Quarterly Notes

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GEOLOGICAL SURVEY OF NEW SOUTH WALES

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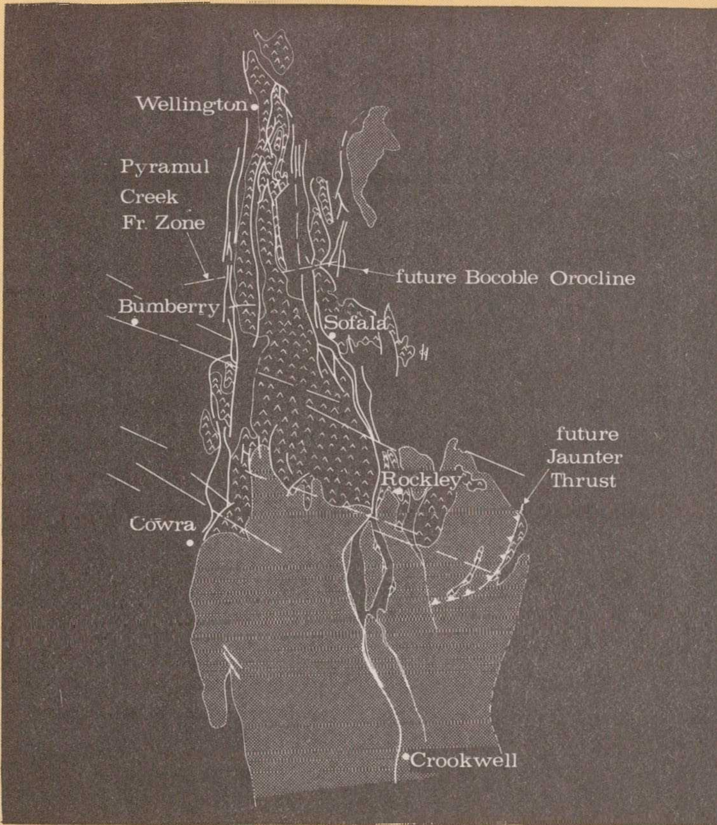

Department of Mines

PROGRESS REPORT ON THE EASTERN LACHLAN FOLD BELT METALLOGENIC MAPPING PROJECT

BY H. N. BOWMAN

Abstract

Metallogenic map coverage of the eastern Lachlan Fold Belt will be provided by fourteen 1:250,000 sheets and one 1:500,000 sheet. Of these, metallogenic maps and accompanying data sheets have been published for one 1:250,000 sheet and completed for six 1:250,000 sheets and the 1:500,000 sheet. Work on the remaining seven 1:250,000 sheets is well advanced.

Ore deposits of the eastern part of the Lachlan Fold Belt are discussed within the structural framework of New South Wales. Certain types of similar deposits are developed in similar tectonic settings. Within the anticlinorial zones, Ordovician gold, copper - gold, and copper deposits occur, generally with marked structural control. Gold deposits are associated with Late Silurian - Early Devonian late-kinematic granites, while deposits associated with Early to Middle Devonian post-kinematic granites are more varied. Deposits within the synclinorial zones consist either of volcanogenic base-metal sulphides, which are associated with acidic volcanics and which may, in part, have been redistributed as a result of deformation, or are associated with post-kinematic Early Devonian or Carboniferous granites and related intrusives. Copper, chromium, and gold deposits associated with belts of serpentinite occur at the margins of one of the synclinorial zones.

Introduction

This paper presents the author's preliminary analysis of the results of the partially completed metallogenic mapping programme in the eastern Lachlan Fold Belt, New South Wales. The eastern Lachlan Fold Belt metallogenic mapping project is one of several such projects currently being carried out by the Geological Survey of New South Wales or planned to commence in the near future. The Lachlan Fold Belt (see figure 1) has been divided arbitrarily into two parts, a "western" — covering much of the Cobar and Mineral Hill Synclinorial Zones and the Girilambone Anticlinorial Zone — and an "eastern". Other Survey metallogenic projects involve the deposits around Broken Hill and in the New England Fold Belt.

The aim of all of these metallogenic mapping projects is to gain an understanding of the distribution of mineral deposits as a function of time and space. From this understanding it is hoped to be able

(a) to delineate metallogenic provinces and/or districts,
(b) to provide basic information for the interpretation of ore genesis and to outline problems concerned with ore genesis, and
(c) to assist in the exploration for metallic deposits in New South Wales.

Information is compiled on data sheets and plotted using standard symbols on modified tectonic 1:250,000 sheets after a comprehensive search of all available published and unpublished information, augmented by field inspections. The type of information to be shown on the data sheets and on the face of the maps may be ascertained by referring to the Bathurst 1:250,000 Metallogenic Map and mine data sheets (Stevens 1972a, b). The information shown is intended to be basically descriptive and to contain a minimum of interpretation. However, interpretative notes for each sheet are also prepared.

Figure 1 illustrates the state of completion of individual projects within the main project.

Preliminary Findings

During discussions with the geologists concerned in individual subprojects, it quickly became apparent that some groups of obviously related mineral deposits transgressing sheet boundaries have been interpreted differently. Hence, the following comments on the preliminary findings are general and do not necessarily reflect the views of all geologists concerned with the project. It is hoped that, with the availability of more data, these differences will be resolved on completion of the project.

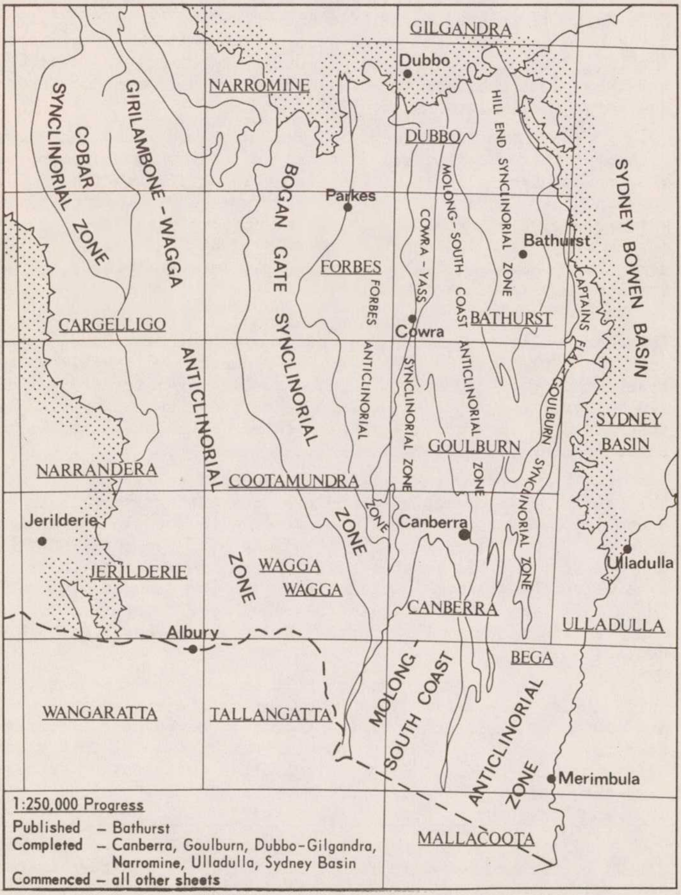

FIGURE 1. PROGRESS OF THE EASTERN LACHLAN FOLD BELT METALLOGENIC MAPPING PROJECT

It has been decided to use Scheibner's (1972b) structural map of New South Wales as a convenient framework within which to discuss the ore deposits, as the mineral districts and provinces emerging from the study are repeated in similar tectonic positions. The structural division simplifies discussion of the tectonic history which is that of Scheibner (op. cit.) (see figure 1).

As would be expected, in areas of primary gold and tin mineralization, eluvial and alluvial deposits of these ores are also found. When gold or tin mineralization is discussed, the associated alluvial deposits will not be explicitly mentioned. However, it should be remembered that they exist and that often they represent the most profitable concentrations of these metals.

As only a few of the sheets have been finished at the time of writing, the following comments will almost certainly require revision in the future.

Wagga Anticlinorial Zone

The Wagga Anticlinorial Zone covers part of the Wagga Wagga, Jerilderie, Narrandera, Cargelligo, Cootamundra, and Forbes 1:250,000 sheets and the most westerly part of the eastern Lachlan Fold Belt.

Ore deposits within this zone in the eastern Lachlan Fold Belt are related to Middle Silurian and Late Silurian to Early Devonian granites which were intruded in the Wagga Arch. The Late Ordovician to Early Silurian synkinematic anatectic granites and gneisses are devoid of any mineralization (Brooks and Leggo 1972, Crook et al. 1973).

The Late Silurian granites are foliated and were probably intruded towards the end of the Quidongan Orogeny. They may thus be classified as late-kinematic granites. They contain only gold - auriferous pyrite - quartz-vein deposits which are of considerable economic significance in some localities (e.g., the Adelong and West Wyalong Gold Fields). The deposits, however, may not be related genetically to the granites but to other intrusives.

The Early Devonian granites are massive and non-foliated. Mineralization is much more abundant and varied, and consists of Sn - Mo - W - Au - quartz veins within the granites and in sediments close to the granite margins, and tin in greisenous phases within the granites. Deposits are restricted to the upper margins of the batholiths and to the rocks forming the roof.

The variety and abundance of deposits associated with the post-kinematic granites and the scarcity of metalliferous deposits, apart from gold, associated with the late-kinematic granites is reflected throughout the whole of the eastern Lachlan Fold Belt. This feature may be a function of the material from which the granites were derived (see for example Brooks and Leggo 1972) or it could be the consequence of deeper erosion of old granites removing the upper massive phases and associated contact aureoles.

In the eastern Lachlan Fold Belt there are basically three types of granites: synkinematic anatectic granites which are void of deposits, late-kinematic concordant foliated granites with some gold deposits, and high-level discordant post-kinematic granites often with varied epigenetic deposits (see the Geological and Tectonic Maps of New South Wales, Pogson 1973 and Scheibner in press respectively).

The origin of granites suggested by Hamilton and Myers (1967) appears to be valid for granites of the eastern Lachlan Fold Belt. Using their model, batholiths are sheet-like bodies which have risen diapirically from shear-heated material on a subduction zone. They spread out below related acid volcanics and are intruded some 150 - 200 km landwards of a subduction zone. As the diapir rises the displaced rock flows back beneath it, forming migmatites which crystallize during plate movement to form synkinematic granites. The lower portions of the batholith crystallize next and are affected by the last stages of plate movement to produce foliated late-stage kinematic granites. The upper portion would crystallize last, subsequent to plate movement, to produce a post-kinematic granite. Most mineral deposits would occur at the top of the batholith, in the massive late-kinematic granites where hydrothermal solutions would be expected to accumulate.

Bogan Gate Synclinorial Zone

The Bogan Gate Synclinorial Zone covers part of the Wagga Wagga, Cootamundra, Forbes, and Narromine 1:250,000 sheets. Deposits other than gold are minor. The main ore deposits consist of gold - pyrite and minor base metals in quartz veins within sediments and contact aureoles associated with small post-kinematic Early Devonian acid - intermediate intrusives which were intruded into the Bogan Gate Terrace and volcanic arches (e.g., the Temora Gold Field). Some minor copper shear-fill deposits (e.g., Black Ridge mine, Parkes) within andesites are found on the eastern edge of the zone at the margin of a microcontinental block.

The Tumut Pond Serpentinite and the Coolac Serpentinite were both emplaced in the Early Devonian but they probably represent Early Silurian oceanic crust. They crop out on the western and eastern margins of the Bogan Gate Synclinorial Zone respectively, on the Wagga Wagga and Cootamundra 1:250,000 sheets. Copper, chromium, and gold are associated with these serpentinites. Scheibner (1972a) interpreted them as obduction zones in which slices of oceanic-plate material have been thrust over continental lithosphere.

Forbes Anticlinorial Zone

Covering part of the Wagga Wagga, Cootamundra, Forbes, Narromine, Dubbo, Bathurst, Goulburn, and Canberra 1:250,000 sheets, the Forbes Anticlinorial Zone has four types of mineral deposits: gold in Ordovician andesites, minor copper - lead deposits in Late Ordovician (?) ultramafics, gold - quartz veins in Late Silurian granites, and copper, gold, and tin in Early Devonian granites.

The oldest deposits consist of vein and generally minor disseminated auriferous pyrite and sporadic copper generally in shear zones within Ordovician andesites which accumulated on the western portion of the Molong Volcanic Rise east of the Wagga Marginal Basin. The andesites are both intrusive and extrusive. This is possibly the most important mineralization in this zone (e.g., Peak Hill, Parkes, and Forbes). These copper deposits associated with andesites, and those of the Molong Anticlinorial Zone to the east, appear to have developed on, and at the margin of, a microcontinental block above a subduction zone. During the Late Ordovician this block was a volcanic arc (island arc). Calc-alkaline magmatic material rich in copper was derived from partial melting of the subducted oceanic crustal material. The deposits were remobilized during deformation into shear zones. Small copper - lead deposits are associated with the Late Ordovician (?) Tantitha Ultrabasics (a contact-metamorphosed clinopyroxenite) south of Narromine.

Gold - quartz veins are developed within the late-kinematic Late Silurian Young Granodiorite which intruded the Yass - Canberra Rise.

Vein-copper deposits are developed within a Late Silurian granodiorite phase of the late-kinematic Yeoval Granite (e.g., the Goodrich Copper mine). A porphyry phase within this granodioritic phase of the Yeoval Granite, which was emplaced into a volcanic arch, contains disseminated and vein copper - molybdenum deposits in its eastern portion. Recent exploration suggests that some of these deposits are of the porphyry-copper type.

Gold and tin deposits are also associated with other Early Devonian post-kinematic granites such as that at Grenfell.

Cowra - Yass Synclinorial Zone

The Cowra - Yass Synclinorial Zone is a mainly narrow belt developed on the Canberra, Goulburn, Bathurst, and Dubbo 1:250,000 sheets.

The most interesting ore deposits in this zone consist of stratiform base-metal sulphides in Middle to Late Silurian acid volcanics in the southern portion of the zone, such as in the Cooma area and at Colinton and Michelago. Some of this mineralization has been redistributed into vein base-metal and gold deposits, for example, in the Bredbo - Michelago area. Volcanogenic hydrothermal vein base-metal deposits are also developed in Late Silurian acid volcanics (e.g., Kangiara).

Only minor auriferous quartz veins are developed in the northern part of the zone in Middle Silurian (?) acid volcanics.

The volcanics were deposited in minor volcanic rifts (both subaerial and submarine) which formed by splitting of the Yass - Canberra Rise as the result of extension in the late Early Silurian. Base-metal mineralization in this zone appears to be generally, but not invariably, developed at the periphery of the marine volcanic rift zones and to be of the Kuroko type as developed in the Kosaka district (Horikoshi 1969).

Molong - South Coast Anticlinorial Zone

The Molong - South Coast Anticlinorial Zone is a quite extensive structural feature covering most of the Bega 1:250,000 sheet, part of the Canberra, Ulladulla, Goulburn, Bathurst, and Dubbo 1:250,000 sheets, and the periphery of the Sydney Basin 1:500,000 sheet.

In the northern portion of this zone, the oldest ore deposits consist of auriferous pyrite, native copper, chalcopyrite disseminations, skarn deposits, and structurally controlled deposits in Early Ordovician andesites (e.g., Cadia, Cargo). These andesites accumulated on the western portion or landward side of the Molong Volcanic Rise which was a volcanic arc during the Early Ordovician. The mineral deposits probably owe their origin to the intrusion of porphyries. In the southern portion of the zone the quartz-rich sediments developed are comparatively devoid of mineralization.

As is the case elsewhere, the late-kinematic Late Silurian to Early Devonian granites, which were intruded into the Molong and Yass - Canberra Rises, contain practically no ore deposits apart from minor gold (e.g., the Wyangala and Snowy Mountains massif granitic bodies).

The Early Devonian post-kinematic granites and associated acid to intermediate intrusives, which were emplaced into the Molong Rise, contain ore minerals in contact metasomatic deposits as disseminations and in veins, greisens, and aplites generally close to the roofs of the plutons. Deposits consist of gold, copper, lead, zinc, minor uranium, molybdenite, wolfram, bismuth, barite, and minor tin (e.g., Browns Creek prospect, Blayney). Recent exploration suggests that some of the deposits are possibly of the porphyry-copper type (e.g., Copper Hill, Carcoar).

Gold-quartz veins in surrounding sediments are probably related to these granites, while deposits in the associated skarns almost certainly are related to them.

Silver - lead quartz-vein deposits which occur within Middle Devonian siliceous volcanics (such as those at Yerranderie within the Bindook Porphyry Complex) are probably subvolcanic emanations related to dacitic - rhyolitic volcanism on the Capertee Rise, although it has been suggested that some or all of this mineralization may be related to Carboniferous granites.

Eden - Comerong - Yalwal volcanic rift zone

The Eden - Comerong - Yalwal volcanic rift zone (G.R. McIlveen, in prep.) is an interesting feature on the Mallacoota, Bega, Canberra, and Ulladulla 1:250,000 sheets. It consists of Middle to early Late Devonian acid volcanics at the base containing disseminated and vein-gold deposits which have been interpreted as being of late-stage volcanic (fumarolic (?)) origin. Examples are the gold fields at Pambula, Sugarloaf, Yalwal, and Grassy Gully.

Hill End and Captains Flat - Goulburn Synclinorial Zones

The Hill End and Captains Flat - Goulburn Synclinorial Zones are related features covering parts of the Bega, Canberra, Goulburn, Bathurst, and Dubbo 1:250,000 Sheets, and the periphery of the Sydney Basin 1:500,000 sheet.

Some of the most productive or potentially productive mines in the eastern Lachlan Fold Belt, such as the Captains Flat and Woodlawn base-metal deposits, are located in these zones within probable Late Silurian acid volcanics. They are generally stratiform, massive, pyritic zinc-lead-copper deposits with some barite, although some sulphides have been remobilized during deformation and concentrated in veins.

These generally stratiform base-metal occurrences may be correlated with Kuroko-type ores of the Kosaka district (Horikoshi 1969) on several grounds. They all show evidence of an exhalative origin, often being associated with flow porphyries within acidic tuff sequences. The occurrences were generally formed towards the close of volcanic activity of any one cycle, as evidenced by their development in the finer units. The Middle to Late Silurian volcanics were deposited in marginal parts of the Hill End Trough (marginal sea) and the Captains Flat Trough (transitional between a marginal sea and a volcanic rift) which resulted from rifting of the Molong Rise. The deposits generally accumulated at the periphery of these volcanic rift zones.

Base-metal mineralization concentrated in a shear zone within Late Silurian basic volcanics (pillow lavas and tuffs) at Currawang (Goulburn 1:250,000 sheet) is of uncertain origin but it appears to be related to the acid volcanics.

In the northern part of this zone, auriferous quartz veins within Late Silurian to Middle Devonian greywackes and slates at, for example, Hill End and Hargraves were prolific producers of gold in the past. The origin of these deposits is unknown, but one may speculate that they were derived from oceanic crust of the Hill End Trough.

The post-kinematic Carboniferous granites such as the Bathurst Granite and similar granites at Ettrema and Tolwong have a variety of ore deposits in or close to their margins. Deposits which are encountered include magnetite, gold, base metals, molybdenum, bismuth, and minor tin within skarns and quartz veins and as disseminations. It has also been suggested that these granites were an alternative source of the gold deposits within the late Silurian to Middle Devonian sediments of the Hill End Synclinorial Zone at localities such as Hargraves mentioned above. These granites may have caused remobilization of gold from the oceanic crust.

Conclusions

It is hoped that completion of the project will bring revised and new data which will enable a better understanding of metallogenesis of the eastern Lachlan Fold Belt. This knowledge should enable delineation of areas warranting prospecting and should provide a guide to control on localization of ore deposits in these areas.

It is apparent that there are many gaps in our knowledge of metallogenesis, but detailed geological mapping and systematic studies of ore deposits will eventually result in a comprehensive theory of metallogenesis in this area. Further investigation of the eastern Lachlan Fold Belt will require the application of geochemical techniques such as age determination, isotope studies, etc., in order better to define the age and source of the mineralization.

Acknowledgements

During preparation of this paper discussions were held with the following people: E. Scheibner (tectonics), G.R. McIlveen (Sydney Basin 1:500,000, Ulladulla 1:250,000 sheets), G. Herzberger (Bega, including part Mallacoota and part Tallangatta, 1:250,000 sheet), P.R. Degeling (Wagga Wagga and Jerilderie, including part Tallangatta and part Wangaratta, 1:250,000 sheets), E.A. Felton (Goulburn 1:250,000 sheet), L.B. Gilligan (Canberra 1:250,000 sheet), B.P.J. Stevens (Bathurst 1:250,000 sheet), C.R. Matson (Dubbo 1:250,000 sheet), W.V. Langley (Gilgandra 1:250,000 sheet), W.J. Stroud Narromine 1:250,000 sheet), K.R. Fitzpatrick (Cootamundra 1:250,000 sheet), and J.P. Heugh (Cargelligo and Narrandera 1:250,000 sheets). The author is responsible for information on the Forbes 1:250,000 sheet. The views expressed in this paper, however, are those of the author.

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The distribution of lithofacies and of volcanic and plutonic activity in relationship to the lineament indicates that it was an important fracture zone, bounding small plates of the Lachlan Pre-Cratonic Province (marginal mobile zone) during Ordovician to Carboniferous time, and that during Mesozoic and Cainozoic time there were episodic resurgences of activity, expressed mainly in igneous processes.

The linear features of the Lachlan River Lineament are described in a separate paper (Scheibner in press b) to which the reader is referred for a schematic structural map.

Distribution of Facies and Igneous Activity

The Girilambone Beds crop out north of the Lachlan River Lineament. They are probably present in the subsurface to the south of the lineament, forming the basement of the Bogan Gate Synclinorial Zone.

In Early and Late Ordovician time strong island-arc volcanism occurred on the meridionally trending Molong Volcanic Rise within the cross-cutting fracture zone and in the segment to the north of it, but was only weakly developed south of the fracture zone. (An analogous relationship is valid also for the andesitic volcanics around Parkes and Forbes.) This distribution could indicate more intensive subduction north of the fracture zone. The fill of the Ordovician Wagga Marginal Sea has been metamorphosed and intruded by granites south of the fracture zone, but not north of it. Practically all Siluro - Devonian orogenic granites occur south of the lineament, especially the composite Murrumbidgee-type intrusions. The northern part of the Cowra Trough apparently developed in Ordovician time by splitting of the Molong Volcanic Rise, but this cannot be proved for the southern segment south of the lineament. This segment probably opened later in the Early Silurian.

Middle to Late Silurian acid calc-alkaline volcanism (partly volcanic rifts) differs in intensity south and north of the lineament. The Cobar Trough had apparently no volcanics north of the fracture zone, while they were widespread south of it (Mount Hope Volcanics). The distribution of acid volcanics in the Mineral Hill Synclinorial Zone is less clearly related to the lineament. In the area immediately east of the Molong Rise on the western side of the Hill End Trough, acid volcanics were developed more to the north and south of the fracture zone than within it. The Mullions Range Volcanics occur practically between the Lachlan River and Pyramul Creek Fracture Zones, i.e., north of the lineament; in the section between Kings Plains and Arkell acid volcanics are absent but they are widely developed south of the lineament (Kangaloolah Volcanics and within the Kildrummie Group). Acid volcanics occur within the lineament further east, associated with volcanic rifts south of the Bathurst Granite; this volcanism may be connected with the fact that the opening of the Hill End Trough south of the fracture zone was three times smaller than to the north of it (cf. discussion below).

Early Devonian volcanic-arch volcanism was strongly developed north of the fracture zone around Bumberry, but was nearly absent just south of it.

Late Silurian to Early Devonian mafic and ultramafic intrusions, probably of the alaskan type (cf. Murray 1972), or circular peridotite-gabbro intrusions (Jackson and Thayer 1972) occur around Fifield within the lineament. Silurian to Early Devonian intrusions (gabbro, diorite, porphyry, syenite, monzonite occur in the wider surroundings of Orange within the lineament. The transverse post-kinematic Bathurst Granite batholith (Late Carboniferous) was emplaced within the lineament (cf. below). Jurassic explosive vents in the Sydney Basin are numerous in the area where the lineament projects, and the

THE LACHLAN RIVER LINEAMENT AND ITS RELATIONSHIP TO METALLIC DEPOSITS

BY E. SCHEIBNER AND B. P. J. STEVENS

Abstract

The west-northwesterly oriented Lachlan River Lineament and associated parallel lineaments in New South Wales probably represents a fossil fracture zone, a transform structure which played an important role in the pre-cratonic development of the Lachlan Pre-Cratonic Province (marginal mobile zone). Episodic activity on this fossil fracture zone can be proved over a long time span, from the Early Ordovician to the Tertiary.

The Lachlan River and Pyramul Creek Lineaments have apparently controlled the location of porphyry-copper-like, molybdenum, and some other deposits, and appear to be boundaries of metallogenic provinces and districts.

Introduction

Hills (1956) pointed out that the upper Lachlan River follows a west-northwesterly trend, but no further arguments or conclusions were mentioned by him. The existence of a major linear zone became obvious on the newly compiled tectonic map of New South Wales (Scheibner in press a), and this discovery was followed up during a recent study of lineament tectonics (Scheibner in press b). The aim of this paper is to draw attention to the fact that not only is varied igneous activity coupled with this major fracture zone, but also that metallogenic processes appear to be associated with it, both directly and indirectly.

Lachlan River Lineament

The Lachlan River Lineament (Scheibner in press b) has been defined as a zone of linear features * about 40 to 50 km wide reflecting the faults and fractures of a fossil fracture zone, the Lachlan River Fracture Zone, a transform structure oriented generally west-northwesterly. It can be traced through eastern and central New South Wales, from the coast at Sydney intermittently towards the Darling River (part of it is indicated on figure 1).

* The lineaments shown on figure 1 are mostly photolineaments interpreted from ERTS-1 images, with some drainage lineaments and a very few geophysical linear features.

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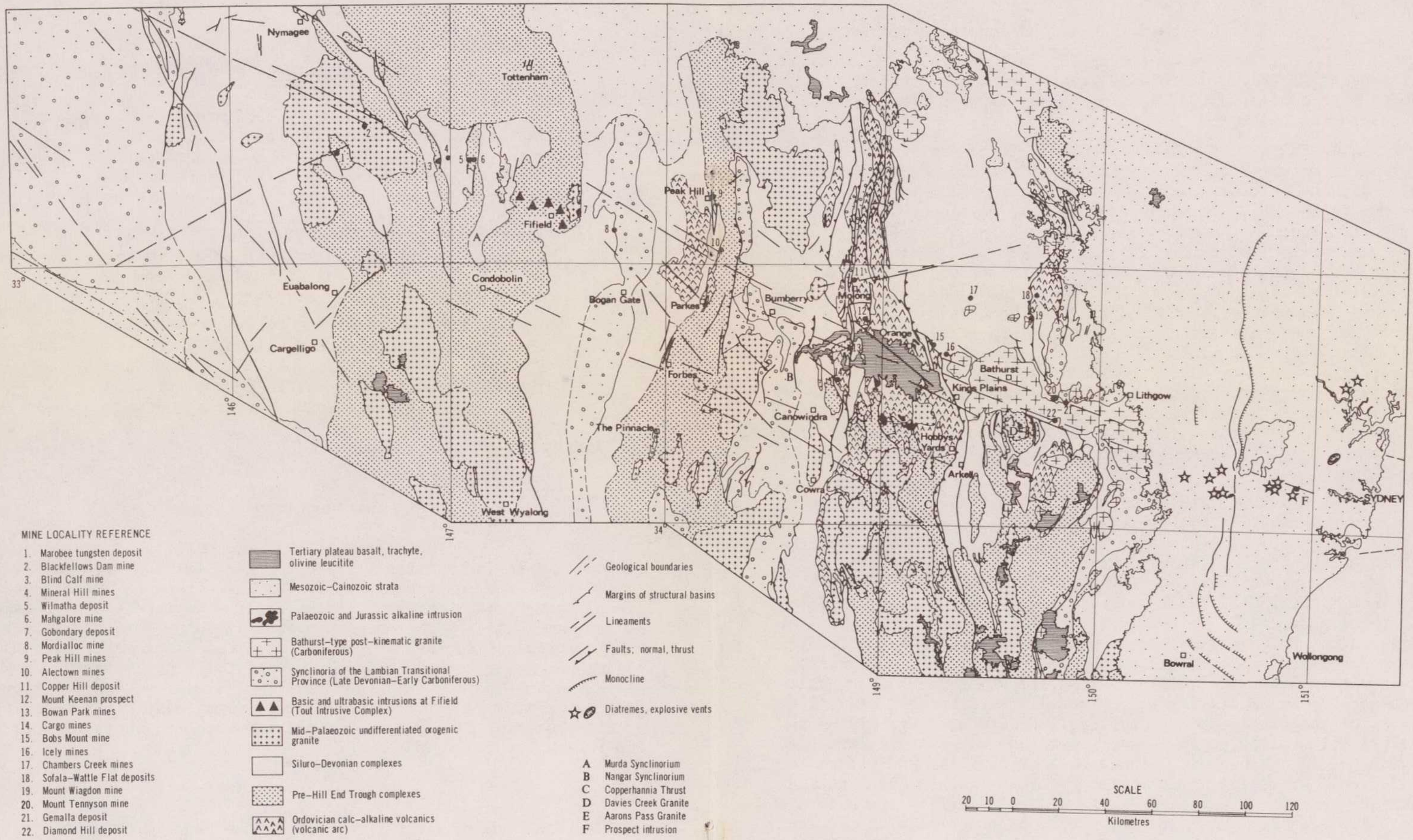

FIGURE 1. THE LACHLAN RIVER LINEAMENT SHOWING ITS RELATIONSHIP TO SELECTED METALLIC DEPOSITS.

Prospect intrusion was also emplaced on it on an intersection with another lineament. South of Orange widespread cratonic volcanic activity has occurred on the lineament, the most obvious being the Canobolas Volcanic Complex.

The location of the Tertiary Penrith Basin also seems to be influenced by the lineament.

The abovementioned facts suggest that the Lachlan River Fracture Zone was active during the Ordovician to Carboniferous, and that resurgence in the form of cratonic igneous activity occurred in the Mesozoic and Cainozoic.

Some Aspects of Reconstruction of the Pre-Hill End Trough Situation

Based on the assumption that the Hill End Trough was a marginal sea during late Early Silurian to mid Devonian time, it is possible to make palinspastic reconstructions by the visual fitting together of pre-Hill End Trough complexes (Stevens in prep.) or with the help of plate geometry (Scheibner in press b). The results of the latter method indicate the opening of the northern segment of the trough was three times larger than that of the southern segment (only the present width of the structural zone is considered). The area just north of the Lachlan River Fracture Zone seems to have opened by rotation on the Pyramul Creek Fracture Zone (figures 2 and 3) which is a latitude to the pole of rotation. The southern part of the Hill End Trough opened around a different pole of rotation. The opening of two segments of the Hill End Trough around two different poles caused the area just north of the Lachlan River Fracture Zone to be distended and later, during the Carboniferous, the Bathurst Granite was emplaced into this weakened area.

To obtain a total closure it is necessary to straighten the Bocoble Orocline (figures 2 and 4). During formation of this orocline the Sofala Volcanics must have been extended, and later, during Carboniferous time, the Aarons Pass Granite was emplaced in an extended area.

To obtain a closer fit for the area south and within the Lachlan Fracture Zone it is necessary to allow oroclinal distortion and translation of lithospheric blocks. A better fit is obtained for the area west of Wisemans Creek if it is assumed that the Davies Creek Granite was emplaced by shouldering aside of the country rock after the formation of the Hill End Trough. Along the Jaunter Thrust the western block must have been thrust over the neighbouring block to the east (figure 4) during the opening of the southern segment of the Hill End Trough.

There are indications that strike-slip movement has occurred along the Lachlan River Fracture Zone. Its longevity and resurgent character and the complex structures tend to obscure the sense of strike-slip movement. Generally, oroclinal bending and translation towards the east could be observed within the lineament (cf. figure 1). The Murda Syncline has a major bend, the Late Devonian Nangar Synclinorium is distorted towards the east, and similarly the Copperhannia Thrust and the synclinorial structures south of the Bathurst Granite tend to be convex towards the east. This would imply clockwise displacement between the fracture zone and the southern block, and anticlockwise between the fracture zone and the northern block.

The exercise of palinspastic reconstructions has practical value in this case because it helps to distinguish moderately extended and rifted areas, where, in late Early Silurian time, volcanic rifts have evolved. Stratiform pyritic zinc-lead-copper sulphide deposits (Kuroko-type) are associated with such volcanic rifts.

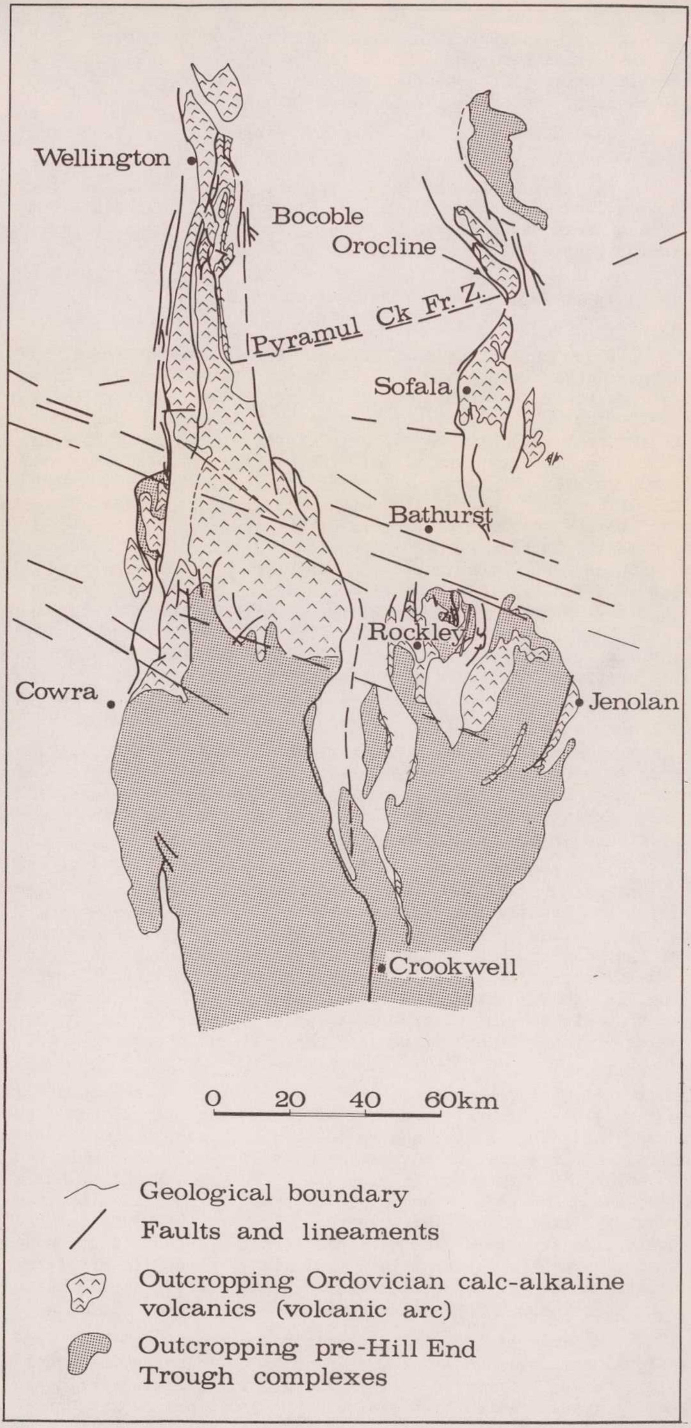

FIGURE 2. SCHEMATIC MAP SHOWING DISTRIBUTION OF PRE-HILL END TROUGH COMPLEXES AND SOME IMPORTANT STRUCTURES

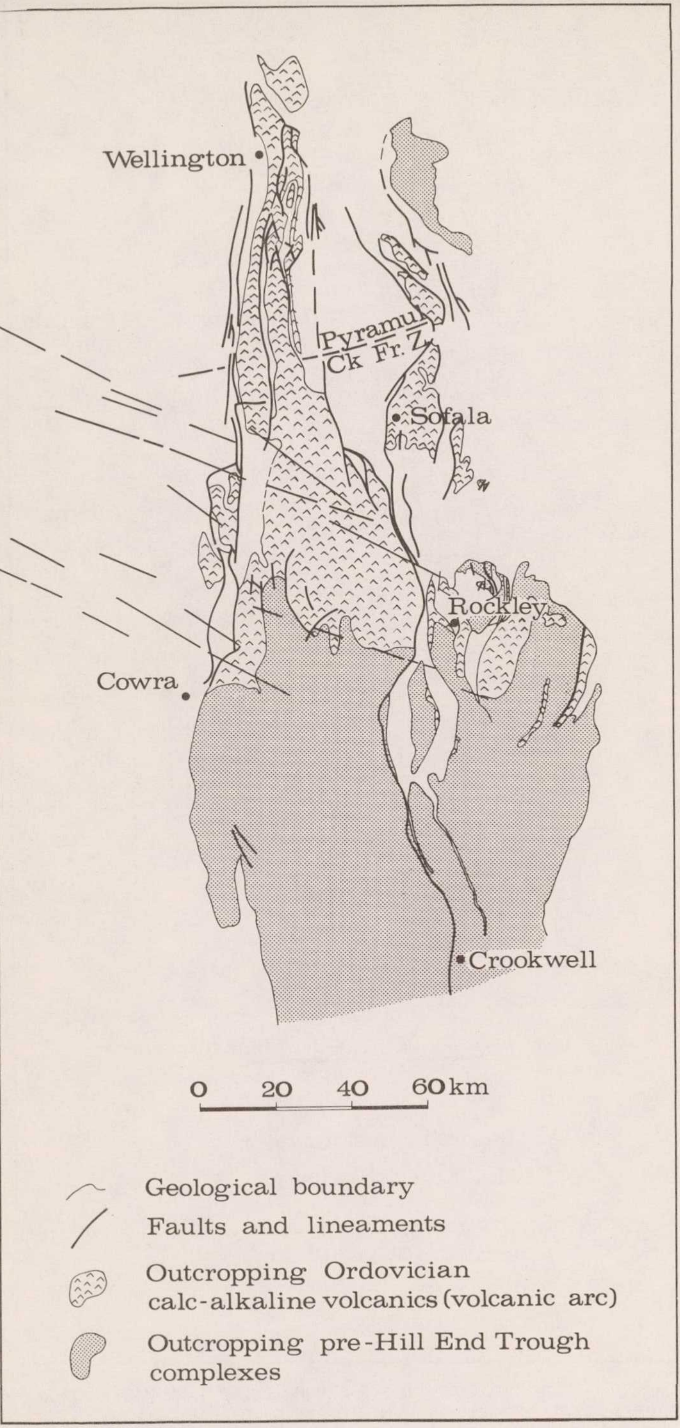

FIGURE 3. RESULT OF RECONSTRUCTION FOR PRE-HILL END TROUGH SITUATION USING DIFFERENT POLES OF ROTATION FOR SOUTHERN AND NORTHERN SEGMENTS OF HILL END TROUGH

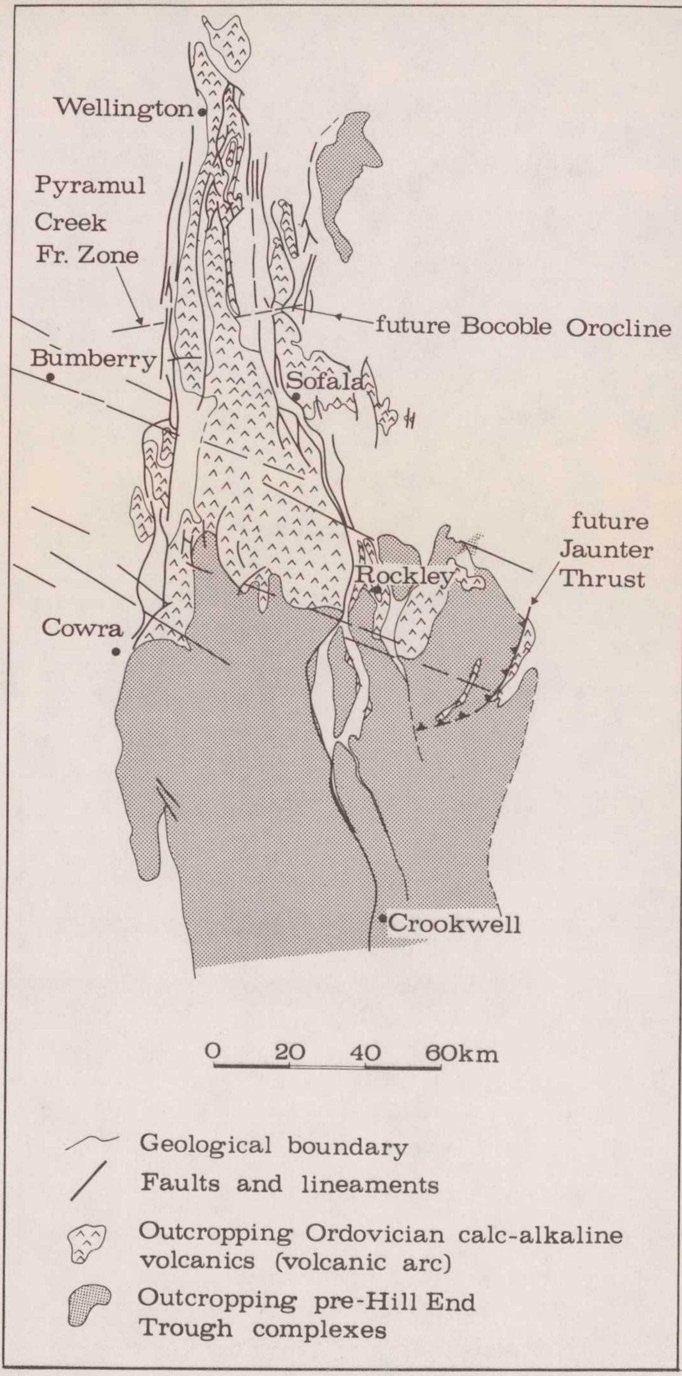

FIGURE 4. RECONSTRUCTION FOR PRE-HILL END TROUGH SITUATION. BETTER FIT IS OBTAINED BY CONSIDERATION OF DISTORTION DURING FORMATION OF OROCLINES, AND TRANSLATION WITHIN THE FRACTURE ZONE. SOME THRUST MOVEMENT MUST BE ASSUMED ON THE JAUNTER THRUST (REVERSE FAULT)

Distribution of Metallic Deposits

Detailed information concerning mineral deposits in the region covered by the Lachlan River Lineament has been obtained from the Bathurst 1:250,000 Metallogenic Map (Stevens 1972a) and from "A Metallogenic Study of the Bathurst 1:250,000 Sheet" (Stevens in prep.). Additional information has been taken from the 1:250,000 metallogenic maps of Dubbo (C. Matson in prep.), Forbes (H.N. Bowman in prep.), Narromine (W.J. Stroud in prep.), and Nymagee (D.W. Suppel in prep.). Figure 1 shows only those deposits referred to in the text, and the overall distribution of deposits is not shown.

A number of exploration company geologists have suspected for some time that cross-cutting lineaments must exist along the southern, suspiciously straight boundary of the Bathurst Granite, and also in the general Bathurst - Orange district, because straight lines can be drawn through fairly large numbers of mine localities. In this paper, however, the lineaments considered have been established during the study of lineament tectonics (Scheibner in press b) and are not those suggested by mine locations.

To test the relationship of known mineral deposits to the Lachlan River Lineament and also to the Pyramul Creek Lineament, the recognized lineaments indicated on the accompanying figures, mainly figure 1, were plotted on the Bathurst 1:250,000 Metallogenic Map. As most of the photolineaments represent wide zones and to allow for inaccuracies of plotting, approximately 1.5 km-wide zones were considered. The results indicate that very few of the known deposits are positioned within recognized individual lineaments (figure 1). However, in the Molong - Cargo district four deposits or groups of deposits consisting of disseminated gold - copper in andesitic terrain occur within the Lachlan River Lineament, on recognized individual lineaments or at intersections of lineaments. These deposits include the porphyry-copper-like deposit of Copper Hill which lies on the Pyramul Creek Lineament and the Cargo deposits of similar type which are located in the Lachlan River Lineament at its intersection with differently oriented lineaments. Minor disseminated gold - copper mineralization at Bowan Park and Mount Keenan is located on a west-northwesterly trending lineament.

Some other deposits are associated with individual lineaments of the Lachlan River Lineament. These include the Mount Tennyson, Gemalla, and Diamond Hill molybdenum deposits, small gold deposits at Chambers Creek and near Mount Wiagdon, fault-related copper at Bobs Mount, and copper veins near Icely. On the Narromine 1:250,000 sheet several deposits lie on lineaments or extensions of lineaments following the general Lachlan River Lineament trend. These include the Mordialloc copper - gold - silver deposit which occurs within a small dioritic intrusion, the Gobondary iron - gold contact deposit, platinum at Fifield associated with gabbroic intrusives of the Tout Complex, and copper - silver - gold deposits at Wilmatha and Mahgalore in a small granophyre intrusive. The disseminated gold - copper mineralization in altered andesite at Peak Hill is on a northwesterly trending lineament. On the Nymagee 1:250,000 sheet, the Blackfellows Dam uranium - base-metal and Blind Calf pyritic copper deposits occur on extensions of west-northwesterly trending lineaments. The Marobee tungsten deposit occurs close to a west-southwesterly trending lineament. On the Dubbo 1:250,000 sheet the Aarons Pass Granite occurs in the Bocoble Orocline on the Pyramul Creek Lineament. Associated with this small granitic body are several gold and copper deposits.

From the abovementioned data it could be concluded that few deposits are physically controlled by lineaments. Only the location of porphyry-copper-like and molybdenum deposits seem to be so controlled. What then is the real relationship of major lineaments and mineral deposits? The answer appears to be that major lineaments (fossil fracture zones) represent boundaries between small plates often with different development of lithofacies, igneous activity, and metallogenesis, and consequently fossil fracture zones represent boundaries of metallogenic districts. The fracture zone itself might form a special metallogenic district. However, because fracture zones cut across elongate features of mobile zones, a fracture zone might be composed of very different areas. It appears that many metallogenic districts can be recognized within the Lachlan River Lineament since many meridionally oriented structural zones are cut by it. For example, south of the Bathurst Granite within the lineament is a district characterized by stratabound pyritic zinc - lead - copper deposits, which probably formed in connection with the development of volcanic rifts. The part of the Molong Anticlinorial Zone within the lineament constitutes one metallogenic district characterized by certain types of copper and gold deposits. To the south the lineament bounds the metallogenic province constituted by the deposits in the Ordovician island-arc volcanics of the Molong Anticlinorial Zone and also between Peak Hill and Forbes. Within the Peak Hill - Forbes belt, gold deposits coincide with west-northwesterly and northwesterly lineaments at Peak Hill, Alectown, Parkes (the Bushman and Phoenix mines), and Forbes (the Britannia mine). At Forbes the andesitic rocks and the mineralization are terminated along the lineament. Although gold reappears in The Pinnacle district further south, it is not related to andesite and may have a different origin. The lineament at Condobolin forms the southern boundary of an area of outcrop of Girilambone Beds containing vein deposits of gold, silver, lead, zinc, and copper. Similarly, the Mount Hope Volcanics with their associated base-metal deposits terminate to the north on the lineament.

The Bathurst Granite batholith is spatially related to the lineament and so, consequently, are the epigenetic deposits associated with it. Similarly, post-kinematic mafic/ultramafic, mafic, and alkaline igneous bodies and associated deposits were spatially controlled by the Lachlan River Lineament.

Conclusion

The Lachlan River and Pyramul Creek Lineaments, both fossil fracture zones, (transform structures), have apparently controlled the location of porphyry-copper-like, molybdenum, and some other deposits. However, their most important role was as the controlling factor over the development of adjacent lithospheric segments, which often differ substantially in respect to metallogenesis. The fossil fracture zones, consequently, appear to be boundaries of metallogenic districts and provinces.

It might be an interesting exercise to calculate metal content within the lineament and compare it with that of surrounding areas. This might indicate to what degree fracture zones recognizable as major lineaments control processes of formation of ore deposits.

It is hoped that this paper will stimulate the interest of exploration geologists, who will contribute more detailed data to support or refute the ideas presented herein.

Acknowledgement

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EDITORIAL NOTE

Quarterly Notes of the Geological Survey of New South Wales enable rapid publication of short notes and progress reports. They are issued on the first day of January, April, July, and October each year and distributed widely throughout Australia. The Quarterly Notes constitute a publication for the establishment of priority for stratigraphic and fossil names.

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