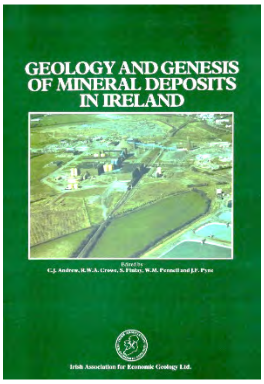

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The zinc-lead and barite deposits at Keel, County Longford.

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Abstract

The Keel deposit was discovered in 1962 by Rio Tinto Finance and Exploration Limited and consists of a small tonnage, medium-grade deposit of zinc and lead with associated cadmium and silver. The mineral occurs as fracture fill, breccia matrix and disseminations within Lower Carboniferous basal clastics immediately south of the Lower Palaeozoic Keel Inlier. Sulphide mineralization is localized on the ENE-trending Keel Fault system. Extensional movement on this system caused preferential fracturing and brecciation of more competent units which created space for the precipitation of sulphides from fluids passing upwards along the Fault.

Another small deposit of stratiform style was outlined by more recent exploration at nearby Garrycam. It occurs within Waulsortian Reef mudbank limestones on the hangingwall side of the Keel Fault. The Garrycam mineral assemblage consists of barite, pyrite and sphalerite with minor galena mixed with argillaceous sediment. Studies of mineral distribution and textures suggest that ponding of sulphates and sulphides occurred in a sea-floor depression between reef mounds. The Keel-type mineralization is believed to represent a feeder system to the Garrycam deposit.

Introduction

The Keel zinc/lead deposit is located on the southern side of a Lower Palaeozoic inlier at Keel, County Longford (Fig. 1), in the northern part of the Irish midlands. The deposit was discovered by Rio Tinto Finance and Exploration Limited during regional reconnaissance stream-sediment sampling in 1962. Follow-up exploration included soil sampling, induced polarization surveying and diamond drilling. In 1965 the decision was taken to sink an exploration shaft to establish the precise nature and continuity of mineralization intersected by drilling.

Diamond drilling and underground development established a deposit of 1.85Mt of indicated and inferred reserves grading 7.71% Zn, 1.04% Pb, 0.12% Cd, 39.6g/t Ag (RTZ Services Limited, 1968). Development work on the project was suspended in 1968.

Exploration since the mid-1970s has located a small barite/pyrite/sphalerite body with minor galena at Garrycam, less than 1km from the Keel shaft. To date the deposit totals 1.35Mt grading 36.14% $BaSO_4$, 2.67% Zn, 0.18% Pb. Within this, a higher grade barite zone has been identified totalling 0.63Mt at 65.48% $BaSO_4$.

Regional stratigraphy

The Keel district was an area of positive relief during the early stages of the Carboniferous marine transgression. This is seen in the development of extensive shoreline deposits of quartz-pebble conglomerate near the base of the succession, which unconformably overlies the Lower Palaeozoics. As the transgression progressed northwards there was a change in the Keel area, through a series of steps, from deposition of shallow-water clastic sediments, to relatively shallow-water carbonate deposition, through to deep-water basinal deposition of Chadian black mudstones and shales.

The general succession can be correlated regionally with the successions at Ballinalack to the east, Moyvore to the south, and Newtown Cashel to the west, all approximately 15km from Keel (Philcox, 1984). At Granard, 20km to the NE, a similar succession can be recognized but most units are considerably thinner.

Local stratigraphy

The stratigraphic succession in the Keel area has been established in considerable detail by surface mapping, diamond drilling and underground development (Patterson, 1970; Philcox, 1982 and 1984). Local stratigraphic sub-divisions have been recognized at Keel which can be correlated with the regional stratigraphy (Fig. 2). Descriptions of the various units are given in Table 1.

Structure

The Keel Inlier displays the ENE Caledonian alignment seen in many of the Irish Lower Palaeozoic inliers (Fig. 1). Reactivation along original Caledonian structures appears to have occurred during the Carboniferous, and tectonism related to the Hercynian orogeny probably resulted in the uplift of the Inlier. Today, the Carboniferous sediments dip off the SE side of the Inlier at between 10 and 30 degrees.

Keel Fault

The Keel Fault is the major structure within the Keel area. It follows the Caledonian structural trend and bounds the Inlier on its SE side, where it can be traced for over 8km along strike. Fault control is less marked along the northwestern boundary of the Inlier.

The Keel Fault consists of a zone of normal step faults rather than a single fault plane (Figs. 3 and 4). In the vicinity of the mineral deposit multiple faulting appears particularly pronounced. How much of this apparent increase in structural intensity is real, and how much reflects

Table 1 — Keel succession

Local unit name	Thickness	Description
"Calp" limestone	Not known in Keel area	Thick succession of thinly bedded calcareous turbidite, crinoidal limestone and shale. Lowermost 25m consists of banded unfossiliferous shale and mudstone.
Viséan Bioclastic Limestone	0-25m	Thinly interbedded crinoidal calcarenite, silty calcarenite and calcareous siltstone. Very similar to Bioclastic Limestone unit.
Reef Limestone	Up to 215m	Stromatactid mudbank micrite, pale-grey in colour. Occasional dark inter-reef shaly and bioclastic intervals up to 75m thick particularly near the top of the reef. Similar intervals are common at reef-base. Reef is sometimes dolomitized. Thin distal tuff bands (~20cm) often occur towards the top of the unit.
Bioclastic Limestone	200m	Uniform lithology, very similar to Viséan Bioclastic Limestone. Patchy chert near top.
Upper Mixed Beds	~76m	Interbedded micrite, oolite, calcareous and non-calcareous sandstone, transitional upwards to the Bioclastic Limestone through silty calcarenite and thin unfossiliferous shale bands towards top.
Bioclastic Dolomites	~11m	Well bedded, dolomitized calcarenite with common fossil debris; medium-grained, vuggy. Occasional black shale partings and thin mudstone bands. Near Keel Fault this unit weathers to form large open dissolution zones.
Lower Mixed Beds	1-11m	Thin calcarenite beds alternating with calcareous sandstone, dark grey mudstone and minor oolite. Unit often dolomitized near Keel Fault.
Upper Quartzitic Sandstone	~38m	Interbedded sandstone and shale. Sandstone is clean, white to grey, medium-grained. Shale is green or black, finely laminated.
Quartz Pebble Conglomerate	~17m	Pebbles up to 20cm diameter of white, green or red quartzite and vein quartz set in matrix of quartzitic sandstone with occasional red jasper pebbles. Small black chert fragments occur in matrix.
Lower Quartzitic Sandstone	15m	Irregularly developed conglomerate of small, poorly rounded pebbles of Lower Palaeozoic grit, shale and vein quartz in a matrix of finer material of the same type.
Red Beds	—	Not preserved in the Keel area but pebbles of red quartzite are seen in the Quartz Pebble Conglomerate.
Lower Palaeozoic	Not known	Dark grey/green grit and mudstone. Often tightly folded and cut by later quartz/carbonate veins. Forms the core of the Keel Inlier.

the far greater amount of data available in the vicinity of the deposit, is difficult to assess.

Each fault within the Keel Fault system dips at about 55°-60° to the SE, with a total normal displacement of around 210m. Few drill holes have intersected the basal succession and the Keel Fault at depth, but there are indications that individual branches flatten and splay. The effect of the Fault at surface in the vicinity of Keel is to throw basal Reef Limestone or Bioclastic Limestone against Upper Mixed Beds. The extent of lateral movement on the Keel Fault is not known.

During drilling and underground exploration at Keel within the Basal Clastics, no evidence was seen for syndepositional movement on the Fault. Although little is known about the Basal Clastics on the downthrow side, there is no indication of rapid variations in lithology or unit thickness compared with the well-documented footwall sequence. Considerable movement occurred after lithification of the Basal Clastics as evidenced by the locally intense fracturing and brecciation which opened the way for the later passage of mineralized fluids. This movement may have occurred as early as the formation of the Waulsortian Reef Limestone because the Keel Fault appears to have exerted a regional facies control, whereby extensive reef mudbanks are developed to the SE while, to the NW, only minor patchy reef is developed. The reef facies in this area is represented by an off-reef argillaceous limestone.

Also, if the Keel and Garrycam mineralizing events were connected (see below), then it seems probable that the mineralization was introduced along the already existing Keel Fault system onto the developing reef mounds on the sea floor.

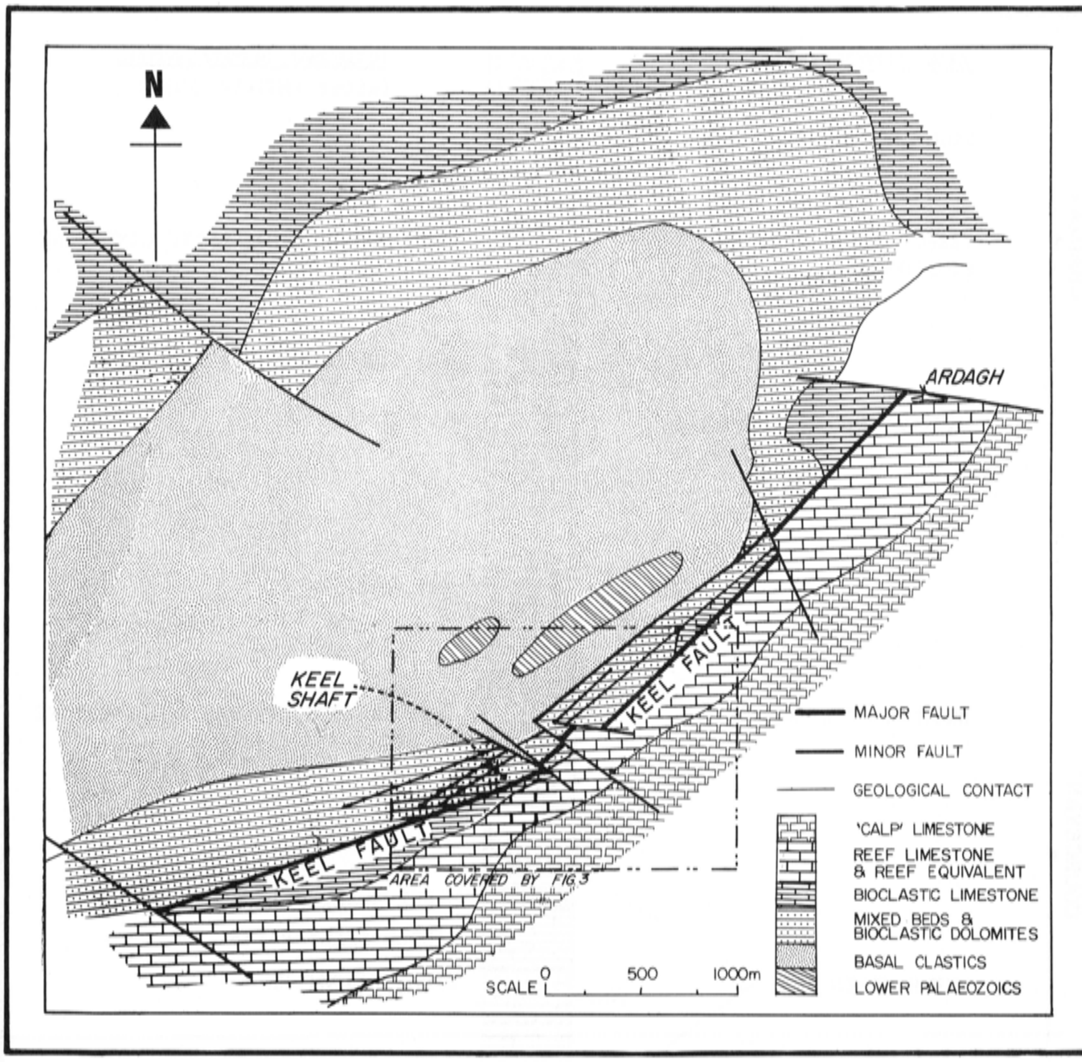

Figure 1. Location map.

Other faulting

A minor set of conjugate faults occurs within the Keel Fault system. These faults strike parallel to the Keel Fault but dip at about 75 degrees to the NW. Throws are only of the order of 0.5m; even so, they are often open and mineralized within the deposit (Patterson, 1970).

The other, more structurally significant, set comprises steeply dipping NW-trending faults, ocasionally swinging to northerly or easterly. These have been identified at Keel and to the NE, at Ardagh.

The NW fault set postdates the Keel Fault, creating relatively minor offsets in the Keel area, but with more significant displacement around Ardagh. Movement on these faults generally appears to post-date the introduction of mineralization, but recent evidence from Garrycam suggests that at least one such fault may have been active during Reef Limestone accumulation (see under "Garrycam — controls on mineralization"). During underground development at Keel a number of minor NW faults were intersected and these were open and unmineralized. They now act as aquifers, and were the main source of the strong water flows encountered at Keel.

Keel deposit

(a) Mineralogy

Patterson (1970) has described the detailed mineralogy of the deposit from polished section and electron-probe analysis, as well as examination of drill core and underground mapping.

Sphalerite constitutes the main sulphide and occurs as coarsely crystalline cavity-fill and as fine disseminations. Colour varies from pale honey-coloured to dark brown, largely due to variations in iron content from 0.3% to 2%. Some of the darker sphalerite contains tiny laths of chalcopyrite which may also account for the colour variation.

No cadmium sulphides have been identified at Keel, but cadmium occurs as an important constituent in solid solution within the sphalerite lattice. It regularly constitutes more than 1% of the sphalerite and the proportion remains identical in all types of sphalerite and over a large assay range (Fig. 5). The average Zn/Cd ratio is 60:1. The high cadmium content in sphalerite is unusual in relation to other Irish zinc/lead deposits.

No published data has been obtained, but at Silvermines

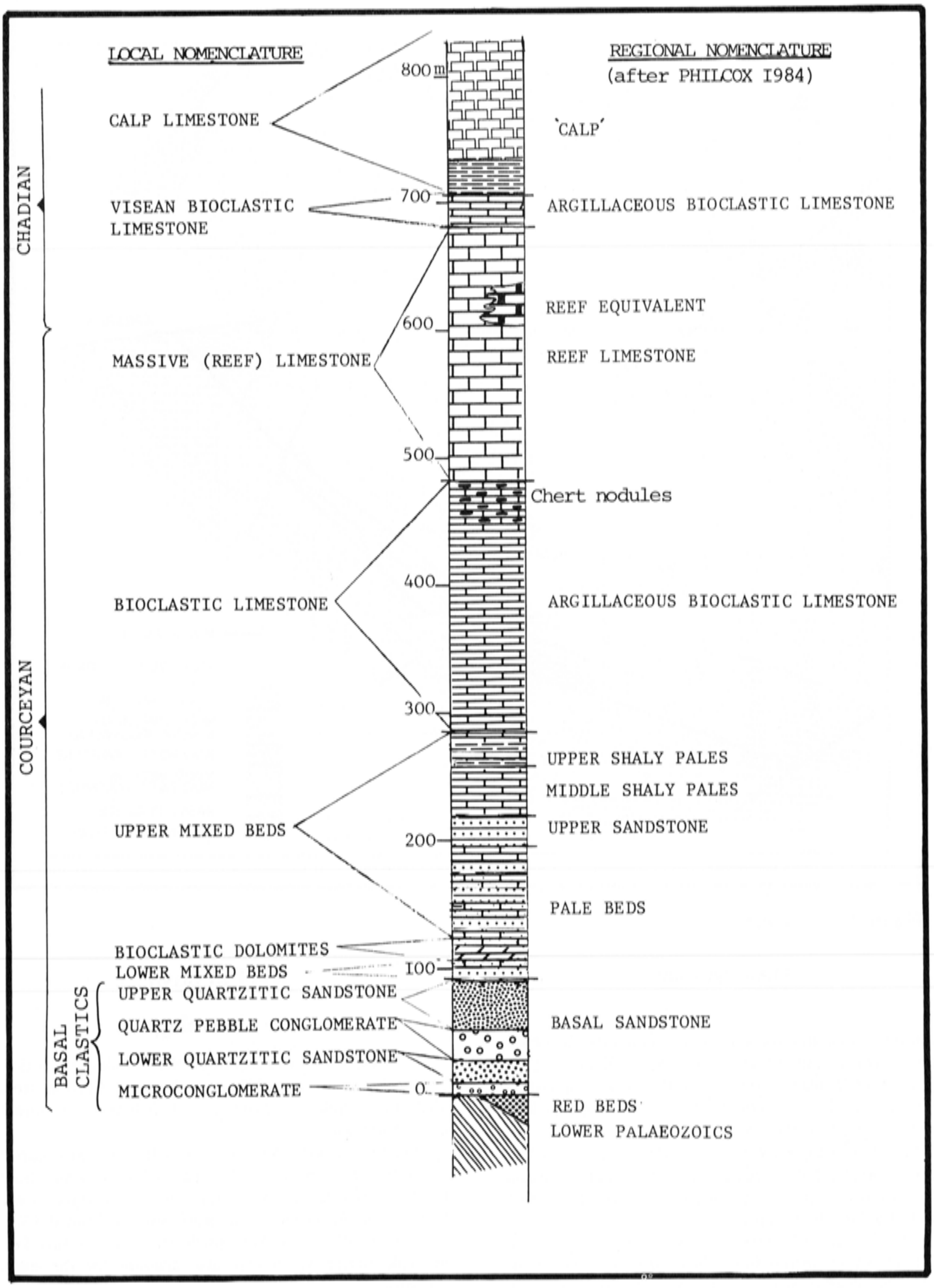

Figure 2. Stratigraphic succession — Keel area.

values ranging from 190-320ppm Cd were reported from average mine ore in the "B" Zone and Upper and Lower "G" Zones, with Zn/Cd ratios from 176:1 to 450:1 (Hobba, 1977). Figures are not available for Navan and Tynagh, but Zn/Cd ratios for these deposits are understood to be also considerably higher than for Keel (J. Ashton, C. J. Andrew, pers. comms., 1984).

Argentiferous tetrahedrite also occurs within sphalerite as minute inclusions, and constitutes an important source of silver, most of which is held in solid solution within the tetrahedrite (Fig. 5).

Galena is the dominant lead mineral but is generally subordinate to sphalerite. Local enrichments occur, particularly in the eastern part of the deposit. The mode

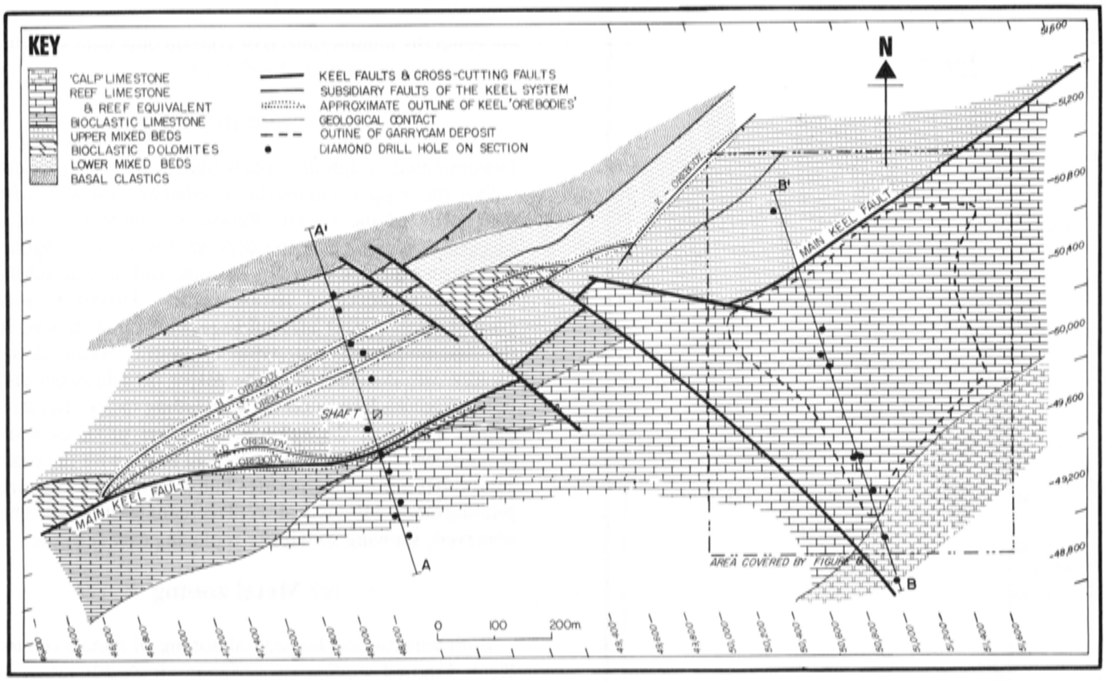

Figure 3. Geology, structure and mineral deposit outlines for Keel and Garrycam at sub-drift elevation.

of occurrence is similar to that of sphalerite, although disseminations are less common. Silver-bearing tetrahedrite is found as mechanical inclusions within the galena which is a more significant source of silver than the sphalerite (Fig. 5). Tetrahedrite appears to replace the galena. The silver content of the tetrahedrite, occuring in solid solution within the lattice, is exceptionally high at Keel, averaging about 20%, but with values ranging up to 70% by weight. Apart from its occurrence within tetrahedrite, silver sulphosalts, such as pyrargyrite and jalpaite, have been identified.

Calcite, dolomite and quartz are the major gangue minerals and these show many different styles of occurrence in filling fractures, cavities, breccias etc. Barite occurs both as an early vein and cavity filling mineral and also as a late phase of crystal growth in the centre of small cavities. It is not of economic importance within the deposit, although some late veins occuring towards the NE are relatively barite-rich. Neither pyrite nor marcasite are of major significance; pyrite occurs largely as late cavity encrustations and occasional blebs and crystals.

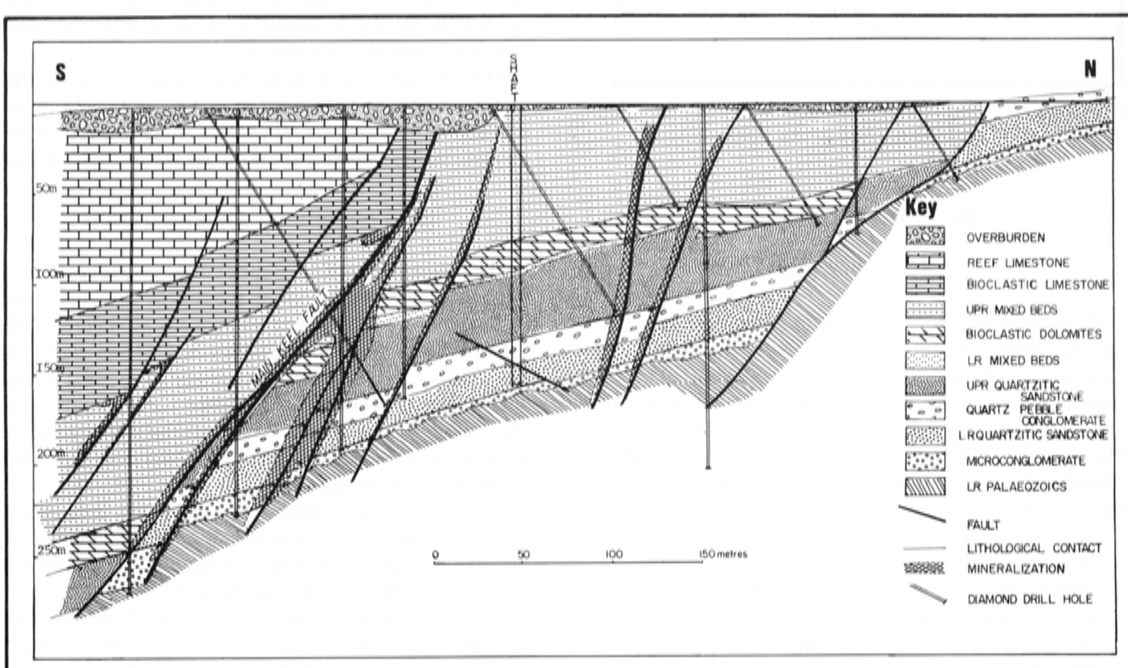

Figure 4. Section A-A′ (48 400 E) across the Keel deposit.

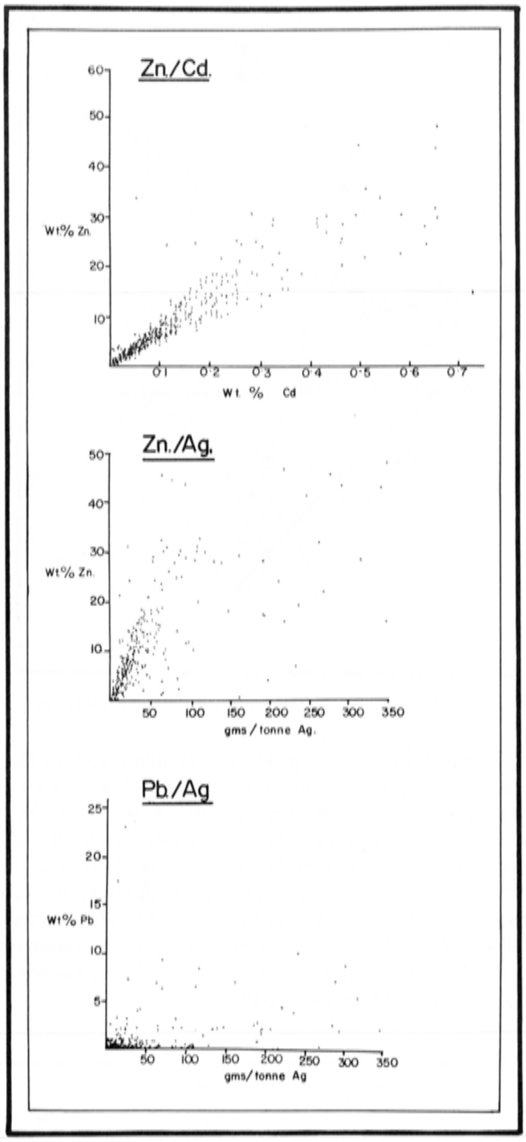

Figure 5. Relationships between major and minor metals in the Keel deposit.

(b) Mineral textures

(i) Breccia mineral

The tectonic breccias hosting much of the mineralization contain angular clasts showing random orientation and ranging in size from less than 2cm in diameter to blocks as large as 40cm × 20cm. The clasts themselves are generally of the same lithology as the adjoining or overlying wallrock. The matrix usually consists of quartz, silicified shale or sulphide. Where the clasts are smaller in size, the grade tends to improve. Mineralized fractures sometimes occur as an envelope around the breccias, providing additional width to ore-grade material.

Sulphide mineralization is best developed adjacent to the main faults but, towards the periphery of the breccia zone, dolomite becomes the dominant matrix component. This suggests that the mineral phase was relatively short, and that the sulphide-bearing fluids were not available for a long enough period to fill all the available open space.

Where NW-trending faults or fractures are known they are generally unmineralized or contain only light smearings of apparently remobilized sphalerite.

(ii) Disseminated mineral

Disseminated sulphide, particularly sphalerite, occurs within the Upper Quartzitic Sandstone and also within the matrix of the Quartz Pebble Conglomerate. It was originally believed that the deposit was a truly syngenetic stratiform type and that the fracture and breccia sulphide was a consequence of remobilization. However, underground development and subsequent drilling showed that the disseminated mineral, while often stratabound, dies out rapidly with distance from the major breccia zones and is not contiguous betweeen the controlling faults. The stratabound nature of the sulphides appears to be caused by porosity contrasts between different units, with the coarser sandstones and conglomerates being favoured by the precipitating fluids. Microscopic replacement textures have been observed, showing sphalerite replacing earlier pyrite.

(c) Metal zoning

Both vertical and horizontal zoning of metals occurs at Keel. Limited studies carried out on Zn/Pb ratios in a vertical direction show a general increase upwards from 1:1 or less in Lower Palaeozoics to approximately 5:1 in the Basal Clastics and often 30:1 in the Mixed Beds.

Horizontal metal zonation was established by taking total assay intersections from diamond drill holes without regard to lithology or assay breaks, and plotting results for total zinc and total lead in metres per cent. The results (Fig. 6) show a broad area of high zinc values in the central and southern parts of the deposit. Peak lead values are concentrated in the eastern part of the deposit, clearly reflecting the 3:1 zinc/lead ratio of the K-"orebody", which is lead-enriched, compared with the 7.4:1 ratio for the Keel deposit as a whole. The other four "orebodies", the C, D, G and H, are all comparatively zinc-enriched. The general ENE orientation of the zonation patterns reflects the strong structural control of the deposit.

The concentration of higher lead values within the lower lithological units and in the east-central part of the deposit suggests upward movement of fluids from this area which, coincidentally or otherwise, is cut by a NW-trending fault.

(d) Controls on mineralization

The shape of the Keel deposit is largely controlled by the availability of open space created by tensional movement on the Keel Fault. This movement occurred after lithification of the Basal Clastics and Mixed Beds, and the consequent fracturing and brecciation is most marked within the more clastic units. Some coarser units within the Lower Palaeozoics are also strongly fractured, but mineralization associated with these units does not usually occur in significant quantities.

Over most of the deposit, the relatively impermeable Bioclastic Limestone restricted upward migration of the mineralized fluids, resulting in concentration of sulphides in the Upper Mixed Beds immediately below.

Underground development and diamond drilling proved conclusively that the main control on distribution of mineralization is structural. Up to thirteen sub-parallel faults were identified within the Keel Fault system and, of these, five contained significant mineralization of potentially

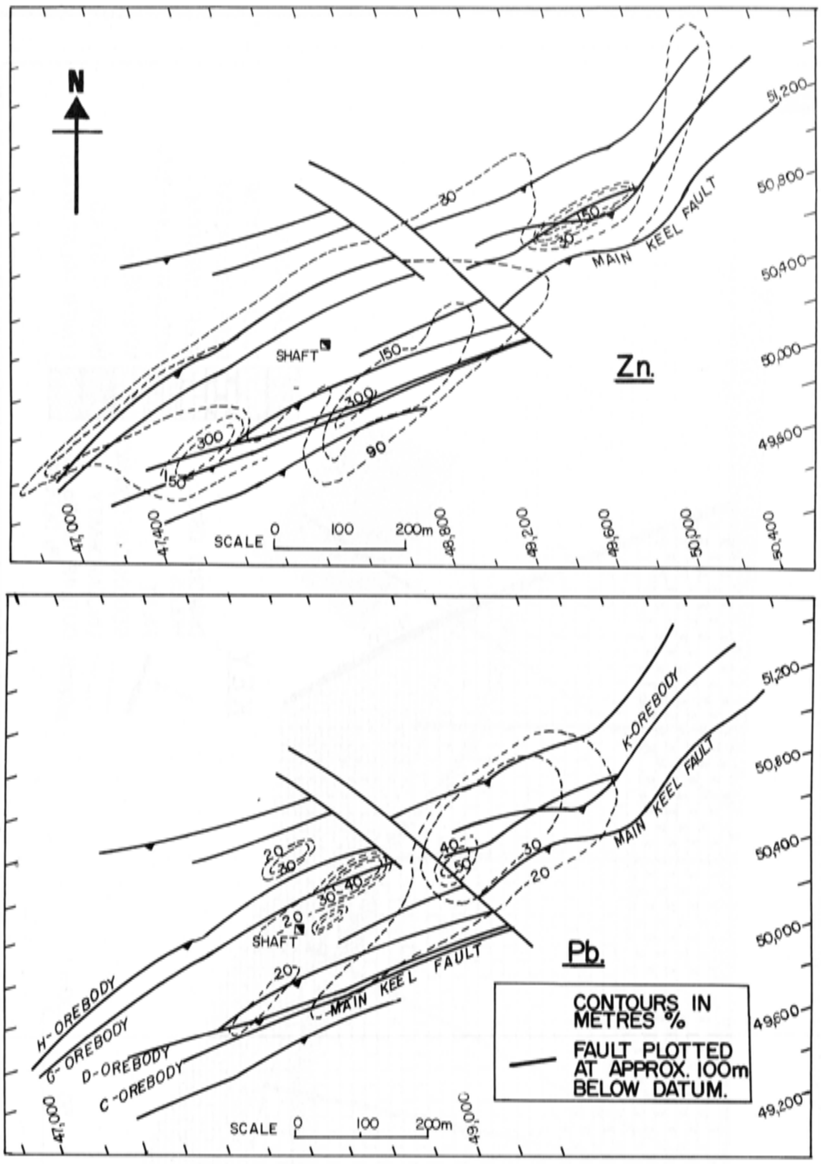

Figure 6. Horizontal metal zoning at Keel.

economic grade within fracture and breccia envelopes around the faults. These were designated as separate "orebodies" making up the bulk of the deposit. Where brecciation is sufficiently intense, two of the "orebodies" can merge. Pinching and swelling of the "orebodies" laterally creates considerable problems in interpreting continuity from drilling.

Garrycam deposit

(a) General

The Garrycam deposit is located 1km east of the Keel shaft. The earliest indication of its existence was seen in the first hole drilled at Keel, in which massive pyrite was found at the base of the Reef Limestone on the hangingwall of the Keel Fault. However, with the concentration on the investigation of the Keel deposit, it was not until the mid-1970s that further exploration was carried out at Garrycam. Analogies were drawn with the Silvermines Zn/Pb deposit where the reef-hosted "B" and Upper "G" orebodies were discovered in proximity to epigenetic disseminated and fracture-fill mineralization in the underlying Devonian sandstones ("K" and "C" Zones) (Taylor and Andrew, 1978).

At Garrycam, drilling eventually outlined a sub-economic barite-sphalerite body, hosted by the Waulsortian Reef Limestone which confirmed the Silvermines analogy.

(b) Mineralogy

Barite is the predominant mineral at Garrycam, with pyrite and sphalerite being of lesser importance. Galena is of minor significance only, and occurs in intimate association with sphalerite. The barite is usually grey in colour, medium- to coarse-grained where recrystallization has taken place, and relatively fine-grained elsewhere. Sphalerite is normally red or reddish-brown in colour and fine-grained. Sphalerite at Garrycam contains only trace

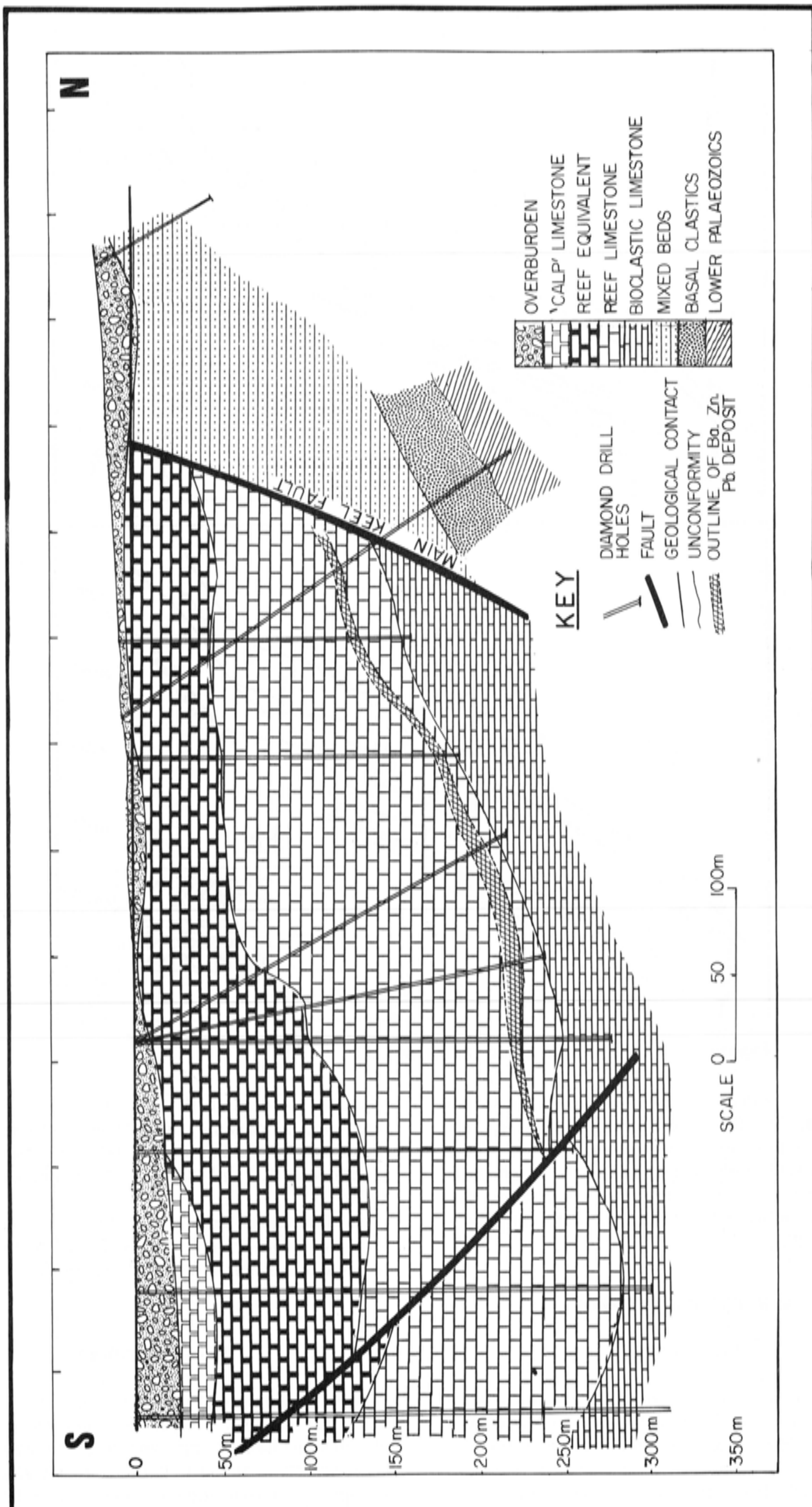

Figure 7. Section B-B' (51 000 E) across the Garrycam deposit (location shown on Figure 3).

amounts of cadmium. Silver is virtually absent, probably because of the scarcity of lead. Pyrite occurs mixed with the barite and also along fractures and lining cavities above the main mineral body.

(c) Mineral textures

Detailed examination of selected drill-core specimens (Strogen, 1981) identified two styles of mineralization within the main zone, the first occurring in association with relatively undisturbed laminated sediment, and the second consisting of an intraformational breccia. In the first type the laminations are marked by thin argillaceous partings, between which bands and nodules of barite occur. Recrystallization of barite during early diagenesis has caused some displacement of overlying sediments. Sphalerite usually occurs as microcrystalline bands.

The breccias contain clasts of reef micrite, barite, sphalerite, pyrite and polymineralic clasts showing bedding textures, set in a sparse argillaceous matrix. Recrystallization has given rise to some relatively massive barite sections.

Over vertical intervals of less than one metre the laminated and breccia sections are themselves interbedded, suggesting that brecciation was contemporaneous with sedimentation, and that a significant palaeoslope existed during deposition.

No cavity encrustation features have been observed within the main mineral zone at Garrycam, but banded pyrite occurs lining stylolites and stromatactis cavities in Reef Limestone above the main zone.

(d) Metal zoning

The barite and sulphides are often closely interbanded, without any distinct vertical zonation. This suggests that a finely balanced Eh-pH system existed during mineral deposition which permitted coprecipitation of sulphates and sulphides to occur.

Any original lateral metal zonation which existed has probably been partly obscured by syn-sedimentary brecciation and debris flow. Also, the relatively low zinc and, especially, lead grades result in very variable Zn/Pb ratios. However, there is still a marked zonation pattern from higher-grade barite in the central portion of the deposit to relatively lower grades, with increasing sulphide content, to the south and east. The average Zn/Pb ratio is 14.8:1.

Manganese haloes have been reported from around the deposits at Tynagh (Russell, 1974 and 1975). Silvermines (Gray and Russell, 1984), Ballinalack (Beale, 1976) and Navan (Finlay et al., 1984). At Garrycam, a manganese anomaly has also been detected within Reef Limestone, but no detailed study has been published to date (Gray and Russell, 1984).

(e) Controls on mineralization

Diamond drilling through the Keel Fault system immediately north and northeast of Garrycam intersected veins of massive and semi-massive barite. In some holes the veins contain breccia fragments of previously mineralized quartzitic sandstone, indicating that the veins post-date the main phase of breccia and disseminated mineralization at Keel. Because of its proximity to Garrycam, and the predominance of barite, this vein swarm is thought to be the main feeder system to the reef-hosted deposit.

Development of the Waulsortian reef mounds on the sea-floor appears to have been controlled by the Keel Fault to the north. Some degree of control is also suggested to the east by a NW-trending reverse fault which has been interpreted from contour plans of the base and top of the Reef Limestone (Slowey and Gribble, 1983).

Isopachs of reef thickness beneath the main mineralized zone (Fig. 8) are believed to show the shape of the reef mounds prior to the introduction of mineralization. A depression existed between the reef mounds to the east and southwest. A short break in reef development is suggested at this stage by the presence of minor amounts of argillaceous material within the main mineral body. Figure 8 also shows isopachs of mineral thickness, and there is an excellent correlation between the zone of greatest mineral accumulation and the inferred depression between reef mounds on the sea-floor.

The apparent control exerted on mineral distribution by the topography of the reef mounds is directly analogous to the Silvermines "B" and Upper "G" Zones and the Ballynoe barite deposit (Taylor and Andrew, 1978; Taylor, 1984).

Genesis

The following genetic sequence is postulated for the formation of the Keel-Garrycam deposits.

1. Lines of weakness existed along NE-trending Caledonian or pre-Caledonian structures.

2. Deposition of Lower Carboniferous sediments occurred as the sea advanced northwards, including units from the Basal Clastics up to the Bioclastic Limestone.

3. The Keel Fault system opened up along a pre-existing line of weakness and extensional movement resulted in the development of fracture and breccia zones around the individual faults making up the system. These zones were particularly well developed in the more clastic lithologies.

4. Sulphide mineralization was introduced along the Keel Fault and precipitated in open spaces within the tectonized units.

5. Waulsortian reef accumulation commenced, possibly accompanied by limited movement on NW-trending faults.

6. A late phase of barite-rich mineralization was introduced along the Keel Fault system north and northeast of Garrycam.

7. Mineralization related to this phase was introduced onto the sea-floor from hot springs along the line of the Keel Fault. The precipitated barite and minor sulphides moved down a palaeoslope southwards from the Keel Fault until trapped in a depression between reef mounds. Seismic activity related to movement on the Keel Fault caused syn-sedimentary brecciation and probable debris flows.

8. Introduction of mineralization onto the sea floor ceased and reef accumulation recommenced.

9. A late pyrite mineral phase occurred, lining stromatactis cavities and stylolites within the Reef Limestone.

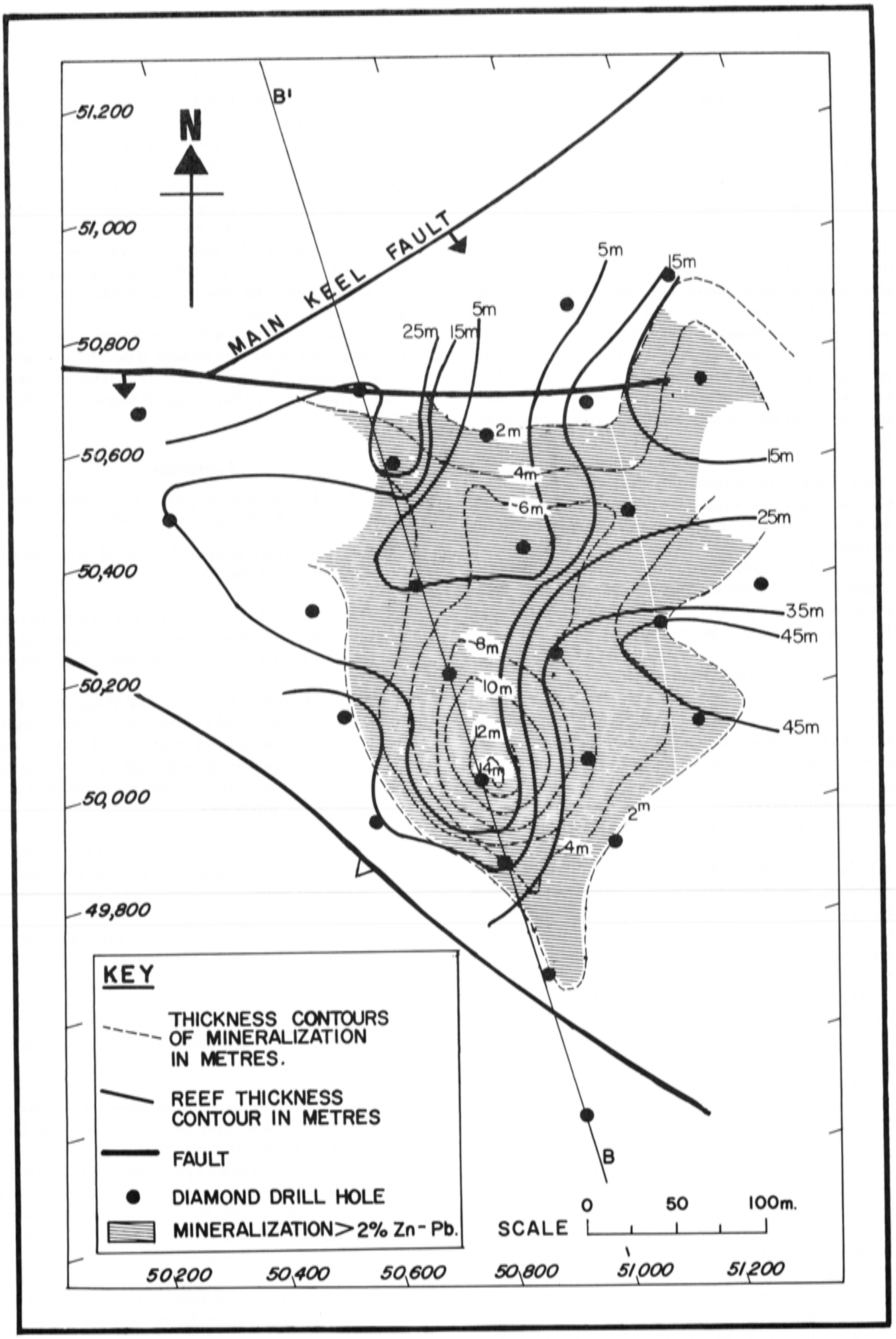

Figure 8. Garrycam — isopachs of mineral thickness and reef thickness below mineral deposit.

Evidence for the exhalative stratiform nature of the Garrycam mineralization is obtained from the excellent fit between the apparent palaeotopography of the reef mounds and the shape of the deposit, the regularity of the shape of deposit, the finely banded nature of some of the mineralization, and evidence of soft-sediment deformation. If a replacive origin were postulated, then an irregularly shaped deposit would be expected with signs of cavity encrustations within the main zone and also, possibly, signs of alteration in the surrounding reef wall-rock. None of these features are seen within the main mineral zone.

Limited fluid inclusion work on sphalerite from the Keel veins (Roedder, 1968) gave a temperature of 180°C for mineral deposition, with salinities of the order of 11-12%. Relatively low temperatures are also indicated by the limited extent of hydrothermal alteration seen in the host rocks. Some silicification of the sediments occurs at Keel but this is quite minor and only found in close association with mineralized faults or fractures. Patchy secondary dolomitization is developed in Reef Limestone, usually associated with adjacent structures, although the thin Bioclastic Dolomite Unit can be recognised as a dolomitized stratigraphic unit over a fairly wide area.

No local volcanic centre is known contemporaneous with mineral emplacement at Keel. However, a number of thin, fine-grained tuffaceous bands occur within the Reef Limestone or reef equivalent beds in the area (Philcox, 1982) but these, because of their uniformly fine-grained nature, almost certainly have a distant source. Rare dolerite dykes have been recorded at Keel but these cross-cut all other features and are probably Tertiary in age.

While igneous activity at depth cannot be ruled out, the most likely heat source would appear to be that produced by a thick pile of Lower Palaeozoic and Lower Carboniferous sediments, with connate or meteoric waters taking metals into solution and rising along the channelway provided by the downward extension of the Keel Fault.

Conclusions

The structural setting of the Keel deposit and the associated Garrycam mineralization shows some of the features typical of the major Irish ore deposits, particularly the control exerted by roughly ENE-trending faults as well as NW-trending faults with later movement.

Major ENE- or NNE-trending normal faults, throwing Lower Carboniferous strata against Old Red Sandstone or Lower Palaeozoics have been described from Tynagh (Derry et al., 1965), Silvermines (Taylor and Andrew, 1978), Navan (Andrew and Ashton, 1982) and Ballinalack (Jones and Bradfer, 1982). Cross-cutting NW-trending faults have been reported from Silvermines and Ballinalack and, at Silvermines, these faults exert a significant control over the distribution of mineralization. There is, perhaps, a hint of this at Keel from the lead distribution pattern (Fig. 6), but it is not of much significance overall.

The Keel/Garrycam deposits fit a pattern of feeder zone mineralization in Lower Palaeozoic to Basal Carboniferous strata leading to stratabound, reef-hosted mineralization which has been reported from Silvermines and possibly from Ballinalack. Limited drilling in the footwall of the Ballinalack Fault intersected disseminated and encrusting-style mineralization in the Mixed Beds (Jones and Bradfer, 1982). This may be similar to the style of occurrence at Keel. The reef-hosted mineralization at Ballinalack shows more obvious cavity-fill textures than the apparently exhalative stratiform Garrycam mineralization. This suggests that the introduction of mineralization at Ballinalack was slightly later than at Garrycam, with a considerable thickness of stromatactid Reef Limestone having already accumulated.

In terms of mineral style and host lithology, the most direct comparison can be made with the Silvermines deposits. The Keel vein, breccia and disseminated style of mineralization hosted by the Basal Clastics, Mixed Beds, and Lower Palaeozoics appears to be directly analogous to the Shallee mine, "C" Zone and "K" Zone mineralization at Silvermines (Taylor and Andrew, 1978).

The Garrycam deposit is very similar in stratigraphic position, mode of occurrence and mineral textures to the Silvermines "B" and Upper "G" Zones and the Ballynoe barite deposit (Taylor and Andrew, 1978; Taylor, 1984). Differences exist in mineralogy and mineral distribution, but this is to be expected in deposits 100km apart. The difference in scale between the two deposits may be related to a smaller hydrothermal system at Keel/Garrycam, or the absence of other suitable reef "traps", or it may reflect the relative amount of exploration carried out within Reef Limestone in the two areas. Nevertheless, the Garrycam deposit represents the most significant stratiform barite discovery in Ireland since Ballynoe.

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Discussion

MURRAY HITZMAN (Chevron Mineral Corporation of Ireland) asked:

1. How extensive, and how thick, are the tuff bands near the top of the reef? 2. Are there zones of dolomitization associated with either the Keel or Garrycam prospect? What is the style of such dolomitization and what is its extent? 3. How extensive is the Waulsortian Reef in the Keel area? Is it ever cut out by supra-reef unconformities?

REPLY:

1. The main tuff band seen near the top of the Reef Limestone-Reef Equivalent Unit is usually about 15cm thick and is fine-grained and pale green in colour. In some drill holes there are a number of thin tuffs rather than a single band, but the reason for this is not known. The author has not carried out any studies on the lateral persistence of the tuff, but it is present in most of the holes drilled in the Garrycam area. In a few holes the tuff appears to be missing altogether, and this may be related to the topography of the reef mounds during deposition of the tuff. The mineralogy of the tuff has not been studied.

2. Three types of secondary dolomitization occur at Keel/Garrycam. The Reef Limestone, and sometimes units underlying it, are locally dolomitized. The reef becomes recrystallized, forming zones of coarse, vuggy dolomite, pale grey in colour. There appears to be an association between dolomitization and faulting, perhaps more particularly with cross-faulting.

At Keel, dolomite is a common, apparently late-stage, gangue mineral occurring in fault zones and as breccia matrix.

In the vicinity of the Keel deposit, the lowermost calcareous unit, the Bioclastic Dolomite, is extensively dolomitized, as its name implies. This may be related to the dolomitization occurring in the fault and breccia zones, but is not seen to the same extent in the higher calcareous beds.

3. In the Keel area, Waulsortian Reef is consistently present although varying in thickness between boreholes. Towards the SW, Reef equivalent lithologies become locally dominant, but the unit is still distinctly recognizable. The author has not observed any supra-Reef unconformity in the vicinity of the deposits.