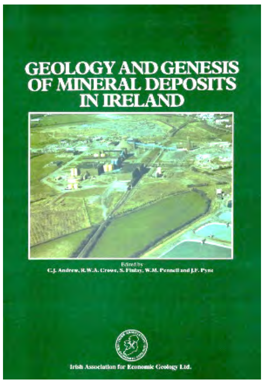

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Tungsten mineralization in SE Leinster, Ireland.

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(Reprinted with amendments from Steiger and Bowden, 1982)

Abstract

Systematic exploration in SE Leinster between 1970 and 1983 has led to the identification of a belt of scheelite mineralization with associated elements, of potentially economic significance. This belt extends along the eastern margin of the Leinster Granite and is defined geologically as a swarm of granitic dykes with a trend subparallel to the Granite margin and parallel to the foliation in the Lower Palaeozoic envelope rocks. The greisen-type mineralization is possibly the product of a late-stage alteration phenomenon associated with the Granite and, apart from scheelite, consists of arsenopyrite, stannite, cassiterite, chalcopyrite, galena, sphalerite and fluorite, together with trace amounts of gold, bismuth and various silver sulphosalts.

Introduction

Prior to 1970, the only reference to the occurrence of tungsten minerals in Ireland was by Mallet (1851) who listed wolfram and cassiterite as having been described earlier by Weaver and identified from the gold-bearing alluvium of the Gold Mines River near Woodenbridge, Co. Wicklow.

The discovery, in 1970, of scheelite in heavy mineral concentrates from streams draining the granite-schist contact near Aughrim, Co. Wicklow, led to a systematic exploration programme that resulted in the identification of several tungsten-bearing environments in Counties Galway, Cavan and in SE Leinster (Steiger and Bowden, 1982). This paper describes the last area and, in particular, an area between Tinahely and Aughrim, Co. Wicklow.

General geology

A dominant geological feature of SE Ireland is the Leinster Granite, the largest exposed granite body in Britain or Ireland. It is composed of five batholiths, numbered 1 to 5 from the north and separated one from another by narrow schist septa. The paratectonic Caledonian country rocks are predominantly pelitic, with lesser quartzites, greywackes and volcanic rocks of Cambrian to Upper Ordovician age.

The rocks generally have a NE strike with a conformable slaty cleavage and, adjacent to the intrusive bodies, have been metamorphosed to schist and hornfels.

The SE margin of the granite units, and particularly that of the largest unit (Tullow Unit or Unit 4), shows that the granite was introduced concordantly with the stratigraphy of the country rocks (McArdle, 1981). Slight discordance is nevertheless apparent along this contact northwards from Tinahely (Gardiner, 1970).

Sub-parallel to the southeastern margin of the Tullow Unit is a suite of minor, dyke-like, acid intrusions viz. granodiorites, microgranites, and quartz-felsites.. They have been described by Brindley and Connor (1972) for the area between Aughrim and Ballinaclash, Co. Wicklow. This paper deals with an area along strike to the SW, between Aughrim and Tinahely, where the minor acid intrusions are predominantly microgranites; these were termed "elvan dykes" by geologists in the second half of the 19th century, as they are similar in aspect to elvan dykes in Cornwall. In this paper the term "microgranite" is used in general, while microadamellite is used in specific cases.

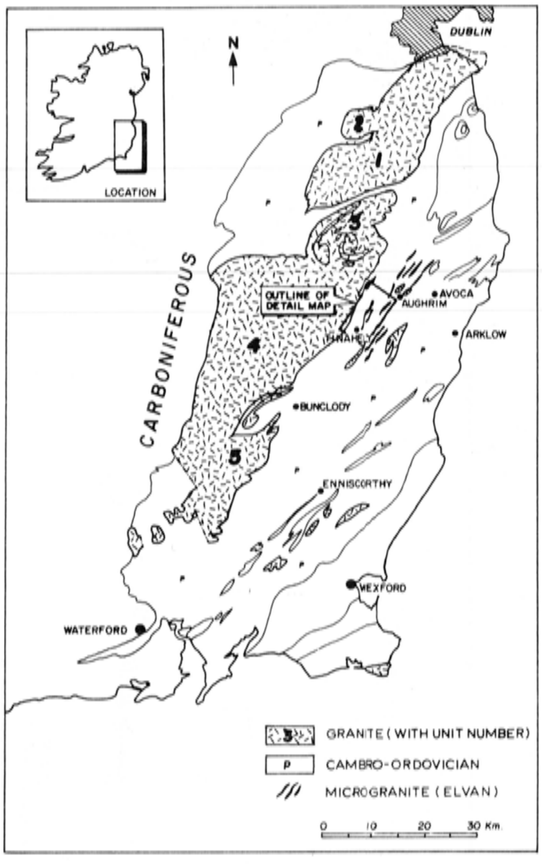

Figure 1. General geology of the SE Leinster region.

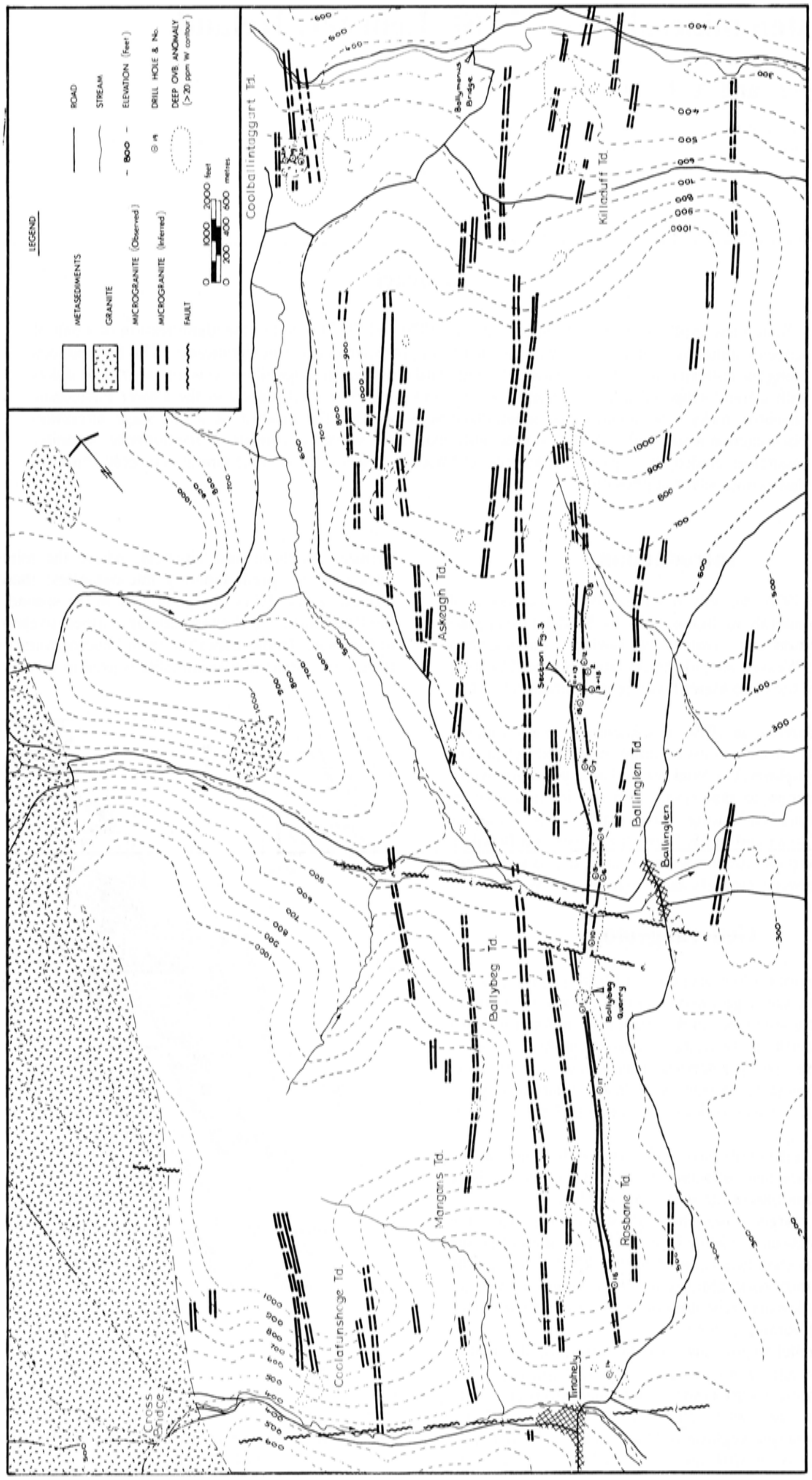

Figure 2. Detailed geology of the Ballinglen area.

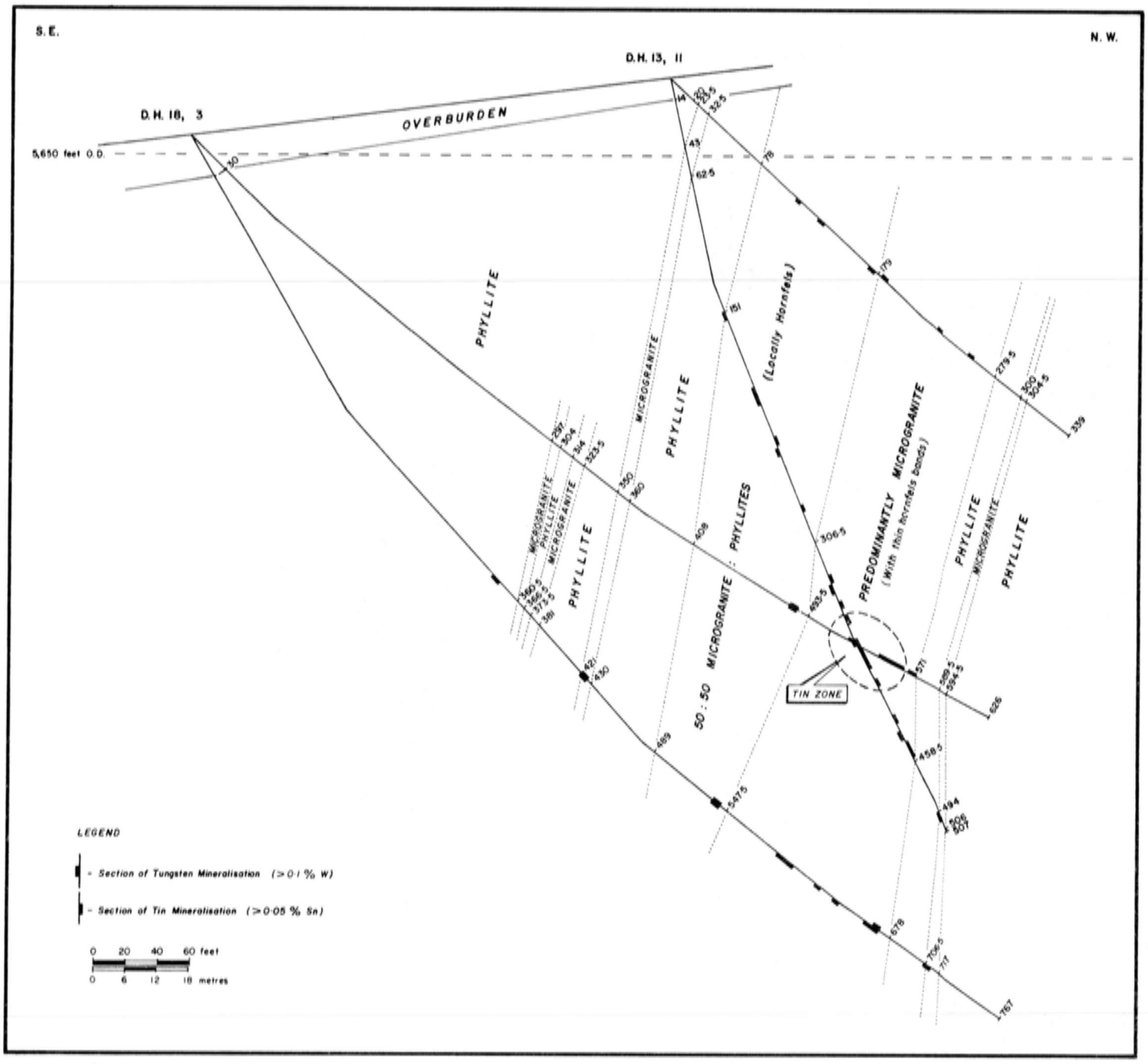

Figure 3. Drillhole intersections in the Ballinglen prospect.

The geology of the Ballinglen area

The Ballinglen area includes a small part of the southern flank of the Tullow Unit of the Leinster Granite. The country rocks form part of the Ballybeg Pelitic and Greywacke Formations which are tentatively correlated with the Bray Head Formation (McArdle, 1981). Those encountered in drilling (Figs. 2 and 3) are dark blue-grey or green-grey phyllites with common, paler grey, silty laminae; cleavage is conformable to bedding and dips steeply to the SE.

Detailed mapping in the area indicates that locally the dips are far more variable and are frequently to the NW. In many places the silty laminae are boudined, and where no silty laminae occur, the phyllites commonly develop thin quartz segregations. In two drill holes (holes 2 and 7), conglomeratic horizons were observed.

In thin section these phyllites can be seen to consist of alternating layers of fine and coarser detrital sediments containing quartz and feldspar clasts in a sericitic groundmass. The finer layers, richer in sericite, contain *schlieren* of organic material and are often rich in tourmaline.

A minor occurrence of metamorphosed volcanic rocks is exposed in Ballybeg Quarry (Fig. 2).

Outcrop and float mapping, a study of the coarse fraction derived from overburden sampling and drilling have all proved the presence of several, minor, granodioritic bodies and multiple micrograntic dykes. A multiple dyke has been proved by drilling to be continuous over approximately 5km, and deep overburden sampling suggests that it is even more extensive. In detail, the dykes are intruded conformably with the cleavage and with the banding of the country rocks. Overall, the dykes show a slight divergence from the granite margin from SW to NE due to the slight discordancy of the Granite contact in the area north of Tinahely.

In contrast with the abundance of minor granite and granodiorite bodies in the area to the NE (Brindley and Connor, 1972), only three small bodies are present in the Ballinglen area. In both areas the exact relationship between the granodioritic bodies and microgranitic dykes has not been established. At Coolballintaggart, drill hole 21 intersected portions of both a granodiorite and microgranite. Contact relations indicate that the microgranite intruded the granodiorite. As the granodiorites are considered to be contemporaneous with the Leinster Granite, (Brindley and Connor, 1972) this evidence suggests that the microgranites are post-Granite in age.

Drilling, together with observations at Ballybeg Quarry,

Table 1.

Detailed analyses of mineralization from Ballinglen.

	Sample 1	Sample 2
Rock Type	Fluoritized microadamellite (1-2 mm grain size) with disseminated sulphides.	Fluoritized microadamellite (finer grained than sample 1) with coarse sulphides.
Core Assays	309 ppm W 3 ppm Mo 163 ppm Sn 2,339 ppm As 75 ppb Au	104 ppm W 46 ppm Mo 314 ppm Sn 2,882 ppm As 15 ppb Au
Heavy Mineral Concentrate (S.G. <2.96) % of total.	2.6%	3.5%
XRF — analysis of Concentrates		
Minor	As, Fe	As, Fe
Major trace	Ti, S, P	Zn, S, P
Trace	Sn, Sr, Rb, Pb, Cu, Zn, Co, Ni, Mn	Sn, Mo, Sr, Rb, Pb, Cu, Co, Ni, Mn, Ti
Possible Trace	Zr, Cr, Y, Bi.	Zr, Y, Cr, Bi,
Minerals (in approximate order of frequency)	fluorite arsenopyrite pyrrhotite scheelite chalcopyrite sphalerite pyrite galena (trace) stannite (trace) native bismuth (trace) cosalite (trace) rutile sphene apatite carbonate minerals	fluorite arsenopyrite pyrrhotite sphalerite chalcopyrite scheelite stannite molybdenite (trace) native bismuth (trace) cosalite (trace) rutile sphene apatite
A comparison of assays and XRF results indicates that all metals of potential economic interest are associated with the heavy mineral fraction.		

clearly show that the dykes are not massive but consist of several parallel dykes forming a well-defined dyke complex, between 75m and 110m wide, intruded into phyllites (Fig. 3). Drill holes on the main dyke complex intersected an average of fifteen individual dykes, up to 12m thick, and which make up about 50% of the complex. The thicker dykes are more common on the NW or footwall side of the complex. Dykes as thin as 2cm have been observed in the area.

Phyllites in contact with, or as xenoliths within, the microgranite are locally hornfelsed, but alteration rarely extends for more than half a metre from the contacts.

Petrology of the microgranites

Where unaltered, the microgranites are pale grey and faintly speckled with fine dark biotite and have a foliation parallel to the edges of the dykes. It is not clear whether this alignment is due to deformational stress or represents a flow texture. Various research workers have classified the "elvans", or microgranites, as microgranodiorite and felsite (Brindley and Connor, 1972), adamellite (Lacharpagne, 1977) or microadamellite (Steed, 1978).

These rocks contain 69-70% SiO_2, 14-18% Al_2O_3, 2-4% CaO, 3.5-4% Na_2O and 1-1.4% K_2O. Mineralogically the main constituents are quartz (30%), orthoclase (10-25%), albite (20-30%), anorthite (10%) and muscovite-biotite (10-20%). Accessory minerals present are rutile, sphene and apatite. The average grain size varies from 1 to 2 mm.

Mineralization

Mineralogy

Assessment of mineralization located during the early stages of exploration indicated a simple scheelite-arsenopyrite association, although even early soil geochemical results showed that W and As do not occur in a constant proportion. In the course of drilling, a much more complex association of elements and mineral paragenesis emerged. Two samples from drill hole 2 were investigated in detail by thin and polished section and by heavy mineral concentrate studies; other samples were studied in less detail.

X-ray fluorescence analyses were conducted on finely-powdered heavy mineral concentrates from core-sections containing scheelite. Mineralogical and petrographical studies were carried out on split samples of the same core specimens. The results are given in Table 1.

Minerals identified in other microgranite and associated

Table 2.

Selected assay values in drillholes 3, 13 and 18.

Drill interval (ft)	W%	Sn%	As%	Cu%	Pb%	Zn%	Ag ppm	Au ppb
Drill hole 3								
480-485	0.15	0.10	0.18	0.01	0.01	0.04	n.a.	<5
530-535	0.01	0.34	0.57	0.31	0.02	0.11	n.a.	n.a.
535-540	0.01	0.36	0.96	0.15	0.43	0.08	119	<5
Drill Hole 13								
151-156	>0.20	0.01	0.13	0.01	—	—	<1	n.a.
412-417	<0.01	0.03	0.53	0.02	—	0.02	<1	110
452-457	<0.01	0.06	1.00	0.02	0.02	0.05	3	5
Drill Hole 18								
537-542	>0.20	0.03	0.56	0.03	<0.01	<0.01	1	n.a.
572-577	<0.01	0.02	0.35	0.02	<0.01	<0.01	<1	n.a.
662-667	0.09	0.04	1.41	<0.01	<0.01	<0.01	1	n.a.

The best Mo value is 0.0005% over 2 ft. n.a.=not assayed

vein quartz samples include tourmaline (intermediate composition between schorlite and dravite), cassiterite, proustite, mackinawite and, possibly, schirmerite and matildite. Silver also occurs in solid solution in galena. Scheelite occurs both as isolated grains and as intergrowths with sulphides and with pyrrhotite in particular. No other tungsten mineral has been found. Commonly stannite is intimately intergrown with chalcopyrite, sphalerite and pyrrhotite, and it is very often associated with bismuth minerals. Sphene and rutile are not commonly associated with ore minerals; in rare cases cassiterite occurs in association with rutile. No free gold was observed, but gold may be associated with pyrite (Table 1 — sample 1) or arsenopyrite. Rare molybdenite is found as isolated fibrous clusters.

In the absence of more systematic investigations along the entire belt, these petrological descriptions and mineralogical contents are taken as being characteristic of the more intensely mineralized and altered portions of the microgranite dykes.

Controls on mineralization

The primary control on the distribution of mineralization in the areas investigated to date is the microgranite. As the host-rock is hydrothermally altered wherever mineralized, and as most mineralization occurs associated with quartz veinlets, a further control is likely to be zones of fracturing induced tectonically or by the introduction of fluids under high pressure. This mechanism would have provided pathways for hydrothermal solutions and also open spaces for deposition of gangue and ore minerals. Figure 3 shows that the strongest tin-bearing zone observed in drillhole 3 coincides with an apparent thinning of the main dyke, possibly due to a structural complexity affecting the intensity of alteration.

The Moyne Fault (Brück and O'Connor, 1980) does not appear to have had any effect on style or grade of mineralization in its vicinity.

Scheelite occurs in association with thin, usually muscovite-greisen bordered, quartz veins, as cream or yellow lumps within the quartz, and/or as fine disseminations in bleached sericitic zones over 2-3cm on either side of the vein. Macroscopically, fluorite and arsenopyrite are commonly associated with scheelite, the arsenopyrite occurring as aggregates within the veins or as euhedral crystals up to 1cm long within the bleached zones.

The bulk of the mineralization observed in drillholes occurs within microgranite, but in drillhole 16 disseminated scheelite was noted within 10cm of the contact hornfels. Euhedral crystals of arsenopyrite are more commonly observed within hornfels very near its contact with the veins. Only very rarely do the scheelite-bearing thin quartz veins extend beyond the microgranite, although scheelite was observed 3m from a microgranite dyke in drillhole 17.

Other styles of scheelite mineralization have been noted in float. Large amorphous aggregates of scheelite have been found in massive white quartz boulders and as abundant disseminations along bedding planes in a folded siliceous metapelite. Weak scheelite mineralization has been observed within granodiorite at Coolballintaggart.

In addition to scheelite, several other minerals of potential economic interest are observed in drill core. In decreasing order of frequency, these are sphalerite, chalcopyrite, stannite, cassiterite and argentiferous galena. Of these, the last two have been observed only in massive quartz veins within the thickest dyke cut by drillholes 3 and 13. These quartz veins, which contain virtually no scheelite, are associated with intense alteration of the microgranite which gives it a translucent green appearance. Weakly disseminated scheelite occurs within this microgranite. To date it has not been possible to recognize any definite zoning patterns.

Economic potential

Drilling to date has proved the dyke complex to be mineralized over its entire tested length of 4.8km. Geochemical results suggest that the entire mineralized strike length is at least 8km. Across strike the mineralization is very erratic (Table 2). Results from prospecting and geochemical surveys outside the main dyke complex indicate that all microgranites are mineralized to some extent. Sporadic mineralization occurs over an area measuring at least 1.5km x 8km.

Table 3.

Range and average content of elements in drillhole 18.

Element	Range (ppm)	Average (ppm) Microadamellite	Average (ppm) entire dyke complex
W	4-2,000+	410+	323+
Sn	6-432	92	52
As	10-14,050	2,828	1,643
Cu	8-280	112	64
Pb	7-36	15	9
Zn	5-458	56	32
Ag	<1-1	<1	<1

As: W ratio range 0.37 to 102.12, average 7.05

All microgranite sections in drillhole 18 were analysed in 5ft. (1.5m) sections to check for the presence of microscopic mineralization. The core interval of 358ft (109m) of dyke complex contained 204ft (62m) of microgranite, and the results are summarized in Table 3.

Grades of mineralization obtained to date are subeconomic. It appears unlikely that small-tonnage, high-grade deposits occur within the area, whereas the presence of one or more high-tonnage, low-grade, economic deposits cannot be excluded.

Comparisons with other deposits in the world are inconclusive in that the Ballinglen area is atypical for greisen-bordered quartz vein mineralization. These normally contain wolframite-huebnerite-ferberite-cassiterite, the last-named often being the predominant ore mineral. However, near Auxelles-Haut in the Vosges Mountains, a potentially economic deposit, with very similar characteristics has been outlined (Coutellier, 1973).

Genetic conclusions

The close spatial association of different mineral assemblages suggests that the Ballinglen mineralization is the result of multiple stages or pulses. Each pulse may have involved either tectonic fracturing of the host microgranite followed by the introduction of the mineralizing solutions or hydrofracturing of the microgranite by the mineralizing fluids themselves, the fluids probably being of comparatively low salinity and acidity. The source of the fluids is not known, but the similar greisens and mineralogy associated with the pegmatites in the Leinster area may indicate a link between the pegmatites and tungsten mineralization.

Certain characteristics allow the mineralization to be classified as a tungsten porphyry formed as part of a fluorine-rich alteration system. Whether the mineralization exposed by the present erosion level represents the deep-seated portion of a sub-volcanic system or is related to an even deeper-seated granitic pegmatitic system, remains unclear.

Acknowledgements

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