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(with 5 Text-Figures)

ABSTRACT

Early Carboniferous sedimentation in the southern part of the New England Belt reflects the gradual filling of the Tamworth Trough and a change from mainly marine to mainly non-marine deposition. Sedimentation was largely controlled by volcanism along the western and southern margins of the trough, but late in the early Carboniferous uplifts associated with the emergence of the New England High combined with the volcanism to influence the configuration of the shoreline. The volcanic arc responsible for the marine regression was produced by the subduction of oceanic lithosphere along a trench in eastern New England.

In the latest Devonian or earliest Carboniferous volcanism and deposition of terrestrial sediments took place locally in the western part of the region, whereas fine-grained deeper water sediments accumulated to the north and east. A marine transgression early in the Tournaisian moved the shoreline westwards and established a region of shallow marine deposition which was linked with the deeper-water environment. Volcanism and rejuvenation of source areas in the late Tournaisian and early Visean resulted in a terrestrial piedmont containing a shallow marine embayment to prograde into the marine shelf. Increased volcanism and uplift in the source areas in the early middle Visean enlarged the piedmont and was responsible for deposition of alluvial sediments and ignimbrites. Offshore, because of the intensity of volcanism, ash-bearing silt and mud were deposited on the marine shelf. In the middle Visean the non-marine environment encroached farther into the marine shelf, but in the southwest the shoreline fluctuated across a coastal plain, resulting in the deposition of paralic sediments. The enormous influx of volcanic detritus into the shallow marine shelf resulted in the deposition of a thick succession in

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a subsiding area around Chichester; a thinner sequence may have been deposited on the incipient Stroud Platform. Late in the Visean the major centres of volcanism shifted from the western to the southern margins of the trough; combined with the emergence of the Stroud Platform the volcanism was responsible for a widespread marine regression. Coarse-grained shallow water sediments were deposited on the platform, and a thicker fine-grained succession accumulated in the subsiding region.

Because of the lack of evidence of late Visean to Namurian tectonism the Kanimblan Orogeny is considered to be of minor significance in the New England Belt. There is little structural evidence for obduction along the Peel Fault Zone (Scheibner & Glen, 1972) at this time, and for the same reason it seems unlikely that the Lord Howe Block collided intermittently during the Carboniferous with the Australian plate as postulated by Solomon & Griffith (1972). The similarity in type and composition of Lower and Upper Carboniferous volcanics weakens the suggestion of Scheibner & Glen (1972) and Scheibner (1972) that subduction ceased with the Kanimblan Orogeny.

INTRODUCTION

This paper deals with the early Carboniferous palaeogeography of a region between the southern margin of the New England Tablelands and the Hunter River extending from Wingen in the northwest to Clarencetown in the southeast (Fig. 1). During the early Carboniferous the region was located in the southern part of the Tamworth Trough (Crook, 1960a); at present it comprises the southern part of the Western Belt of Folds and Thrusts (Voisey, 1959), equivalent to the southern Tamworth Synclinorial Zone (Scheibner & Glen, 1972). Sedimentation during the early Carboniferous reflected the shallowing and infilling of the trough prior to major tectonic uplift of the new England Arch and the complete emergence of the western and southern margins in the late Carboniferous. The style of sedimentation and the positions of the ancient shorelines were controlled to a large degree by contemporaneous volcanism and in the late early Carboniferous by uplift associated with the emergence of the New England Arch.

Until recently there were insufficient data available from New South Wales for the detailed reconstruction of early Carboniferous palaeogeographies. The first reconstructions, made by David (1950) and Voisey (1955), were generalized. More detailed maps were later given by Campbell (*in* Packham, 1969). The interpretations presented in this paper are based on work completed since publication of 'The Geology of New South Wales' (Packham, 1969). We have included data collected by us in the Rouchel and Gresford district (Roberts & Oversby, in press; Roberts, in prep.). We also acknowledge the opportunity to use unpublished data collected by workers at Newcastle University in the Camberwell district and the Stroud-Gloucester Syncline; by workers from the University of New South Wales in the Gresford and Salisbury districts; by Manser in the Waverley district; and by Pogson in compiling a revised Geological Map of New South Wales. Important published sources deal with the Waverley district (Manser, 1968), Balickera (Rattigan, 1967 a & b) and Barrington (Campbell & McKelvey, 1972). Our interpretations assume that the Lower Carboniferous rocks south of New England are autochonous, and have not been affected by strike-slip faults. If this assumption is correct our palaeogeographic maps (Figs. 3 & 4), which show present spatial relationshi are palinspastic; if the assumption is subsequently proved to be incorrect, future reconstructions will be more complex.

The aim of this paper is to summarize and interpret published and unpublished data so that they can be used to build up a picture of the evolution of the New England Belt. We also hope to show conclusively that the terms Burindi (Benson, 1913) and Kuttung (Sussmilch & David, 1919), whic have become entrenched in the literature, have long outlived their usefulness and are confusing. We appeal to workers not to use these names, even in a facies sense (Engel, 1965), but instead to discuss and interpret the rocks in terms of the stratigraphic units appropriate to them as recommended in the Australian Code of Stratigraphic Nomenclature. The incompatibility between concepts inherent in the stratigraphic code and the Burindi-Kuttung terminology has already been noted (Voisay, 1958; Engel, 1965).

The time framework for the early Carboniferous of eastern Australi is based mainly on brachiopod zones (Roberts, 1965; Campbell et al. 1969; Campbell & Roberts, *in* Packham, 1969; Campbell & McKellar, 1969; Roberts & Oversby, in press; Jones, Campbell & Roberts, in prep.). Evidence from ammonoids, conodonts and foraminifers assist in dating the brachiopod zones in terms of European zones (Fig. 2). Non-marine formations are tied into the time framework by the existance of intertonguing marine sediments, and widespread ignimbrites. Correlation within the non-marine sediments is based mainly on the presence of ignimbrites which are mappable over large areas and are interpreted as time parallel units; some of the ignimbrites and volcanics have been dated radiometrically (Evernden & Richards, 1962; Roberts & Oversby, in press) and can be tied in with the absolute time scale for the Carboniferous (Francis & Woodland, 1964). The term chron (George, et al., 1969) is an interval of time subsidiary to an age; in this paper it is used exclusively for the interval of time represented by a brachiopod zone.

PALAEOGEOGRAPHY

EARLY TOURNAISIAN

Early Tournaisian rocks are known only in the Waverley and Rouchel districts and do not provide sufficient data to form the basis of a palaeogeographic reconstruction. Two distinct environments of deposition are recognised: an extensive marine shelf in deep water to the north and shallow water in the south; and a region, west of Rouchel, of terrestrial deposition and volcanism.

Around Lake Glenbawn, in the western part of the Rouchel district, volcanics, sand and mud (Kingsfield Beds) were deposited in the terrestrial environment. The age of the Kingsfield Beds is not precisely known, but is probably late Devonian or earliest Carboniferous; the beds are overlain, possibly disconformably, by sediments containing brachiopods tentatively referred to the _Spirifer sol_ Zone (Roberts & Oversby, in press).

In the Waverley and northern Rouchel district, laminated mud with interbeds of medium-grained arenite (Goonoo Goonoo Mudstone*) were deposited on the deeper part of the shelf. Crudely graded greywackes (_sensu_ Crook, 1960b), probably deposited by distal turbidity currents, predominate amongst the arenites in the Goonoo Goonoo Mudstone, but cross bedded sandstone becomes increasingly common towards the top of the formation. Some of the sandstones appear to have been derived almost directly from tuffs. Manser (1968) suggested that the terrigenous material in the mudstone originated from a volcanic and plutonic source north or northwest of Waverley. The depth of water and possibly a continuous influx of mud inhibited colonization of the sea bed by benthonic organisms.

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* Footnote. Manser (1968) divided the upper part of the Goonoo Goonoo Mudstone (Crook, 1961) into the Glenlawn and Martindale Mudstones, but because the units are not objectively based where we have studied them Crook's nomenclature is retained.

During the early Tournaisian (Spirifer sol Chron) the sea transgressed westwards across the Kingsfield Beds, forming the shallower part of th marine shelf, and depositing mud, lithic sand and oolitic material (Dangarfield Formation). These shallow water sediments, which appear to have been restricted to around Lake Glenbawn, contain a rich benthonic fauna and are considered to be laterally equivalent to the upper part of the Goonoo Goonoo Mudstone (Fig. 2). Terrigenous material in the Dangarfield Formation was derived from essentially the same source responsible for the arenites in the Goonoo Goonoo Mudstone, although a local source, probably exposed Kingsfield Beds, provided angular to sub-angular detritus. At one time during the Spirifer sol Chron the influx of terrigenous material into the Glenbawn area was sufficiently low for oolite sand to accumulate as the Brushy Hill Limestone (Osborne, 1928; Roberts & Oversby, in press). The Kingsfield Beds and Dangarfield Formation are inferred to grade laterally into the Goonoo Goonoo Mudstone across a line extending from the head of Lake Glenbawn to Upper Rouchel village. The localization of the Kingsfield Beds and Dangarfield Formation to the Glenbawn area, coincident with the Brushy Hill Fault and Anticline (Branagan et al,, 1970; Roberts & Oversby, in press) might be tectonically significant, and it is possible that a precursor of one or both of the structures was active in the early Tournaisian and controlled sedimentation. Localization of rock units to the Glenbawn area is not evident after the early Visean.

LATE TOURNAISIAN - EARLY VISEAN Schellwienella cf. burlingtonensis & Pustula gracilis Chrons (Fig. 3A)

Late in the Tournaisian, source areas in the north and west were rejuvenated, probably by uplift and volcanism, and there was an influx of cross-bedded lithic sand into the Waverley and parts of the Rouchel districts. The sands prograded across the marine shelf and eventually built up a terrestrial piedmont plain containing a distinct embayment (Fig. 3A). Marine sediments comprising mud, fine-grained sand and carbonate sediments continued to accumulate as the Dangarfield Formation in the embayment around Glenbawn. Sandstones in the Waverley Formation are interbedded with conglomerate, siltstone and mudstone, and contain a suite of terrigenous material suggesting the principal source was the same as that contributing to sandy phases in the Goonoo Goonoo Mudstone. Sandstones in the lowermost beds of the Waverley Formation, and higher beds in the eastern part of the Rouchel district, are green in colour because of a chlorite and calcite cement, and contain interbeds of fossiliferous mudstone and siltstone. The Waverley Formation is interpreted as wholly marine in the eastern part of the Rouchel district, where it contains a greater proportion of fossiliferous beds than in the west, and in addition has minor oolitic and skeletal limestones. Sandstones in the west, particularly those in the upper part of the formation, are coarse-grained, contain numerous conglomerate interbeds and lenses, and are cemented by zeolite (clinoptilolite or mordenite). Marine fossils are rare, and these sediments are interpreted as terrestrial or littoral. Lenses of heavy mineral sandstone, which we suggest are beach concentrates, are present north and south of the marine embayment.

A situation similar to that in the Schellwienella cf. burlingtonensis Chron existed during the early part of the Visean. Slightly later, however, during the later part of the Pustula gracilis Chron, the western source area was rejuvenated and gravels and coarse terrestrial sands (Isismurra Formation) spread across the piedmont into the marine shelf. The uplift in the west heralded the beginning of a period of intense ignimbritic volcanism. Locally the Pustula gracilis Zone is absent, suggesting that the uppermost beds of the Waverley Formation had been eroded prior to the deposition of the Isismurra Formation. Details of the Isismurra Formation are included in the discussion of the early middle Visean palaeogeography (p. 8).

Southeast of the Rouchel district in the vicinity of Gresford and Dungog the oldest Tournaisian rocks are fossiliferous mudstone and siltstone of the Bingleburra Formation. Most sediments in the formation are thinly and regularly bedded and lack current structures, suggesting that they were deposited below wave base. Others, notably the lenses of oolitic limestone, crinoidal limestone and lithic sandstone within the formation were deposited at or above wave base. Brachiopods of the Schellwienella cf. burlingtonensis Zone have been collected from the Bingleburra Formation in the Lewinsbrook Syncline (Roberts, in prep.) and from Mt. Richardson, midway between Gresford and Dungog (Southgate, 1972; Sparke, 1972). Rocks from the Lewinsbrook - Trevallyn fault block, south of Gresford, which were previously assigned to the Bingleburra Formation (Roberts, 1961) are now identified as Ararat Formation and Bonnington Siltstone.

Later in the Tournaisian an upsurge of volcanism south of Gresford and Dungog caused sands and gravels to prograde northwards across the marine shelf, resulting in a marine regression and deposition of the Ararat Formation. Lithologically the unit is dominated by sandstone containing volcanic rock fragments cemented by chlorite and calcite; the sandstones are well sorted in lower parts of the formation, but are coarser and more poorly sorted in the upper parts. Conglomerate members are common in the south but diminish in importance northwards where oolitic and crinoidal limestone and mudstone become prevalent. Ignimbrites associated with the Trevallyn Conglomerate Member of the Ararat Formation at the southern extremity of the Lewinsbrook-Trevallyn fault block (Hall, 1972) indicate that at least part of the formation was deposited on a terrestrial piedmont built northwards from the volcanic source. Some of the conglomerates, however, are marine; one immediately east of Gresford Quarry contains brachiopods of the <u>Schellwienella</u> cf. <u>burlingtonensis</u> Zone.

The Ararat Formation has been mapped as far north as the Salisbury district (McDonald, 1972) and a short distance east of Dungog (Mrs. N. Morris, pers. comm.). Sediments in a number of localities in the Gresford-Dungog district previously mapped as Ararat Formation by Roberts (1961, 1964a & b) are now positively identified from both lithological and palaeontological evidence as Flagstaff Sandstone. These include sandstone on Mt. Ararat (Hall, 1972), sediments at Greenhills (Hamilton, 1972), and sandstone between Wiragulla and Dungog (Sparke, 1972).

The nature of sedimentation and the position of the shoreline between the Gresford and Rouchel district during the late Tournaisian and early Visean is obscure because the region is covered by younger sediments. It is likely, however, that sandstones similar to those in the Waverley and Ararat Formations were deposited during this time, with late modification in the Rouchel district in the Visean because of upwarping of an area to the west and deposition of widespread piedmont conglomerate (Ayr Conglomerate). Little is known about the style of deposition east of Dungog.

EARLY MIDDLE VISEAN <u>Orthotetes</u> <u>australis</u> Chron (Fig. 3B)

On the western margin of the region the extensive piedmont plain formed early in the Visean continued to receive fluvial sediments and ignimbrites (Isismurra Formation). The Isismurra Formation is dominated by red to pink cross bedded lithic sandstone with interbeds and lenses of poorly bedded pebble to boulder conglomerate; siltstones containing plant debris are also present throughout the succession. The sandstones and conglomerates contain terrigenous detritus from both volcanic and plutonic sources; iron-stained zeolite (clinoptilolite or mordenite) which pseudomorphs glass shards is the most common cement. The basal unit of the Isismurra Formation, the Ayr Conglomerate Member, is widespread throughout the Rouchel and Waverley districts; locally around Glenbawn it is preceeded by alluvial sands. We suggest that uplift prior to, or contemporaneous with, ignimbritic volcanism was responsible for the widespread distribution of the blanket of conglomerate; in places the member reaches a thickness of 200 m. Highly silicic ignimbrites in the Isismurra Formation throughout the Waverley and Rouchel districts were first laid down early in the Visean (probably late in the Pustula gracilis Chron) and continued to accumulate in the early middle Visean. The ignimbrites in the lower half of the Isismurra Formation reach a thickness of more than 500 m near Aberdeen, where they comprise mainly welded ignimbrites of the Native Dog Member; they become thinner and intertongue with alluvial sediments towards the east, where the Native Dog Member splits into two main tongues, the Curra Keith and Oakfields Tongues. Hornblende from the uppermost part of the Oakfields Tongue gave K/Ar ages of 308 and 309 ±6 my (Roberts & Oversby, in press). Ignimbrites in the Isismurra Formation extend southeastwards to around Singleton (Fig. 3B).

The absence of marine fossils and the presence of welded ignimbrites in the Isismurra Formation indicates that the rocks were deposited in a non-marine environment. The persistent coarseness, lenticularity, poor sorting and cross bedding of most sediments are features consistent with them having been deposited by braided streams. Ignimbrites show no marked local variations in thickness, suggesting that they were extruded on to a piedmont of low relief. The zeolite cement which is common in the sedimentary rocks and in some ignimbrites may have formed in response to the action of saline groundwater on volcanic glass shards. The type of zeolite does not vary with stratigraphic level, and hence is not a product of burial metamorphism. The source of the ignimbrites, particularly those in the Native Dog Member, was evidently near Aberdeen. Osborne (1950) inferred that a volcanic centre existed at Muscle Creek, in the southwestern Rouchel district, but we have found no supporting evidence.

During the early middle Visean the fluvial piedmont sloped gently eastwards and southeastwards into a shallow marine shelf which received silt, mud, lithic sand and minor carbonate sediment (Woolooma Formation). The marine and non-marine sediments intertongue across much of the eastern half of the Rouchel district because of a gradual westerly marine transgression during the early middle and middle Visean. During a period of intense volcanism when the Oakfields Tongue and the upper part of the Native Dog Member were extruded in the west, silt was deposited on the western part of the marine shelf. Volcanic detritus in the silt was responsible for producing a hard blue-grey rock on lithification; some tuffaceous interbeds are now zeolitized laminated vitric tuffs. Eastwards, apparently out of range of the ash showers, the silt was replaced by brown and grey mud. Apart from the volcanic part of the silt, most of the Woolooma Formation probably represents the fine fraction of loads carried by streams extending across the fluvial piedmont. A maximum of 300 m of Woolooma Formation was deposited in the eastern Rouchel district compared with about 150 m of Isismurra Formation on the piedmont; this indicates a faster rate of subsidence in the marine shelf.

Siltstone (Bonnington Siltstone) similar to that in the western area of outcrop of the Woolooma Formation was deposited on a marine shelf around Gresford, Dungog and Clarencetown. Unlike the area to the northwest, volcanics equivalent to the siltstone are unknown in the south, presumably because they are covered by younger rocks. The Bonnington Siltstone consists dominantly of thinly bedded hard grey siltstone containing volcanic ash particles in addition to detritus derived from a normal terrigenous source. We envisage an active volcanic source to the south, perhaps in the vicinty of Maitland, which blew ash northwards into the sea; the shoreline in Figure 3B is tentative because of the absence of outcropping early middle Visean rocks south of Trevallyn and Clarencetown. Softer grey siltstone and mudstone beneath the Flagstaff Sandstone at Brownmore is identified as Bonnington Siltstone (Roberts,in prep.), and equated lithologically with the silty mudstone in the Woolooma Formation in the eastern Rouchel district.

Both the lower part of the Woolooma Formation, equivalent to the Oakfields Tongue and the upper part of the Native Dog Member, and the Bonnington Siltstone are essentially devoid of beds of coarse sandstone, yet they are located close to the site of deposition of ignimbrite. The absence of coarse detritus, which contrasts with the situation in the late

Tournaisian - early Visean during deposition of the Ararat Formation, may indicate the rapidity with which the blanket of ignimbrite and partly ash-derived siltstone was deposited.

MIDDLE VISEAN   Delepinea aspinosa Chron   (Fig. 4A)

On the western margin of the region deposition of alluvial sediments and ignimbrites (Isismurra Formation) continued into the middle Visean. The Isismurra Formation received three distinctive red ignimbrites; these are mappable from the northern part of the Rouchel district to Carrow Brook (Roberts & Oversby, in press; Kristensen, 1969). Red ignimbrites are also present in the Waverley district (Manser, 1968), but they have not been mapped in sufficient detail to allow correlation with those at Rouchel.

Deposition of the Wooloomа Formation continued offshore from the volcanic piedmont province, and at one stage (early Delepinea aspinosa Chron) the sea transgressed briefly almost as far west as Glenbawn. Later, however, there was a marked regression and the shoreline migrated beyond the southeastern boundary of the Rouchel district (Fig. 4A). The possible area of marine sedimentation northeast of Rouchel portrayed in Figure 4A was probably of brief duration; rocks older than Isismurra crop out in this area and hence it is difficult to determine the precise time of regression. In most parts of the Rouchel district the sea had withdrawn before deposition of the first red ignimbrite in the Isismurra Formation.

Marine conditions persisted to the southeast around Dungog and Chichester during the middle Visean despite the influx of an enormous quantity of sand-sized volcanic material from the south and possibly the west. The marine sediments were deposited on a shallow shelf which consisted of three parts: a subsiding region around Chichester containing an expanded sequence; a marginal zone to the west and south which included an area of paralic sedimentation nearest the shore; and a region of possibly thinner sediments between Stroud and Gloucester named the Stroud Platform (Campbell & McKelvey, 1972). Because of the paucity of fossil evidence in beds on the Stroud Platform it is difficult to demonstrate an area of thinner sedimentation in the middle Visean (late Delepinea aspinosa Chron). Campbell & McKelvey (1972) suggested that the lensing out of the Verulam Oolite, a member of the Wootton Beds, north of Barrington indicated a transition into deeper water. The platform was definitely in existence and probably partly emergent in the late middle Visean when coarse shallow water sediments of the Conger Formation (Engel, 1962) were deposited.

The southwestern shoreline fluctuated across a broad coastal plain between Carrow Brook and Gresford. The coastal plain is shown as the area of paralic sediments and ignimbrites in Figure 4A. Early in the Delepinea aspinosa Chron the region received thinly bedded muds containing benthonic organisms, particularly Productina margaritacea (Phillips). These muds may have accumulated in a protected environment behind a sandy barrier bar complex; laterally they pass northeastwards into a thick unit of lithic sandstone (Flagstaff Sandstone). Later in the Delepinea aspinosa Chron a succession of thickly bedded and cross stratified greenish-brown lithic sandstone, ignimbrite (Mount Rivers Member) and plant-bearing silty siliceous bands was deposited in the region. This later sequence is interpreted as non-marine because of the welded nature of the ignimbrite, the presence of plants in positions of growth, and the absence of marine fossils. Laterally equivalent marine sands, however, were deposited close by at Mt. Ararat, east of Gresford, and the Mount Rivers Member passes northwards into devitrified tuff before reaching Allynbrook. O'Neill (1972) interpreted the devitrified part of the ignimbrite as having been deposited in a marine environment. East of Gresford, near Hilldale, the Mount Rivers Member is represented by a water distributed conglomeratic tuff (Hamilton, 1972). South and southwest of Gresford the sandstone overlying the Mount Rivers Member passes laterally and vertically into the Wallaringa Formation.

Workers from Newcastle University have termed the upper sandstone unit of the paralic succession and its ignimbrite member the Dyrring Formation (Pogson, 1973). We regard both the upper and lower parts of the paralic sequence as the feather edge of the Flagstaff Sandstone.

The western margin of the region of paralic sedimentation is drawn near Carrow Brook at the approximate eastern limit of the suite of ignimbrites characteristic of the Isismurra Formation. The ignimbrites have been mapped south and east from Rouchel by Rudd, (1967), and Kristensen (1969). East of the boundary on Figure 4A the ignimbrites from Rouchel are replaced by the Mount Rivers Member. The sediments associated with the ignimbrites also change from red alluvial sandstone, conglomerate and shale (Isismurra

Formation) to the greenish-brown sandstones deposited in the paralic region. The change in the configuration of the ignimbrites suggests separate volcanic sources: one near Aberdeen which supplied material for ignimbrites in the Isismurra Formation; and the other, probably around Stanhope, which was responsible for deposition of the Mount Rivers Member.

Offshore from the paralic region a thick succession of lithic sandstone and interbedded mudstone (Flagstaff Sandstone) accumulated on the marine shelf. The Flagstaff Sandstone contains mainly thickly bedded lithic sandstone immediately east of the zone of paralic sediments (Fig. 4A) but becomes increasingly rich in mudstone and limestone east of Chichester (Roberts, in prep; McDonald, 1972). The distribution of sediments suggests the presence of a shoreline (possibly a barrier-bar complex) or shallower water to the west. The thick nature of the succession around Chichester was first recognised by Stuntz & Rose (1961) and later by Campbell & McKelvey (1972) who described the region as one of two areas of expanded sequences on either side of the Stroud Platform. Sections measures by one of us (J.R.) show that about 2000 m of sediments were deposited during the <u>Delepinea aspinosa</u> Chron in the Chichester region. The large thickness and the shallow water nature of the sediments indicates an area of steady subsidence which we have termed a 'subsiding area with expanded sequence' (Fig. 4A). South of Chichester towards Gresford the succession is thinner; in the Lewinsbrook Syncline the Flagstaff Sandstone is 1300 m thick (Roberts, in prep.); and sediments of <u>Delepinea aspinosa</u> Chron between Greenhills and Vacy are estimated by Hamilton (1972) to be 550 m thick.

The Wootton Beds, deposited on the Stroud Platform, consist of medium to coarse grained laminated sandstone, conglomerate, thick successions of mudstone and siltstone, and lenses of oolitic limestone, notably the Verulam Oolite Member (Campbell & McKelvey, 1972). The Wootton Beds contain fossils belonging to the <u>Delepinea aspinosa</u> Zone at Barrington (Campbell & McKelvey, 1972), and at a locality west of Buladelah Mountain on the Girvan Anticline (Engel, 1962).

During the latest <u>Delepinea aspinosa</u> Chron volcanism in the Stanhope region produced an alluvial piedmont which prograded over the southern part of the region of paralic sedimentation and into the marine shelf. The alluvial sediments (Wallaringa Formation) both overlie and intertongue with the upper parts of the Flagstaff Sandstone (Fig. 2). Sediments in the Wallaringa Formation comprise channel lag conglomerate, such as the Wallarobba Conglomerate Member, coarse grained haematite-stained zeolitic lithic sandstone, and thinly bedded siltstone which were deposited in cycles of fining upwards (Rattigan, 1967b). From investigations around Balickera, Rattigan suggested that the unit was deposited by meandering streams. Similar cyclic deposition in the Wallaringa Formation has been recorded from the vicinity of The Pass on the Singleton-Gresford road (Hall, 1972). Clasts of granite, and metamorphic and sedimentary rocks in association with a majority of acid volcanic clasts in many of the conglomerates suggests that the piedmont plain was established in response to a widespread uplift as well as volcanism in the source area to the south. At the same time, an uplift was responsible for the partial emergence of the Stroud Platform.

At Stanhope, south of Gresford, Scott (1948) described a succession of volcanics and conglomerate more than 885 m thick that are apparently equivalent to the Wallaringa Formation. The volcanics, which include rhyolite, pyroxene andesite and felsite (probably ignimbrite, Scott, 1948, p.239; Osborne, 1950, p.298) underlie the assumed equivalent of the Martins Creek Andesite. It is possible that the two felsites (ignimbrites) below the Martins Creek Andesite equivalent at Stanhope are the Mount Rivers Member.

In the latest middle Visean a succession of lithic sandstone and conglomerate, the Conger Formation (Engel, 1962), was deposited east of Dungog on the Stroud Platform. The coarse lithology of the formation contrasts with that of the underlying Wootton Beds, and suggests that the Conger Formation was deposited on a newly shallowed or emergent platform; rare shelly fossils indicate that the formation was at least partly marine. Present outcrops of the Conger Formation are restricted to the flanks of the Stroud-Gloucester Syncline, the eastern limb of the Girvan Anticline, and to a belt west of the Waukivory Fault (Rose et al., 1966). This suggests that the formation was originally confined to the Stroud Platform. Because of its stratigraphic position above the Wootton Beds and beneath the Nerong Volcanics the Conger Formation is assumed to be laterally equivalent to the Wallaringa Formation. On this basis it seems likely that the greater part of the Stroud Platform became shallow or emergent immediately prior to the commencement of late Visean volcanism.

LATE VISEAN <u>Rhipidomella fortimuscula</u> Chron (Fig. 4B)

Late in the Visean widespread volcanism took place over the southern half of the region, forming an extensive piedmont area which received volcanics, both ignimbrites and flows, and alluvial sediments. Although volcanics were extruded in the Rouchel district the main area of volcanism shifted southeastwards; the volcanic centre around Stanhope (Scott, 1948) became increasingly active and new centres were established towards Clarencetown and Booral. In comparison with the situation in the middle Visean (Fig. 4A) the shoreline remained in about the same position between Gresford and Carrow Brook, but as a result of the late middle Visean uplift and increased volcanism in the east it regressed approximately 50 km northwards in the area between Stroud and Gloucester.

At Rouchel, a dark coloured ignimbrite which contains hornblende dated at 319 ±9 my (Roberts & Oversby, in press) was deposited in the uppermost beds of the Isismurra Formation. Despite complex faulting the ignimbrite can be traced southeastwards towards Gresford (Rudd, 1967; Kristensen, 1969; White, 1969) where it appears to be the same unit as the Martins Creek Andesite in the Gilmore Volcanics.

West of Gresford the Gilmore Volcanics contain the Martins Creek Andesite and the remnants of a second ignimbrite interbedded with red to purple sandstone, conglomerate and shale. South and southeast of this area volcanic rocks are increasingly common in the Gilmore Volcanics. For example at Vacy there are five separate ignimbrites (Hamilton, 1972), and at Stanhope there is a succession of flows and ignimbrites 1286 m thick (Scott, 1948). Other thick successions of Gilmore Volcanics containing both flows and ignimbrites were recorded from Glenoak and Gilmore Hill near Clarencetown by Osborne (1922). South of Clarencetown, at Balickera, the Gilmore Volcanics have been divided into two formations, the Mossman Swamp Andesites and the Eagleton Volcanics (Rattigan, 1967a). Farther to the east the late Visean volcanics, the Nerong Volcanics (Engel, 1962), consist of toscanite, dacite, horneblende andesite and minor ignimbrite. According to Engel the Nerong Volcanics are thickest in the vicinity of Nerong and become thinner towards the north and east. Engel (1972) showed that the Nerong Volcanics and their equivalents lens out along a line drawn between Berrico and Stratford. The area in which the volcanics become remarkedly thinner and are interbedded with marine sediments is shown in

Figure 4B as a region of periodic emergence and volcanism.

Sediments deposited on the Stroud Platform immediately north of the region of periodic emergence have been described by Campbell & McKelvey (1972). The Copeland Road Formation is a marine unit which consists of coarse well sorted lithic sandstone containing conglomerate bands, breccias derived from volcanics, and thin interbeds of mudstone and siltstone. The bulk of the formation represents deposition on a marine shelf situated close to a volcanic province.

West and southwest of the Stroud Platform in the vicinity of Chichester sediments equivalent in age to the Copeland Road Formation consist of an unnamed succession of mudstone and siltstone with interbedded sandstone and in places lensoidal bodies of boulder conglomerate and welded ignimbrite; the largest of these lenses, south of Salisbury (Roberts, in prep.) is interpreted as the remant of a volcanic island. Brachiopods of the Rhipidomella fortimuscula Zone are present throughout the unnamed succession at Salisbury and indicate deposition of a greater thickness of sediment (760 m) than on the Stroud Platform (maximum of about 180 m). The sediments in the subsiding region are mainly muds deposited in quiet conditions below wave base, probably in deeper water than on the Stroud Platform; interbedded gravelly sandstones and conglomerates reflect shoaling around volcanic islands.

TECTONIC SETTING

During the Carboniferous the northern Hunter Valley region constituted the southern part of the Tamworth Trough in the New England Belt. Recent plate-tectonic analyses of the Tasman Geosyncline, which included the New England Belt, agree that the Palaeozoic evolution of the geosyncline was controlled by the interaction of a western continental lithospheric plate and an eastern oceanic plate (Oversby, 1971; Solomon & Griffiths, 1972; Scheibner & Glen, 1972; Scheibner, 1972). Subduction of the oceanic plate produced a series of arc-trench systems which migrated eastwards throughout time, following the consuming plate margin. Disagreements between authors mainly concern the presence or absence of a continental Lord Howe Block (Solomon & Griffiths, 1972), the timing of different cycles of subduction, and the tectonic significance of various orogenies.

We have shown (this paper) that early Carboniferous volcanism was an important factor in controlling sedimentation in the Hunter Valley region. Volcanism also took place during the late Devonian or earliest Carboniferous, as indicated by tuffs, lavas and probable ignimbrites in the Kingsfield Beds, and probably by tuffs and detrital volcanic material in the Goonoo Goonoo Mudstone. We consider that the volcanism took place along an arc, now mostly beneath the Sydney Basin, to the west and south of the present westerly limit of Lower Carboniferous exposures (Fig. 5), and might have been initiated in the early Devonian (Oversby, 1971); the basement of the arc, may have become partially cratonized by the early Carboniferous. Wilkinson (1971) concluded that the relatively mafic rocks in the Gilmore Volcanics (particularly the hypersthene-augite dacites) were probably derived from upper mantle material by partial melting; more silicic magmas may have been produced by low-pressure fractional crystallization of the partial melt. The volcanic arc was probably formed in response to subduction of oceanic lithosphere along a trench in eastern New England (Fig. 5), perhaps corresponding to part of the Nambucca Block (Fig. 1). The arc-trench interval was probably more positive than the Tamworth Trough, and formed the New England High (Fig. 5); the high was locally eroded in the earliest Permian and late Carboniferous (?) (Price, 1973), and coincided with the site of a Permian volcanic arc (Schiebner & Glen, 1972).

Scheibner & Glen (1972) regard the Kanimblan Orogeny as a major late Visean to early Namurian tectonic event, and consider that the Peel Fault Zone formed by obduction at the same time. We consider the magnitude of the Kanimblan Orogeny to have been small in relation to the Taberabberan or Hunter-Bowen Orogenies, and suggest that the intrusion of granites around Bathurst, Gulgong and Bungonia, and the relatively gentle folding of the Upper Devonian rocks in the Lachlan Belt took place mainly in response to instability in and adjacent to the volcanic arc. If obduction had taken place we would expect evidence of major late Visean deformation on a regional scale in the New England Belt, and of erosion of oceanic lithosphere. Possible oceanic lithosphere was eroded on the New England High during the late Carboniferous or earliest Permian (Price, 1973), but not to the extent expected if obduction had taken place. We regard the Peel Fault Zone, as now exposed, as a relatively steep high-level structure formed in response to faulting and remobilization of small slices of oceanic lithosphere during the middle to late Permian Hunter-Bowen Orogeny

(Oversby, 1971). We see no evidence for the suggestion that subduction ceased during the Namurian (Scheibner & Glen, 1972): Upper Carboniferous volcanic rocks in the Hunter Valley are as abundant as, and have essentially the same composition as Lower Carboniferous volcanics. There is, however, a widespread lowest Permian basalt-rhyolite suite which suggests that the area underwent regional extension in the early Permian, possibly following a cessation of subduction at that time. Later in the early Permian a volcanic arc was established along the New England High, presumably following relocation of subduction along a trench farther east in the Nambucca Block.

We doubt that the Lord Howe Block collided with the main continental lithospheric plate intermittently throughout the Carboniferous as suggested by Solomon & Griffiths (1972). If this had happened we would expect more severe orogenic effects than are evident. Hence, it is doubtful whether a continental microplate equivalent to the Lord Howe Block existed during the Carboniferous.Collision may have been responsible for the middle to late Permian Hunter-Bowen Orogeny, when there was widespread deformation throughout the New England Belt, and ancient tectonic lineaments were propogated to high structural levels as the Hunter-Mooki and Peel Fault Zones. The Hunter-Mooki Fault Zone corresponds approximately to the western edge of the postulated pre-Carboniferous trench (Oversby, 1971), and the Peel Fault Zone to the eastern edge of the same trench (Fig. 5); the former might contain serpentinites at depth. The curvature of these and other structural features around the southern end of New England implies that the fundamental trends which they follow were concave eastwards.

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J. Roberts,
School of Applied Geology,
University of New South Wales,
KENSINGTON. N.S.W. 2033

B.S. Oversby,
Bureau of Mineral Resources,
Geology and Geophysics,
Box 387,
CANBERRA CITY. A.C.T. 2601

Fig. 1. Simplified geological map of the Hunter Valley region showing the main localities mentioned in the text. Inset: major structural elements in and adjacent to New England (after Scheibner & Glen, 1972).

Fig. 2. Correlations of Lower Carboniferous formations in the Hunter Valley region.

Fig. 3. Palaeogeographic reconstructions of the Hunter Valley region:

A. Late Tournaisian to Early Visean (*Schellwienella* cf. *burlingtonensis* and *Pustula gracilis* Chrons)

B. Early Middle Visean (*Orthotetes australia* Chron)

Fig. 4. Palaeogeographic reconstructions of the Hunter Valley region:

A. Middle Visean (*Delepinea aspinosa* Chron)

B. Late Visean (*Rhipidomella fortimuscula* Chron)

Fig. 5. Hypothetical restored section across the southern part of the New England Belt for the early Carboniferous.

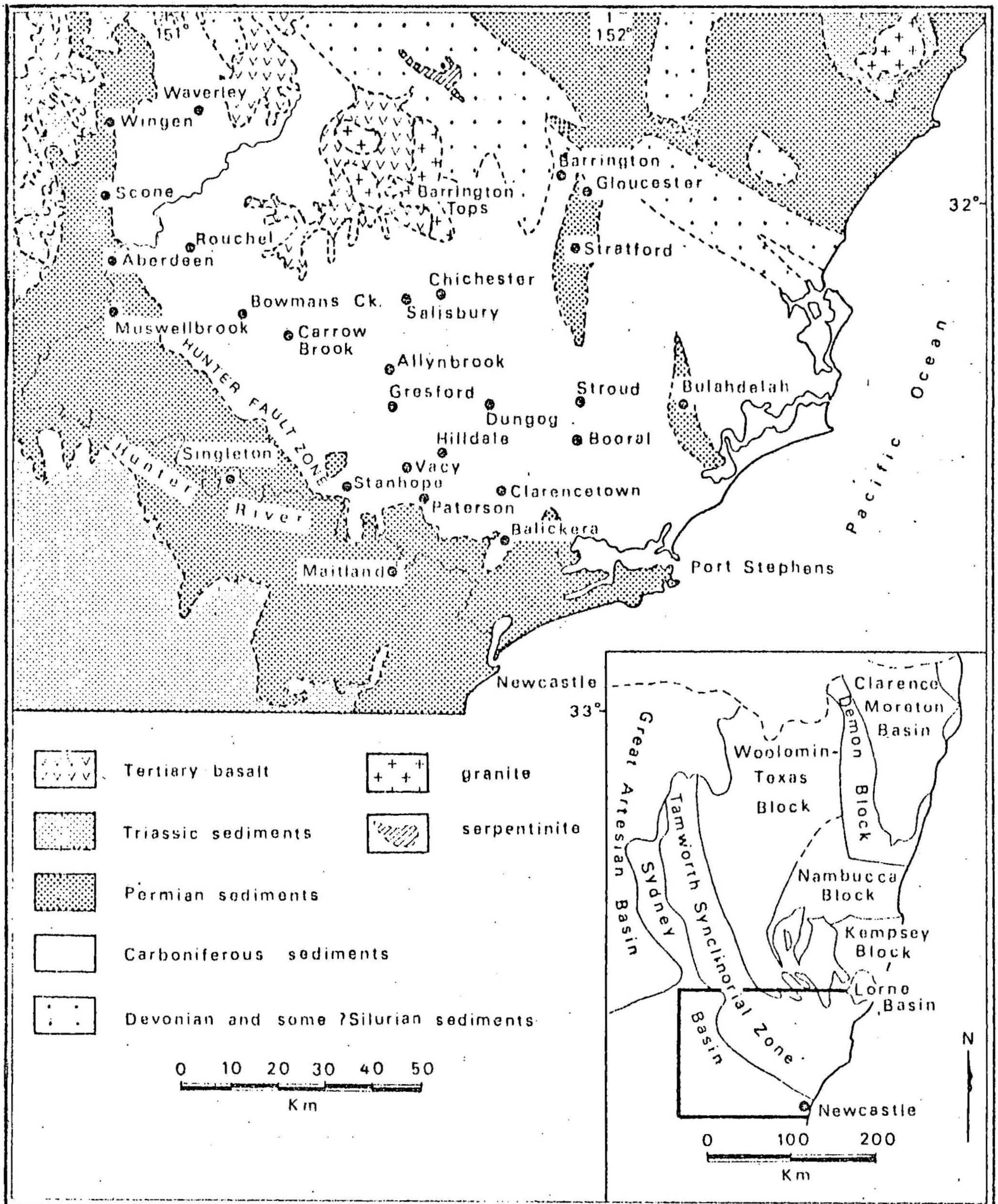

151°
152°
32°
33°
Waverley
Wingen
Scone
Barrington
Gloucester
Barrington Tops
Rouchel
Aberdeen
Stratford
Chichester
Bowmans Ck.
Salisbury
Muswellbrook
Carrow Brook
Allynbrook
HUNTER FAULT ZONE
Gresford
Stroud
Bulahdelah
Dungog
Hilldale
Booral
Singleton
Vacy
Hunter River
Stanhope
Clarencetown
Paterson
Balickera
Maitland
Port Stephens
Pacific Ocean
Newcastle
Tertiary basalt
granite
Triassic sediments
serpentinite
Permian sediments
Carboniferous sediments
Devonian and some ?Silurian sediments
0 10 20 30 40 50
Km
Clarence Moreton Basin
Demon Block
Woolomin-Texas Block
Great Artesian Basin
Tamworth Synclinorial Zone
Sydney Basin
Nambucca Block
Kempsey Block
Lorne Basin
N
Newcastle
0 100 200
Km

Fig 1.

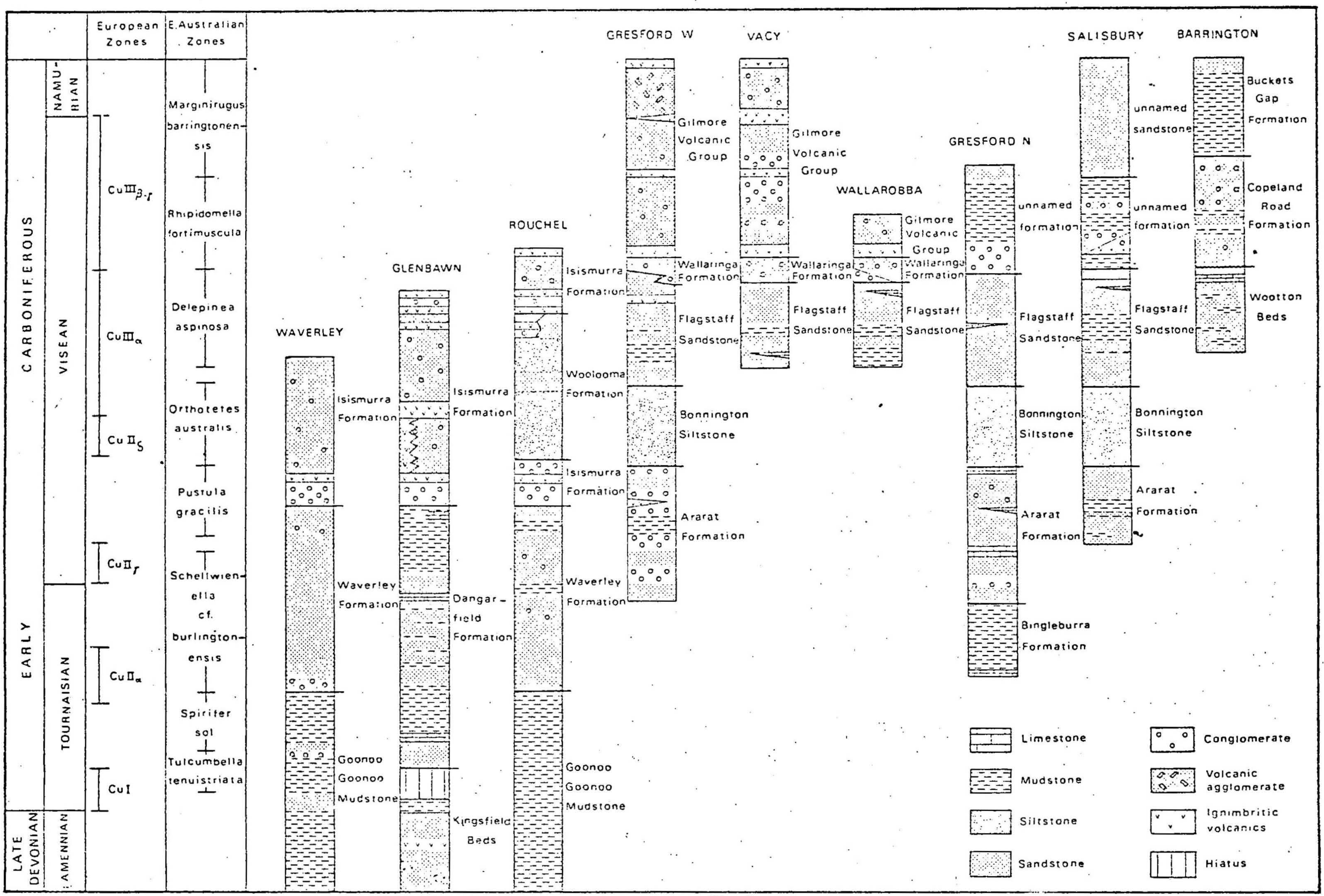

European Zones
E.Australian Zones
CARBONIFEROUS
EARLY
LATE DEVONIAN
NAMURIAN
VISEAN
TOURNAISIAN
FAMENNIAN
CuIII β-γ
CuIII α
CuII S
CuII γ
CuII α
CuI
Marginirugus barringtonensis
Rhipidomella fortimuscula
Delepinea aspinosa
Orthotetes australis
Pustula gracilis
Schellwienella cf. burlingtonensis
Spirifer sol
Tulcumbella tenuistriata
WAVERLEY
GLENBAWN
ROUCHEL
GRESFORD W
VACY
WALLAROBBA
GRESFORD N
SALISBURY
BARRINGTON
Isismurra Formation
Waverley Formation
Goonoo Goonoo Mudstone
Dangarfield Formation
Kingsfield Beds
Woolooma Formation
Gilmore Volcanic Group
Wallaringa Formation
Flagstaff Sandstone
Bonnington Siltstone
Ararat Formation
Bingleburra Formation
unnamed formation
unnamed sandstone
Buckets Gap Formation
Copeland Road Formation
Wootton Beds
Limestone
Mudstone
Siltstone
Sandstone
Conglomerate
Volcanic agglomerate
Ignimbritic volcanics
Hiatus

Fig 2

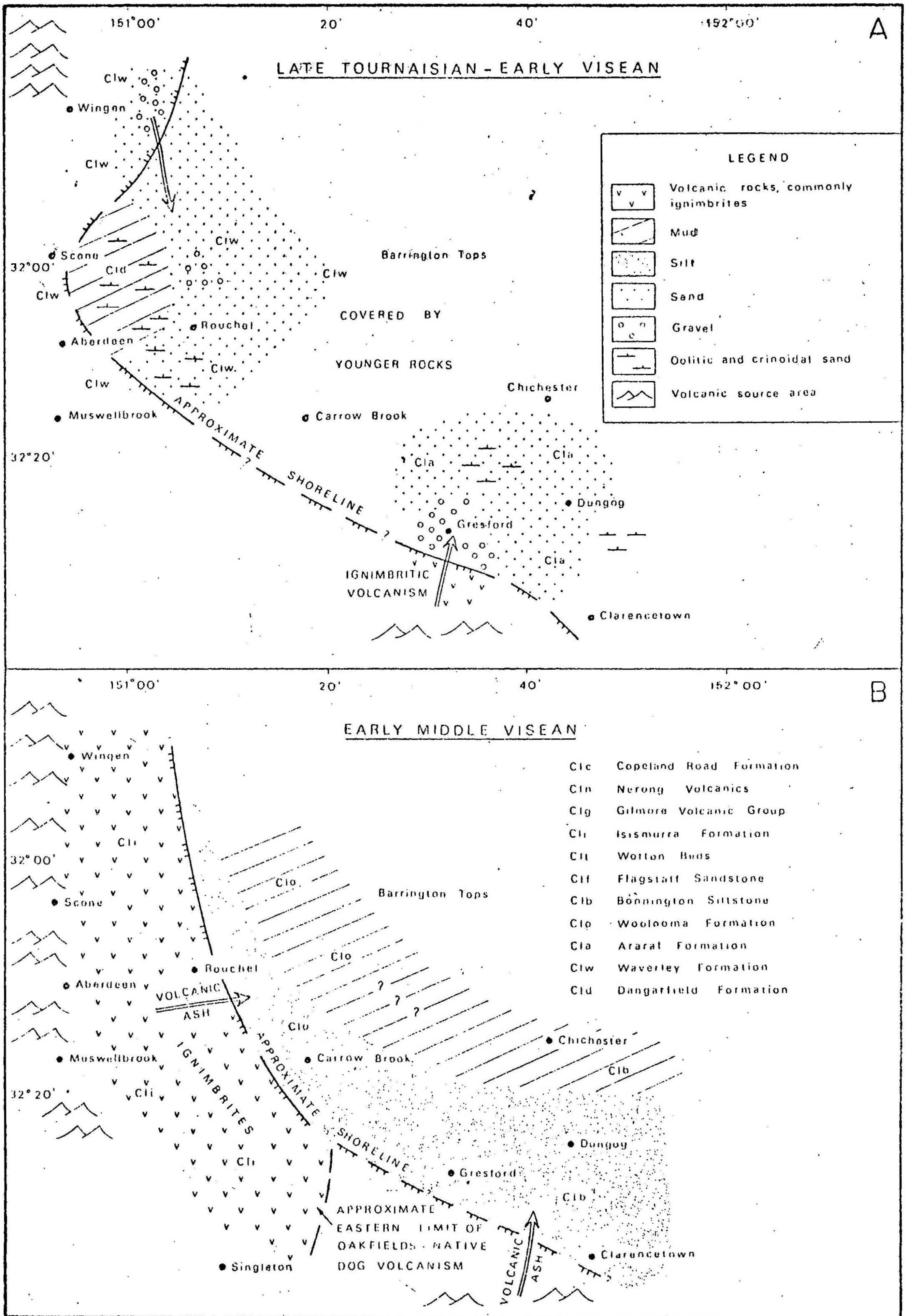
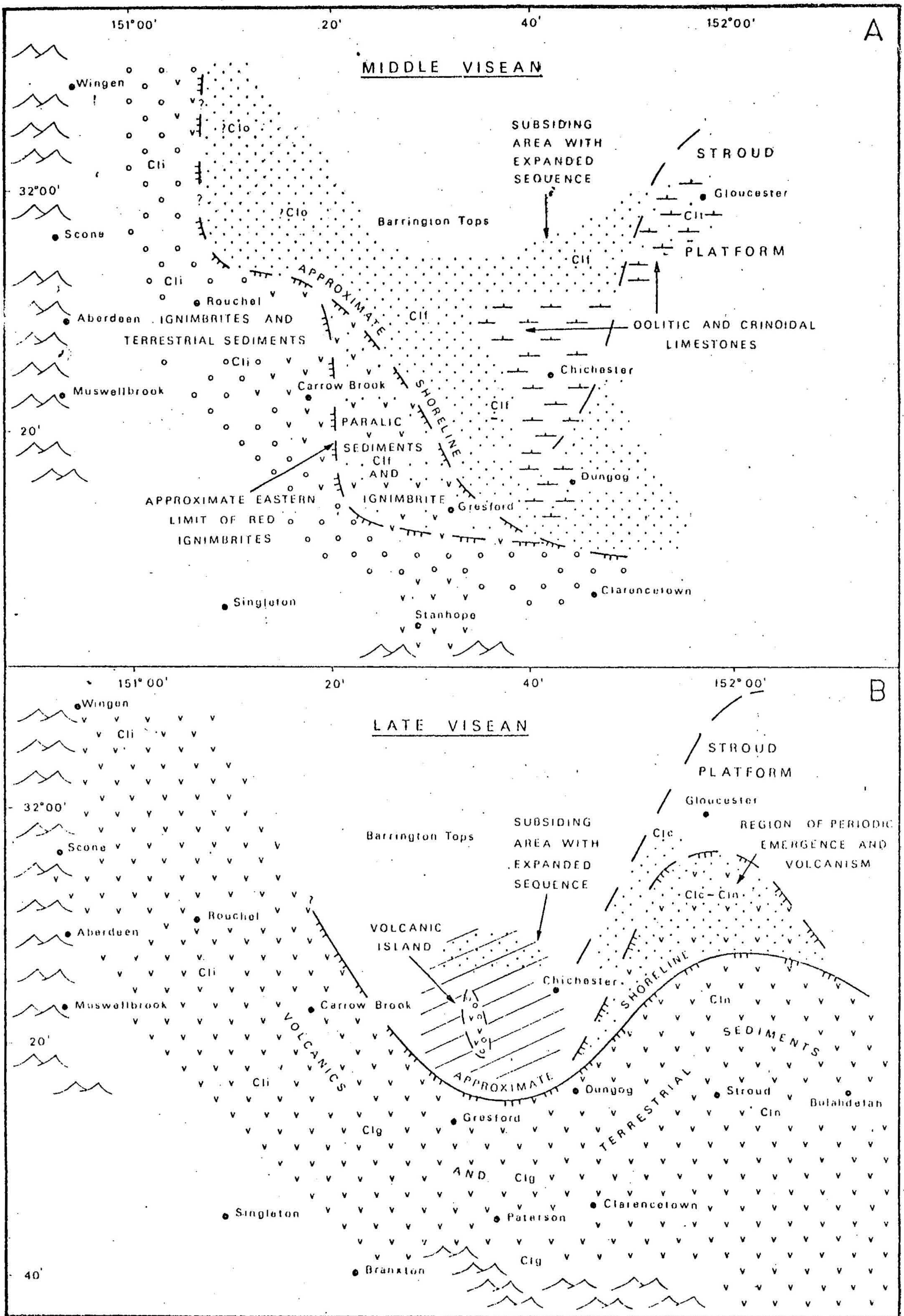
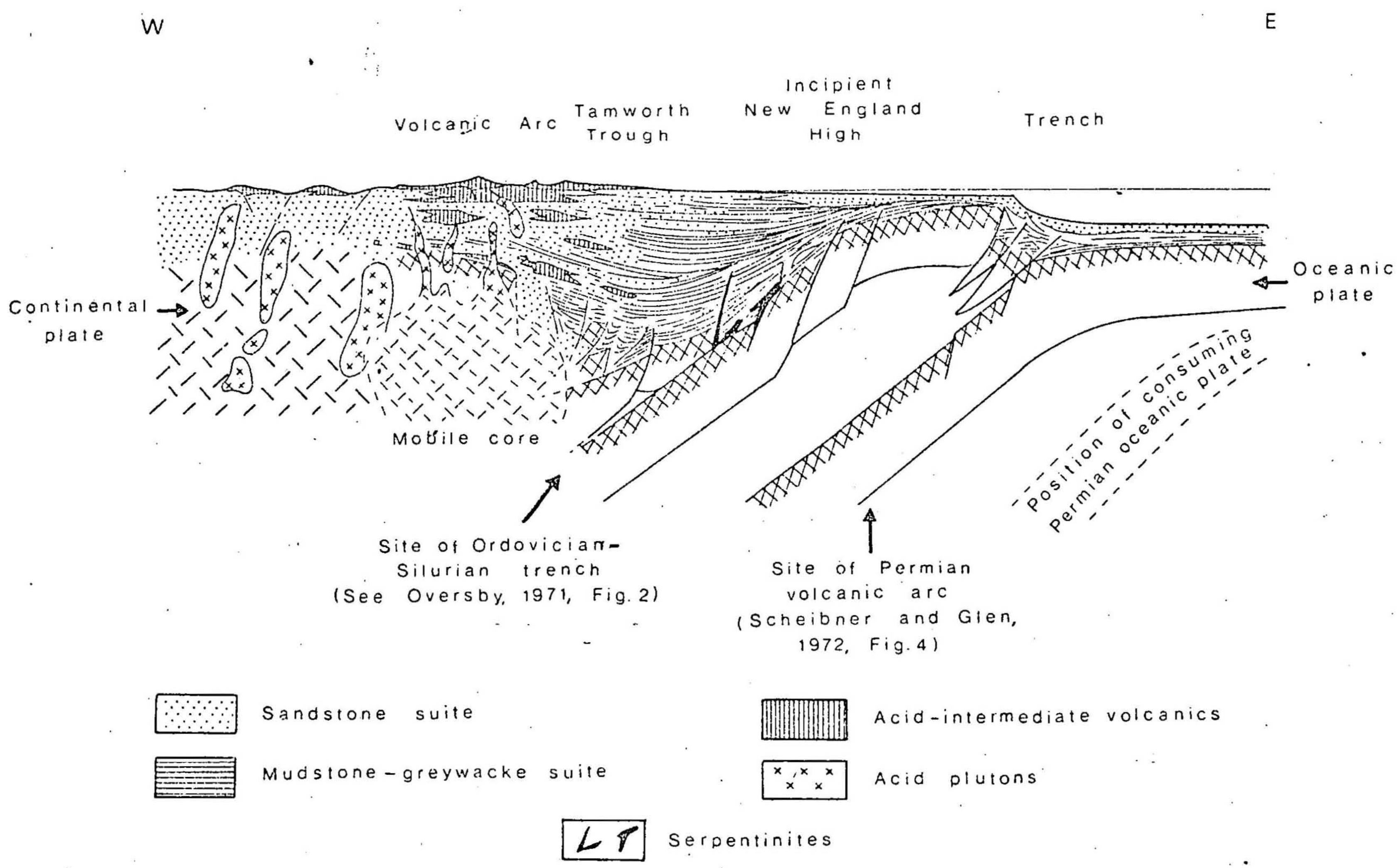

A
LATE TOURNAISIAN - EARLY VISEAN
151°00'
20'
40'
152°00'
32°00'
32°20'
LEGEND
Volcanic rocks, commonly ignimbrites
Mud
Silt
Sand
Gravel
Oolitic and crinoidal sand
Volcanic source area
Wingen
Scone
Aberdeen
Rouchel
Muswellbrook
Carrow Brook
Barrington Tops
COVERED BY
YOUNGER ROCKS
Chichester
Dungog
Gresford
Clarencetown
APPROXIMATE SHORELINE
IGNIMBRITIC
VOLCANISM
Clw
Cld
Cla
B
EARLY MIDDLE VISEAN
Clc Copeland Road Formation
Cln Nerong Volcanics
Clg Gilmore Volcanic Group
Cli Isismurra Formation
Clt Wotton Beds
Clf Flagstaff Sandstone
Clb Bonnington Siltstone
Clo Wollooma Formation
Cla Ararat Formation
Clw Waverley Formation
Cld Dangarfield Formation
Barrington Tops
VOLCANIC
ASH
IGNIMBRITES
APPROXIMATE SHORELINE
APPROXIMATE
EASTERN LIMIT OF
OAKFIELDS - NATIVE
DOG VOLCANISM
Singleton
Cli
Clo
Clb

Fig 3.



A
MIDDLE VISEAN
151°00'
20'
40'
152°00'
32°00'
20'
Wingen
Scone
Aberdeen
Muswellbrook
Rouchel
Carrow Brook
Singleton
Stanhope
Gresford
Dungog
Chichester
Clarencetown
Gloucester
Barrington Tops
?Clo
Cli
Clf
SUBSIDING AREA WITH EXPANDED SEQUENCE
STROUD PLATFORM
OOLITIC AND CRINOIDAL LIMESTONES
IGNIMBRITES AND TERRESTRIAL SEDIMENTS
APPROXIMATE SHORELINE
PARALIC SEDIMENTS Clf AND IGNIMBRITE
APPROXIMATE EASTERN LIMIT OF RED IGNIMBRITES
B
LATE VISEAN
151°00'
20'
40'
152°00'
32°00'
20'
40'
Wingen
Scone
Aberdeen
Muswellbrook
Rouchel
Carrow Brook
Singleton
Branxton
Paterson
Gresford
Dungog
Chichester
Clarencetown
Stroud
Bulahdelah
Gloucester
Barrington Tops
Cli
Clg
Cln
Clc
Clc – Cln
STROUD PLATFORM
SUBSIDING AREA WITH EXPANDED SEQUENCE
REGION OF PERIODIC EMERGENCE AND VOLCANISM
VOLCANIC ISLAND
APPROXIMATE SHORELINE
VOLCANICS AND
TERRESTRIAL SEDIMENTS

Fig 4.



W
E
Volcanic Arc
Tamworth Trough
Incipient New England High
Trench
Continental plate
Oceanic plate
Mobile core
Position of consuming Permian oceanic plate
Site of Ordovician-Silurian trench (See Oversby, 1971, Fig. 2)
Site of Permian volcanic arc (Scheibner and Glen, 1972, Fig. 4)
Sandstone suite
Mudstone-greywacke suite
Acid-intermediate volcanics
Acid plutons
Serpentinites

Fig 5