillholes. These are S-4, 2+02N, 7+81E; S-9, 0+52N, 6+21E; S-10, 0+52N, 6+71E; S-12, 1+02N, 7+24E; S-13, 1+02N, 6+74E; S-16, 3+45N, 6+88E; S-17, 4+47N, 6+99E; and S-20, 4+47N, 7+88E. These diamond-drillholes may be located on Figure 4, using the base line shown on the map.

Host Rock for Tungsten Mineralization

At Lime Hill (Fig. 4), the calcareous rocks of the George River Group form a roof pendant in granite. The grade of metamorphism is extreme. The hydrothermal mineralization came later and its attendant alteration is superimposed. Zinc mineralization is in the magnesian skarn and the tungsten mineralization in calcareous skarn. These skarns are almost identical to those already described from the Boisdale Hills

TABLE 2

Powder X-ray data for Scheelite ($CaWO_4$) from Boisdale Hills.
For Comparison the data for Powellite ($CaMoO_4$) are also included.

Camera Diameter 114.6 mm, $CuK\alpha_1$ radiation

	Scheelite NSDM 11K/7108		Scheelite ASTM 7-210 and 8-145		Powellite Berry & Thompson (1962) No. 292, p. 226	
θ	d	I/Io	d	I	d	I
9.3	4.77	M	4.76	53	4.80	60
14.45	3.09	vs	3.10	100	3.11	100
15.8	2.83	w	2.844	14	2.87	40
17.1	2.61	w	2.622	23	2.62	40
19.6	2.29	w	2.296	19	2.29	30
23.55	1.92	s	1.92	28	1.937	90
24.55	1.85	w	1.853	12	1.855	40
25.95	1.76	vw	1.727	5	1.701	50
27.15	1.609	m	1.68	16		
28.15	1.63	w	1.633	10	1.64	10
29.0	1.59	s	1.59	30	1.593	80
29.7	1.55	w	1.55	14	1.558	40
32.25	1.445	vw	1.442	6	1.439	10
∿						
∿						
∿						
∿						
38.0	1.252	s	1.251	80	1.256	70
39.55	1.211	vw	1.22	2	1.209	20
40.3	1.192	w	1.19	4	1.193	20

θ = the measured value of the glancing angle
I = intensity
d = the interplanar spacing between regularly spaced identical planes measured in Angstrom units
I/Io = visual estimate of intensities
vs = very strong; s = strong; m = medium; w = weak;
vw = very weak

Figure 3. Electron beam scanning pictures of scheelite from Boisdale Hills. NSDM Sample No. 11K/7108. Field of view 320 microns (≈x400).
A. X-ray intensity display of WLα(43.46) radiation from scheelite grains.
B. X-ray intensity display of CaKα(39.38) radiation from scheelite grains.
C. X-ray intensity display of SiKα(47.88) radiation from prismatic diopside grains.
D. X-ray intensity display of MoKα radiation from scheelite grains.
E. X-ray intensity display of CuKα radiation from scheelite grains. From the intensity display it would appear that both Mo and Cu occur as minor substitution in scheelite.
F. X-ray intensity display of FeKα from phlogopite grains.

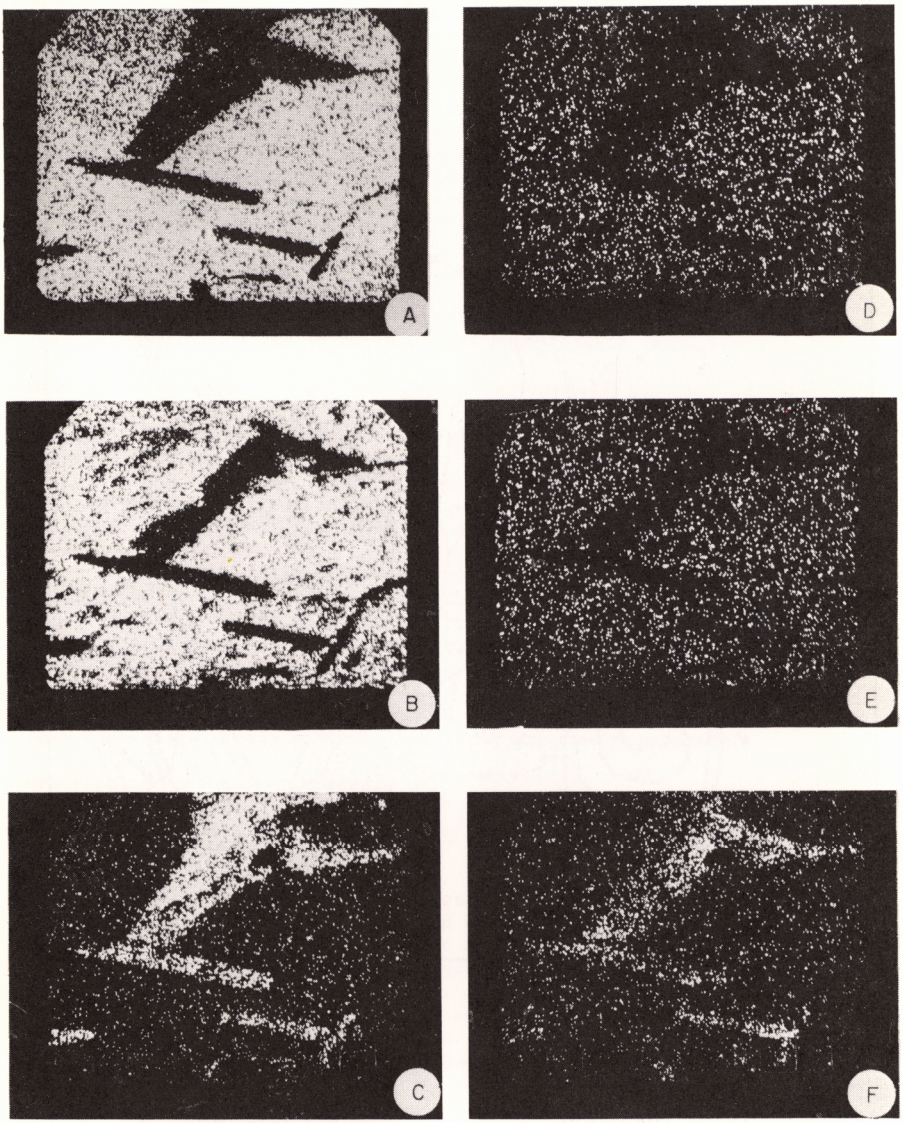

Figure 3

Electron beam scanning pictures of scheelite from Boisdale Hills. For explanation see page 8.

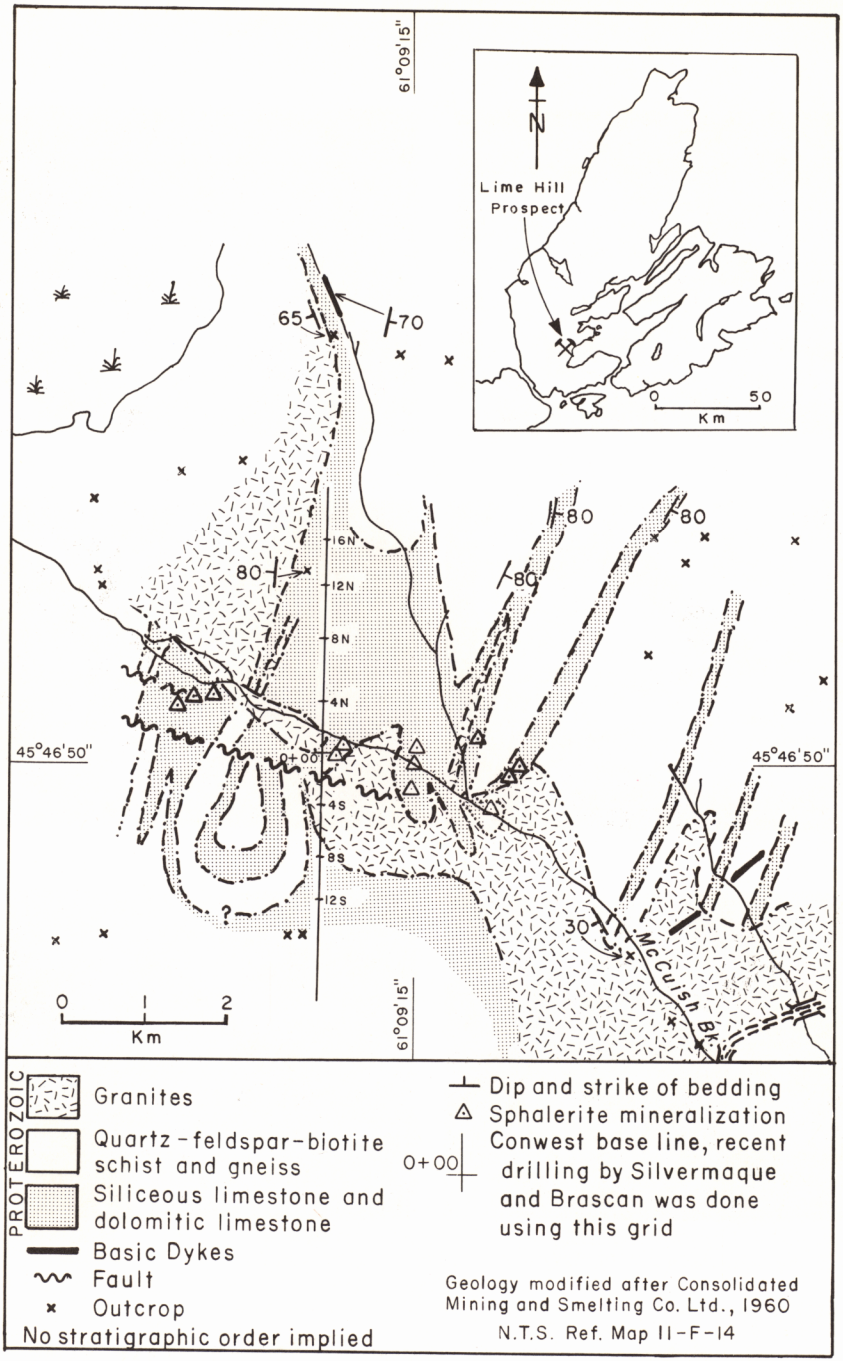

Figure 4

Surface Plan, Lime Hill Prospect

except that the magnesian skarn also contains zinc mineralization (≈2.0 million tons, 2.5% Zn) and the mineral zoning in the calcareous skarn is more predominant. In two drill holes (S-17 and S-20) thick sections of almost pure wollastonite* were observed. Another distinctive feature is the intense alteration. The magnesian skarn, which is the host for zinc mineralization, is associated with 6(2)-layer orthosilicate. On the other hand the calcareous skarn, which contains tungsten mineralization, is associated with 1-layer orthosilicate (lizardite). The X-ray powder data on wollastonite and lizardite are shown in Table 3.

Nature of Tungsten Mineralization

The tungsten bearing minerals from Lime Hill are scheelite ($CaWO_4$), hydrotungstite ($H_2WO_4.H_2O$) and sanmartinite ($ZnWO_4$).

Mode of Occurrence

Scheelite occurs as grains disseminated in massive sphalerite (Plate 2A and B), as massive granular aggregates with diopside, wollastonite and lizardite (Plate 2C and D), as nodular replacement patches with molybdian (Plate 3A and B), and as thin (<1 cm) layers following the original compositional layers of the calcareous rocks (Plate 3C and D).

Hydrotungstite occurs as yellowish white, dull, earthy granular coatings on scheelite and calcite. The grains of hydrotungstite range in size from 5 microns to 25 microns. It also occurs as radiating needles (≈1/2 cm in long dimension) forming rosettes in fractures and cavities (Plate 4A). The core of the rosettes is in every case, made of calcite.

Sanmartinite is rare and is exclusively associated with sphalerite. This mineral is easily mistaken for light coloured sphalerite.

Description of Tungsten Minerals

Scheelite was identified in transmitted light, by X-ray diffraction and microprobe analyses.

Radiating crystals of hydrotungstite forming rosettes on rhombohedral calcite crystals were observed on fractures (Plate 4A) and they resemble the scalenohedron variety of calcite. However, when tested with dilute HCl, the crystals of hydrotungstite turned dark yellowish brown and showed no reaction with the acid. A semiquantitive spectrographic analysis, by Dr. H. Champ of the Geological Survey of Canada, showed the principal metal to be tungsten (G.S.C. Lab. Report No. R48-77, Lab Records

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* The potential of wollastonite as an industrial mineral for use in the ceramic industry is worth evaluating. It can serve as a replacement, in whole or in part, for quartz sand, feldspar, china clay and other traditional material. It also has advantages of its own in that it improves the mechanical properties of the articles and because firing time is considerably reduced if more than 20 per cent of wollastonite is used. An addition of 50 per cent wollastonite to a ceramic mixture can cut down the firing time of 20 to 70 hours to an hour or two, thus effecting a large saving in fuel consumption.

TABLE 3

Powder X-ray Data for Wollastonite (DDHS-17 - 152')* and 1-layer Orthosilicate (DDHS-13 - 43'4"**; and Patino DDH-18 - 49', 66', 68', 294' and 296'), Lime Hill Zinc Prospect
Camera Diameter 114.6 mm, $CuK\alpha_1$ radiation

Wollastonite				1-layer orthosilicate			
NSDM Film No. 8998		ASTM 19-249 Wollastonite		NSDM Film Nos. 8941, 8942, 8943, 8944, 8945 & 8946		ASTM 11-386 1-layer orthosilicate	
d	I/Io	d	I	d#	I/Io	d	I
7.63	m	7.68	50	7.25	vs	7.25	60
3.86	m	3.838	60	4.62	s	4.62	20
3.51	m	3.510	70	3.89	vw	3.90	5
3.30	s	3.312	80	3.65	vs	3.624	60
3.08	s	3.080	70	2.659	vw	2.669	5
2.98	vs	2.976	100	2.495	vs	2.504	100
		2.522	40				
2.508	s	2.510	20	2.456	m	2.415	16
		2.470	60	2.151	s	2.149	35
		2.328	40	1.82	m	1.812	5
2.321	m	2.320	50	1.79	m	1.791	15
		2.296	60	1.74	vw	1.747	5
		2.209	40				
2.191	m	2.179	70	1.541	s	1.541	25
		2.161	40	1.517	m	1.507	20
1.613	m	1.612	40	1.49	m	1.499	15
		1.598	50	1.44	w	1.450	5
1.537	vw	1.533	20	1.427	w	1.418	5
1.476	w	1.474	40	1.316	m	1.313	10
1.366	w	1.356	50				

* Silvermaque diamond-drill hole No. 17 (4+47N, 4+88E), depth 152'.
** Silvermaque diamond-drill hole No. 13 (1+02N, 6+74E), depth 43'4".
\# Represent the average of values obtained from six X-ray powder films of six different samples.

d = the interplanar spacing between regularly spaced identical planes measured in Angstrom units
I = intensity
I/Io = visual estimate of intensities
vs = very strong; s = strong; m = medium;
w = weak; vw = very weak

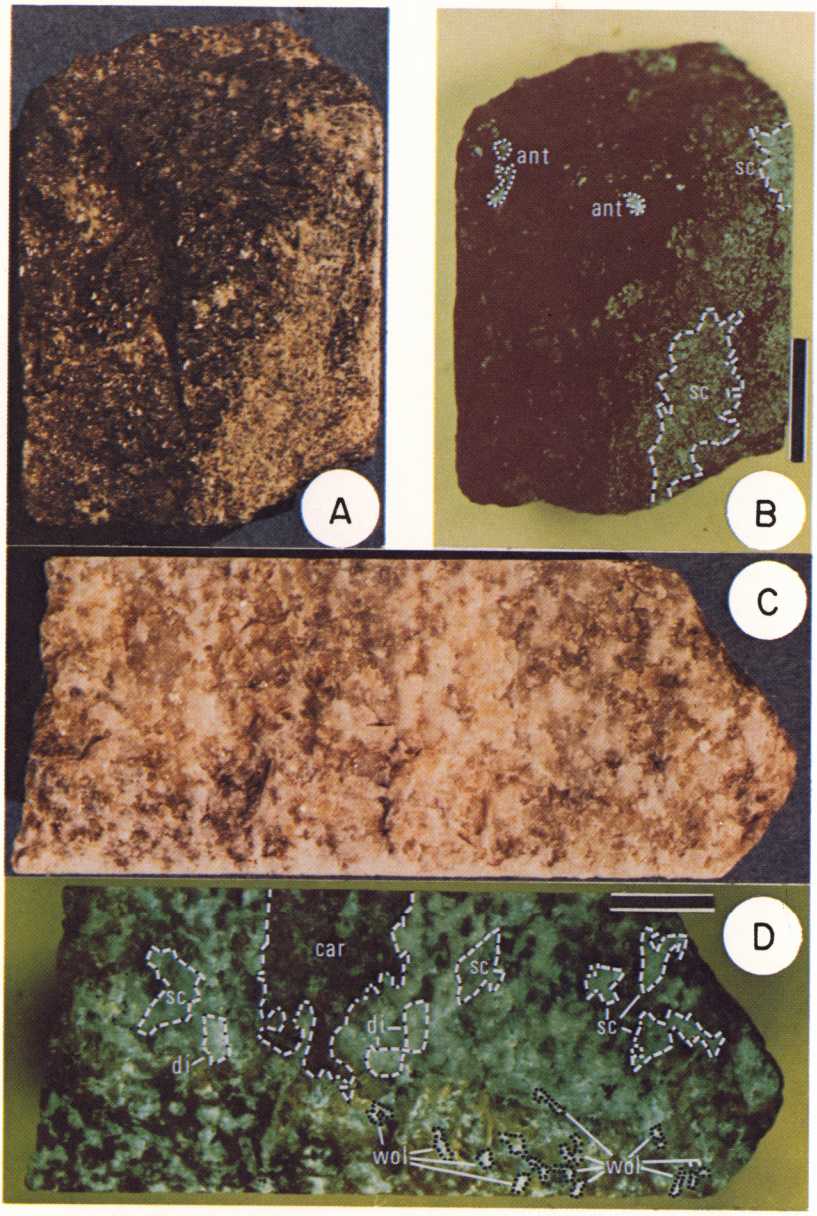

Plate 2

Photographs showing the mode of occurrence of scheelite at Lime Hill. Bar represents 1 cm. A, Disseminated scheelite with massive sphalerite. B, Photograph of the same specimen in short-wave ultraviolet light. Both the 6(2)-layer orthosilicate and scheelite are fluorescent (DDHS9-169'). C, Massive granular aggregate of scheelite in diopside-wollastonite skarn. D, Photograph of the same specimen in short-wave ultraviolet light. Note the slight differences in fluorescence colour between scheelite, diopside and wollastonite (Sample No. DDHS9-143'6"). car, carbonate; sc, scheelite; sp, sphalerite; ant, antigorite; di, diopside; wol, wollastonite

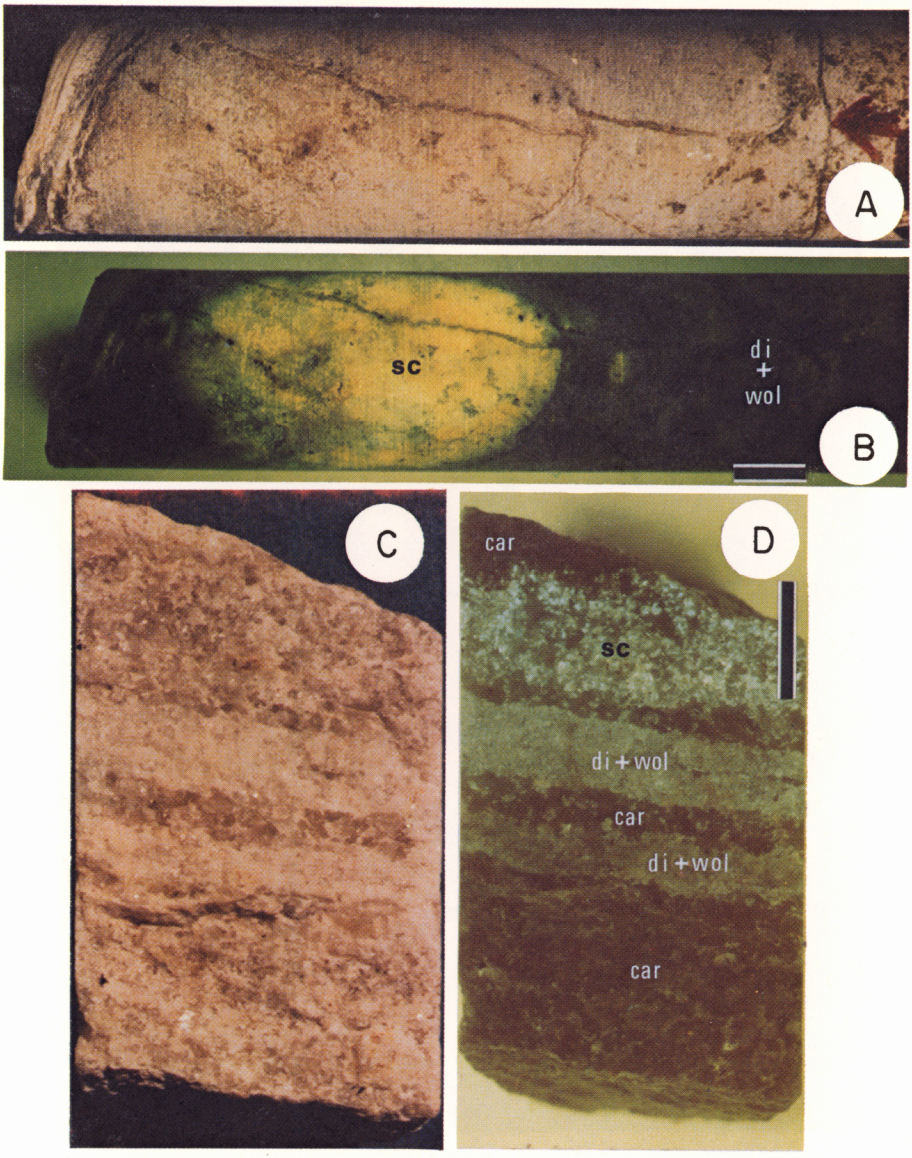

Plate 3

Photographs showing the mode of occurrence of scheelite at Lime Hill. Bar represents 1 cm. A, Scheelite and molybdian as nodular replacement patches in diopside-wollastonite skarn (Sample No. DDHS13-250'). B, Photograph of the same sample in short-wave ultraviolet light. C, Scheelite as thin layers following the compositional layers of wollastonite skarn (Sample No. DDHS4-82'). D, Photograph of the same sample in short-wave ultraviolet light. car, carbonate; sc, scheelite; di, diopside; wol, wollastonite.

9054, 9055a). Subsequently X-ray powder data were obtained (see Table 4). Visually, the X-ray powder film compares well with photographs of films of hydrotungstite published by Kenn and Young (1944) and the d-spacings listed by Mitchell (1963). The electron beam scanning pictures (Plate 4B, C and D) of hydrotungstite showed it is almost pure tungsten oxide.

Sanmartinite was identified by X-ray diffraction analysis in one sample of massive sphalerite DDHS12-165'. It is probably of rare occurrence.

Grade of Tungsten

Tungsten content of 2.80 per cent WO_3 is the highest established in one sample (DDHS-9, 143'3"-143'6").

WHYCOCOMAGH MOUNTAIN

Scheelite-chalcopyrite-molybdenite-magnetite mineralization is located on Whycocomagh Mountain, about one mile northeast of the village of Whycocomagh, Inverness County. Fletcher (1884) reported that "a specimen of iron ore from this locality .... was found to contain about 50 per cent magnetite and traces of copper pyrite and green carbonate". In 1960, Kerr-Addison Mines carried out geological and geophysical investigations and a program of diamond drilling and concluded that "copper mineralization in the form of chalcopyrite, accompanied by magnetite in an altered limestone is of limited extent and occurs in irregular pods and/or lenses".

Host Rock for Tungsten Mineralization

The general geology of the area is not well known. Only small outcrops are present in the trenches and stream beds. Lithologically these are amphibolite, quartzites, garnetiferous quartz-feldspar-biotite schists and gneisses, in addition to altered dolomitic limestones which appear to be the chief host rock for the mineralization. These have been intruded by porphyry, diabase and granite (Fig. 5). The general strike of the lithological units is NNE and the dip to the southeast.

Nature of Tungsten Mineralization

Mode of Occurrence

The scheelite is typically euhedral and coarse-grained (Fig. 6) and ranges in grain size from less than 1 mm to more than 3 cm across. It occurs as scattered grains, and as sub-massive concentrations along layers with monticellite, chondrodite, forsterite and diopside in association with 6(2)-layer orthosilicate (antigorite). It also occurs as rhombic to rounded masses, suggesting that it is pseudomorphic after dolomite, diopside and forsterite.

TABLE 4

Powder X-ray Data for Hydrotungstite and Calcite from Lime Hill Zinc Prospect

Camera Diameter 114.6 mm, $CuK\alpha_1$ radiation
NSDM Sample Number S-12.72*
NSDM Film Number 8927: Good contrast on low angle side. No high angles.

			Hydrotungstite ASTM 16-166		Calcite ASTM 5-0586	
θ	d	I/Io	d	I	d	I
23.8	3.74	m				
26.1	3.42	s	3.46	60		
27.2	3.276	m	3.27	80		
29.5	3.03	vs	3.02	10	3.035	100
33.0	2.715	m	2.63	50		
36.1	2.488	m	2.46	50	2.495	14
37.5	2.398	m				
28.6	2.332	m	2.31	50		
39.5	2.281	w			2.285	18
41.0	2.202	w				
43.0	2.104	m	2.09	50	2.095	18
45.8	1.981	s	1.96	60		
∿		vw				
48.5	1.877	m	1.88	10	1.875	17
50.1	1.820	w	1.85	10		
			1.81	20		
52.5	1.743	s	1.73	50		

Note: Because some strong and medium reflections are only accounted for by the tungsten mineral, one could conclude that it is present in higher proportion than the calcite. However, the atomic scattering factor of tungsten is essentially higher than that of calcium, hence, no comparison can be made without quantitative intensity measurements and calculations. See Plate 4 B, C, & D for microprobe analysis.

θ = the measured value of the glancing angle
d = the interplanar spacing between regularly spaced identical planes measured in Angstrom units
I = intensity
I/Io = visual estimate of intensities
vs = very strong; s = strong; m = medium;
w = weak; vw = very weak

* Silvermaque diamond-drill hole #12 (1+02N, 7+24E) depth 72'.

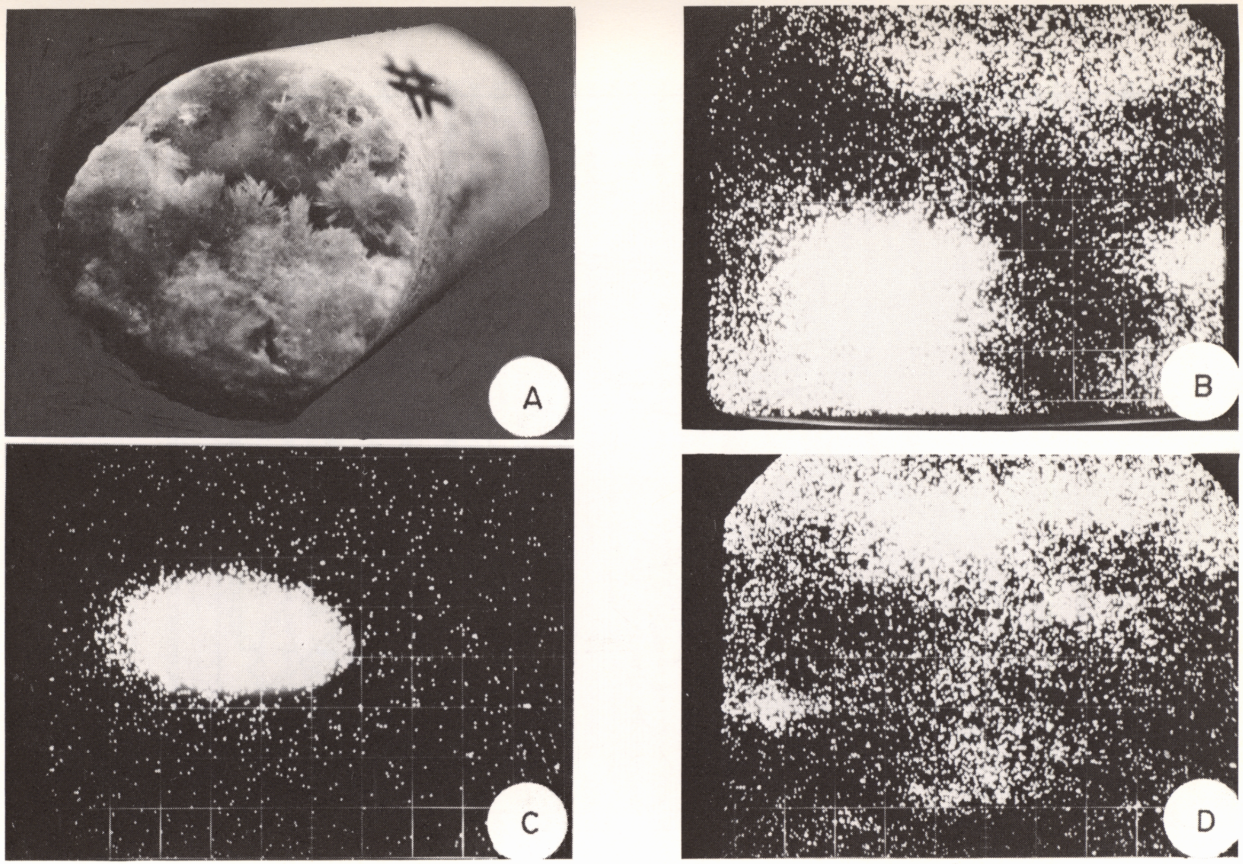

Plate 4

A, Photograph of a specimen showing the radiating crystals of hydrotungstite forming rosettes on rhombohedral calcite crystals (see Table 4 for X-ray diffraction data) from Lime Hill. Bar represents 1 cm (Sample No. S12-72'). B, X-ray intensity display of CaKα(39.38) radiation from a grain of hydrotungstite. C, X-ray intensity display of WLα(43.46) radiation from the same area as in B. D, X-ray intensity display of SiKα(47.88) radiation from the same area as in B. Field of view for B, C and D - 53.3 microns (≈X2400). Sample No. S9-169'.

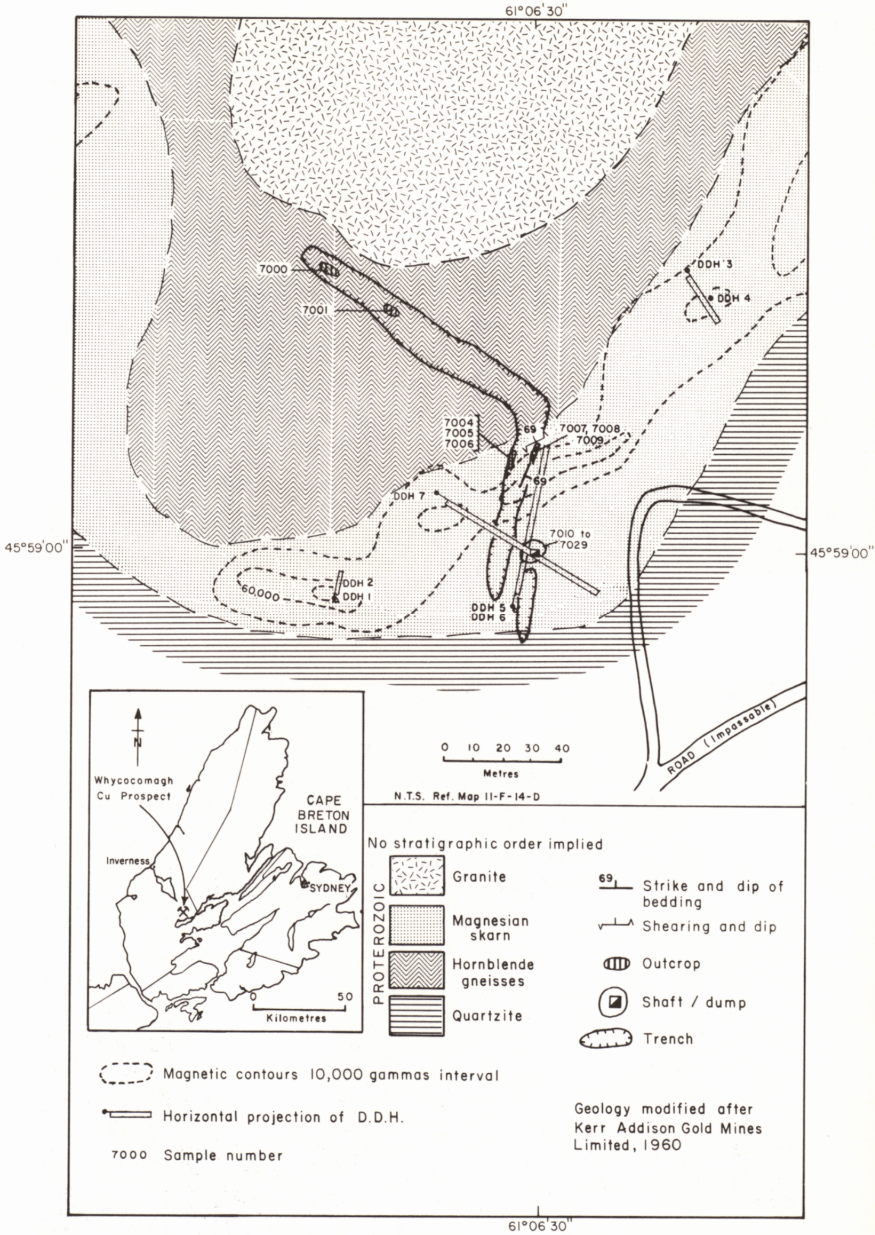

Figure 5

Whycocomagh Copper Prospect

Description of Tungsten Minerals

Scheelite is the major tungsten bearing mineral identified from this locality. It fluoresces bright yellow in short-wave ultraviolet light. An X-ray spectrographic scan (Fig. 7) has revealed minor amounts of Cu and Mo, which probably substitute for W in the structure.

A minor amount of wolframite is found in a few samples collected from the dump material adjacent to the shaft. It occurs as thin blades or needle-like crystals. It is commonly associated with scheelite, magnetite, pyrrhotite and antigorite.

Grade of Tungsten

Tungsten content of 1.97 per cent WO_3 is the highest established in one sample (11F14-7004). The dump adjacent to the old shaft has many large samples weighing more than 50 pounds in which the scheelite content (visual estimate) would exceed 15 per cent by volume.

SUMMARY

Many authors have suggested that skarns are generally favourable host rocks for tungsten mineralization. The presence of tungsten minerals in the skarns of the George River Group of Cape Breton Island has never been reported, and has therefore, received little attention for this type of mineralization. This paper documents the presence of tungsten minerals within the diopside-wollastonite skarns in the Boisdale Hills and at Lime Hill; and with the altered monticellite-forsterite-diopside skarns at Whycocomagh. Other associated minerals are magnetite, chalcopyrite and bornite. Tungsten content of 0.55 per cent WO_3, 2.80 per cent WO_3 and 1.97 per cent WO_3 is the highest established from Boisdale Hills, Lime Hill and Whycocomagh respectively. The predominant tungsten mineral is scheelite; but at Lime Hill, hydrotungstite and sanmartinite, and at Whycocomagh, wolframite are also present.

The following are pertinent points regarding the identification of scheelite:

(1) The use of ultraviolet light in detecting scheelite is of limited help because the fluorescent colours of diopside, wollastonite, lizardite and antigorite are somewhat similar to scheelite, hence these minerals may easily be mistaken for scheelite.

(2) In transmitted light scheelite is an easy mineral to identify because of its high refractive index and uniaxial positive character. Unfortunately in standard text books on optical mineralogy, scheelite has not been mentioned.

(3) The X-ray diffraction data are again of limited use because the powellite series of minerals has approximately similar d-spacings and intensities.

(4) Microprobe analysis together with chemical tests seems to be the only assured means of establishing the presence of scheelite.

Figure 6

Photograph of a specimen in short-wave ultraviolet light showing the distribution of sub-hedral to euhedral grains in scheelite in an altered monticellite-forsterite-diopside skarn. Other associated opaque minerals are magnetite, chalcopyrite and minor bornite. Bar represents 1 cm. (Sample No. 11F14/7016: Whycocomagh Mountain)

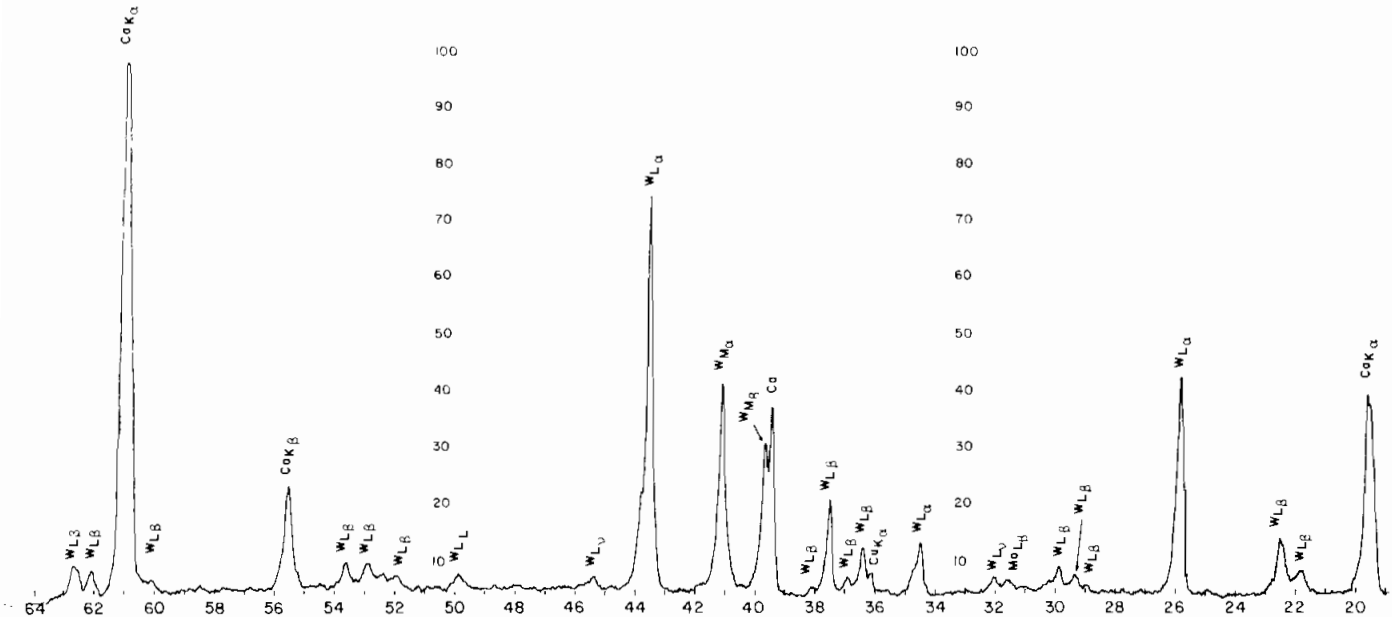

Figure 7

X-ray spectrographic scan of scheelite (see Figure 6 for the analyzed grain) from the Whycocomagh Mountain (Sample No. 11F14/7016). The sensitivity for the scan is 10^3x1 counts per second.

For quantitative determinations of tungsten the thiocyanate method is preferred by the author, as the results were found reproduceable even at low levels (≈0.025 per cent WO_3).

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APPENDIX I

Analytical Methods for the Determination of Tungsten

Tungsten in the samples from Boisdale Hills, Lime Hill and Whycocomagh was determined by four different methods. The results are summarized in Table A-1.

Thiocyanate Method

0.25 and 0.5 gram of samples were decomposed in a platinum dish with 5.8M hydrochloric, hydrofluoric and phosphoric acids. Emission spectrograph analyses of all the samples showed the presence of molybdenum and iron and, because these two elements produce higher results for tungsten, the interference was eliminated by separating the chlorocomplex from a hydrochloric acid medium by isoporpyl ether extraction. Tungsten was reduced with stannous chloride and potassium thiocyanite was added to develop the colour. The absorbance of this solution was determined on spectrophotometer. The absorbance value for the sample solution was corrected by subtracting that obtained for the blank solution. The tungsten content of the aliquot was determined by reference to the appropriate calibration curve.

Atomic Absorption

Na_2O_2 Fusion: 0.5 gm of sample was fused in a nickel crucible with Na_2O_2 and leached with water, filtered and determined by atomic absorption.

Na_2CO_3 Fusion: 0.5 gram of the sample was fused in a platinum crucible with Na_2CO_3, leached with water, filtered and determined by atomic absorption.

Gravimetric Method

Tungsten was determined by digesting 1.0 gram of sample with acids and cinchonine. The method is rather slow and is not suitable for routine analysis. The gravimetric method generally gives higher tungsten content than the thiocyanate method. Detailed analytical procedures are given in a text book on applied inorganic analysis by Hillbrand, Lundell, Bright and Hoffman (1955).

Emission Spectrograph

To test the presence of molybdenum and iron together with tungsten 0.1 gram of the sample was mixed with 0.525 gram of graphite and 0.125 gram buffer (mixture of Li_2CO_3, L, F, K_2SO_4, Eu_2O_3 and PdI_2). 0.5 gram of this mixture was fired to completion on the spectrograph.

TABLE A-1

Sample Number/Locality	Spectrophotometric Thiocyanate method Sample weight 0.25 gm - 0.5 gm	Atomic Absorption Jarrell Ash 810 Na_2O_2 fusion	Atomic Absorption Jarrell Ash 810 Na_2CO_3 fusion	Gravimetric	Semiquantitative emission spec. NSDM Plate No. 77-438
11K/7109: Boisdale Hills	0.37 - 0.37	0.37	0.55*	0.55	m
11K/7120: Boisdale Hills	0.026	ND	ND	ND	FT
DDHS-9 143': Lime Hill	1.94 - 2.20	2.02	2.42	2.80*	M
DDHS-9 166': Lime Hill	<0.025	ND	ND	ND	FT
11F14-7004: Whycocomagh	1.48 - 1.50	1.26	1.70	1.97*	M

* Results reported in the paper
ND Not determined
M Major 1.0 to 100 per cent
m Minor 0.1 to 10 per cent
FT Faint trace <0.001 to 0.1 per cent