Cu-Ag mineralization at Tullacondra, Mallow, Co. Cork.

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Abstract

Mineralization discovered at Tullacondra, 10km NNW of Mallow, Co. Cork in 1973 has been previously described as a copper-silver deposit containing approximately 3.6Mt of 0.7% copper and 27.5g/t silver. Further exploration has indicated a significant silver-rich portion of the deposit which is estimated to contain approximately 0.6Mt grading 150g/t silver with 0.6% copper. The bulk of the deposit occupies a broad, near-vertical zone, cross-cutting varied Lower Carboniferous strata close to the hinge line of a north-facing, steep, monoclinal flexure. By contrast, the contiguous silver-rich mineralization is contained within a thin (5-10m), gently dipping, stratabound zone straddling the sandstone-shale contact in the Lower Carboniferous/Old Red Sandstone transition sequence. To the east and west along strike, the mineralization and fold structure are truncated by northerly-trending faults. Consequently, the localization of mineralization shows strong structural control. The mineralogies are also distinctive, the copper-rich zone being essentially composed of fairly coarsely crystalline bornite and chalcopyrite, while the silver-rich zone contains considerable amounts of very finely disseminated tennantite. Silver occurs in its native form as discrete, occasionally visible, grains.

Introduction

In 1973 a substantial zone of copper and silver mineralization was discovered in the townland of Tullacondra, 10km NNW of Mallow, Co. Cork. The first diamond drill hole, sited on the basis of geochemical and geophysical anomalies and apparent geological similarities to other Irish copper-silver occurrences (particularly the Gortdrum deposit) intersected low grade mineralization in basal Carboniferous limestones, shales and sandstones (Wilbur and Royall, 1975). Apart from a brief reference on the 19th century Geological Survey of Ireland 6 inch to 1 mile manuscript field sheets to "traces of copper" in a small quarry at Tullacondra, there was no previous record of mineralization or mining in the area.

The first phase of diamond drilling in 1973, with fairly widely spaced holes, indicated the possible existence of 3.6Mt grading approximately 0.7% copper and 27g/t silver. This drilling outlined the deposit over an E-W strike length of 370m extending from suboutcrop (beneath 2-15m of overburden) to a vertical depth of 120m. Mineralization, composed predominantly of bornite and chalcopyrite, was found to occur in a near-vertical body, cross-cutting the northward-dipping limestone host rock.

Subsequent drilling has shown that a southern extension of the previously known mineralization is significantly different, being both silver-rich and stratabound. It has been estimated that this portion contains approximately 0.6Mt grading 150g/t silver and 0.6% copper.

Neither the entire deposit nor the shallow silver-rich zone is currently considered economic, but exploration is continuing in the hope of finding significant amounts of additional mineralization in the vicinity of Tullacondra. The recognition of the stratabound silver-rich zone obviously enhances the exploration potential in this area.

General geology

The Carboniferous succession, which conformably overlies the Old Red Sandstone (O.R.S.) series exposed in the core of the Kilmaclenine anticline (Fig. 1) is approximately 1 800m thick in the north Cork area. Hudson and Philcox (1965) recognized five major units including two distinctive 'reef' limestone units, a lower Waulsortian Reef Complex and a higher "Cracoean" (Asbian) Reef Complex (Table 1).

These five divisions have since been further refined into nine distinct lithostratigraphic units, with the carbonate succession ranging in age from Courceyan to Brigantian. The complementary synclines to the north and south of the Kilmaclenine anticline contain Namurian Shales and, in the Kanturk area to the SW, Coal Measures. At Subulter, 7km west of Tullacondra, thin-bedded pyroclastic deposits occur at the top of the Waulsortian Reef and are probably equivalent in age to the Chadian volcanics of SW Co. Limerick (Strogen 1977). Detailed mapping around the core of the Kilmaclenine anticline revealed similar pyroclastic material less than 1km east of Tullacondra. It seems likely that this exposure is part of an intrusive volcanic vent breccia, since it is surrounded by much older basal Carboniferous units.

The structure of the region is dominated by the effects of the strong N-S compression produced by the Hercynian Orogeny at the end of the Carboniferous. This compression is concentrated in SW Ireland along the zone of thrust faulting which can be traced westwards from Mallow to Dingle Bay, bringing, in some areas, O.R.S. rocks from the south over Coal Measures. North of the Hercynian thrust front the effects of this compression are gradually diminished in intensity and tend to be manifested in broad folding along E-W to ENE-WSW axes, with minor parallel thrust and reverse faulting. Compensatory N-S orientated

Table 1.

Regional stratigraphy of the Kilmaclenine Anticline area (after Hudson and Philcox, 1965)

Division	Thickness	Description
Coal Measures		Thin coal seams, sandstones and shales
Namurian		Black shales overlain by sandstones and shales
Liscarrol Limestone (Asbian-Brigantian)	200m	Bedded, dark bioclastic limestone with chert common.
Ballyclough Limestone (Asbian-Brigantian)	400m	Dark, fine-grained, bedded limestones, cherty towards base
Upper (Cracoean) 'Reef' Complex (Asbian)	0-300m	Unbedded pale calcilutites and thin calcarenites. Lacks bryozoa. May pass laterally into Copstown Limestone.
Copstown Limestone (Chadian-Holkerian)	150-300m	Dark bedded argillaceous limestones, cherty near base. May be dolomitic.
Subulter Volcanics (Chadian)	0-100m	Dark thin-bedded pyroclastics.
Lower (Waulsortian) 'Reef' Complex (Courceyan)	450m	Massive, pale bryozoan calcilutites, may be dolomitized and cherty at base.
Kilmaclenine Limestone (Courceyan)	100m	Uniformly bedded grey bioclastic limestone. May be dolomitized.
*Lower Limestone Shales (Courceyan)	90m	Shaly crinoidal limestones. Oolites, sandy calcarenites includes Ballyvergin Shale marker.
*Transition Series (Courceyan)	25m	Dark shales, calcareous sandstones and conglomerates.
Old Red Sandstone	> 500m	Quartzitic sandstones and shales.

* — Section known in detail from diamond drilling. See Table 2.

faults may also have developed at this time. (Such folding and faulting is clearly exhibited around the Kilmaclenine inlier.) The combined effects of these structures has been to divide the area into discrete segments or blocks, and with each block commonly exhibiting an individual structural pattern. Philcox (1964) described these features as "Compartment Deformation".

Local geology

Stratigraphy

At Tullacondra the copper-silver mineralization is mostly confined to the basal 125m or so of the Carboniferous carbonate sequence. This is well below the stratigraphic level of the Waulsortian Reef Complex which appears to be a favoured horizon of the lead-zinc deposits elsewhere in Ireland. Mineralization around this lower stratigraphic horizon is, however, typical of the other copper-silver deposits at Aherlow, Gortdrum and Ballyvergin (Cameron and Romer, 1970; Thompson, 1967; Tyler, 1979; Hallof et al., 1962).

The basal Carboniferous succession, known in considerable detail from the extensive diamond drilling, has been divided into eleven clearly distinguishable, lithostratigraphic units (Table 2). Overall, the sequence reflects the gradual transition from continental to marine conditions during the early Courceyan in this area. The Ballyvergin Shale, a distinctive marker horizon known throughout the SW Midlands, was recognized in the first diamond drill hole permitting early correlation with surrounding areas.

While all the lithostratigraphic units are readily identifiable in drill core, a second very distinctive marker horizon occurs close to the base of the Upper (Shaly) Transition unit. This marker horizon contains small, often rounded, red haematitic concentrations within a 30cm zone of pale calcareous sandstones. This unit, recognised at Tullacondra, has been identified elsewhere around the inlier, but there are variations in thickness.

Local structure

As mentioned above, the general periclinal or domal structure of the Kilmaclenine inlier is cut by low-angle thrusts and by steep N-S faults. The fault blocks so formed produce a series of structurally discrete N-S sections (Fig. 1). The anticlinal structure is elongated along an ENE-axis with the flanking limestones usually exhibiting gentle bedding dips to the north and south. Higher bedding dips probably indicate the proximity of faulting, and for this reason the sudden increase in dip from 15°N to 70°N noted during initial reconnaissance mapping at Tullacondra, together with traces of copper mineralization, was regarded as being

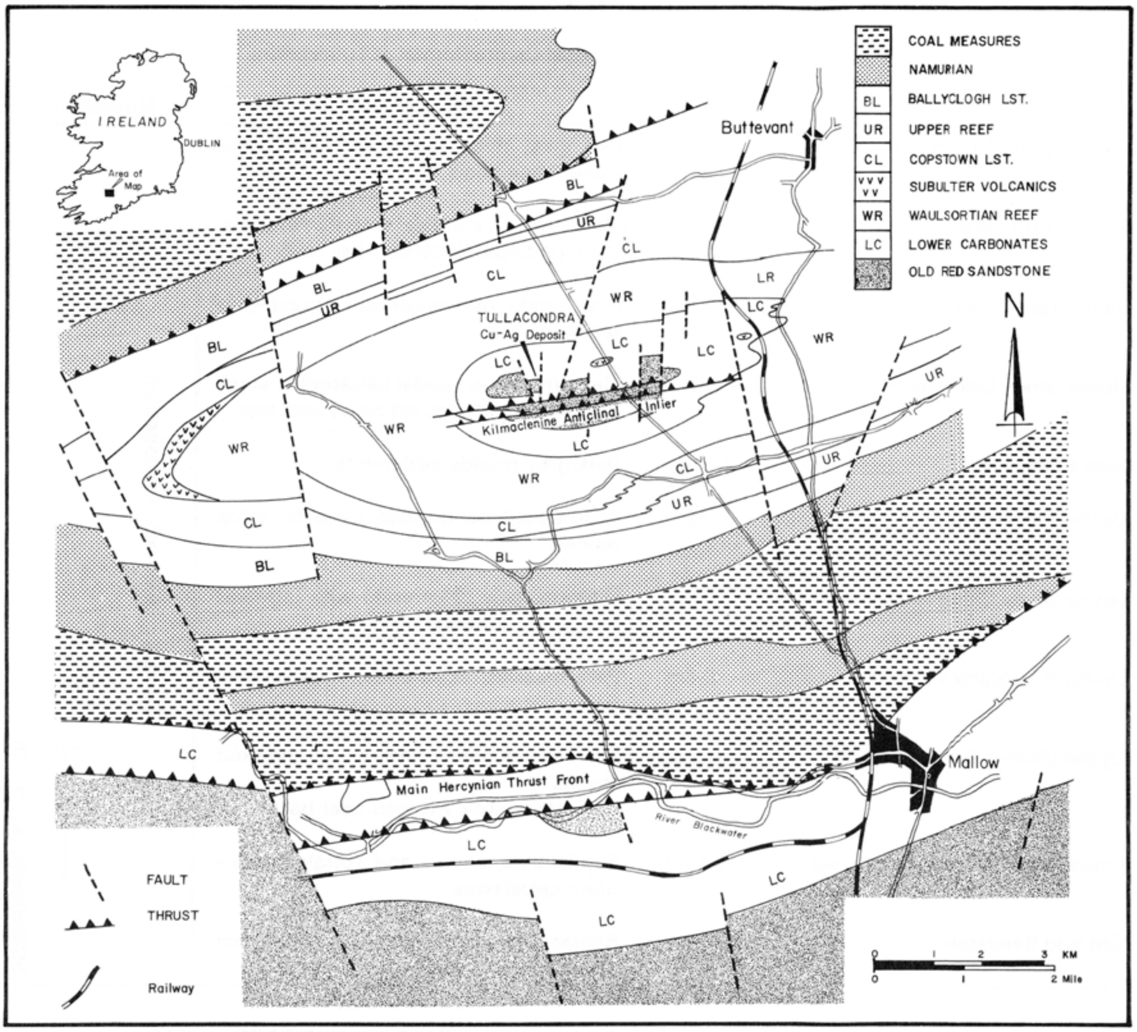

Figure 1. Regional geology of the area NW of Mallow, Co. Cork.

highly significant because of similarities to the Gortdrum discovery situation (Thompson, 1967).

The rapid increase in dip is clearly evident from the stratum contours drawn on the Haematitic Horizon (Fig. 2). It has the effect of downthrowing the beds to the north by approximately 80m along a sharp monoclinal flexure over a N-S distance of less than 100m. On the northern and southern sides of this zone, beds assume the typical dip of about 15°N.

To the east, the monocline is truncated by a NNE-trending structure beyond which the flexure is no longer distinct. To the west, a well-defined normal fault, trending 010° downthrows the strata to the west by 15m. The steep dips continue with an apparent change in strike. Further west, the monoclinal flexure is less apparent and there is evidence of a strike swing which defines the western nose of the anticline; however, borehole information in this direction is insufficient to define the exact structures.

The monoclinal structure extends, therefore, for an E-W distance of at least 290m, mostly coinciding with the area of most intense mineralization.

Mineralization

The bulk of the mineralization at Tullacondra occurs in a near-vertical zone some 40m wide within the steeply dipping strata of the monocline. The mineralization extends from suboutcrop to at least 120m depth, and is hosted by all lithologies from the O.R.S. to the top of the Tullacondra Limestone. Along strike, little significant mineralization has been found far beyond the two faults just described (Figs. 3 and 4). The mineralization in this vertical zone is predominantly composed of bornite and chalcopyrite, with minor covellite, chalcocite and neodigenite. Occasional tennantite, pyrite and arsenopyrite occur but, perhaps significantly, sphalerite and galena are very rare. The principal gangue mineral is calcite, although dolomite, quartz and sporadic barite are also present. The sulphides occur in a complex of small veins (<0.25cm in width), disseminations and spots frequently parallel to the bedding. This vertical zone accounts for as much as 80-85% of the deposit; characteristically it carries only modest silver values around 27g/t along with 0.8% copper. The remaining 15-20% of the deposit is distinctly different, both in its composition and mode of occurrence. Compositionally, although chalcopyrite and bornite still occur, tennantite is common and specks of native silver can be identified. The principal gangue mineral is calcite, although quartz veining is common. The differences in mineral composition are clearly reflected in the analyses, especially the enhanced silver values, with as much as 463g/t recorded over a 1.5m section. As the tennantite is not argentiferous, the overall silver content

Table 2.

Detailed stratigraphy of the basal Carboniferous at Tullacondra

Division	Thickness	Description	Mineralization
Kilmaclenine Limestone	100m	Pale grey, thick-bedded bioclastic limestone, often shale free	
Tullacondra Limestone	35m	Medium grey, crinoidal with thin irregular shale partings, siliceous near base.	
Ballyvergin Shale	1—1.2m	Fine sandy non-calcareous, green-grey siltstone.	Vertical copper-rich mineralization
Upper Shaly Calcarenite	15-20m	Medium grey crinoidal calcarenite, abundant shale partings, siliceous near top.	
Silty Calcarenite	2-2.5m	Dark grey muddy calcarenite.	
Oolitic Calcarenite	9-12m	Interbedded oolites and crinoidal calcarenites.	
Lower Shaly Calcarenite	6-9m	Uniform, pale calcarenite with interbedded, shaly crinoidal units.	
Uniform Calcarenite	5-6m	Pale massive calcarenite, mostly shale free.	
Upper (Shaly) Transition Series	12-15m	Black shales, sandy calcarenites and sandstones. 0.3m Haematitic Horizon near base.	Stratabound silver-rich mineralization (< 10m thick)
Lower (Sandy) Transition Series	12-15m	Sandstones, shales and conglomerates, often calcareous.	
Old Red Sandstone	> 500m	Shales, quartzitic sandstones, conglomerates and red beds.	

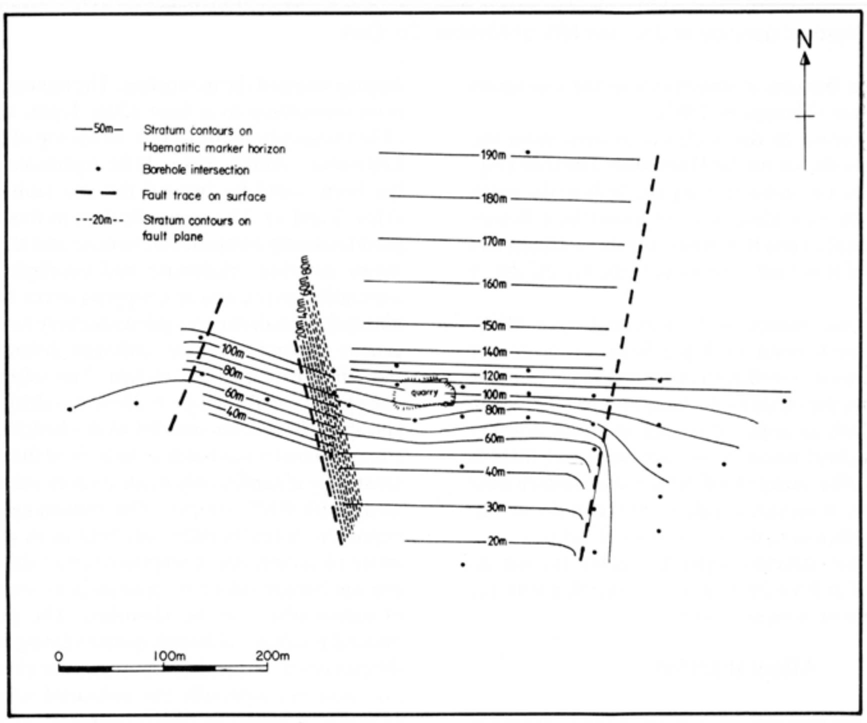

Figure 2. Stratum contours drawn on the Haematitic Horizon, Tullacondra area.

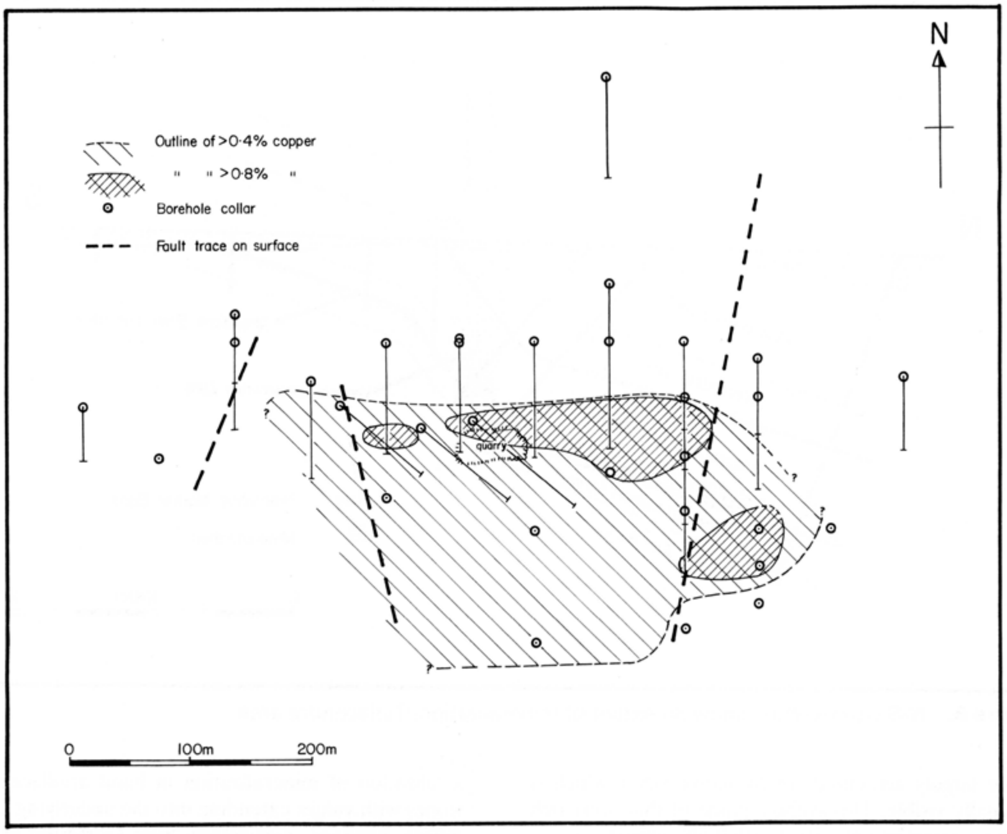

Figure 3. Extent of significant copper mineralization, Tullacondra area.

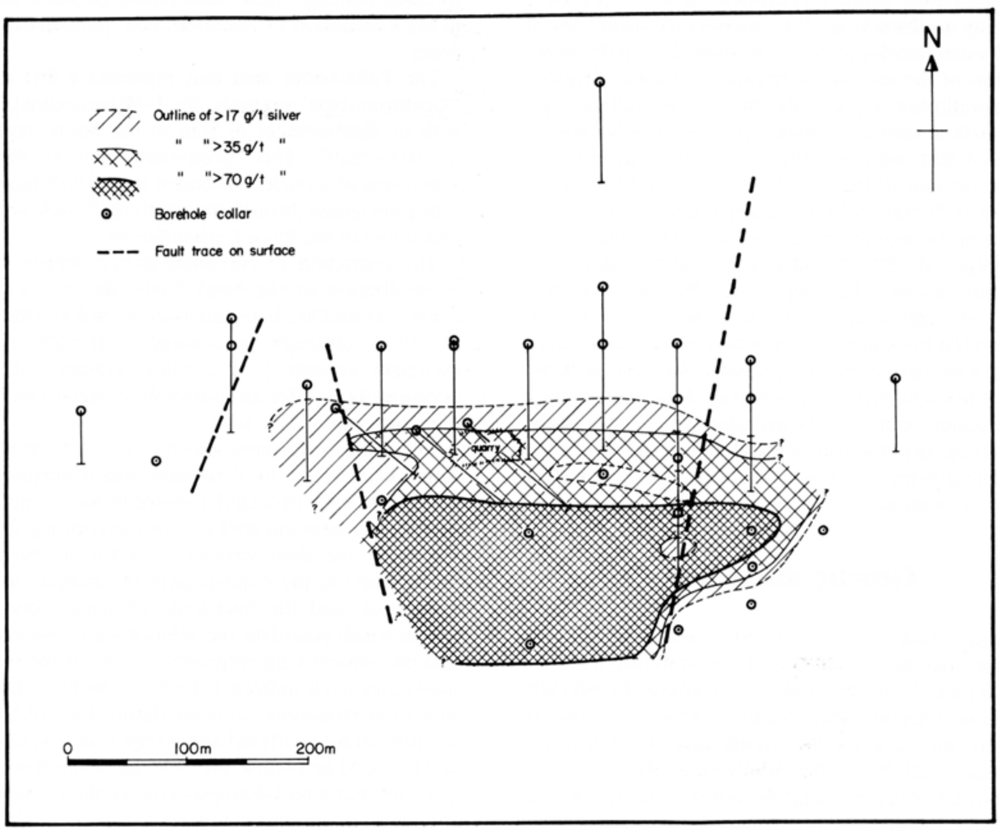

Figure 4. Extent of significant silver mineralization, Tullacondra area.

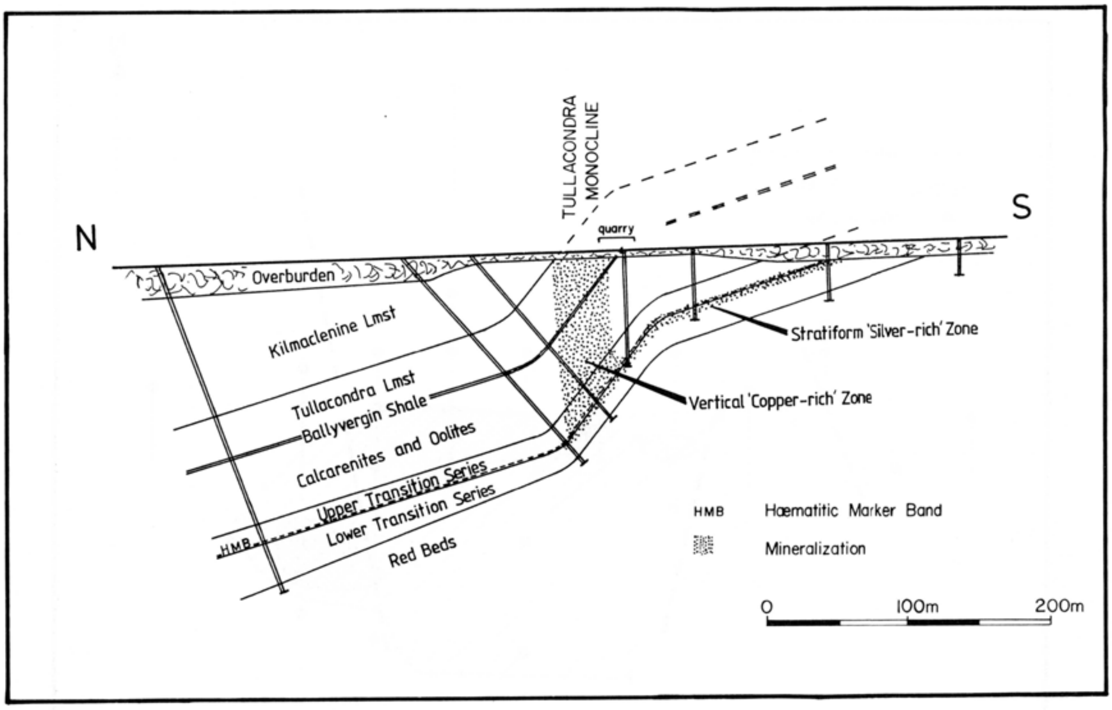

Figure 5. N-S cross-section showing extent of mineralization, Tullacondra area.

must be largely accounted for by native silver which is occasionally visible. The average grade of this silver-rich portion is approximately 150g/t with 0.6% copper.

The silver-rich material occurs in a distinctive stratabound zone 5-10m thick at the Upper (Shaly) Transition/Lower (Sandy) Transition junction. The zone dips gently northwards at 15° to intersect the main vertical zone of mineralization at the point where the rapidly increasing dips of the monoclinal flexure commence. Overall, the mineralization assumes the form of an inclined "V" shape, with a vertical left-hand limb and gently dipping right-hand limb when looking towards the east (Fig. 5). The intersection of the two zones is marked by copper values of 1-2% but not by exceptional silver values.

North of the monocline, where the bedding dips revert to the regional 15°N, the silver-rich stratabound zone is apparently absent. The copper oxysalts, malachite and azurite, are only common in the upper few metres of weathered bedrock and in the vicinity of the western bounding fault where dolomitization (possibly associated with the faulting) has rendered the rock porous. Low grade copper mineralization, composed of malachite and azurite in the suboutcropping sandstones of the O.R.S. series nearer the axis of the anticline, extends to depths of 30-40m, reflecting the more porous nature of these host rocks.

Genetic discussion

Mineralization in the Tullacondra area is significantly different from the stratabound and/or stratiform lead-zinc orebodies which are often considered typical of Irish carbonate-hosted deposits. In particular, the virtual absence of lead and zinc minerals, the stratigraphic position of the host rocks well below the Waulsortian Reef, and the obviously late structural controls on mineralization place it firmly in a sub-group along with Ballyvergin, Gortdrum and Aherlow. A characteristic of these deposits is the localization of mineralization in basal argillaceous limestones with values extending into the underlying O.R.S. It differs, however, particularly from Gortdrum and Aherlow, in the relative simplicity of the folded, mineralized structure and especially in the absence of any major ENE-trending faulting. Such faults clearly played a major part in the localization of mineralization, particularly at Gortdrum.

The Tullacondra area may represent a first stage of a "Gortdrum-type" orebody, the E-W monoclinal structure, with its displacement of 80m to the north, representing a "proto-fault". This "proto-fault" may be the shallow expression of a buried basement fault which has not been fully propagated through the relatively flexible argillaceous limestones of the basal Carboniferous.

The restriction of carbonate-hosted copper and silver mineralization to the basal Carboniferous strata in SW central Ireland has been discussed elsewhere (Morrissey et al., 1971), although the presence in the SW of an ORS basement consisting of a thick sequence of arenites, occasionally cupriferous, is considered significant in providing a proximal source rock.

The Tullacondra area also has, in common with Gortdrum, evidence of local volcanic and/or intrusive activity which may have provided a source of water, metals, heat, or simply a later channelway for mineralizing fluids. Furthermore, the clear structural control on the extent of mineralization, the emplacement of sulphides in zones of movement, and the fracturing, all suggest one or more events which post-date the lithification of the carbonates, and consequently an epigenetic origin for the bulk of the mineralization is indicated. It also seems likely that accommodation structures, created during the folding of the monoclinal zone, offered ample opportunities, along joints, cracks, bedding planes, etc., for the introduction, deposition and later remobilization of the sulphides. Significantly, the undisturbed gently-dipping sediments to the north of the monocline have, so far, proved unmineralized.

The stratabound zone could be explained in a similar way, with the junction between the Upper (Shaly) Transition and Lower (Sandy) Transition marking a major contrast in competency. Consequently, any movement is likely to have been taken up along the bedding planes of the shales immediately above the sandstones viz. a zone of décollement. This zone of movement would inevitably create the porosity to enable mineralizing fluids to migrate and to deposit their metal content. Alternatively, the zone may represent a chemical front, being the first reactive carbonate horizon which ascending, metal-rich fluids would encounter.

The relationship between the silver-rich mineralization of the stratabound zone and the more copper-rich mineralization of the vertical zone is conjectural in the absence of any advanced mineralogical studies.

The two zones may represent two stages of mineralization — an early silver-rich phase along planes of early movement on the shale/sandstone junction, followed by a depletion of the silver content of the fluids and deposition of the copper-rich vertical zone. Alternatively, the differences in mineralization may reflect appropriate variations in the chemistry of the depositional sites.

Conclusions

The copper-silver deposit at Tullacondra is a relatively small, but nonetheless interesting, deposit occurring in basal Carboniferous carbonates, shales and sandstones. It consists of two zones, a near vertical copper-rich zone centred on a north-facing monoclinal flexure, and a subsidiary, gently dipping, stratiform silver-rich portion to the south. The zones show evidence of similar structural control and a close association between the two ore types.

Since the structural controls in the area are almost certainly of Hercynian age, the mineralization must be post-Hercynian. This very late age for the copper-silver mineralization contrasts with the early Carboniferous age now postulated for most of the lead-zinc mineralization in Ireland, but is compatible with the age indications for the Gortdrum copper-mercury-silver deposit (Steed, 1975; Steed and Tyler, 1979).

The copper minerals in the clearly epigenetic, cross-cutting mineralization may have been remobilized at some stage from an earlier phase of copper-silver stratabound mineralization, with a consequent depletion in copper and relative increase in the proportion of silver.

Although the deposit as presently known is not economic, the recognition of stratabound silver mineralization provides interesting exploration opportunities, both on a local and regional scale. Furthermore, the apparent relative simplicity of the structure and mineralization of the deposit might, with further research, provide insights into the genesis of the larger, more complex base metal deposits found elsewhere in the Lower Carboniferous of Ireland.

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References

CAMERON D. E. and ROMER, D. M. 1970. Denison copper-silver deposit at Aherlow, County Limerick, Ireland. *Trans. Instn. Min. Metall. (Sect. B:Appl. Earth Sci.),* Vol. 79, p. B171-B174.

HALLOF, P. G., SCHULTZ, R. W. and BELL, R. A. 1962. Induced Polarization and geological investigations of the Ballyvergin Copper deposit, County Clare, Ireland. *Trans. Am. Inst. Min. Engrs.* 223, 312-8.

HUDSON, R. G. S. and PHILCOX, M. E. 1965. The Lower Carboniferous stratigraphy of the Buttevant area, County Cork, Ireland. *Proc. Roy. Irish Acad.* Vol. 64, p. 65-79.

MORRISSEY, C. J., DAVIS, G. R. and STEED, G. M. 1971. Mineralization in the Lower Carboniferous of Central Ireland. *Trans. Instn. Min. Metall. (Sect. B:Appl. Earth Sci.),* 80, B174-85.

PHILCOX, M. E. 1964. Compartment deformation near Buttevant, County Cork, Ireland and its relation to the Variscan thrust front. *Sci. Proc. R. Dublin Soc.,* A2, p. 1-11.

STEED, G. M. 1975. The geology and mineralization of the Gortdrum district, Ireland. PhD Thesis, Imperial College, University of London.

STEED, G. M. and TYLER, P. 1979. Lithogeochemical haloes about Gortdrum copper-mercury orebody, County Tipperary, Ireland. *In: Prospecting in areas of glaciated terrain.* Instn. Min. Metall. (London). p. 30-39.

STROGEN, P. 1977. The evolution of the Carboniferous volcanic complex of southwest Ireland. *J. Geol. Soc., Lond.* 133.

THOMPSON, I. S. 1967. The discovery of the Gortdrum deposit, County Tipperary, Ireland. *Trans. Can. Inst. Min. Metall.* 70, p. 85-92.

TYLER, P. 1979. The Gortdrum deposit. *In: Prospecting in areas of glaciated terrain: Excursion Handbook* (ed. A. G. Brown). Irish Assoc. for Econ. Geol. Dublin.

WILBUR, D. G. and ROYALL, J. J. 1975. Discovery of the Mallow copper-silver deposit, County Cork, Ireland. *In: Prospecting in areas of glaciated terrain.* Instn. Min. Metall. London. p. 60-70.