MINERALIZATION IN THE SURROUNDINGS OF THE
"TURKEY CREEK (HUCKITA)" LEAD-ZINC PROSPECT, N.T.

REPORT
TO
ENTERPRISE EXPLORATION CO. PTY. LTD.
BY
E.K. STURMFELS

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MINERALIZATION IN THE SURROUNDINGS OF THE
TURKEY CREEK LEAD - ZINC PROSPECT, N.T.

Report
to
Enterprise Exploration Company Pty. Ltd.

by
E.K. Sturmfels, D.Sc.
Consulting Geologist

With 3 Plates

Diamond Creek, Vic.  30th September, 1960
CONTENTS

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
<th>Sect.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Location and Access</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Prospecting Work</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Stratigraphy</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Structure</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Mineral Occurrences</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Turkey Creek Lead-Zinc Prospect</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Galena on Ooratippra Station</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Other Mineral Occurrences</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Origin of Mineralization</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Conclusions</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

Plates

1. Locality Map, Turkey Creek Prospecting Area, N.T.  
2. Geological Sketch Map, Surroundings Turkey Creek Lead-Zinc Prospect, N.T., Eastern Sheet.  
3. Geological Sketch Map, Surroundings Turkey Creek Lead-Zinc Prospect, N.T., Western Sheet.
CONTENTS

Summary 2
Introduction 3
Location and Access 3
Prospecting Work 4
Stratigraphy 5
Structure 8
Mineral Occurrences 8
  Turkey Creek Lead-Zinc Prospect 8
  Galena on Ooratippra Station 9
Other Mineral Occurrences 10
Origin of Mineralization 10
Conclusions 13

Plates
1. Locality Map, Turkey Creek Prospecting Area, N.T. √
2. Geological Sketch Map, Surroundings Turkey Creek Lead-Zinc Prospect, N.T., Eastern Sheet.
3. Geological Sketch Map, Surroundings Turkey Creek Lead-Zinc Prospect, N.T., Western Sheet.

SUMMARY

During a five weeks reconnaissance survey Upper Cambrian limestones and dolomites in the surroundings of the Turkey Creek Lead-Zinc Prospect were searched for further indications of mineralization. Two additional occurrences of galena were found on Ooratippra Station. Mineralization is localized in disturbed parts of otherwise rather flat-lying beds. Galena occurs either as irregular masses or as disseminated grains. Sphalerite was noticed in one of the Turkey Creek bores. Rich surface ore contrasts with much poorer ore at depth. Main gangue mineral at Turkey Creek is barytes. Magnesite and crypto-crystalline quartz have been found in association with lead mineralization as well as elsewhere. The country rock has been changed into dolomite and silicified. Chert layers are connected conspicuously with surface mineralization. The origin of the ore is as obscure as that of similar base metal deposits in sedimentary beds overseas. No further prospecting work is recommended.
INTRODUCTION

When the Company's Chief Geologist C.L. Knight and Geologist K. Phillips first investigated the Turkey Creek Prospect they found that it was very similar in appearance to important lead-zinc deposits in sedimentary rocks overseas. Experience in these overseas deposits suggested that there was a reasonable chance of similar or even larger base metal accumulations within the same beds in the surrounding area and that regional prospecting would be warranted. An application for an Authority to Prospect (A.P. 794) over an amended area of 3,000 sq. miles was granted by the Administrator of the Northern Territory on 15th June, 1960, for a period ending on 8th August, 1960 (1). An option over the Turkey Creek Prospect itself had been obtained previously.

The writer was requested to carry out five weeks' regional prospecting to be completed before the 8th of August. He was also requested to log the bores drilled at Turkey Creek during this period. This report contains a short account of the information collected by the writer, including the results of drilling up to the 3rd of August. The results of later work, in particular of detailed mapping on the Turkey Creek Prospect itself and of further drilling, have not been available to the writer and could not be used. Detailed bore logs of the bores drilled during June and July, 1960, have already been submitted to the Company (2).

LOCATION AND ACCESS

The Turkey Creek Prospect itself is situated on the right bank of Turkey Creek in the Northern Territory of Australia, about 155 miles north-east of Alice Springs (Plate 1). The Authority to Prospect (A.P. 794) covers most of the outcrops of Cambrian limestones and dolomites within a radius of about 50 miles in two separate areas: 2,100 sq. miles around Turkey Creek and in the country to the east of it, and 600 sq. miles further to the west along the foot of a north-west stretching mountain range (Dulcie Range).

The outcrops of Cambrian limestones and dolomites occur in undulating or flat country and at elevations of between 1,000 ft and over 1,500 ft above sea level.

(1) A previous Authority (A.P. 781) had been cancelled at the request of the Company.

The climate is semi-arid. A number of springs are arranged around the main mountain range, apparently the overflow of a perched aquifer in this synclinal basin. Otherwise natural water holes are few and far between. Most of the bores obtain potable water from considerable depth. In the bore just north of the Turkey Creek Prospect (Box Hole Bore) the ground water level is reported to be at about 400 ft below the surface.

The distance by road from Alice Springs to the Turkey Creek Prospect is about 205 miles, 143 miles on bitumen, for another 130 miles on a well-graded road as far as McDonald Downs Homestead, and the remainder on a graded bush track, rough in places (Plate 1). Another route of access leads to the eastern part of the prospecting area via the Harts Range Depot and the Jervois Copper Mine to Lucy Creek Homestead. Tracks within the area are suitable for four-wheel drive vehicles only. Landing grounds for smaller aircraft exist at present in the vicinity of McDonald Downs Homestead and near Lucy Creek Homestead.

PROSPECTING WORK

The writer arrived in the area on 1st July and returned to Alice Springs on 4th August. A preliminary survey of the Turkey Creek Prospect itself during the first few days indicated that the chert layers, contrary to previous expectations, were restricted to the mineralised portions and could not be used as marker beds for regional prospecting. The lack of recognizable marker beds made a systematic approach impossible and the writer concentrated his efforts to begin with on places from which unconfirmed rumours had reported lead or copper mineralization, to the east of Old Coratippra Homestead and in the vicinity of Old Huckitta Homestead. Attention was also paid to those parts where faulting or other structural complications had increased the likelihood of a mineral find. Little time, however, was spent in the vast area of flat-lying monotonous limestones and sandstones between Coratippra Creek and Arthur Creek.

The labour position was unsatisfactory. Two local natives who were employed for short periods each made initial efforts to earn the promised rewards, but quickly lost interest in work. In the short time available and with hardly any assistance it was not possible to do more than a reconnaissance survey of the three-thousand sq. miles. The small number of mineral occurrences found therefore does not necessarily indicate a lack of mineralization.


STRATIGRAPHY

The general stratigraphy of the area has been investigated by geologists of Frome-Broken Hill Co. Pty. Ltd. and of the Commonwealth Bureau of Mineral Resources. A report on the work carried out by the former has been compiled by K. Phillips (3). The results obtained by the latter have not yet been published, but the Resident Geologist at Alice Springs very kindly supplied the writer with some advance information. A publication by G.F. Joklik contains mainly information on the basement rocks (4). The fossil content of the Cambrian is described in a paper by Casey and Gilbert-Tomlinson, but their stratigraphical conclusions are superseded (5).

The writer's own observations were confined to the Cambrian limestones and dolomites, and the stratigraphical table below has been compiled from all available sources. There are differences of opinion regarding the nature and stratigraphical position of sandstone beds in the Middle and Upper Cambrian, a question which is of some importance for the problem of mineralization and the stratigraphical position of the mineralized beds. The writer's observations are in agreement with the findings of the B.M.R. geologists and their nomenclature has therefore been accepted for this part of the sequence.


<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Approx. Thickness</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Devonian</td>
<td>Dulcie Fish-Beds</td>
<td>100 ft</td>
<td>Sandstones and siltstones</td>
</tr>
<tr>
<td></td>
<td>(Phillips)</td>
<td></td>
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<tr>
<td>Middle Ordovician</td>
<td>Dulcie Sandstone</td>
<td>2,000 ft</td>
<td>Sandstones interbedded with siltstones and argillaceous sandstones</td>
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<td></td>
<td>(Joklik)</td>
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<tr>
<td></td>
<td>Eurowie Beds</td>
<td>7&quot; - 120 ft</td>
<td>Glaucitic sandy limestones and calcareous siltstones</td>
</tr>
<tr>
<td></td>
<td>(Phillips)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disconformity (?) or Unconformity (?)</td>
<td></td>
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<tr>
<td>Lower Ordovician to</td>
<td>Jinka Sandstone</td>
<td>500-1,000 ft</td>
<td>Calcareous sandstones with siltstones and sandy limestones (calcarenites) and glauconite horizons</td>
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<tr>
<td>Upper Cambrian</td>
<td>(Phillips)</td>
<td></td>
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<tr>
<td>Upper Cambrian</td>
<td>Arrinthurga Formation (B.M.R.)</td>
<td>1,500-3,000 ft</td>
<td>Limestones and dolomites interbedded with calcareous siltstones, sandstones in distinct horizons</td>
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<td></td>
<td>(=Huckitta Limestone, Phillips)</td>
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</tr>
<tr>
<td>Middle Cambrian</td>
<td>Arthur Creek Beds</td>
<td>500-1,000 ft</td>
<td>Bituminous limestones (calciolutes), sandstones and siltstones</td>
</tr>
<tr>
<td></td>
<td>(B.M.R.)</td>
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<tr>
<td></td>
<td>(=Boundary Hill Sandstone + Lucy Creek Limestone, Phillips)</td>
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<tr>
<td>Lower Cambrian (?)</td>
<td>Mount Baldwin Formation (B.M.R. &amp; Phillips)</td>
<td>400-750 ft</td>
<td>Sandstones and siltstones with grits and shales and local development of limestone</td>
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<td></td>
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</tr>
<tr>
<td>Lower Cambrian or</td>
<td>Grant Bluff Formation (B.M.R. &amp; Phillips)</td>
<td>500-1,100 ft</td>
<td>Mostly siltstones with subordinate sandstones</td>
</tr>
<tr>
<td>Upper Proterozoic</td>
<td></td>
<td></td>
<td></td>
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<td>do.</td>
<td>Oorabra Arkose</td>
<td>80-2,400 ft</td>
<td>Arkose</td>
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<td></td>
<td>(Joklik)</td>
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<tr>
<td>Upper Proterozoic</td>
<td>Mt. Cornish Formation (B.M.R.)</td>
<td>0 - 1,250 ft</td>
<td>Mostly glacigenic boulder beds with subordinate siltstones and sandstones</td>
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<td></td>
<td>(=Kuri Beds, Phillips)</td>
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<tr>
<td>Lower Proterozoic</td>
<td></td>
<td>Major Unconformity</td>
<td>Granite, schists and other metamorphosed sediments</td>
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<tr>
<td>Archaeozoic</td>
<td>Harts Range Group (Joklik)</td>
<td>Major Unconformity</td>
<td>Gneiss, granite and other igneous rocks, all more or less metamorphosed</td>
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</tbody>
</table>
The Middle Cambrian Arthur Creek Beds are the older of the two limestone formations. In the vicinity of Lucy Creek Homestead, these beds consist essentially of thin-beded bituminous limestones interbedded with calcareous siltstones and sandstones and some chert. Further to the west, on the southern side of the Dulcie Range, the upper part of the Arthur Creek Beds contains sandstones (orthoquartzites), siltstones and chert with subordinate limestone, the lower part, mainly argillaceous limestones (calcilutites).

The limestones and dolomites of the Upper Cambrian Arrinthurunga Formation are interbedded with calcareous siltstones and shales. Algal limestones are common. Oolitic limestones have been found in places. Sandstones occur at various horizons: a few hundred feet of interbedded calcareous sandstones and limestones pass without obvious unconformity into the overlying Jinkta Sandstone (6). The main sandstone member of unknown, but possibly somewhat greater thickness in the middle part of the Arrinthurunga Formation extends in a north-south belt from near the Old Coratippra Homestead in the north to the edge of the Pre-Cambrian in the south (Plate 2), but appears to be absent to the south of the Dulcie Range. Sandstones to the north of Lucy Creek Homestead and to the east of Old Coratippra Homestead could be repetitions of the same sandstone member. The amount of sandstone present in the formation appears to be very much less to the south of the Dulcie Range. The interbedded sandstones and limestones at the top are hardly more than a hundred feet thick and the main sandstone member seems to be replaced by layers of sandstones and sandy limestones (cancerines) alternating with thin-beded and algal limestones and dolomites. The base of the formation appears to rest on the Arthur Creek Beds conformably as indicated by exposures to the south of Old Nuckittita Homestead.

To the west of the Dulcie Range, the limestone-dolomite facies of the Arrinthurunga Formation is replaced by a facies in which calcareous siltstones and very fine-grained sandstones seem to predominate, with only a few intercalated limestone beds. Outcrops here are generally poor and it was not possible to separate the equivalents of the Arrinthurunga Formation from the equivalents of the Arthur Creek Beds (Plate 3). Chert with limestone layers which covers a large area to the north of MacDonald Downs Homestead could be derived from calcareous siltstones by secondary processes, but its stratigraphical position is not known.

(6) An unconformity reported by Phillips (l.c.), was not found by the writer.
STRUCTURE

The area under investigation represents the south-western end of the extensive, but rather shallow Georgina Basin. Towards the south, it abuts against the Pre-Cambrian metamorphics of the Harts Range. The Dulcie Range Syncline which contains beds as young as Upper Devonian, is the predominant structural feature in the western part of the area. Other synclines and anticlines do not exceed a few miles in extent. The Cambrian limestones and dolomites occur in a belt surrounding the Dulcie Range Syncline, narrow towards the south and south-west, but spreading over a wide area towards the east where the beds are flat-dipping or practically horizontal.

Along the southern edge of the basin, the structure is fairly complicated, with much folding and faulting, but decreasing in intensity rapidly towards the north. To the east of the Dulcie Range a conjugate pattern of south-south-east and south-south-west trending faults with vertical displacements of not more than a few hundred feet predominates (Plate 2). The southern edge, however, is controlled by west-south-west and west-north-west trending faults, some of them with vertical displacements of well over a thousand feet.

The latest orogenic movements are of post-Upper Devonian age. The rather gentle folds in the Ordovician and Devonian beds in the Dulcie Range in contrast to the more pronounced folding and faulting in the Cambrian beds suggest, however, that some movements took place during Cambrian and Lower Ordovician time.

MINERAL OCCURRENCES

Turkey Creek Prospect

Strikingly rich surface occurrences of galena on Turkey Creek are interspersed among cherts and silicified dolomites of the Arrinthuranga Formation on the flanks of a faulted and asymmetrical syncline. Mineralization in the outcropping beds extends over a vertical thickness of up to about 100 ft in the southern part and up to nearly 200 ft near the northern end, the same bed forming the base of mineralization in each case. Horizontally, mineralization reaches over a north-south distance of 5½ miles, but is not equally distributed. In the southern half of the syncline, it is confined to the eastern flank, the other flank apparently not exposing any beds so low in the sequence. In the northern half, mineralization is restricted to the western flank; beds on the north-eastern flank which are ore-bearing elsewhere are barren. In either case, it seems, mineralization is restricted to the up-throw side of a central strike fault (Plate 2).
There is also a significant difference in the mineral assemblage: at the extreme northern end, barytes, on most of the north-western flank, barytes plus galena, and on the south-eastern flank, galena with barytes in one or two places only. In the surface exposures, galena occurs mostly in irregular masses in the dolomite or chert, but to a lesser extent also in disseminated form.

In contrast to the massive and well preserved surface occurrences of galena, mineralization in the bores drilled during June and July, 1960, is much weaker and the original ore is largely leached. Small subangular to round cavities of up to a few millimeters in diameter are mostly arranged parallel to the bedding. They are lined with cerussite crusts or, less common, filled with pseudomorphs of cerussite after galena. These casts of former mineralization are distributed in layers up to a few feet thick and might amount, on an average, to between 2% and 10% of the respective layer. One of the bores contained at 185 ft depth a seven-inch band with about 15% of sphalerite and galena, whilst in a nearby bore of similar depth only a few crystals of galena and traces of zinc were found in the same horizon. Larger cavities in the ore-bearing horizon, which could have been derived from the leaching of massive ore similar to the surface material, were noticed in one place only, in one of the shallower bores.

Galena on Ooratippra Station

Two occurrences of galena were found on Ooratippra Station, slightly more than half a mile apart and some 16 miles east of the Old Ooratippra Homestead (Plate 2). In both places galena occurs in siliceous dolomites of the Arrinhrunga Formation, which are interbedded with sandstones. The two occurrences are found in what appears to be a horizon very much lower in the stratigraphical sequence than the ore-bearing beds on Turkey Creek and separated from them by a major sandstone member. Structurally they seem to occupy the western flank of a very gentle syncline. The nearest mapped faults are about a mile away, but it is quite possible that other faults are concealed under the alluvium-covered flat immediately to the north-west.

In the western occurrence, the mineralized zone is at least 150 ft long and 5 ft thick. Galena occurs in small irregular masses. Some leaching of disseminated ore seems to have taken place: small cavities in silicified dolomite, lined with calcite or filled with opal and arranged parallel to the bedding planes, appear to be casts of galena. The only accessory mineral noticed is crypto-crystalline quartz.
Most of the galena in the eastern occurrence was found in the soil. This occurrence seems to be even smaller than the western one as far as can be judged from the poor exposures available, and perhaps 50 ft higher in the sequence.

Other Mineral Occurrences

Casts of a cubic mineral were found in a thin chert layer in dark-grey limestones in a fault wedge about one mile south of Lucy Creek Homestead. The crystal forms indicate that these casts are derived either from pyrite or from galena.

Magnesite occurs in the form of concretionary crusts over chert nodules. It has been found at the Turkey Creek Prospect as well as in a number of other places shown on Plates 2 and 3, in all cases in the vicinity of faults.

Crypto-crystalline quartz or opal in the form of thin veins or crusts was seen in many places. It seems to be particularly abundant in the vicinity of the two small lead shows on Ooratippra Station.

Phillips (7) reports "perfectly developed barytes rosettes" and "small globular ferruginous pisolitic and turret-shaped encrustations" from the bituminous limestones of the Arthur Creek Beds. The writer found the ferruginous encrustations in various horizons and he agrees that they are probably replacements of pyrite nodules. He also found some crypto-crystalline quartz crusts, but no barytes rosettes. In any case, the mineral content of the Arthur Creek Beds suggests a syngenetic origin under anaerobic conditions and does not seem to be connected with the base metal occurrences in the Arrinthuranga Formation.

ORIGIN OF MINERALIZATION

Mineralization in the area under investigation is characterized by galena and sphalerite as the main ore minerals. Gangue minerals are barytes, crypto-crystalline quartz and probably also magnesite. The ore occurs along well defined horizons in Cambrian limestones which have been silicified and

(7) l.c.
changed into dolomite. The base metal sulphides are present either in the form of irregular masses which seem to fill crevices or joints, or alternatively as disseminated grains. Sphalerite is absent from surface exposures, but has been found in bores. Chert layers are connected conspicuously with ore deposition and are absent outside the area of main mineralization. The rich surface lead ore contrasts with the much poorer disseminated lead and zinc ore in the bores, which has been leached to considerable depth. The ore occurs in structurally disturbed parts of generally rather flat-lying beds, but the apparent connection with synclinal structures could be coincidental. The thickness of sediments above the Pre-Cambrian basement is probably not more than 3,000 or 4,000 ft, if that, but there are no indications of igneous activity.

The occurrences on Turkey Creek as described above resemble very closely other lead-zinc deposits in flat-lying sedimentary beds overseas, including such important producers as the Tri-State District, South-East Missouri, and Upper Silesia. The origin of these deposits, despite several generations of research, is still problematic, evidence for a low-temperature magmatic origin contradicting evidence for a syngentic, sedimentary origin. If we could decipher the origin of the Turkey Creek ore it would help us greatly in exploration and regional prospecting, but unfortunately, its origin is just as obscure. We have at least three main theories from which to choose, and none of them wholly convincing: (a) original deposition in sediments, later on concentrated by descending surface water or rising thermal water, an origin which would conform to Knight's source bed concept (6); (b) base metal deposits in the basement, dissolved and re-precipitated during later metamorphic processes or orogenic movements as suggested by Schneiderhöhn (9); and finally (c) deposition from hypogen hydrothermal solutions of magmatic origin, which might have been mixed with groundwater and carried over a large area.

The disseminated galena and sphalerite mineralization as it has been found in the Turkey Creek bores could be regarded as an original syngentic sulphide deposit. However, we would expect such a deposit to be associated with bituminous shales rather than with limestones or dolomites. Neither could this theory explain the large masses of galena which have been found near the surface. The richness of the surface material and the absence of the more soluble sphalerite suggest secondary enrichment. The puzzling feature is the presence of sulphide instead of the common sulphates or carbonates. Even if groundwater were capable of leaching metal sulphides out of large blocks of limestone or dolomite, the mechanics of precipitation would remain a mystery.

Lead and zinc could be present in solution as sulphates, bicarbonates or chlorides (10). From a sulphate solution, the base metals could be reduced to sulphides and precipitated by organic matter. If they are present as bicarbonates or chlorides, reaction with hydrogen sulphide must be assumed. However, there are no indications of any sources of hydrogen sulphide or of any beds with more than a very small amount of organic matter.

The ore near the surface was apparently protected by particularly strong silicification, whilst the ore below was leached down to groundwater level. The downward decrease of silica suggests secondary enrichment. The silicification of the country rock could be regarded as a product of lateritization if its lateral extent were not so obviously connected with the ore occurrences.

The Pre-Cambrian is mineralized as shown by the copper and lead deposits at Jervois, some 35 or 40 miles away. Ore in the Pre-Cambrian, possibly ore of sub-commercial grade, might have been dissolved by thermal waters rich in chlorides, and re-deposited in the overlying limestones or dolomites, according to the concept first proposed by Schneiderhöhn (11). However, there was no regional metamorphism after the deposition of the Cambrian limestones, and the orogenic movements in the Turkey Creek area were very much less than the movements in alpine regions from which ore bodies likely to have such an origin have been described.

Many features could best be explained by a hypogene, hydrothermal origin, as in particular the restricted local extent of the occurrences, the zoning with barytes at one end and galena at the other, and the deposition of magnesia and silica in the ore-bearing rocks. The main difficulty, as in the Mississippi Valley and in other base metal deposits in sediments, is the complete absence of magmatic activity during or after the deposition of the ore-bearing beds. If we think of the other similar lead and zinc occurrences in the Cambrian dolomites in this part of Australia, including Bulman in Arnhem Land, MacArthur River on the Gulf of Carpentaria, and Morstone near Camooweal, we are also confronted with an immense area for which a similar mechanism of deposition must have applied, another difficulty for the theory of hydrothermal origin, which has been stressed by Knight (12) and Ohle (13).

---


(11) I.c.

(12) I.c.

No single theory fits our occurrences completely. All we can say at the moment is that there is a very strong stratigraphical control, that there are definite indications of a structural control and that additional base metal occurrences are most likely to occur where the dolomites or other favourable beds have been subjected to minor folding and faulting.

CONCLUSIONS

The two additional occurrences of galena found during the writer's survey are not likely to be of economic importance. However, the survey has covered only a very small fraction of the 3,000 sq. mile area and it is quite likely that there are more small occurrences of base metals or leached outcrops. The chances of finding any really large surface deposits of the same size as, or larger than, the Turkey Creek Prospect itself are remote. Following the interest roused by the work on Turkey Creek such deposits would probably have been reported by the local natives. However, deposits which are completely leached near the surface and are therefore inconspicuous could exist, but would be hard to find.

The writer recommends that the Company should abstain from further regional prospecting and concentrate on the Turkey Creek Prospect itself, at least for the time being. If the Authority to Prospect were abandoned, it would be advisable to cover by a Lease the possible subsurface extent of the Turkey Creek ore towards the west and south-west for a distance of 2 or 3 miles as already suggested (14).

If regional prospecting were to be resumed at a later stage, it would be advisable to engage several local natives to accompany the geologist or prospector. Natives have, in addition to their local knowledge, a faculty of observation far superior to that of a white man. Their interest could probably be kept alive by granting bonuses for any mineral finds.

(14) Memorandum re Regional Prospecting in Areas surrounding Turkey Creek Lead-Zinc Prospect, N.T., of 6/8/60.