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SYDNEY BASIN EXPLANATORY NOTES AND STRATIGRAPHIC COLUMNS

by

V.L. Passmore

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CONTENTS

ABSTRACT

The Sydney Basin in eastern New South Wales underlies an area of 43 000 km^2, mostly onshore, and forms the southern part of the Sydney-Bowen Basin. The basin which developed as a late phase of the cratonic accretion in the Tasman Fold Belt system is underlain and partly bounded by the Lachlan and New England Fold Belts. The Sydney Basin contains mainly Permo-Triassic rocks up to 6000 m thick. Basal glacigene sediments and volcanics underlie an Early Permian sequence of shallow marine, coastal, and deltaic clastics. The overlying thick Late Permian coal measures are succeeded by Triassic deltaic clastics, non-marine redbeds, and lithic and quartzose sandstone. The sediments have been modified locally by Late Permian syndepositional folding and igneous activity, and by regional postdepositional Mesozoic and Cainozoic igneous activity and movement.

Half of Australia's black coal production is supplied from the Sydney Basin. High-volatile, low-rank bituminous coal, is mined chiefly in the northern coal districts, and low-volatile, high-rank coal, in the southern ones. Economic deposits of oil shale, heavy-mineral sands, clay, and construction materials have been or are being exploited.

SYDNEY BASIN

Introduction

The Sydney Basin contains a flat-lying, largely undeformed, sequence of mainly Permo-Triassic rocks along the eastern edge of New South Wales. The basin has an area of 43 000 km^2, mostly onshore. Sedimentary, metamorphic, and volcanic rocks of the New England and Lachlan Fold Belts underlie the basin and form its main onshore limits; along the northeastern edge, the contact between rocks of the Sydney Basin and New England Fold Belt has been modified by the Hunter Thrust System (Fig. 1). The Mount Coricudgy Anticline marks the northwestern boundary, which separates the Sydney Basin from the contiguous Gunnedah Basin. The eastern boundary is taken as the edge of the continental shelf, although the basin originally extended farther eastward (Mayne & others, 1974).

The Sydney Basin forms the southern end of a large elongate basin, the Sydney-Bowen Basin (Bembrick & others, 1973). Faunal evidence suggests intermittent connection between the Sydney and Bowen parts of the Basin in the Permian (Runnegar, 1970). The Sydney portion contains up to 6 km of Permian and Triassic sediments (Mayne & others, 1974). Basal glacigene sediments and volcanics underlie an Early Permian sequence of shallow marine, coastal and deltaic clastics. The overlying thick Late Permian coal measures are succeeded by Triassic deltaic clastics, non-marine redbeds, and lithic and quartzose sandstone. The thickest accumulation in the Sydney Basin was in a rapidly subsiding Permian trough at the northern end of the basin.

Three tectonic episodes can be recognized in the Sydney Basin, roughly corresponding to the Early Permian, Late Permian, and Triassic. Major post-depositional tectonic events in the Mesozoic and Tertiary have also left their imprint on the basin. The majority of the structures in the basin (Fig. 2) developed from movements in the Mesozoic and Tertiary, although there is

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Figures Au4a and Au4b and these explanatory notes were prepared as a contribution for the United Nations ESCAP Atlas of Stratigraphy.

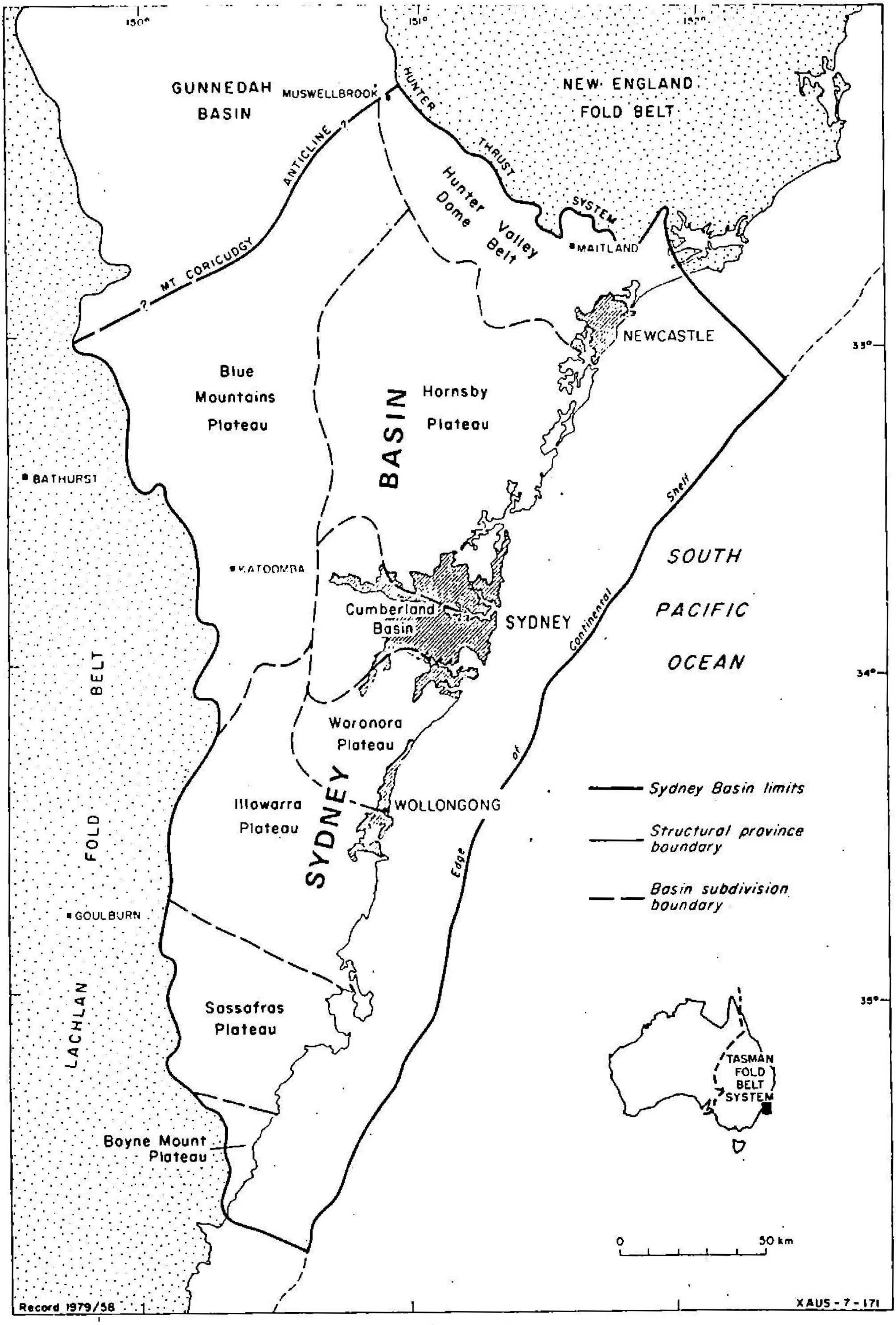

Fig.1 Regional structural setting (after Bembrick and others, 1973)

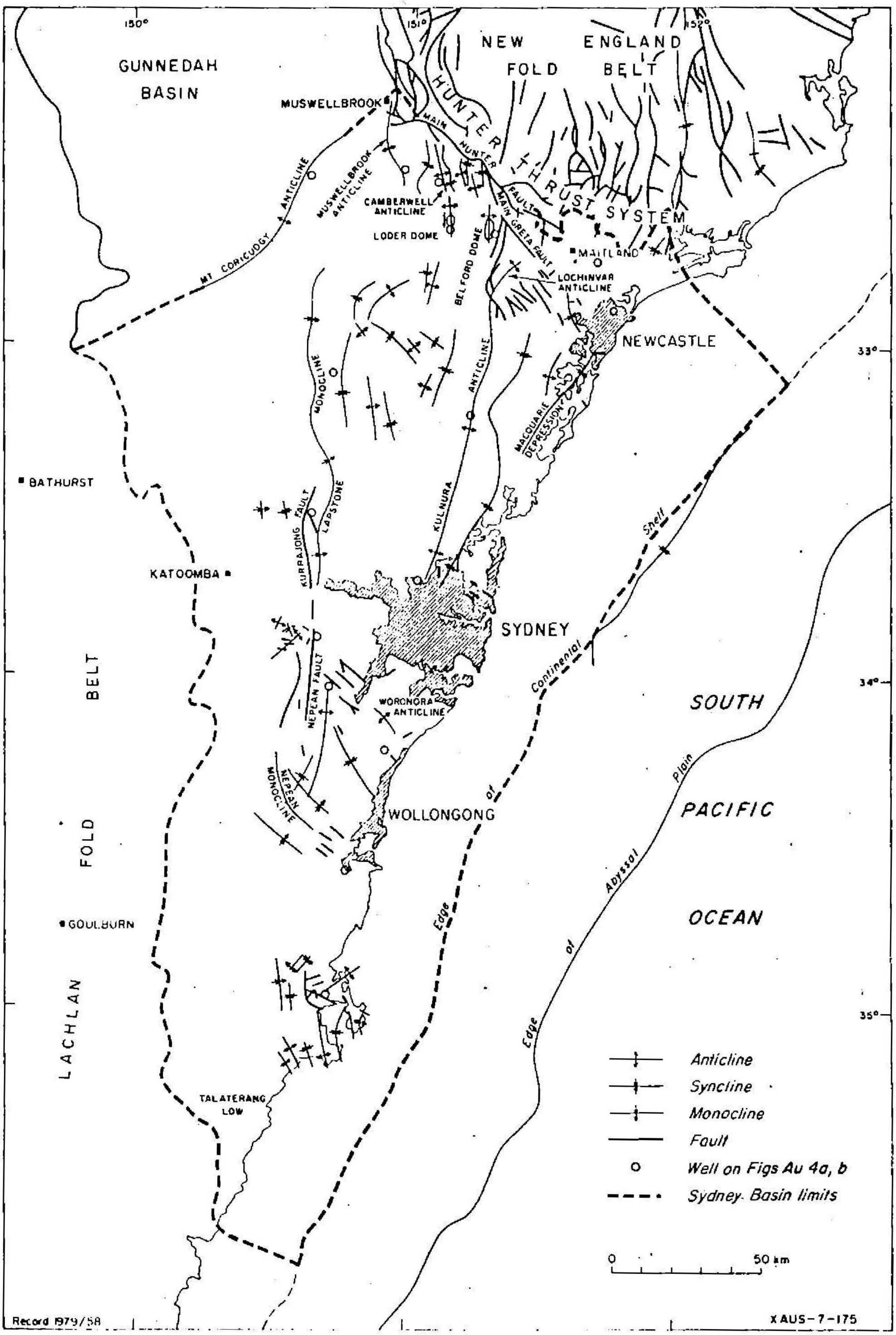

Fig. 2 Structural elements of the Sydney Basin (after Mayne and others, 1974)

evidence of syndepositional growth in the Hunter Valley Dome Belt. The present structural subdivisions of the basin (Fig. 1) reflect Tertiary warping. Post-depositional igneous activity in the basin appears to be related to stabilization of the general region, opening of the Tasman Sea, and separation of Australia and Antarctica.

The vast coal resources of the Sydney Basin make it one of the more economically important basins in Australia. Earlier in this century the basin was also a major source of oil shale. More recently, extensive heavy-mineral sand mining has been carried out along the coast.

Data Compilation

The cross-sections on Figures Au4a and Au4b have been adapted from well correlations by Mayne & others (1974). Lithology, correlations, formation names and tops are those of Mayne & others; modifications in a few wells represent more recent data. The rest of the information depicted on the columns was taken from company reports, petrological studies by the Bureau of Mineral Resources, and personal communications (Table 1). The age and environmental relationships of the formations are shown in Figures 3 and 4, respectively.

A wealth of information has been written on the Sydney Basin; these notes have been compiled mainly from the more recent reviews.

Regional Tectonics

The Sydney Basin developed in the Late Palaeozoic as part of a multi-stage process of Palaeozoic cratonic accretion in the Tasman Fold Belt System (Fig. 1). Continental accretion apparently progressed in an easterly direction, as shown by the decreasing age of tectonic events from west to east within the Tasman Fold Belt System. Austin & Williams (1978) ascribe these episodes of tectonism to periodic eastward continental drift and periodic clockwise continental rotation. The tectonic evolution and geological development of the Sydney Basin and adjacent region has been investigated by many authors (including Bembrick & Lonergan, 1976; Branagan & others, 1976; Crook, in press; Day & others, 1978; Harrington & Korsch, 1979; Leitch, 1974a, 1974b; Mayne & others, 1974; Scheibner, 1976, 1973; and Voisey, 1958).

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TABLE 1 - GEOLOGICAL CONTROL USED IN CROSS-SECTIONS (Figs Au4a, Au4b)

WELLS

COMPANY WELL NAME	YEAR	T.D.(m)	STRUCTURAL SUBDIVISION	REFERENCE
AUSTRALIAN OIL AND GAS CORPORATION LTD				
Kurrajong Heights 1 (see EXOIL)	1954	1450	Blue Mountains Plateau	BMR Record 1968/81
Mulgoa 2	1959	1717	Cumberland Basin	BMR File 62/1024
Loder 1	1963	2064	Hunter Valley Dome Belt	BMR Record 1968/130
Woronora 1	1964	2314	Woronora Plateau	BMR Record 1968/58
Kulnura 1	1964	2474	Hornsby Plateau	BMR Record 1969/102
Kirkham 1	1964	2564	Cumberland Basin	BMR Record 1969/61
Belford 1	1965	1176	Hunter Valley Dome Belt	BMR Record 1968/68
Camberwell 1	1965	1908	Hunter Valley Dome Belt	BMR File 65/4179
Martindale 1A	1967	1182	Blue Mountains Plateau	BMR Record 1969/62
ESSO (EXPLORATION AND PRODUCTION AUSTRALIA INC.)				
Jerrys Plains 1	1969	1596	Hunter Valley Dome Belt	BMR File 69/2004
Howes Swamp 1	1970	2562	Hornsby Plateau	BMR File 71/34
EXOIL N.L.				
Kurrajong Heights 1 (see AOG)	1962	deepened to 2785	Blue Mountains Plateau	BMR Record 1978/81
PLANET EXPLORATION CO. LTD				
East Maitland 1	1962	3051	Hunter Valley Dome Belt	BMR Record 1969/14

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COMPANY WELL NAME	YEAR	T.D.(m)	STRUCTURAL SUBDIVISION	REFERENCE
FARMOUT DRILLERS N.L.				
Stockyard Mt 1	1962	1072	Illawarra Plateau	BMR Record 1968/31
SHELL DEVELOPMENT (AUSTRALIA) PTY				
Dural South 1	1966	3061	Hornsby Plateau	BMR Record 1967/160
GENOA OIL N.L.				
Coonemia 1	1969	797	Illawarra Plateau	BMR File 69/2010
AUSTRALIAN AGRICULTURAL COMPANY				
Bore		914	Hunter Valley Dome Belt	GS NSW Memoir 4(1)

MEASURED SECTIONS - COMPOSITE

AREA NAME	1:250 000 SHEET AREA	THICKNESS (m)	STRUCTURAL SUBDIVISION	REFERENCE
Durras-Ulladulla	Ulladulla SI/56-13	488	Boyne Mount Plateau	Dickins & others, 1969
Katoomba-Yerranderie	Sydney/ Wollongong SI/56-5 / SI/56-9	750	Blue Mountains Plateau	C.S. Bembrick, Geological Survey of New South Wales, pers. comm.

BMR - Bureau of Mineral Resources
GS NSW - Geological Survey of New South Wales
BMR File - Company well completion reports held at the Bureau of Mineral Resources.

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Cratonization of the Lachlan Fold Belt extended the eastern edge of the continent to the Sydney Basin region in the Carboniferous. By Late Carboniferous a complex trench-arc system existed east of the Fold Belt (Scheibner, 1973), comprising a back-arc area, site of the fiture Sydney Basin, and a volcanic chain and accretionary wedge fronting the chain (the New England Orogen), which developed above a westerly dipping subduction zone, whose trench lay east of the present Australian continent. A southwards shift of the Australian continent during the Carboniferous brought the region within the south polar latitudes (Embleton, 1973).

The Sydney Basin was initiated near the end of the Carboniferous as a back-arc basin between an eastern orogenic zone (New England Orogen) and a western craton (Lachlan Fold Belt). The basin became a sheltered sediment trap, comprising a rapidly subsiding trough in the north that developed over the southern edge of the orogen and the mobile eastern edge of the craton, and a gently subsiding shelf on the edge of the craton.

Subduction ceased in the Benioff zone to the east of the present New England Fold Belt in the Early Permian, prior to the main orogenic movement of the Hunter Bowen Orogeny in the mid-Permian (Leitch, 1974a). During the orogeny, the New England Orogen was deformed and uplifted, and parts of it were regionally metamorphosed. Extensive folding and thrust faulting occurred along the western edge of the orogen, welding it to the craton and producing the Hunter-Mooki Thrust (Branagan & others, 1976). In response to overthrusting of the newly formed New England Fold Belt against the older more stable Lachlan Fold Belt, a foredeep developed on the site of the back-arc basin. Gentle folding occurred in the foredeep immediately southwest of the Hunter Thrust System in the Hunter Valley Dome Belt (Fig. 1). A rapidly subsiding trough developed in the Newcastle area of the Sydney Basin in the Kazanian and remained active until the end of the Permian. The disappearane of this northern trough at tne end of the Permian marked the end of the foredeep.

An intracratonic basin developed at the end of the Permian between the stable Lachlan and New England Fold Belts, over the Late Permian foredeep. This latest phase of the Sydney Basin represented the final development of the basin, when it became more unified and less complex.

The Sydney Basin and New England Fold Belt became sites of several episodes of intrusive and extrusive igneous activity. The earliest volcanic activity began in the Late Permian and was probably associated with the Hunter Bowen Orogeny and stabilization of the New England Fold Belt. Stabilization of the Tasman Fold Belt System produced further intrusions in this region in the Late Triassic and Jurassic.

The eastern edge of the New England Fold Belt and Sydney Basin was rifted during opening of Tasman Sea in the Late Cretaceous and Paleocene (Hayes & Ringis, 1973), giving rise to a new episode of volcanic activity to the west (McDougall & Wellman, 1976). Rifting and northward drift of Australia from Antarctica in the Tertiary produced a further episode of volcanism in the region, and Tertiary movements related to development of the Eastern Highland caused warping within the Sydney Basin.

Basin Evolution

The earliest deposits in the Sydney Basin appear to be glacigene clastics (Talaterang Group and other conglomerates) (Fig. 3) derived from the Lachlan Fold Belt to the west and laid down during the latest Carboniferous and earliest Permian in deep valleys or channels in older Palaeozoic basement rocks. Although the sediments exhibit glacial characteristics, and alpine glaciers and a continental ice sheet crowned parts of the Lachlan Fold Belt in the Late Carboniferous and Early Permian respectively, there is little evidence of glaciation within the Sydney Basin, and these deposits were most likely formed by downhill sliding and stream transport of glacial debris (Crowell & Frakes, 1971). The floor of the basin must have had moderate relief at this time as shown by the clastic sediments over 200 m thick in places, which were confined to the channels. Herbert (1972) estimates a relief exceeding 600 m.

In the northwestern part of the Sydney Basin, calcalkaline basalts and andesites (Lochinvar Formation and associated volcanics) (Fig. 3) extruded from a volcanic zone in the vicinity of the Hunter Valley Dome Belt (Fig. 1), may form the basal rock unit. In places the composition of the volcanics becomes more acidic near the top, and rhyolite is interbedded with or overlies the basalt. The volcanics are undated and their age and stratigraphic relationship

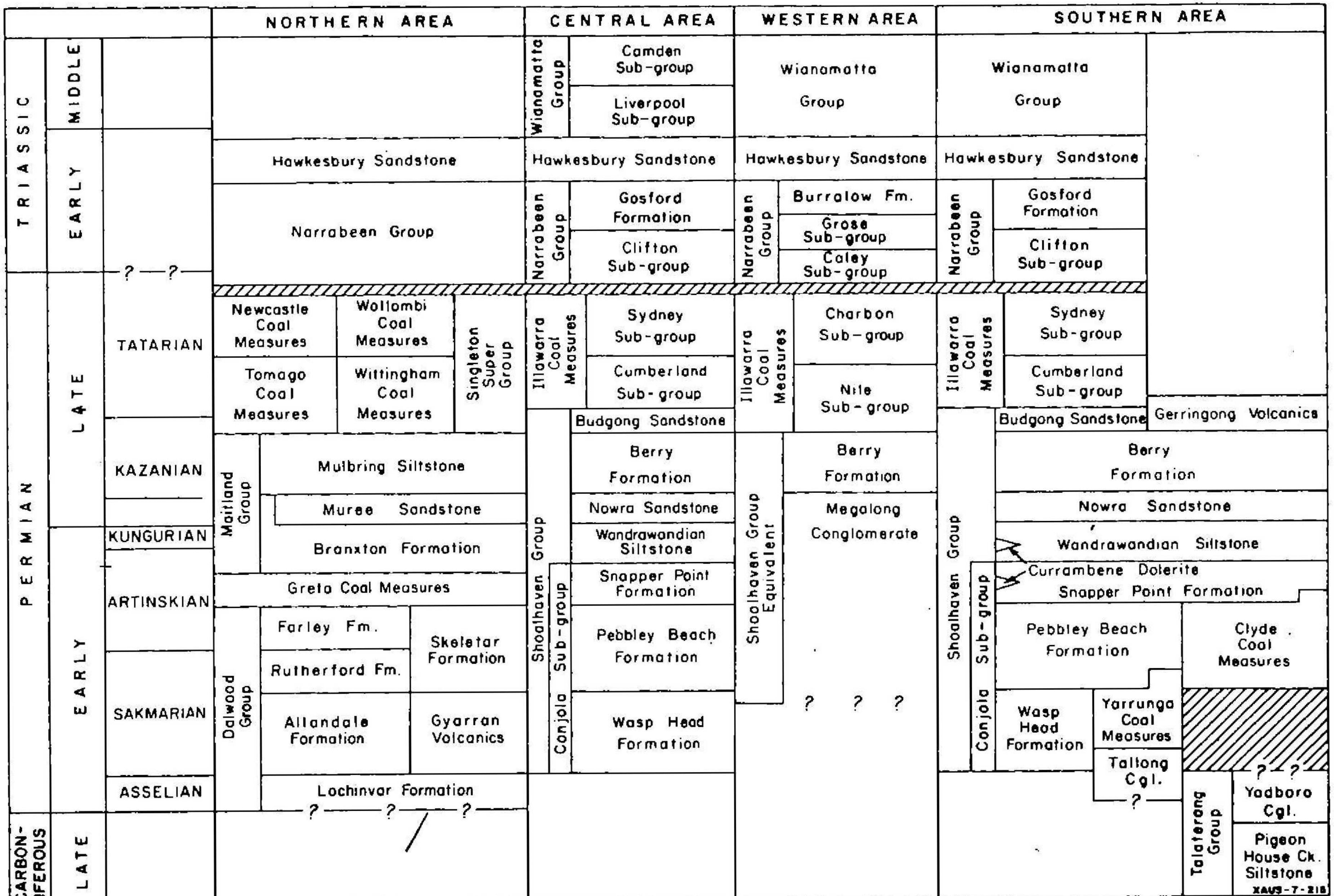

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Fig. 3 Time-rock correlation Sydney Basin (After Bembrick & Lonergan, 1976; Mayne & others, 1974)

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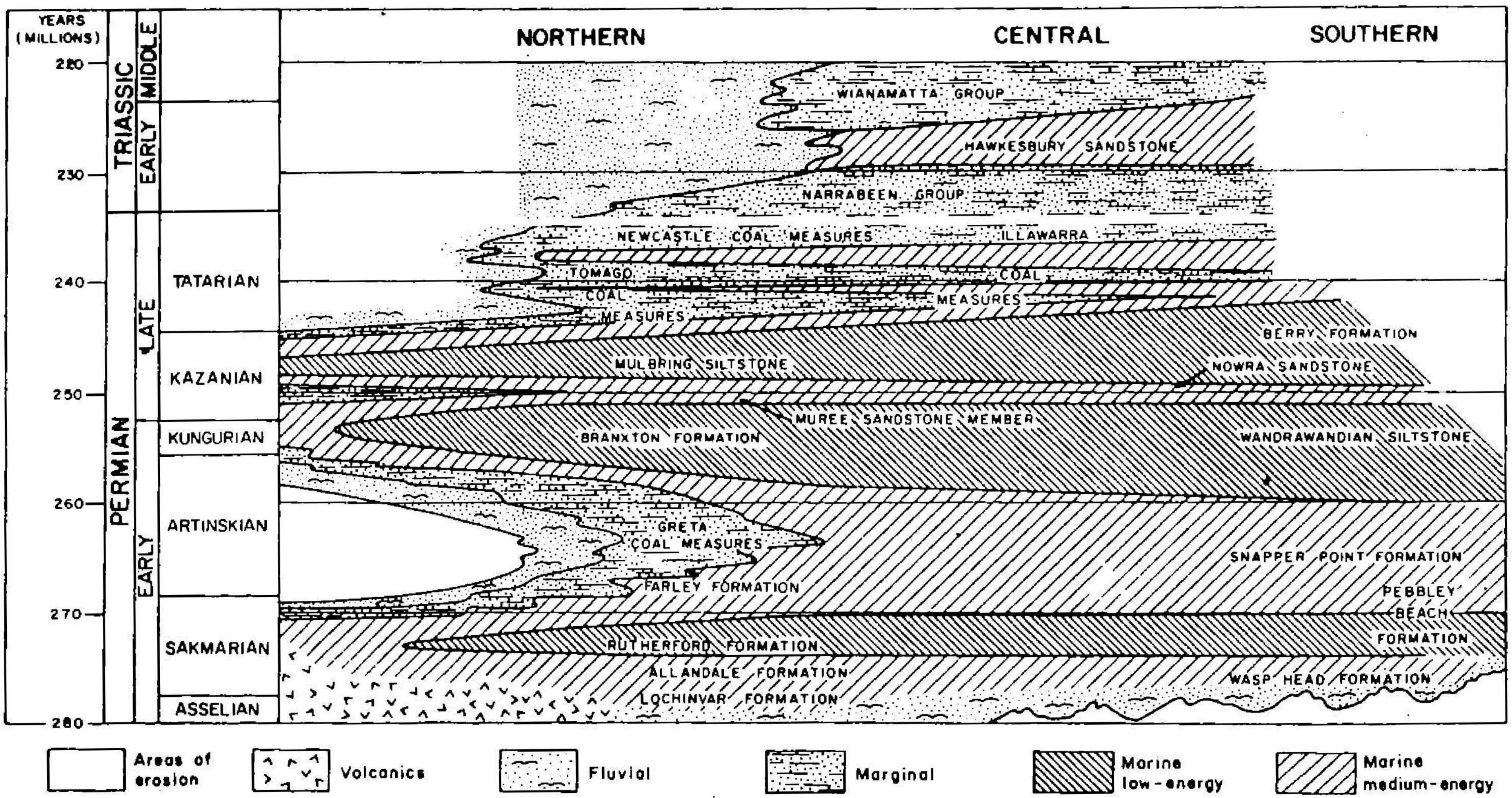

Fig. 4 Depositional history of the Sydney Basin (after Mayne and others, 1974)

to the largely undated glacigene clastics are uncertain. Fossiliferous sediments interbedded with the upper part of the volcanics (Fig. Au4b) imply a very early Permian age, although the base of the volcanics could be older.

In the earliest Permian a westerly transgressing sea inundated the basin, depositing marine clastics of the Conjola Sub-group in the south and the Dalwood Group in the north (Fig. 3). A northwesterly trending trough or depression developed in the Hunter Valley Dome Belt, but in the central and southern parts of the basin the sea gradually onlapped the Lachlan Fold Belt across a broad, slowly subsiding shelf. As vulcanism waned in the north, the volcanics were succeeded by marginal marine and marine clastics (Fig. 4). By the mid-Sakmarian, active vulcanism had ceased in most parts of the Sydney Basin, although volcanics within the Skeletar Formation and in the adjacent Gunnedah Basin (Leitch, 1974a) indicate volcanic activity continued later in the north of the basin. Rapid thinning northeast of the trough suggests possible local uplift of parts of the source area. A link with the Bowen Basin to the north may have been established in the middle Sakmarian (Fig. 4) (Mayne & others, 1974).

The sea regressed southward from the northern part of the Sydney Basin in the late Sakmarian and Artinskian (Fig. 4). Behind the retreating sea, coal swamps developed in which clastics and plant debris accumulated, forming the economically important Greta Coal Measures. Coarsening and thickening of conglomerates within the coal measures at the northern end of the Lochinvar Anticline (Fig. 2) indicate a rising source area to the north and northeast. This uplift may have been an early phase of the deformation that culminated in the Hunter-Bowen Orogeny in the mid-Permian. The coal swamps extended as far south as the latitude of Newcastle, where the Greta Coal Measures gave way to their marine equivalent in the south, the Snapper Point Formation (Figs. Au4a, Au4b). A marine transgression in the late Artinskian and Kungurian covered the coal swamps and re-established marine conditions over most of the Sydney Basin (Fig. 4). Marine clastics of the Maitland Group were deposited in a northern trough, the axis of which had apparently changed from a northwesterly to a more northerly direction in the late Early Permian.

Except for the short period of vulcanism in the very Early Permian, the Sydney Basin seems to have remained tectonically quiet through its back-arc tectonic phase. There is no evidence of deformation, and the only movement within the basin appears to have been subsidence. Ice-rafted erratics, in sediments ranging from Sakmarian to Kazanian, suggest that in the Early Permian the basin's southern and western margins were periodically covered by lobes of a continental ice sheet that lay west of the basin (Crowell & Frakes, 1971). Marine invertebrate fauna (Dickins, 1978) show the sea remained cold to cool until the Late Permian.

Marine sedimentation which was re-established basin-wide in the Artinskian, continued uninterrupted into the Kazanian. A minor regression at the beginning of the Kazanian is reflected in the sediments as an increase in the sand content of the clastics (Figs. Au4a, Au4b). These coarser clastics are called the Muree Sandstone in the north and the Nowra Sandstone farther south (Fig. 3). The Hunter-Bowen Orogeny, which deformed and uplifted the New England Orogen in the mid-Permian, had little effect on the sediments of the Sydney Basin. The basin appears to have been largely cushioned from diastrophism by the Hunter Thrust System (Fig. 2) (Branagan & others, 1976). Some of the north-trending structures in the Hunter Valley Dome Belt (Fig. 1) such as the Lochinvar Anticline, Dural Dome, and Kulnura Arch (Fig. 2) first appear in the Kazanian, and these most likely developed in response to deformation to the northeast of the basin. Thinning of Late Permian and Triassic sediments over these features show they remained active during the later depositional history of the basin.

The sea advanced to its maximum extent in the middle Kazanian (Fig. 4), when a marine connection with the Bowen Basin was re-established (Runnegar, 1970) and apparently remained open until a major regression in the Upper Kazanian marked a basin-wide change from dominantly marine to dominantly marginal conditions. Coal swamps again formed behind a southward regressing sea. But regression was slow and marine conditions predominated in the south and central areas until the early Tatarian. The basin-wide distribution of the Illawarra Coal Measures and their equivalents in the north (Fig. 3) show the Late Permian coal swamps spread far beyond the limits of the Early Permian ones. The sea regressed to the eastern edge or out of the basin for most of the Tatarian, but marine tongues within the Illawarra, Tomago, and Newcastle Coal Measures, and Singleton Super-group (shown as Singleton Coal Measures on Figures Au4a, Au4b) demonstrate that there were several brief transgressions (Figs Au4a, Au4b). The coal measures reach a total thickness of 1500 m (Bembrick & Lonergan, 1976). The numerous coal seams and lateral and vertical facies changes indicate the coal measures were deposited in complex and changing environmental conditions. Vertical distribution of the coal seams (Figs. Au4a, Au4b) imply that conditions favourable to coal accumulation were prevalent during most of the deposition of the coal measure clastics, however, the culmination of coal development is marked by the Newcastle Coal Measures (Mayne & others, 1974). Most of the basin's production of coal is mined from seams within the Late Permian coal measures.

The Lachlan Fold Belt, diminished in importance in the Late Permian as a major source of detritus to the basin, and the newly formed New England Fold Belt supplied most of the sediment during the rest of the basin's depositional history.

Late orogenic igneous intrusions and volcanic activity in the New England Fold Belt (Harrington & Korsh, 1979; Leitch, 1974a) were accompanied by similar activity in the southern and eastern parts of the Sydney Basin in the Kazanian and Tatarian (Facer & Carr, 1979). Vulcanism commenced south of Wollongong in the southeastern part of the basin with the extrusion of the Gerringong Volcanics and shallow igneous intrusions (Currambene Dolerite and related intrusive) into the Shoalhaven Group (Fig. 3) in the Ulladulla region. Joplin (1964) suggests the intrusives and flows were derived from shoshonitic magmas. Branagan & others (1976) relate this activity to a shift or rotation of the basin from a northerly to a northwesterly orientation, and with less certainty to orogeny north of the basin. A northwest-trending trough, the Macquarie Depression (Fig. 2), developed in the Newcastle area (Fig. Au4b) at this time and remained active until the end of the Permian. Volcanogenic debris in the coal measures shows that explosive volcanicity continued on a large scale in the east (Mayne & others, 1974) and that the zone of volcanism extended northward in the Tatarian.

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A widespread hiatus at the top of the coal measures (Fig. 3) suggests a break in sedimentation at the end of the Permian (Helby, 1973). Renewed sedimentation began with deposition of the Narrabeen Group clastics (Fig. 3) into an intracratonic basin that succeeded the Late Permian foredeep. Uplift of the New England Fold Belt source area provided sediment to the southeasterly prograding and coalescing Narrabeen Group delta complex. The Narrabeen deltas were covered in the late Early Triassic by blanket sands of the Hawkesbury Sandstone. The environment of deposition of this unit is controversial, and suggestions range from marine to fluvial. There was a shift of paleocurrent direction from southeast to northeast at this time, which Branagan & others (1976) attribute to tectonic tilting of the basin to the northeast. The Middle Triassic deposits of the Wianamatta Group, which conformably overlie the Hawkesbury Sandstone, were derived from a westerly source and deposited into a regressive, low energy, marginal marine environment. Subsequent erosion has removed the Wianamatta Group clastics from all except the central part of the basin (Fig. Au4a). Volcanic tuff and ash interbedded with or occurring as minor constituents in Early and Middle Triassic sediments probably represent a continuation of the extrusive volcanic activity that occurred in the eastern part of the basin during the Late Permian.

The final regression of the Wianamatta Group marked the end of the Sydney Basin as a depositional feature. Areas north of the Sydney Basin show evidence of Late Triassic folding and erosion followed by deposition of Jurassic sediments (Day & others, 1978). Although no Jurassic rocks are known in the basin, indirect evidence (Mayne & others, 1974) suggests a similar sequence of events may have occurred in the Sydney Basin.

Potassium-argon dating (McDougall & Wellman, 1976) of the igneous rocks intruding Permian and Triassic sediments in the basin indicates that much of the igneous intrusive activity was not concurrent with deposition, but belongs to a Late Triassic to Late Jurassic post-depositional episode. McDougall & Wellman (1976) associate the mainly alkaline igneous activity with the final stages of stabilization of the Tasman Fold Belt System, a stage that postdates much of the folding and granitoid emplacement of the New England Fold Belt. The rarer tholeiitic intrusives, which are more indicative of rifting, probably represent an early phase of the tectonism which preceded opening of the Tasman Sea in the Late Cretaceous. As the sea floor spread along this eastern rift zone, the eastern edge of the Sydney Basin, which remained attached to the Lord Howe Rise, was separated from the rest of the basin and carried away.

The basin was further modified in the Cainozoic by uplift and warping related to development of the Eastern Highlands. Much of the present structure (Fig. 2) and geomorphology (Fig. 1), particularly large features such as the Lapstone Monocline, were formed as a result of this warping (Bembrick & Lonergan 1976). Further volcanic activity was initiated in the Eocene and Miocene in the basin, in response to the northward drift of Australia, following separation of the continent from Antarctica (Wellman & McDougall, 1974).

Resources

Black Coal

The Sydney Basin supplies over half of Australia's present production of black coal. In 1976, 44 million tonnes of raw coal were mined, 46% of which was exported (NEAC, 1977). Coal is mined from several districts in 4 coalfields (Fig. 5) but the chief production comes from high volatile, low rank coking coal in the Northern Coalfield and low volatile, high rank coking coal seams in the Southern Coalfield. Approximately 80% of the coal is extracted by underground mining operations (BMR, 1979). Open-cut operations are restricted to the Northern Coalfield, chiefly the Singleton-Muswellbrook Coal District (Fig. 5), where the overburden is thin and seam development is extensive.

Most types of black coal are present in the basin in commercial quantities. The wide variation in coal type and rank across the basin is the result of different geological and environmental conditions of formation. The bulk of the coal is bituminous, but anthracite occurs locally in the Berrima Coal District (Fig. 5), associated with igneous intrusions (Traves & King, 1975). Economic reserves are presently restricted to those deposits having an overburden less than 600 m thick, a minimum seam thickness of 1.5 m, and a maximum ash content of 30%. Known reserves are over 15,000 million tonnes, and inferred or estimated reserves are at least 47,000 million tonnes (NEAC, 1977). No figures are available for sub-economic coal resources, but they are believed to be very large, as large areas of the basin contain coal measures that do not meet the present economic criteria.

Coal seams within the Illawarra, Newcastle, Tomago, and Greta Coal Measures and the Singleton Super-group (Fig. 3) are presently being mined, but only flat-lying or gently dipping seams are being worked. The Clyde and Yarrunga Coal Measures at the southern end of the Sydney Basin are considered uneconomic because the seams are of limited extent, thin, lenticular and discontinuous, and generally of inferior quality (Robinson & Shiels, 1975).

All coal measures currently producing coal in the basin except for the Illawarra Coal Measures, are mined only in the Northern Coalfield. The Greta Coal Measures are at an economic depth only in this field at the northern edge of the basin. They are best known around the Lochinvar Anticline (Fig. 2) where they have been extensively mined, but are also exposed on the Muswellbrook Anticline. The coal is low rank bituminous, commonly containing plies of cannel coal and kerosene shale. The perhydrous nature of the coal makes it suitable for synthetic oil or gasification processes but economic reserves are lacking (Robinson & Shiels, 1975). The Tomago Coal Measures are mined in the East Maitland-Tomago Coal District (Fig. 5). The coal seams commonly split and coalesce, causing seam potential to vary from area to area. The Tomago Coal Measures are overlain by the Newcastle Coal Measures (Fig. 3); mining of these younger coal measures is mainly farther south within the Newcastle Coal District (Fig. 5), in the Macquarie Depression (Fig. 2). Like the underlying Tomago Coal Measures, the Newcastle Coal Measures seams exhibit splitting and coalescence. Both units are a source of high volatile coking coal. The Singleton Super-group is the most economically important coal unit in the Singleton-Muswellbrook Coal District (Fig. 5), and contains the greatest development of coal seams within any coal measures in New South Wales (Robinson & Shiels, 1975). Units within the group show rapid variation in lithology, and beds are extremely lenticular. The Wollombi Coal Measures (Fig. 3) (upper Singleton Super-group) are not being worked, as they lack coking potential, but the underlying Wittingham Coal Measures (lower Singleton Super-group) have much better coal, although quality

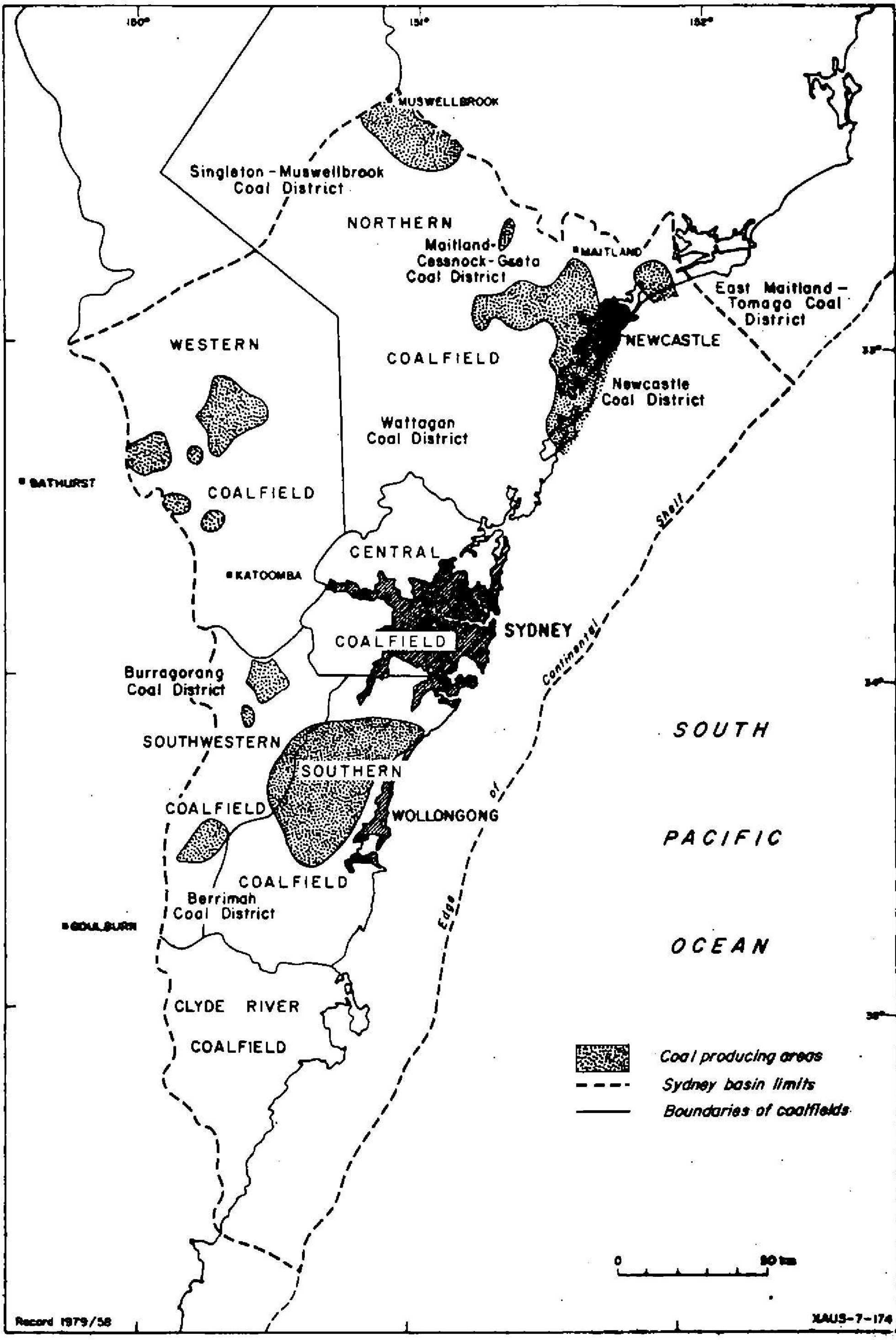

Fig.5 Coal producing districts in the Sydney Basin (after Mayne and others, 1974; Traves and King, 1975)

may vary owing to lateral changes in rank across the coal district (Menzies, 1974). Numerous shallow and coalescing seams in the Wittingham Coal Measures make open-cut mining economic, and approximately 70% of all production is mined by open-cut methods (BMR, 1979). The Singleton-Muswellbrook Coal District (Fig. 5) presently produces 90% of the Sydney Basin's open-cut coal production.

Production from the Western, Southern, and Southwestern Coalfields (Fig. 5) comes wholly from the Illawarra Coal Measures, a correlative of coal measures of the Singleton Super-group and the Newcastle and Tomago Coal Measures (Figs. 3, Au4a, Au4b). Seams within the Illawarra Coal Measures are generally more uniform and persistent over large areas than those in the Northern Coalfield, although variation in seam thickness and quality occur. Mainly medium volatile steaming coal is mined from the Western Coalfield and parts of the Southwestern Coalfield. In the Southern Coalfield the seams contain high rank, low volatile coking coals. The effects of geological structures upon mining are most important in the southern part of the basin, where coal is mined at greater depths.

The Central Coalfield (Fig. 5) has no production, although deep exploration drilling has shown the Illawarra, Tomago, and Newcastle Coal Measures, and the Singleton Super-group (Fig. 3) are present. An overburden exceeding 600 m to the top of the shallowest coal measures puts the area outside present economic criteria.

Oil Shale

Torbanite deposits occur in the Permian coal measures, commonly associated with the coal seams. Although of high grade, most deposits are lenticular and small (Lishmund, 1974). Most of the 33 known occurrences crop out along the western margin of the basin within the Late Permian Illawarra Coal Measures. Torbanite was mined intermittently from 1865 to 1952 as a source of lighting oil and wax, and later for motor spirits and oil. Total recorded production is 3.8 million tonnes (Menzies, 1974), however, there has been no production since 1952 and the potential for future exploitation is low. The richest and thickest deposits have been nearly exhausted and the reserves of the largest deposits, 20 million tonnes, are insufficient for commercial oil shale mining operations (Lishmund, 1974).

Hydrocarbons

Shows of flammable gas from much of the Triassic and Permian sequence have stimulated petroleum exploration in the Sydney Basin since 1910. Gas shows were recorded in many of the 77 exploration wells drilled, but none contained commercial quantities of gas, although natural gas from the basin was used as emergency fuel for motor vehicles during World War II (Mayne, 1970). Few wells have recorded oil shows.

Oil shale deposits, and hydrocarbon shows (Figs. Au4a, Au4b) indicate source rocks are present in the basin. Source rock studies of the coal measures suggest any hydrocarbons present, derived from a coal source, are probably gas or lighter oil (Mayne & others, 1974). Vitrinite reflectance values of 2.56 to 2.88 (Raphael & Saxby, 1979) for the Mulbring Siltstone and Nowra Sandstone (Fig. 3) in Dural South 1 well indicate marine source rocks are over-mature for oil and at present have gas potential only.

The apparent absence of good reservoir rocks, however, must downgrade the basin's hydrocarbon potential. Porosity and permeability are generally low, largely as a result of early diagenesis of the rocks and poor sorting. Only the onshore part of the basin has been drilled; in particular, the Triassic and Late Permian rocks have been well tested by coal exploration bores and petroleum exploration wells. All major structures onshore have been drilled without success (Bembrick & Lonergan, 1976); however, many of the wells did not penetrate below the Late Permian coal measures. The offshore part of the basin is untested, but without an improvement in permeability over that of most of the onshore rocks, the hydrocarbon potential offshore will be low.

Recent studies have been carried out on the potential of the Sydney Basin for gas storage (Ozimic, 1979). The Muree and Nowra Sandstones and the Snapper Point Formation (Fig. 3) appear to have adequate porosity and permeability for the storage of gas.

Clay

Deposits of clay and shale, suitable primarily for use in structural and refractory clay products, are mined in the Sydney Basin. Greatest production comes from the Wianamatta Group (Holmes & others, 1978), although significant amounts are also extracted from the Hawkesbury Sandstone, and the Greta, Newcastle, Tomago, and Illawarra Coal Measures (Fig. 3) (Menzies, 1974). Locally, clay and shale deposits in the Illawarra Coal Measures are also mined for pottery clay. Clay production is wholly for domestic use and exploitation of most deposits is determined by proximity of the deposits to large population centers. Beds of bentonite clay, up to 7.5 m thick near Muswellbrook, occur in the upper part of the Wollombi Coal Measures and in the Newcastle Coal Measures (Fig. 3) (Menzies, 1974). To date there has been no bentonite production within the basin.

Building and Construction Materials

The Hawkesbury Sandstone has been the main source of building stone in eastern New South Wales since the early part of the last century; more recently, the Hawkesbury Sandstone and sandstone from the Narrabeen Group (Fig. 3) has been used chiefly as facing material and for ornamental stonework.

Low cost construction materials are readily available within the Sydney Basin. The Hawkesbury Sandstone and conglomerate in the Newcastle Coal Measures provide suitable sand and gravel, respectively, but the bulk of the aggregate comes from unconsolidated Quaternary beach and river deposits (Holmes & others, 1978) overlying the basin rocks. Crushed aggregate is largely obtained from the Permian and Mesozoic volcanic rocks that intrude the basin sediments.

<u>Heavy Mineral Sands</u>

Pleistocene and Holocene coastal sands, which overlie Sydney Basin sediments along the present coastal margins, are mined for heavy minerals (rutile, zircon, monazite, and ilmenite) (Holmes & others, 1978). Mineral-sand mining is largely confined to the northeastern area of the basin, where the more economic minerals, rutile and zircon, predominate. The coastal sands farther south contain high fractions of ilmenite and magnetite, which have little value at present, because of the high chromium content in the ilmenite (Winward, 1974). The heavy minerals are extracted by dredging the older beach ridge systems, where the heavy minerals have been concentrated. Most of this production is exported.

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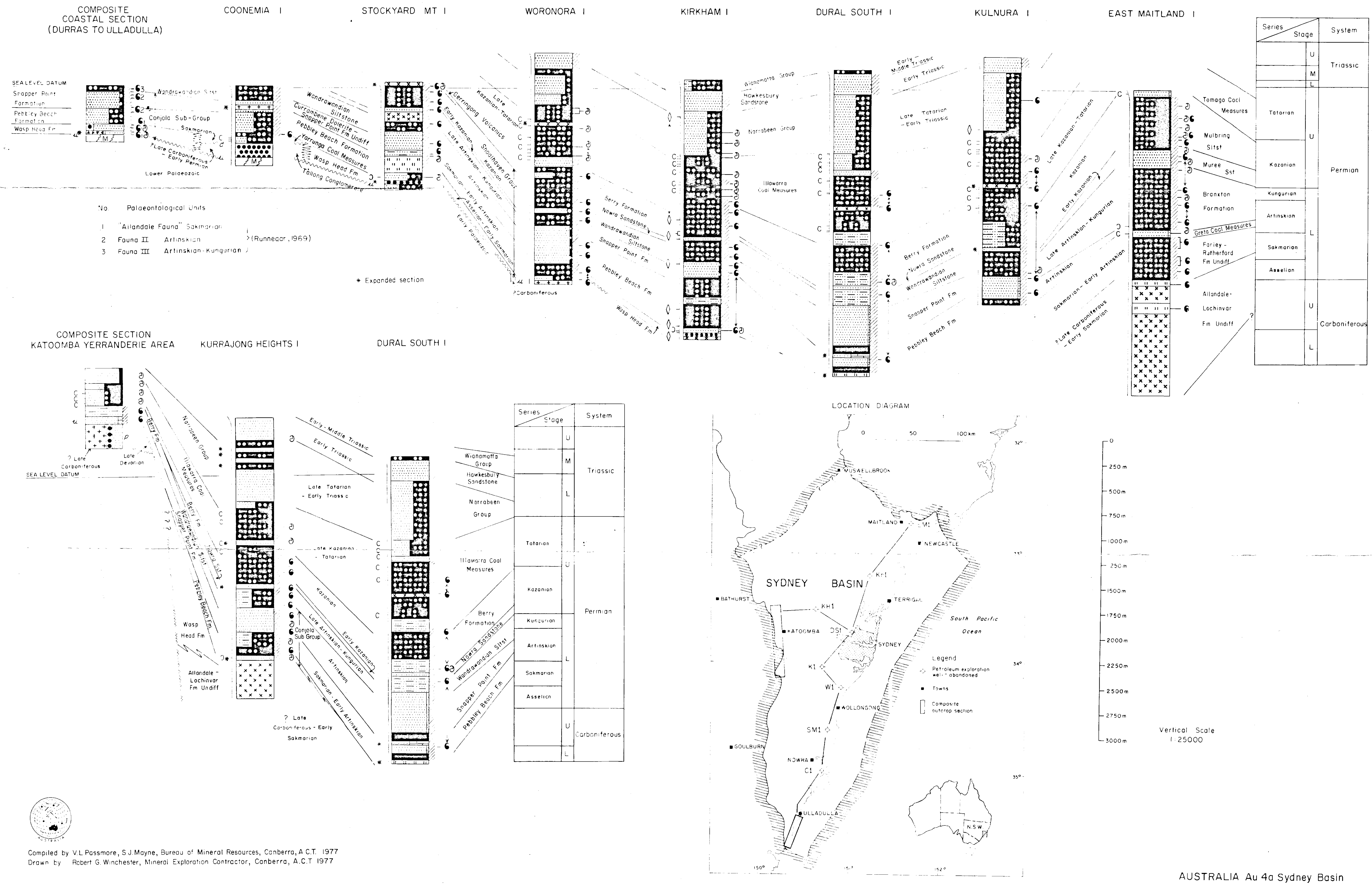
AUSTRALIA

SYDNEY BASIN: EASTERN NEW SOUTH WALES

ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No. 32)

Legend: See Figure Au 4

Fig. Au 4a



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AUSTRALIA
SYDNEY BASIN : EASTERN NEW SOUTH WALES
ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No. 32)

Legend: See Figure Au 4

Fig. Au 4b

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