PALAEOGEOGRAPHY 18

THE ORDOVICIAN PALEOGEOGRAPHY OF AUSTRALIA

P.J. COOK AND J.M. TOTTERDELL

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
ONSHORE SEDIMENTARY & PETROLEUM GEOLOGY
BMR RECORD 1990/41

BMR RECORD 1990/41

THE ORDOVICIAN PALAEOGEOGRAPHY OF AUSTRALIA

by

P.J. Cook and J.M. Totterdell

BUREAU OF MINERAL RESOURCES/
AUSTRALIAN PETROLEUM INDUSTRIES RESEARCH ASSOCIATION
PALAEOGEOGRAPHIC MAPS PROJECT
1990

This record contains early drafts of material to be edited for eventual publication as part of the Palaeogeographic Atlas of Australia, and is issued to make it publically available at an early date. Copies of the data maps, on which the interpretation maps are based, are available separately (1: 5 000 000 scale) from BMR Copy Service (Tel: 062-451374; fax: 062-472728) at a cost of $5.00 each plus postage.

FOREWORD

Palaeogeographic maps are commonly used by research and teaching institutions to present concepts on the geological evolution of a region. They are widely used by the petroleum and minerals industries as an aid to exploration, and by government and industry as the basis for a broad scale assessment of undiscovered resources. Despite their importance, a comprehensive series of Phanerozoic palaeogeographic maps has yet to be produced for Australia as a whole. In order to fill this gap a palaeogeographic map project was initiated in 1984 within the Division of Continental Geology of the Bureau of Mineral Resources, Geology and Geophysics. The project was funded through the Australian Mineral Industries Research Association (AMIRA). Geoscientific input has come not only from BMR geologists and the many exploration geologists with the sponsoring companies, but also from the State Geological Surveys and Mines Departments, universities and individuals with specialist knowledge. We have endeavoured to summarize and interpret this wealth of published and unpublished information in this collection of maps and charts.

Maps of a each geological Period are being published as they are completed. The final product of the project will be a complete series of Phanerozoic maps with a common legend. For each period the same approach to data compilation and interpretation has been taken in order to produce a uniform series of maps, but the authors are individually responsible for interpreting the data for each period.

The compilation of basic information was inevitably one of the most protracted phases of the project, requiring the perusal and summarising of many publications and other documents and the preparation of a comprehensive bibliography. For the most part the data used were in the public domain, but where previously confidential information was released to the project, then this too was incorporated into the data base. Well completion reports were consulted wherever possible and a summary of subsurface data prepared. Detailed stratigraphic data columns were compiled in order to summarise the stratigraphic information for each basin or area in a uniform manner. Rather than trying to compile the maximum number of stratigraphic columns possible, this phase of the project aimed at using the minimum number of columns required to characterise the stratigraphy of a basin as well as the continent as a whole. Two types of information were compiled for each column: basic data and interpretative data. The basic data include formation name, thickness, grain size, lithology, sedimentary structures, fossil assemblages, and biochronological or isotopic age. The interpretative data include inferred depositional environment, provenance, tectonic environment, sea-level changes, and palaeocurrent directions. This detailed stratigraphic information was summarised in a single column and placed within biochronological and radiometric frameworks. A composite set of columns for the whole continent (correlation chart) was then prepared for each period.

The geological time-scale of Harland & others (1982) was used wherever possible, although it was frequently necessary to modify their epoch/stage nomenclature for Australia. The summary stratigraphic columns were used not only for intrabasinal and interbasinal correlations, but also to delineate major time breaks or to determine where major changes in sedimentological or tectonic style took place. The major lithological and tectonic changes and time breaks were then used to determine the palaeogeographically significant time slices in each period.

"Time slices" rather than "snapshots" were used as the basis for the palaeogeographic maps. The difference in the two approaches is that in the case of a snapshot the palaeogeographic map is an attempt to represent the palaeogeography at an instant in time, rather than being a summation of a period of time or time slice. If precise biostratigraphic control is available the snapshot approach gives an accurate representation of the palaeogeography, but it suffers from the disadvantage that data between snapshots are essentially lost. For this reason, and also because of the imprecision of a number of the Phanerozoic time lines, the time slice approach was taken. However, it was also decided that the greatest possible resolution should be attained with the time slices, so that within the limits of our present knowledge the time slices would be short, that is, cover a minimum time span. Nevertheless there is a practical limit to the number of time slices that can be delineated, and in a number of cases significant, but very short-lived, highstands and lowstands of relative sea level cannot be shown. Where several rapidly changing environments succeeded each other in the same area within a time slice, it may be possible to only show one, or if they developed in different areas at different times, although within the same time slice, they may have to be shown as contemporaneous. These limitations should be constantly borne in mind by the user.

With the time slices established, data maps were compiled for each at a scale of 1:5 000 000, summarising the most important data. These maps show areas of outcrop, subcrop (where established by drilling) and inferred subcrop, and well intersections of rocks within the time slice, and their lithology (using the standard symbols already used for the stratigraphic columns), including the presence of such environmentally significant minerals as evaporites, collophane (phosphorites), glauconite and organic matter. Where available, measured current directions are indicated, and generalised isopachs or spot thicknesses shown.

Maps showing the structural elements for each period were compiled, as major structural features are likely to have profoundly influenced the palaeogeography. Palinspastic reconstructions have not been used because of the lack of an accepted set of reconstructions for much of the Phanerozoic.

Finally, the palaeogeographic maps were interpreted from the data maps for each time slice. Early in the project it was decided that all maps would be compiled and drawn using computer-assisted drafting techniques, not only because this was more economical, but also because data can be manipulated and the maps readily upgraded as new data become available.

It is our hope that this series of palaeogeographic maps together with the stratigraphic columns, data maps, structural elements map, and the accompanying text provides an account of the Phanerozoic history of the continent that is not only comprehensive and informative, but will also prove to be a valuable aid in the search for and assessment of Australia's mineral and energy resources.

CONTENTS

LIST OF FIGURES

SUMMARY

Initial compilation for this study of the Ordovician palaeogeography of Australia was carried out at the Australian National University in 1980-81 in conjunction with a study of the Cambrian. The Ordovician study was incorporated into the BMR-APIRA Palaeogeographic Maps Project in 1984; since then it has undergone considerable revision.

Forty-five summary stratigraphic columns representing the Australian Ordovician sequences were compiled. Four time slices were then selected to illustrate the Ordovician palaeogeography of the continent: 1. Datsonian-Bendigonian (505-484 Ma); 2. Chewtonian-Yapeenian (484-479 Ma); 3. Darriwilian (479-469 Ma): and 4. Gisbornian-Bolindian (469-438 Ma). The time scale used is that of Harland and others (1982), however the Ordovician/Silurian boundary follows Strusz (1989). Data maps and interpretive palaeogeographic maps were compiled for each time slice. A Cambro-Ordovician structural features map was used to aid compilation of the palaeogeographic maps.

Biostratigraphic correlation between the Ordovician cratonic and Fold Belt areas is often difficult to establish. Sequences throughout the Fold Belt can be correlated using the Victorian graptolite zonation, which can also be tied to the international schemes, however its usefulness in the cratonic basins is limited. Conodont faunas provide a means of correlating both within Australia (including between the craton and the Fold Belt) and internationally; shelly faunas are also used for interbasinal correlation.

During the Ordovician Australia lay on the northern margin of Gondwana, the craton bordered by a tectonically active margin (now represented by the Tasman Fold Belt System). There is considerable debate about the nature of this margin (convergent or not?) and about the nature of the crust in eastern Australia at this time (continental or oceanic?). The model used during compilation of these maps is that the relatively stable Australian craton was flanked to the east by a convergent margin with a westerly dipping subduction zone; a marginal sea lay to the west of the volcanic arc (which may have developed on a sliver of continental crust), and an abyssal plain and trench to the east. Arc volcanism

and deep water turbidite deposition occurred in the Fold Belt throughout the Ordovician, however Late Ordovician volcanics and turbidites are especially abundant. Gold and copper mineralisation is associated with the arc volcanics in a number of localities in New South Wales.

The most striking palaeogeographic feature of the Early Ordovician was the establishment of the Larapintine Sea, a trans-cratonic seaway linking the Canning and Amadeus Basins with the open ocean to the east and west. This seaway probably developed in response to a eustatic sea level rise and was the site of deposition of phosphorites and organic-rich shales. The seaway reached its maximum extent during the Middle Ordovician, but had disappeared by the Late Ordovician. The fall in relative sea level that is reflected in the Late Ordovician palaeogeographic patterns may be due to eustasy, regional tectonics or both. Nevertheless, a marked change in palaeogeography occurred in the Late Ordovician, with the marine environments that had prevailed in most cratonic basins replaced by paralic and continental depositional environments, or by the complete cessation of deposition.

Much of the southeastern part of the craton and parts of the Fold Belt were affected by the Late Cambrian-Early Ordovician Delamerian Orogeny. This period of folding, metamorphism and uplift was accompanied by the emplacement of mostly granitic intrusives. Coarse detritus was shed off uplifted highlands in the southeastern corner of the craton, however the effect on most cratonic basins appears to have been minor.

INTRODUCTION

This record is the preliminary edition of the Ordovician palaeogeographic maps folio. The folio is one of a series depicting the palaeogeographic evolution of Australia through the Phanerozoic, and together with a set of Cambrian maps, was the first period to be compiled in the Phanerozoic Palaeogeographic Maps of Australia study. The early Palaeozoic is perhaps the most difficult era for which to provide palaeogeographic maps; this is the result of limited biostratigraphic control for many sequences, the difficulties in correlating from the Fold Belt to the craton, and the structural complexity of the Fold Belt. Despite these difficulties a number of generalized Ordovician palaeogeographic maps for the continent have been produced, notably by Brown and others (1968), Cook (1972), Veevers (1976), Webby (1978), Veevers (1984) and Wilford (1983). Detailed palaeogeographic studies have also been undertaken in specific areas such as the Amadeus Basin (Wells & others, 1970; Wells, 1976; Gorter, in press; Walley & Cook, in press), the Georgina Basin (Shergold & Druce, 1980; Radke, 1980; Draper, 1977), the Canning Basin (McTavish & Legg, 1976; Brown & others, 1984; Legg, 1987), and the Tasman Fold Belt (Crook & Powell, 1976; Cas & others, 1980; Cas, 1983; Powell, 1984).

However, given its economic significance in Australia, it is perhaps surprising that greater attention has not been paid to the Ordovician, particularly to its palaeogeography. This economic significance is derived, for example, from the presence of mineralization throughout the Tasman Fold Belt. Ordovician sediments in the Amadeus Basin and Canning Basin are host to oil and gas and, in addition, there are thick sequences of black organic rich mudstones and claystones which may constitute petroleum source rocks. Similarly there are important Ordovician evaporites which could potentially contain potash-rich salts, and Ordovician phosphorites are widespread in the Amadeus and Georgina Basins. The occurrence of virtually all of these resources can be related to Ordovician palaeogeography. It is hoped that the maps provided in this record/folio will assist the search for, and the assessment of, resources that occur within rocks of Ordovician age.

Initial compilation of the Ordovician palaeogeographic maps and correlation chart took place in 1980/81. They were considerably revised in 1984 when the Harland

and others (1982) time scale was adopted. Further updating was done in 1987, 1989 and 1990, however the revised time scale of Webby and Nicoll (1989) could not be incorporated. The Ordovician/Silurian boundary used here (434 Ma) follows Strusz (1989).

ACKNOWLEDGEMENTS

F. Jeffries (Esso Australia Ltd) encouraged the early phase of this study, which was initiated whilst the authors were at the Research School of Earth Sciences, Australian National University. K.A.W. Crook (ANU) contributed his wide knowledge of the Tasman Fold Belt and his help was greatly appreciated. C.A. Brown and P.N. Southgate (ANU) compiled some of the basic data. Essential biostratigraphic information was provided by P.J. Jones, R.S. Nicoll, and J.H. Shergold (BMR). Comments on early drafts of the maps and the provision of additional published and unpublished data by the State Geological Surveys and Mines Departments was a most valuable contribution to the maps and stratigraphic columns. Most of the computing requirements for the Palaeogeographic Maps Project were provided by S. Holliday (BMR). Cartography was carried out by staff of the Computer Assisted Drafting and Colour Design Groups of the BMR Drafting Office; we would especially like to thank G.A. Young. Figures for this record were drafted by P.J. Brown. C.R. Scotese kindly allowed us to use a set of Ordovician plate tectonic reconstructions. J.P. Cook provided assistance with typing. Comments on the text were given by G.E. Wilford, H.I.M. Struckmeyer, A.M. Walley, P.E. O'Brien, D. Wyborn, J.R. Laurie, R.J. Korsch, M. Owen, and R.P. Langford. J. Bailey of the Petroleum Division of the Australian Mineral Industries Research Association (APIRA), was most supportive of the Project. Finally a large number of people, from the BMR, the APIRA sponsoring companies, universities and the Geological Surveys, have freely contributed time and information to the Project. To all those people we offer our thanks.

CORRELATIONS

As an essential adjunct to the preparation of maps for the Palaeogeographic Maps Project, a number of detailed biostratigraphic charts and accompanying notes are being prepared for all Periods. The recently published Ordovician biostratigaphic charts and explanatory notes (Webby & Nicoll, 1989) document all the primary biostratigraphic data on which many of the maps and summary charts in this folio are based. Therefore discussion herein is restricted to the major biostratigraphic features and problems of the Ordovician as they relate to the preparation of the palaeogeographic maps.

Correlation of Ordovician sedimentary sequences throughout the continent is difficult to achieve, with few common faunal elements between the shallow "shelly" faunas of the craton and the deep water faunas of the Tasman Fold Belt. The original zonation for the Fold Belt was based primarily on the graptolite zones and stages of the Victorian succession (e.g. Thomas, 1960; Beavis, 1976; Webby, 1976) which have in turn been linked to the European and North American stages with varying degrees of confidence. Graptolites, whilst not abundant, do occur in some of the cratonic sequences, notably in the Canning and Amadeus Basins. However, as pointed out by previous authors (McTavish & Legg, 1972; Webby, 1978), there are major differences in the graptolite faunas of the cratonic and Fold Belt areas; for example, *Didymograptus artus* is abundant in the Canning and Amadeus Basins, but it does not occur in the Victorian succession - the reverse case can be demonstrated for other species and faunas (Webby, 1978). There are also few radiometrically-dated Ordovician sequences in the Fold Belt or the craton. Ordovician ages have been obtained for a number of granites in the Kanmantoo Trough area which provide a minimum age limit for the sediments; within the craton there are no Ordovician volcanics or granites to date. Glauconitic sequences exist and may hold some promise for dating, however the precision likely to be achieved from such dating is presently less than that achievable through biostratigraphy.

Perhaps the best tie lines are those provided by conodonts, which give a link between international zonations, the Fold Belt and basins of the craton. Conodont faunas have been described from the Warburton (Cooper, 1986), Amadeus

(Cooper, 1981; Shergold & others, in press), Georgina (Druce & Jones, 1971; Shergold & Druce, 1980) and Canning (McTavish, 1973; McTavish & Legg, 1976) Basins, and from a number of localities in the Tasman Fold Belt including Tasmania (Burrett, 1979) and the Canberra area (Nicoll, 1980). However, conodonts provide only a limited number of ties and a considerable amount of extrapolation is necessary for the intervals between them. Shelly faunas offer good prospects for inter-basinal correlations. The Ordovician faunas of the Amadeus Basin in particular are well developed and together with the coexisting conodont and graptolite faunas should provide a higher degree of inter-basinal correlation than is currently achievable. Work on this is presently in progress (Shergold & others, in press). Shelly faunas may also provide the potential for more accurate correlation between the craton and the Ordovician sequences of Tasmania, and perhaps also with Asia. Jell and others (1984), Burrett and Stait (1985, 1987) and Stait and Burrett (1987) have demonstrated the value of shelly faunas, including nautiloids, for correlation between southeast Asia and Australia.

Within individual cratonic basins the degree of biostratigraphic resolution is quite variable.

AMADEUS BASIN

The Ordovician sequence of the Amadeus Basin comprises up to 2000 m of sediments of the Larapinta Group in the northern part of the basin but thins considerably to the south. The Larapinta Group was defined by Wells and others (1970) following the earlier work of Tate (1896), Madigan (1932), Chewings (1935) and Prichard and Quinlan (1962). The Ordovician rests conformably on the Cambrian in many parts of the basin, and is overlain by ?Silurian-Devonian Mereenie Sandstone. Although the Ordovician Larapinta Group contains a diverse and abundant fauna, including bivalves, brachiopods, trilobites, gastropods, nautiloids, conodonts and other microfossils, detailed work on the biostratigraphy of the basin has only recently been undertaken (Cooper, 1981; Shergold & others, in press). It is anticipated that this will ultimately lead to a well defined faunal scheme that will provide a standard for all the cratonic basins. At present, only a generalized zonation is available.

CANNING BASIN

Ordovician sediments crop out mainly on the northern margin of the Canning Basin, but are present in the subsurface throughout most of the basin, reaching a thickness of greater than 2000m. The base of the Ordovician has not been reached in outcrop, however rocks as old as late Tremadocian were encountered in Samphire Marsh No. 1 (McTavish & Legg, 1976). The base of the Ordovician section, where it has been intersected in sub-surface or seen in outcrop, is an unconformable contact between Ordovician sediments and Precambrian rocks or Early Cambrian basalts. Cambrian sediments have not been intersected in the Canning Basin but they may be present. The upper contact of the Ordovician sequence is somewhat uncertain; well-dated middle Ordovician sediments are overlain by the Carribuddy Formation, which has uncertain biostratigraphic affinities. Koop (1966), Veevers (1967, 1971) and Glover (1973) have all suggested that the Carribuddy Formation may be in part Ordovician. McTavish and Legg (1976), however, favoured a Devonian age for the Carribuddy Formation, as originally suggested by Combaz and Peniguel (1972). More recent information now supports inclusion of at least the lower part of the Carribuddy Formation in the late Ordovician (R.S. Nicoll, BMR, pers. comm.). Various biostratigraphic schemes have been suggested for the Canning Basin. The most comprehensive of these, based on both microfossils and macrofossils, was developed by McTavish and Legg (1976). They proposed a scheme comprising 10 macrofossil zones, 10 conodont zones and 5 microflora zones which provides ready correlation with the Amadeus Basin in particular, although recent information (Nicoll & others, 1988) suggests a need to revise some of the earlier correlations between the Amadeus and the Canning. Legg (1987) suggested that it is possible to recognize six discrete periods of Ordovician deposition in the Canning Basin based on six faunal (trilobite-graptolite-conodont) units.

GEORGINA BASIN

A well developed sequence, spanning almost the entire Ordovician, occurs along the southern margin of the Georgina Basin, reaching a thickness in excess of 1000 metres in places (Draper, 1980b). The Ordovician rests conformably on the Cambrian and is unconformably overlain by ?Devonian or younger sediments. Using trilobites and conodonts Shergold and Druce (1980) developed a biostratigraphic scheme based on the earlier work of Jones and others (1971) and Shergold and others (1976). This scheme provides a high degree of biostratigraphic resolution within the shallow marine carbonates and allows correlation between the Lower Ordovician successions in the Georgina, Daly and Bonaparte Basins. Webby (in Webby & others, 1981), however, suggested that the scheme was of limited usefulness for correlation purposes outside northern Australia. Nevertheless, the scheme makes it possible to develop a fairly accurate picture of the Cambro-Ordovician palaeogeography of northern Australia, particularly the Georgina Basin (see Shergold & Druce, 1980).

DALY BASIN

In excess of 500 m of Ordovician sediments occur in the Daly Basin, resting conformably on Cambrian sediments in some areas and unconformably on Cambrian sediments or volcanics elsewhere. The top of the Ordovician interval is everywhere an erosional surface. Biostratigraphic control, whilst not well defined, allows correlation with the Georgina Basin sequence to the southeast; the sequence appears to be entirely of early Ordovician (Datsonian to Bendigonian) age (Jones, 1971).

BONAPARTE BASIN

The Ordovician section in the Bonaparte Basin is composed of up to 180 m of sandstone. It conformably overlies Cambrian sediments but the top of the sequence is everywhere eroded. The age of the sequence (Early Ordovician) has been established on the basis of conodonts and a shelly fauna (Kaulback & Veevers, 1969). A single radiometric age on glauconites from the Pander Greensand indicates a minimum age of Lower Ordovician (Kaulback & Veevers, 1969). There is no well-defined Ordovician biostratigraphic scheme available for the Basin.

WISO BASIN

A sequence of sediments containing shelly fossils and conodonts of Ordovician (Arenig-Llanvirn) age (Hanson River beds) occurs in the Wiso Basin. The upper and lower contacts are probably disconformable. No detailed biostratigraphy is available for the Wiso Basin but Kennewell and Huleatt (1980) proposed correlation with the Amadeus (Larapinta Group) and Georgina (Carlo-Mithaka-Nora Formations) sequences. Radiometric ages ranging from 465-441 Ma obtained on glauconites from Unit 2 of the Hanson River beds (Kennewell & Huleatt, 1980), appear to be too young in relation to the overlying faunas.

NGALIA BASIN

Up to 1000 m of ?Ordovician sediments are present in the Ngalia Basin but fossils are absent and the suggested Ordovician age (Wells & Moss, 1983) is based solely on lithological similarity with the Larapinta Group of the Amadeus Basin. Cooper and others (1971) provided a few ages on glauconites in the Ngalia Basin. The Djagamara Formation gave a late Ordovician (447 Ma) age although they considered that this was a minimum age and that a true age of around 475 Ma (Early Ordovician) was more likely (Wells and Moss, 1983).

OFFICER BASIN

There is no biostratigraphic scheme available for the Officer Basin. Correlations are based essentially on lithological similarity (Jackson & van de Graaff, 1981; Kreig, 1973). Up to 2000 m of ?Ordovician sediments are present in the eastern parts of the basin, resting disconformably on probable Cambrian sediments and unconformably overlain by ?Devonian sediments.

WARBURTON BASIN

A large number of exploration wells have intersected the Ordovician Dullingari Group, which may be several kilometres thick, but only three of these have provided biostratigraphic information (Gatehouse, 1983, 1986). Grapolite remains indicate an Early to Middle Ordovician age (Daily, 1963). The discovery of conodont remains in the partly coeval "Innamincka Red Beds" (Cooper, 1986) provides a more definite age of early Arenig for part of the Dullingari Group, slightly older than the mid-Arenig Horn Valley Siltstone of the Amadeus Basin (Cooper, 1981).

BANCANNIA TROUGH/GNALTA SHELF

A thick sequence (approximately 2800 m in the Scopes Range area) is present in this region but, in general, ages are poorly constrained. Webby (1976) and Shergold (1971) reported that there are faunal similarities between the Horn Valley Siltstone of the Amadeus Basin (which has a well-constrained Arenig age) and the Tabita Formation of the Gnalta Shelf area, but few other biostratigraphic control points are available.

KANMANTOO TROUGH

The Kanmantoo Trough is a Cambrian depositional feature; sedimentation ceased in the Late Cambrian as a result of the commencement of the Delamerian Orogeny. During the orogeny a series of granites with ages extending into the Ordovician were intruded into the sedimentary sequence (White & others, 1967; Thomson, 1969; Webb, 1976; Milnes & others, 1977; Cooper & Grindley, 1982). These do not provide any stratigraphic control, other than minimum ages for the sediments they intrude, but do provide some age constraints for the Delamerian Orogeny.

LACHLAN FOLD BELT

Tasmania: The Ordovician sequence comprises the clastics of the upper Denison Group and equivalents, and the carbonates and minor siliciclastics of the Gordon Group. This sequence contains a varied fauna (including stromatoporoids, corals, brachiopods, bivalves, gastropods, cephalopods, trilobites, conodonts and graptolites) which allows correlation within Tasmania, regionally and internationally (Banks & Baillie, 1988). Banks and Burrett (1980) proposed a preliminary biostratigraphic system for Tasmania based on these faunas, which comprises twenty faunal assemblages (OT 1 to 20). These assemblages can be correlated with North American and Asian assemblages.

Victoria: The Ordovician sedimentary sequence of eastern and central Victoria contains an extremely rich and diverse graptolite fauna. It provides the type sequence for the biostratigraphic subdivision of the Ordovician in eastern Australia and New Zealand, and can be correlated with the standard British Series. The Lower Ordovician sequence was divided by Hall (1895, 1899, 1912, 1914) into stages or series. This scheme was further developed and refined by Harris (1916, 1933, 1935), Harris and Keble (1932), Harris and Thomas (1938b), Thomas (1960) and VandenBerg (1981). The Upper Ordovician sequence was first subdivided by Thomas and Keble (1933) into three stages. This scheme was further subdivided and refined by Thomas (1935, 1960), Harris and Thomas (1938b) and VandenBerg (1981). In recent years conodonts have also become important biostratigraphic tools for dating both the graptolitic and non-graptolitic Ordovician sequences (Cas & VandenBerg, 1988).

New South Wales: The Upper Ordovician limestones of New South Wales contain a rich coral-stromatoporoid fauna. Webby (1969, 1972, 1975) proposed a biostratigraphic subdivision for use in local correlation, based on four faunal assemblages (Faunas I-IV); Fauna III has since been divided into IIIa and IIIb (Webby & others, 1981). Both Sherrard (1954, 1962) and Sherwin (1971, 1973) have produced Ordovician graptolite zonal schemes for sequences in New South Wales, however their correlation with each other or with the Victorian scheme is imprecise (Webby, 1976).

TAMWORTH TROUGH

Allochthonous limestone blocks within a number of fault blocks in the Tamworth Trough have yielded Middle-Late Ordovician conodonts and diverse Late Ordovician coral assemblages, both with North American affinities (Webby, 1987).

NORTHERN QUEENSLAND

The Cambro-Ordovician rocks of the Mount Windsor Subprovince are assigned to the Seventy Mile Range Group, a possibly 12 km thick sequence of volcanics and marine sediments. Henderson (1983) recognised four biostratigraphic assemblages (A-D) within the two youngest formations of the group, which could be correlated with the Victorian Stage divisions. A coral fauna in the Carriers Wells Limestone (a partial equivalent of the Wairuna Formation) of the Broken River Province can be correlated with Fauna IV assemblages of the Molong High in New South Wales. Some aspects of the fauna indicate affinities with Asia and Alaska (Webby, 1987). A diverse conodont fauna has been described from Ordovician sediments of the Anakie Inlier. This fauna has some North American links (Webby, 1987).

This biostratigraphic framework has allowed the correlation of Ordovician sequences across the continent, and the subsequent delineation of four time slices. The limits of these time slices are generally based on the recognition of regionally significant breaks or changes in sedimentation and changes in depositional environment. The duration of the time slices ranges from five to thirty-five million years.

TECTONICS

INTRODUCTION

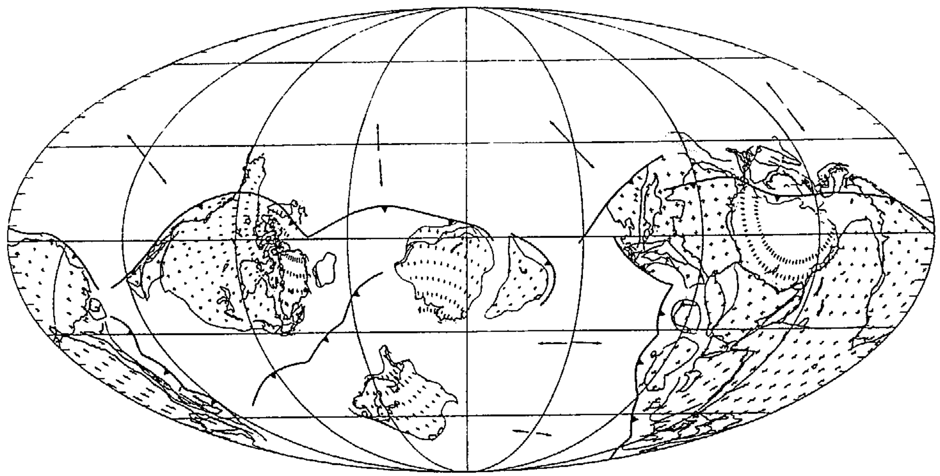
During the Ordovician Australia lay in low to equatorial latitudes on the northern margin of Gondwana (Scotese, 1986, in press; Fig. 1). A broad, relatively stable Proterozoic craton was flanked to the (then) south and west by a number of southeast Asian microcontinents, and to the (then) north by a probably convergent margin, now represented by the Tasman Fold Belt System. Various models have been proposed to explain the tectonic evolution of the Tasman Fold Belt System, particularly the Lachlan Fold Belt and some of these are discussed below. Orogenesis affected the southeastern corner of the craton and adjacent areas of the Tasman Fold Belt System in the Late Cambrian-Early Ordovician (Delamerian Orogeny) and most of the Lachlan Fold Belt in the latest Ordovician-Early Silurian (Benambran Orogeny). Deposition occurred throughout most of the Ordovician in a number of intracratonic basins such as the Amadeus, Canning, and Georgina basins; in other intracratonic basins (for example, the Bonaparte, Wiso and Warburton basins) deposition was less continuous. A period of uplift and deformation, the Rodingan Movement, affected a number of the central Australian basins, possibly in the Late Ordovician.

The Cambro-Ordovician structural features map included in this folio is the same as that published previously in the Cambrian palaeogeographic atlas (Cook, 1988). This map illustrates the major tectonic features that influenced deposition during the Cambrian and Ordovician; the reader is referred to Cook (1988) for a full discussion of the map. Aspects of Australia's tectonic history particularly relevant to the Ordovician are, however, outlined below.

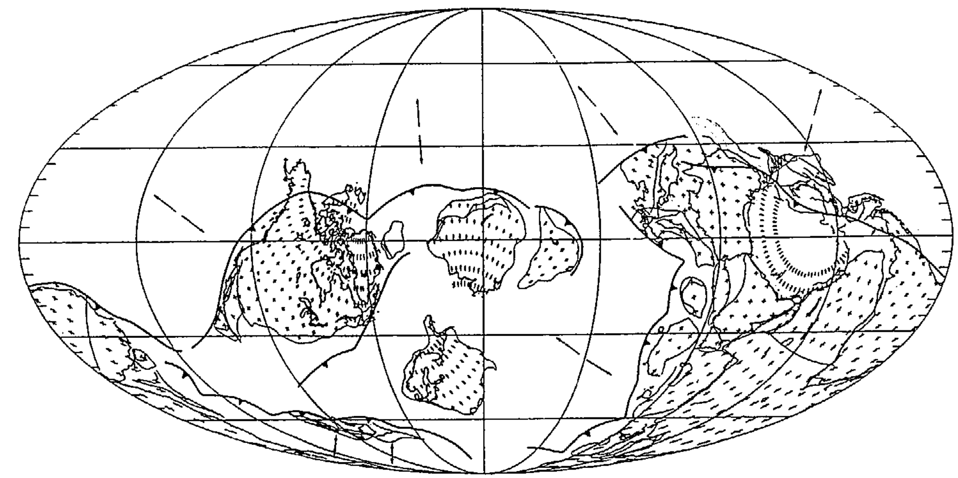
PLATE TECTONIC SETTING

Lachlan Fold Belt

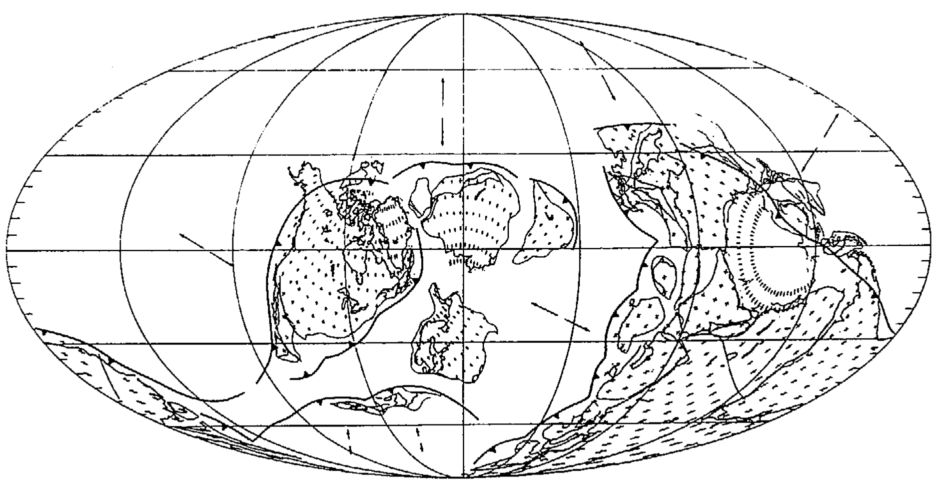
In order to compile palaeogeographic maps of fold belt areas, a model of the tectonic evolution of the region needs to be adopted. However, despite the amount of work that has been done on the Tasman Fold Belt, its palaeogeographic



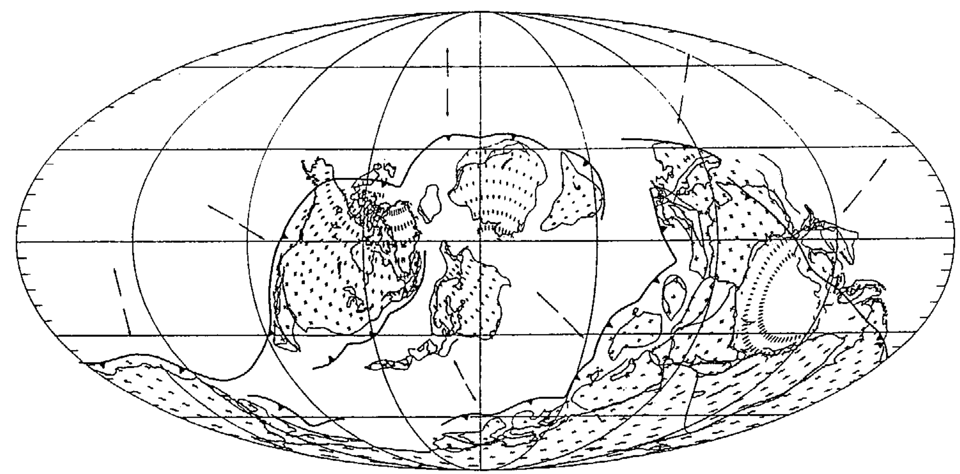
Earliest Ordovician (Tremadoc)



Early Ordovician (Arenig)



Middle–Late Ordovician (Llandeilo–Caradoc)



Late Ordovician (Ashgill)

Figure 1. Ordovician plate tectonic reconstructions; arrows indicate areas of probable plate divergence (courtesy of C.R. Scotese).

and tectonic settings remain obscure. As Coney (1988) noted, "unambiguous plate tectonic settings are not commonly recognised, or those that are recognised are not always agreed upon by general consensus". Numerous tectonic models have been put forward to explain the distribution of facies in the Ordovician of southeastern Australia (Lachlan Fold Belt). Most of the proposed models (e.g. Oversby, 1971; Solomon & Griffiths, 1972; Packham, 1973; Scheibner, 1973a, 1976, 1985, 1989; Cas & others, 1980; Cas, 1983; Powell, 1983, 1984) agree on a number of basic tectonic and physiographic elements, i.e. a westerly dipping subduction zone, the volcanic arc flanked to the west by a marginal sea, and to the east by abyssal plain and trench (Fig. 2). Crook (1980) interpreted the tectonic development of the Lachlan Fold Belt in terms of the successive accretion and subsequent cratonisation of a number of intra-oceanic volcanic arcs. The apparent presence of some pre-Ordovician continental crust in the Fold Belt (see below) and the lack of demonstrable successive arc - fore-arc - accretionary prism sequences argues against this model. Crook's model was used for the Cambrian palaeogeographic atlas, including the Cambro-Ordovician structural features map (Cook, 1988), as this was thought to be the most applicable model available at the time of compilation (i.e. 1981). The "terrains" and Siluro-Devonian extensional features shown on the structural features map in southeastern Australia are therefore those of Crook (1980). The Ordovician palaeogeographic maps, however, are based on the tectonic model for the evolution of the Lachlan Fold Belt of Cas and others (1980) and Powell (1983; 1984). This model, which retains and incorporates some features of models developed by earlier writers, particularly Scheibner (1973a, 1976, 1985, 1989), is one of continental-margin arc-splitting with marginal sea formation, i.e. a continental volcanic arc or continental sliver split prior to the Ordovician, creating a passive continental margin and a young, ocean-floored marginal sea behind it. The volcanic arc, which by the Late Ordovician stretched from Louth, near Cobar, south to Kiandra, was thus established on a basement of pre-Ordovician continental crust or on the remnants of a postulated Cambrian island arc. This is similar to Scheibner's model, in which the Ordovician volcanic arc developed on the eastern margin of the hypothetical Molong microcontinent in the Late Cambrian-Early Ordovician. Scheibner suggested that the Wagga Marginal Basin (Wagga Trough) may be partly, or wholly, a remnant from an earlier marginal sea between the Victorian and Molong microcontinents. Scheibner's model differs from

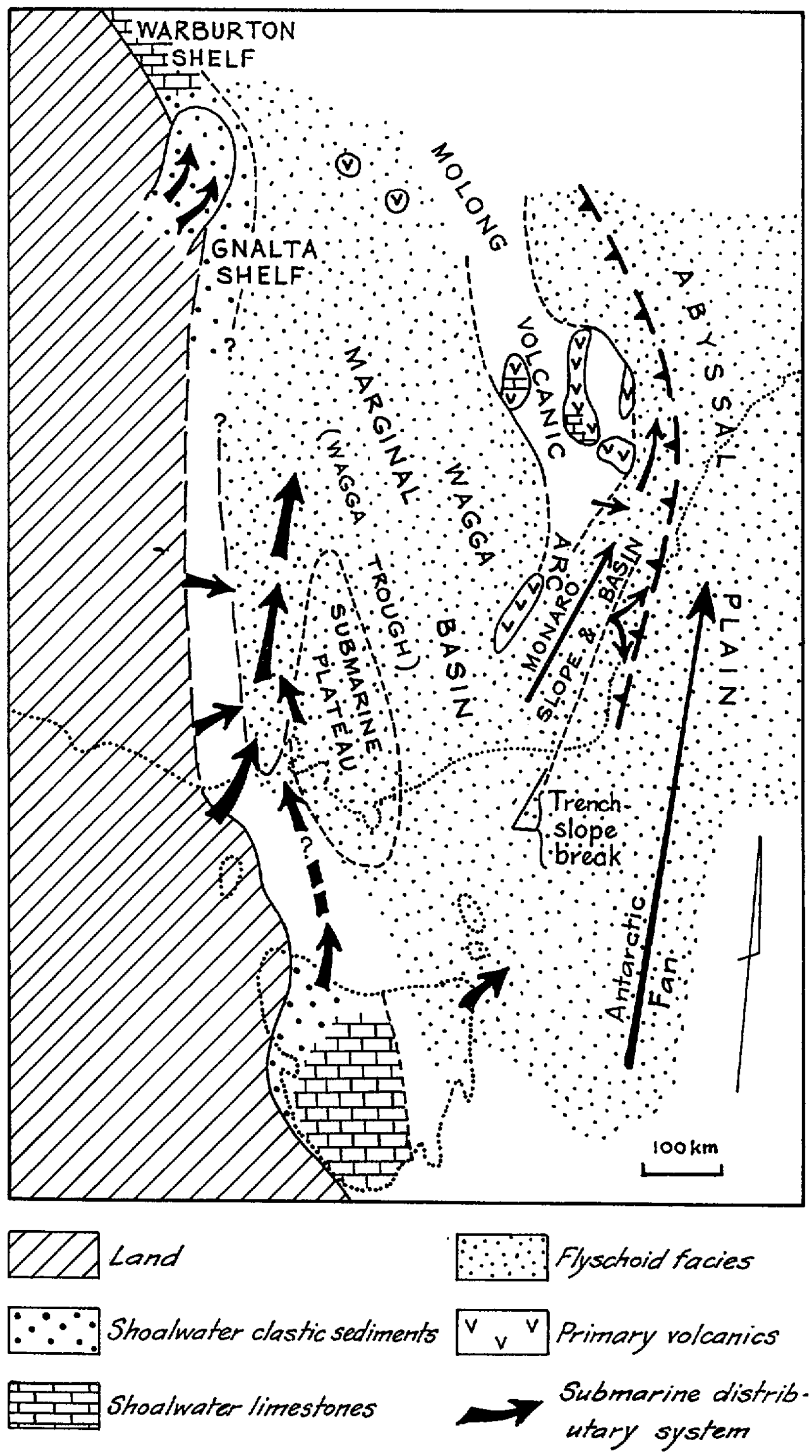


Figure 2 Late Ordovician facies patterns of southeastern Australia (adapted from Powell, 1983)

that of Cas and Powell in that it invokes interarc rifting in the Parkes area in the Early Ordovician, and the arrival of an oceanic plateau at the subduction zone in the Late Ordovician, with subsequent tectonic underplating, and arc reversal in the latest Ordovician. Scheibner (1989) also argued that on geophysical evidence (e.g. Murray & others, 1989), the volcanic arc had a near meridional orientation and did not veer northwestwards, as suggested by Cas and others (1980).

Using the Cas/Powell model, the Ordovician of southeastern Australia can be divided into four main depositional and tectonic realms (Cas, 1983; Powell, 1984; Fig. 2): a western belt of shallow-water marine to terrestrial clastics and carbonates, commonly with conglomerates towards the base, deposited in continental shoreline and shelf environments; an extensive central zone of relatively deep-water clastics (turbidites) deposited in a marginal sea (Wagga Marginal Basin or Trough); a central-eastern belt of mafic-intermediate volcanics and associated limestones deposited in a volcanic island arc; and an eastern zone of turbiditic terrigenous clastics, black shales and mafic volcanics that are interpreted as fore-arc basin and accretionary prism deposits. The Ordovician sedimentary sequences in the Lachlan Fold Belt are dominantly quartz-rich indicating derivation from the craton; volcaniclastic sediments are much less abundant and are found only in association with mafic-intermediate volcanics and carbonates of the volcanic arc.

A number of authors, however, disagree with such models and have questioned the existence of any oceanic crust or subduction related processes during the Ordovician. Rutland (1976) proposed that thin, Precambrian continental crust extended under most of the Lachlan Fold Belt. Geochemical studies of the Silurian-Devonian granitoids of southeastern Australia (e.g. Wyborn & Chappell, 1979; Compston & Chappell, 1979; McCulloch & Chappell, 1982) also suggest that some pre-Ordovician continental crust was present in the Fold Belt. Using geochemical characteristics, Chappell and White (1974) divided granitoids into two distinct groups, I-type and S-type: I-type granitoids are those derived from igneous source rocks, and S-type granitoids from sedimentary source rocks. Chappell and others (1988) argued that most S-type granitoids in the Lachlan Fold Belt were produced by partial melting of thick, unexposed pre-Ordovician metasedimentary crust, and that the I-S line, which separates I-type granitoids in the east from dominantly S-type granitoids in the west (White & others, 1976; Shaw & others, 1982), represents the eastern limit of that crust. Chappell and others (1988) proposed that the Lachlan Fold Belt consists of a number of distinct blocks of continental lithosphere, which they termed basement terranes. They interpreted these basement terranes as Proterozoic microcontinents which assembled prior to the Ordovician.

Owen and Wyborn (1979) demonstrated that many of the Ordovician volcanics have the chemical characteristics of a particular basaltic association, shoshonites. They argued that the controversy surrounding the tectonic setting and petrogenesis of Cainozoic shoshonites prevented a determination, by analogue, of the plate tectonic setting of the Ordovician Molong Volcanic Arc. Morrison (1980) proposed that shoshonites are characteristic of orogenic areas and occur above the deeper parts of the Benioff zone. Other authors (e.g. Meen & Eggler, 1987; Wyborn, 1988), however, have argued that subduction has little or no influence on the genesis of shoshonites and that they are derived from older subcontinental lithospheric mantle. The role of subduction in the genesis of shoshonites is therefore equivocal. Owen and Wyborn (1979) argued that the most that could be said about the tectonic conditions under which the Ordovician shoshonites had been generated was that the mantle underlying the arc had been modified. This modification may have been caused by subduction (although subduction need not have been contemporaneous with volcanism) or by the incorporation of material from the low-velocity zone into the mantle (Owen & Wyborn, 1979). Wyborn (1988) argued that the contrasting Late Ordovician and Early Silurian tectonic regimes are not easily resolved with models involving continental collisions and proposed that the Ordovician volcanics developed on thin continental crust. Certain conditions in the mantle (perhaps foundering of the subcontinental lithosphere) triggered melting of the lithosphere to produce the shoshonites, which show a broader distribution pattern (see Fig. 2) than the curvilinear belts typical of island arcs (Wyborn, 1988). Scheibner (1989) attributed this distribution to Silurian extension.

Northern Tasman Fold Belt System

The tectonic relationships between the Lachlan Fold Belt and sections of the Tasman Fold Belt System further north are difficult to establish. The palaeogeographic and tectonic significance of allochthonous blocks of fine clastics and limestones of Ordovician age in the Tamworth Trough (Tamworth Terrane of Cawood & Leitch [1987]) is poorly understood (Webby, 1987). Their occurrence within Devonian-Carboniferous convergent margin sequences suggests that they are probably allochthonous, and therefore they may have little bearing on the Ordovician palaeogeography of southeastern Australia (Powell, 1984). However, it has been suggested (Cawood & Leitch, 1987) that the Tamworth Terrane and Lachlan Fold Belt were in close proximity during the Early Palaeozoic and that the Cambro-Ordovician clastics of the Tamworth Terrane were sourced by the arc volcanics of the eastern Lachlan Fold Belt.

Henderson (1986) proposed that the Lower Ordovician succession near Charters Towers in northern Queensland (Mount Windsor Sub-province) was deposited in a north-south oriented back-arc basin, formed by continental extension, which lay to the west of an Andean-type volcanic chain (as the palaeogeographic maps are not palinspastic it is difficult to illustrate these tectonic relationships accurately). An early bimodal phase of the Ravenswood Batholith was intruded into rocks of the Mount Windsor Sub-province during the ?Early-Middle Ordovician. Partial melting was probably caused by the underplating of thin Proterozoic to Early Palaeozoic continental crust by mantle derived mafic material; this event took place about 480 Ma (Hutton & others, 1990). These conclusions are not inconsistent with Henderson's (1986) back-arc spreading hypothesis. The Middle-Upper Ordovician rocks of the Broken River Province are also believed to have been deposited in volcanic arc and back-arc basin settings (Withnall & others, 1988). The relationship or connection between the proposed convergent margin segments in the Lachlan Fold Belt and northern Queensland is uncertain, as this area is obscured by younger fold belts and basins. Powell (1984) proposed that much of the plate boundary between these segments was a transform margin.

Tasmania

The geographic position of Tasmania (or the terranes that subsequently made up Tasmania) during the Early Palaeozoic has been the subject of some debate. Many authors have favoured the view that Tasmania occupied essentially its present position and was part of the cratonic margin of Australia during the Ordovician (e.g. Solomon & Griffiths, 1972, 1975; Webby, 1976, 1978; Cas & others, 1980; Cas, 1983). Crawford and Campbell (1973), however, proposed that Tasmania originally lay further east and that it was transported to its present position during the Early Ordovician when 300 km of dextral movement occurred on a mega-shear parallel to the southern margin of Australia. Daily and others (1973) argued that there was no geological evidence to support such large scale horizontal displacement. Findlay (1987) also proposed that the Tasmanian microcontinent lay well to the east of its present position in the Cambrian, but argued that it reached its pre-Mesozoic break-up position adjacent to northeastern north Victoria Land during a Late Cambrian-Early Ordovician collisional event. Harrington and others (1973) proposed that Tasmania originally lay to the south of the Adelaide Fold Belt and that sinistral movement on the postulated Gambier-Beaconsfield fracture zone took place between the Late Ordovician and the middle Devonian.

Western margin

The tectonic nature of the western margin of the craton during the Ordovician is largely unknown. Various authors (see e.g. Veevers, 1984) have speculated that a divergent continental margin developed along the western edge of the craton during the Cambrian as a result of spreading of the Tethyan Ocean, and interpret the voluminous, probably Early Cambrian Antrim Plateau Volcanics as a product of this rifting. Veevers (1984) suggested that the Early Palaeozoic sediments of the Bonaparte, Canning and Carnarvon basins represent the subsequent fill of "failed arms" initiated during rifting of the northwestern margin.

DELAMERIAN OROGENY

During the Late Cambrian and Early Ordovician, much of South Australia, western Victoria, western New South Wales, Tasmania and parts of Antarctica were affected by the Delamerian Orogeny (Thomson, 1969), a series of at least two, possibly four, orogenic events (Parker, 1986). In South Australia and western Victoria, sediments of the Late Proterozoic-Cambrian Adelaide Fold Belt and the Cambrian

Kanmantoo Trough were uplifted, folded and regionally metamorphosed (Webby, 1978). Preiss (1987) reported that two distinct Delamerian fold phases (an initial meridional to northwest trending set and a second east to east-northeast trending set) can be identified in the Adelaide Fold Belt. Most of the Fold Belt was affected by low-grade (up to greenschist facies) metamorphism, although some areas, such as the eastern and southern Mount Lofty Ranges, underwent higher-grade metamorphism (Preiss, 1987). Syn-orogenic and post-orogenic intrusives of Ordovician age were emplaced throughout the Kanmantoo region and in the Mount Painter Block at the northern end of the Adelaide Fold Belt. These intrusives are predominantly granitic but include some mafic intrusives and dykes. The bimodal nature of the post-tectonic intrusive suite may suggest a period of extensional tectonics shortly after the close of the Delamerian Orogeny (Turner & others, 1989). Parker (1986) suggested that the initial Delamerian orogenic event occurred prior to the emplacement of the Encounter Bay granites at about 515-500 Ma, and the second major event at 495-470 Ma, prior to the intrusion of the Murray Bridge granites. Large bodies of carbonate-cemented breccias that occur in the Flinders Ranges have been interpreted as diapirs (Webb, 1960), many of which show evidence of intrusion during a late phase of the Delamerian Orogeny (Preiss, 1987). Some diapirs that first developed in the Precambrian or Cambrian were remobilised during this period; the late-phase breccias were emplaced as apophyses or plugs (Preiss, 1987).

There is sedimentological evidence of uplift during the Late Cambrian-Early Ordovician. At this time there was an influx of coarse clastic material into shallow marine and non-marine environments in western New South Wales and Tasmania. A delta was established on the Gnalta Shelf fed by the uplifted hinterland of the Adelaide Fold Belt to the south and west. In western Tasmania the Cambro-Ordovician Owen Conglomerate and equivalents were derived from the uplifted Precambrian basement (Tyennan Block) to the east and south. There is also evidence of a widespread Early Ordovician thermal event in western Tasmania which reset Rb-Sr and K-Ar systems (Adams & others, 1985). Deformation of Cambrian sediments at Rosebery has been dated at 470±8 and 474±3 Ma (Adams & others, 1985) and Rb-Sr dating of the Leven Gorge dyke in the Dial Range Trough has given an age of 480±18 Ma (Jago & others, 1977); the associated Lobster Creek Volcanics have been dated at 456±22 Ma (Adams & others, 1985). Stratabound base-metal sulphide mineralisation within the Gordon Limestone has also been attributed to this thermal event (Collins & Williams, 1986).

The Delamerian Orogeny has been attributed to convergence between a microcontinental block (the "Victorian microcontinent" of Scheibner [1985]) or a rifted marginal plateau, and the Precambrian cratonic margin (Brown & others, 1988). Scheibner (1985) regarded the Kanmantoo plutons as terrane stitching orogenic granites. However, Preiss (1987) has argued that until the former existence of oceanic crust and a subduction related trench has been established, the application of a convergent margin model to explain the Delamerian Orogeny will remain speculative, and that an intra-plate origin should be considered as an alternative.

The Delamerian Orogeny has been correlated with the Ross Orogeny that affected areas of neighbouring Antarctica (particularly northern Victoria Land) at the same time (Oliver, 1972; Findlay, 1987). Findlay (1987) interpreted the Cambrian-Ordovician tectonic history of northern Victoria Land, Tasmania and New Zealand in terms of the collision of a tectonically linked system of island arcs and microcontinents with the East Antarctica-Australian sector of the Gondwanan margin.

Large areas of New South Wales and Victoria underwent deformation and granitic emplacement during the latest Ordovician-Early Silurian Benambran Orogeny. This has been discussed in considerable detail by Walley (1987) and Walley & others (in press), and will not be covered in these notes.

INTRA-CRATONIC BASINS

The effect of the Delamerian Orogeny on the cratonic basins is less marked. There, the role of tectonics versus eustasy is often difficult to determine. The hiatus within or at the top of the Kelly Creek Formation in the Georgina Basin (Shergold & Druce, 1980) possibly reflects a local tectonic event, the Kelly Creek Movement (Webby, 1978; Nicoll & others, 1988), and may correlate with a later phase of the Delamerian Orogeny. However, Nicoll and others (in press) proposed that this hiatus, which can be correlated with a break between the Pacoota Sandstone and the Horn Valley Siltstone in the Waterhouse Range area of the Amadeus Basin, is the result of a sealevel lowstand (the Kelly Creek Eustatic Event). Shergold (1986) attributed time breaks within the Late Cambrian Goyder Formation of the Amadeus Basin and its equivalents in other basins to the effects of the Delamerian Orogeny.

Korsch and Lindsay (1989) and Lindsay and Korsch (1989) proposed that the evolution of the Amadeus Basin during the Ordovician was driven by thermal recovery and subsidence following two earlier phases of extension at about 900 and 620 Ma. Thermal subsidence was probably the dominant controlling mechanism behind the evolution of other intracratonic basins, such as the Bonaparte, Ord, Wiso, Georgina, Ngalia, Officer and Warburton, as these basins had also undergone one or two earlier periods of extension (Lindsay & others, 1987). No sediments older than Ordovician occur in the Canning Basin, however, as mentioned previously, it is possible that an early period of extension also took place there, and that subsidence during the Ordovician was therefore controlled by thermal subsidence. Sediment thickness patterns indicate that syndepositional movement took place in the Canning Basin on the bounding faults of grabens (e.g. Willara Sub-basin) and basement highs during the Ordovician (Brown & others, 1984).

Parts of central Australia, including the Arunta Block and Amadeus Basin, were affected by the Late Ordovician Rodingan Movement. The exact timing of this event, however, is the subject of some debate. Wells and others (1970) placed the Rodingan Movement in the Silurian(?) following deposition of the Carmichael Sandstone, stating that a low-angle unconformity exists between the Carmichael and Mereenie Sandstones in the northern and northeastern parts of the basin. Lindsay and Korsch (1989), however, argued that the major break occurs beneath the Carmichael Sandstone, but suggested that as this erosion surface is seismically conformable in large areas of the basin it may be related to basin dynamics rather than orogenesis. Nicoll and others (in press) proposed that the Rodingan Movement occurred during the Late Ordovician following deposition of the Stokes Siltstone, which accumulated during a long period of relative tectonic stability. The sudden change in deposition from mudstone (Stokes Siltstone) to coarse clastics (Carmichael Sandstone) is believed to be a reflection of tectonic activity (Nicoll & others, in press). This view is supported by M. Owen (BMR, pers. comm.), who suggested that the Carmichael Sandstone is more closely related to the Mereenie Sandstone cycle of deposition than it is to the Larapinta Group, and as such could be considered as the basal member of the Mereenie Sandstone. Shaw (in press), however, proposed that the tectonic activity preceding deposition of the Carmichael Sandstone was a precursor to the larger Rodingan Movement, which, as originally defined by Wells and others (1970), is represented by a long time break between the Carmichael and Mereenie Sandstones. However, recent work on the Carmichael and Mereenie Sandstones indicates that the two are conformable with a gradational boundary (M. Owen, BMR, pers. comm.). Based on the isopach maps of Wells and others (1970), Warren (1983) suggested that up to 4000 metres of uplift may have occurred in the Arunta Block to the northeast of the basin during the Rodingan Movement. The northeasternmost part of the basin, adjacent to the Arunta Block, was also uplifted and appears to have been high ground from the time of the Rodingan Movement until the Devonian. In the eastern part of the basin, regional tilting that has been attributed to the Rodingan Movement resulted in the erosion of up to 3000 metres of section (Shaw & Wells, 1983; Lindsay & Korsch, in press). There is evidence of structural growth on anticlines such as the Waterhouse Range Anticline during the Rodingan Movement, probably driven by salt tectonics (Nicoll & others, in press).

PALAEOGEOGRAPHY

TIME SLICE 1: DATSONIAN-BENDIGONIAN (505-484 Ma)

For much of the Late Cambrian a large part of the Australian craton was subaerially exposed (Cook, 1988). This may be attributable largely to the effects of the Delamerian Orogeny; the published sealevel curves of Vail & others (1977) and Hallam (1984) show a steadily increasing sealevel in the Late Cambrian, with a possible fall in the latest Cambrian (Struckmeyer & Brown, 1990). The Delamerian Orogeny, and syn- and post-orogenic emplacement of granites, continued well into the Ordovician in the southeastern part of the craton. At about the beginning of the Ordovician, marine conditions once again returned to the central part of the craton. In the Bonaparte Basin region there was essentially continuous marine sedimentation from the Cambrian into the Ordovician, possibly a consequence of an earlier phase of sea floor spreading to the northwest, with the development of a "failed arm" providing access to open marine conditions to the west and northwest (Veevers, 1984). In the Bonaparte Basin itself, glauconitic and slightly phosphatic sands were deposited under relatively shallow marine conditions. There may have been a connection further to the east into the Daly Basin where carbonates were deposited, possibly under semi-emergent marine to emergent conditions. Hypersaline conditions occurred at times and some thin evaporites (halite and sulphates) were deposited (the area was at a palaeolatitude of about 15° at this time). Minor sedimentation may have taken place at this time in the Ngalia Basin. There, thin, partly glauconitic sandstones of the Djagamara Formation were deposited under very shallow marine conditions, with a possible marine connection to the south and east.

The only evidence of Ordovician sediments in the Georgina Basin is in the southeast corner, where a broad zone of shallow submergent to semi-emergent ooid shoals developed. Locally, emergent and evaporitic conditions existed. In the south there was some clastic sedimentation, represented by the Tomahawk Beds, but overall, sedimentation was dominated by carbonates of the Ninmaroo and Kelly Creek Formations. Sedimentation may have been discontinuous in the southeast Georgina Basin area as a consequence of the latest Tremadoc Kelly Creek Movement (Nicoll & others, 1988). In the Amadeus Basin, deposition at this time was dominated by the Pacoota Sandstone. This unit, which extends down into the latest Cambrian (Payntonian), comprises thick sequences of mature quartz sandstones showing, for the most part, a well-defined westerly source. Glauconitic and phosphatic intervals are consistent with fairly open marine conditions. The clastic intervals were generally deposited on a shallow shelf, with intertidal and subtidal sand sheets, and offshore bar and bank deposits in places. Kennard and others (1986) suggested that water depths reached a maximum during deposition of the middle part of the unit, however there is little doubt that shallow marine conditions predominated throughout the eastern end of the Basin. A thin clastic unit, the Mt Chandler Sandstone, may have been deposited at this time in the Officer Basin to the south.

An important feature of this first Ordovician time slice was the initiation, possibly in the latest Tremadoc, of sedimentation in the Canning Basin. This was a result of the development of the Larapintine Sea in response to a eustatic sea level rise (Nicoll & others, 1988). Although biostratigraphic control in the early part of the sequence is poor, it appears that there was a well-defined link between the Georgina, Amadeus and Canning Basins by the late Tremadoc (McTavish & Legg, 1976; Webby, 1978; Nicoll & others, 1988). Carbonates of the Emanuel Formation were widespread on the northern margin of the basin (the Lennard Shelf) at this time. Fine argillaceous sediments were deposited adjacent to the area of carbonate deposition, with the sedimentation pattern probably strongly controlled by bathymetry. As pointed out by Brown and others (1984) and other writers, the sedimentation patterns in the Canning Basin, commencing in Ordovician Time Slice 1, were strongly fault-controlled, with various grabens such as the Willara Sub-basin, and basement highs such as the Broome Platform exerting a profound influence. In the more marginal areas relatively coarse clastics such as the Carranya Beds were deposited. These are interpreted by Yeates and others (1984) as beach deposits composed of sandy detritus derived from the coastal erosion of basement rocks. The shoreline and nearshore sandstones of the lower Nambeet Formation, the Carranya Beds and perhaps also the Wilson Cliffs Sandstone of the Kidson Sub-basin were deposited around basement highs and along the basin margins under very shallow marine conditions. The shales and carbonates of the Nambeet Formation were, by contrast, deposited in subsiding intertidal to shallow subtidal environments. It is probable that there was a connection from the Canning Basin west to the open ocean. On the basis of faunal evidence, Legg (1987) proposed that during the Early Ordovician, the sea encroached from the west in two tongues on either side of the Broome Platform. The nature of the marine connection to the east during this time slice is less certain. Fluctuations in sealevel probably resulted in the severing and re-establishment of the connection before it was fully developed as a seaway by the beginning of Ordovician 2.

On the eastern side of the craton, there was probably an open connection between the Amadeus Basin and a shelfal area in the Warburton Basin. A thick sequence of argillaceous sediments of the Dullingari Group was deposited on this shelf at this time. In the vicinity of the Packsaddle No. 1 well in northeastern South Australia, sediments of Time Slice 1 age known as the "Innamincka Red Beds" (Cooper, 1986), suggest nearshore-paralic conditions and close proximity to a source of sandy detritus, perhaps reflecting the continuation of the Delamerian Orogeny.

A thick sequence of Upper Cambrian-Lower Ordovician fluvial to shallow marine, quartz-rich sandstones, conglomerates and carbonates occurs in western New South Wales on the Gnalta Shelf (Wopfner, 1967; Rose & Brunker, 1969; Shergold, 1971; Webby, 1976). Sediments in the southern part of the shelf (Scopes Range) were deposited in a large deltaic complex derived from part of the uplifted Adelaide Fold Belt to the south and west. Shallow to marginal marine sediments which crop out further north (Bynguano Range and Mt Arrowsmith) were deposited further offshore, beyond the dominating influence of the delta (Webby, 1976). Paralic to shallow marine sediments of this age are also present in western Tasmania, where coarse clastics predominate (Reeds, Owen and Duncan Conglomerates) (Corbett & Banks, 1974; Corbett, 1975a; Corbett & others, 1977; Burns, 1964). These Tasmanian sediments, derived from the Precambrian Tyennan Block, are a product of deformation and uplift during the Late Cambrian-Early Ordovician Delamerian Orogeny. An isolated area of shallow marine sediments (Digger Island Limestone) occurs in Victoria towards the southern end of the Mount Wellington Axis (Singleton, 1973). Elsewhere on the axis, the occurrence of carbonaceous sediments and the local presence of phosphorites, suggests the development of some areas of high organic productivity at this time.

To the east and north of this zone of shelf facies is a zone of deep water terrigenous clastics. Bathyal-abyssal graptolitic shales and turbidites were deposited by north-flowing currents in the Ballarat and Melbourne Troughs (Keble, 1950; Beavis, 1976; Vandenberg, 1978); similar distal turbidites (Mathinna beds) may also have been deposited at this time in northeast Tasmania. Deposition of graptolitic shales ("Eskdale beds") in the Wagga Trough (or Wagga Marginal Basin of Scheibner, 1973a) commenced in the Bendigonian (Kilpatrick & Fleming, 1980). The Jindalee beds, a sequence of metamorphosed mafic volcanics, cherts, quartzites and ultramafics in the Cootamundra area, are possibly of this age (Basden & others, 1975). Scheibner and Pearce (1978) suggested that the metabasalts within the Jindalee beds represent ocean-floor basalts of marginal basin origin. To the north, deposition of the turbiditic Girilambone beds probably continued from the Cambrian.

Mafic to intermediate volcanics (Nelungaloo Volcanics, Fairbridge Volcanic Group) are present around Parkes and Molong in central western New South Wales (Adrian, 1971; Sherwin, 1973, 1979; Sherwin & others, 1987). Sediments associated with these basaltic andesites (Yarrimbah Chert Member, Hensleigh Siltstone) indicate that deposition occurred in marine environments; the absence of associated limestones could indicate depths below the photic zone (Cas, 1983).

A westerly-dipping subduction complex was initiated in the latest Cambrian or Early Ordovician in the Narooma-Batemans Bay area. The Wagonga beds, abyssal plain deposits comprising cherts, mudstones, greywackes, mafic volcanics and limestones, are thought to represent the accretionary prism (Packham, 1973; Powell, 1983). The limestone and basalt are believed to have been deposited on the flanks of a seamount from the Middle Cambrian to the Early Ordovician. Westerly-derived turbidites (coastal greywackes and slates) were deposited at the foot of the outer-arc slope of the subduction complex by an eastwards-prograding submarine fan. These sediments interfinger with the abyssal plain deposits and contain latest Cambrian-Early Ordovician conodonts (Prendergast, 1987; Bischoff & Prendergast, 1987).

Possible Lower Ordovician marine fine clastics (Pipeclay Creek Formation) are present in the Tamworth Trough in northeastern New South Wales. These sediments appear to have been derived from a westerly source and were deposited in a submarine fan complex (Cawood & Leitch, 1985). Although the relationship of the Tamworth Terrane (Cawood & Leitch, 1987) to other Ordovician elements is unclear, biogeographic evidence suggests closer links with North American faunas than with faunas of the Gondwanan margin (Webby, 1987).

In the Mount Windsor Subprovince in northern Queensland (see Lolworth-Ravenswood Block column on correlation chart), siltstones, shales, sandstones and volcanics of the Trooper Creek and Rollston Range Formations (Seventy Mile Range Group) were deposited in moderately deep marine environments in a back-arc basin. This basin was probably oriented in a north-south direction and lay to the west of a volcanic chain of Andean type (Henderson, 1986). The Balcooma metavolcanics of the Georgetown Inlier are possible equivalents of the Seventy Mile Range Group (Henderson, 1986). Extensive, steeply-dipping, phyllitic and quartzitic sediments and mafic volcanics occur throughout the subsurface in western Queensland. The age of these rocks is uncertain, however, limited radiometric dating indicates an Early-Mid Palaeozoic age (Murray & Kirkegaard, 1978). These rocks possibly correlate with the Lower-Middle Ordovician sequence in the Warburton Basin to the west.

TIME SLICE 2: CHEWTONIAN-YAPEENIAN (484-479 Ma)

Palaeogeography during Time Slice 2 was dominated by the establishment of a well-defined trans-cratonic seaway, the Larapintine Sea (Keble & Benson, 1939; Webby, 1978), which extended across the Warburton Basin, into the Amadeus Basin and through to the Canning Basin. The southeastern Georgina, Wiso and Ngalia Basins lay on its northern margin, and the Officer Basin on its southern margin. In the Canning Basin sedimentation patterns continued to show the strong structural control evident in Time Slice 1. The rise in sea level reflected in the establishment of the Larapintine Sea is evident from changes in the depositional patterns. Legg (1987) noted that at this time pelitic facies (represented by the Gap Creek Formation) extended eastwards into the Kidson and Gregory Sub-basins, whilst the sandy facies (represented by the Wilson Cliffs Sandstone) was deposited only in the eastern extremities of the Basin.

Further east in the Amadeus Basin, sedimentation during Time Slice 2 was notable for the deposition of the organic-rich shales, siltstones and thin limestones of the Horn Valley Siltstone. This interval contains abundant fossils including graptolites and a distinctive conodont and trilobite fauna which has been used to correlate this interval and delineate a marked highstand of sea level in the Amadeus, Georgina and Canning Basins (Nicoll & others, 1988). Kennard and others (1986) suggested that the Horn Valley Siltstone was deposited on a "normal marine shelf" with "normal marine salinity" although the presence of abundant black shales is taken to represent euxinic bottom conditions (in which the pelagic fauna is well preserved) with more oxygenated conditions represented by limestones. The present Chile-Peru shelf, where the oxygen minimum zone periodically impinges upon an open shelf, may provide an alternative model. Alternatively the high organic productivity conditions evident from the sediments of the Horn Valley Siltstone may be a consequence of upwelling generated within the Larapintine Sea in response to the coastal configuration, bathymetry and prevailing current directions.

Outside the Amadeus Basin, the sedimentation patterns are much less distinctive. The interval is represented in the southeastern Georgina Basin by the thin siltstones and carbonates of the Coolibah Formation, however, much of the Time Slice 2 section may have been lost from this area as a result of an episode of sub-aerial exposure and erosion. In the Wiso Basin, deposition of the sandstones and siltstones of the Hanson River Beds may have commenced during Time Slice 2. Biostratigraphic control in the Officer Basin is poor, but on lithological grounds it is assumed that the Indulkana Shale is the time equivalent of the Horn Valley Siltstone and was deposited during Time Slice 2, (Krieg, 1973), though under more oxydizing conditions than those of the Amadeus Basin to the north. Sediments of the Dullingari Group, which were deposited throughout much of the Warburton Basin, are predominantly argillaceous, but include minor sandstones and limestones. Rare fossils within the Dullingari Group include graptolites, which strongly suggests a connection to the open sea further to the east. Closer to the shoreline, sands and muds of the Innamincka Red Beds were deposited (Gatehouse, 1986).

Deposition of predominantly clastic facies (Tabita, Pingbilly and Rowena Formations) on the Gnalta Shelf/Bancannia Trough continued under open marine shelf conditions (Wopfner, 1967; Rose & Brunker, 1969; Shergold, 1971). During this time interval a shallow marine carbonate shelf became established in western Tasmania (Gordon Group and equivalents) with clastic sedimentation locally dominant (e.g. Dial Range Trough). Lower Ordovician, possibly Castlemainian, graptolitic shales of distal turbidite facies (Mathinna beds) were deposited in northeastern Tasmania by north-flowing currents (Banks & Smith, 1968; Powell, 1984). Palaeofacies remained much the same in Victoria, with the deposition of a turbiditic sequence. Accumulation of the Girilambone beds in western New South Wales probably continued during this time slice.

Mafic-intermediate volcanism continued in the central-eastern volcanic chain. Again, deposition was probably submarine; pillow basalts occur in the Walli Andesite (Packham, 1969). The Jagungal Basalt, which occurs further south near Kiandra, is possibly of this age (Owen & Wyborn, 1979; Cas & others, 1980). Palaeogeographic and sedimentation patterns in the subduction complex on the south coast of New South Wales were probably similar to those described for the previous time slice.

Sedimentation patterns in the Mount Windsor Subprovince were similar to those in the previous time interval, with deposition in moderately deep marine environments of the youngest formation of the Seventy Mile Range Group, the Rollston Range Formation (Henderson, 1986).

TIME SLICE 3: DARRIWILIAN (479-469 Ma)

At about the close of Time Slice 2 there appears to have been a major regression in the Amadeus, Georgina and Canning Basins and probably elsewhere. Nicoll and others (1988) related this to a global eustatic event evident in other parts of the world including Canada (Miller, 1984) and Scandinavia (Linstrom & Vortisch, 1983). However, early in Time Slice 3 this regression was followed by a major transgression, and Time Slice 3 palaeogeography is for the most part dominated by high relative sea levels and the maximum Ordovician marine inundation of the craton. The Larapintine Sea was well developed at this time and had an important influence on sedimentation.

In the Canning Basin, deposition during Time Slice 3 is represented by the interbedded siltstones, claystones, sandstones, limestones and dolomites of the Goldwyer Formation and by the dolomites of the overlying Nita Formation. Deposition took place under relatively shallow, warm marine conditions (Foster & others, 1986). Brown and others (1984, Fig. 9) have proposed a facies pattern for this time consisting of shallow sub-tidal to intertidal platform carbonates over the Broome Platform with possible basinal shales to the north in the Fitzroy Sub-basin. To the east and south conditions became progressively shallower, with shallow sub-tidal carbonates and rare clastics followed by intertidal muds and finally supratidal carbonates. A notable feature of Canning Basin sedimentation at this time is the occurrence of organic-rich sediments of algal origin (Foster & others, 1986) particularly within the Goldwyer Formation.

To the east there was limited shallow marine sedimentation in the Wiso Basin where siltstones, limestones and dolomites of the Hanson River Beds were deposited (Kennewell & Huleatt, 1980). There may also have been limited deposition in the Ngalia Basin at this time (Wells & Moss, 1983).

The main marine connection to the east was through the Amadeus Basin. There the Stairway Sandstone and the lower part of the Stokes Siltstone were deposited under predominately shallow marine conditions, with a well-defined current direction from the east and southeast (Cook, 1972). Maximum water depth was attained during deposition of the middle and upper parts of the Stairway Sandstone, at which time black shales and phosphorites were deposited throughout much of the basin, probably in a high organic productivity system; the association of phosphorites and organic matter is characteristic of sediments deposited in an upwelling zone (Parrish, 1982). Sandstones were deposited under shallower conditions ranging from intertidal to sub-tidal. The depositional conditions in both the Canning and Amadeus Basins were very similar at this time, a reflection of the marine connection between them. In the southern Georgina Basin, the sediments were mostly siltstones, shales and sandstones with minor carbonates. The dominant depositional conditions were probably paralic (barrierlagoon) to shallow marine, but it is evident from the presence of phosphorites that at times the conditions were more marine, for example during deposition of the Nora Formation. A tidal to sub-tidal origin is apparent for sandstones such as the Carlo Sandstone (Draper, 1977; Green & Balfe, 1980).

To the south, in the Officer Basin, biostratigraphic control is poor but lithological similarites between the Stairway Sandstone and the Blue Hill Sandstone-Cartu Beds interval (Krieg, 1973) suggest that a marine environment may have existed. Similarly in the Warburton Basin it is possible that sedimentation of the Dullingari Group extended into Time Slice 3.

In western Tasmania there was continued deposition of extensive shelf carbonates (Gordon Group). Deep water turbidite deposition continued in Victoria and possibly in northeast Tasmania. Further north, Late Darriwilian-earliest Gisbornian conodonts have been recorded from the Girilambone Group (Stewart & Glen, 1986). Graptolite faunas from the Tallebung Group in western New South Wales indicate that turbidite deposition probably commenced in this area during the Darriwilian (Sherwin, 1983). Similarly, a graptolite fauna recorded from slates of the Wagga Metamorphic Complex suggests a Middle Ordovician age for at least part of this sequence (Webby & others, 1981).

Submarine mafic to intermediate volcanism may have continued in the Wellington-Molong region and near Kiandra (Jagungal Basalt). To the east of the arc represented by the Jagungal Basalt, quartz arenites, siltstones and shales of distal turbidite facies (Boltons and Nungar beds, Pittman Formation) were deposited in a deep water environment at the outer front of a large submarine fan (Owen & Wyborn, 1979). Further east, Darriwilian graptolites have been found in turbiditic sediments inland of the coastal Wagonga beds (Jenkins, 1982). These sediments (the "inland greywacke and slate association" of Powell [1984]) were deposited in a fore-arc basin (Bischoff & Prendergast, 1987). The Cambrian limestones and associated volcanics within the Wagonga beds are thought to have formed on a seamount which was incorporated into the accretionary prism during subduction in the Middle to Late Ordovician (Bischoff & Prendergast, 1987).

Darriwilian conodonts have been recorded from allochthonous limestone clasts in a sequence of debris-flow breccias and limestones in the Tamworth Terrane. Stratigraphic relationships imply a more or less contemporaneous age relationship between the faunas and the deposition of the limestone (Cawood, 1976; Cawood & Leitch, 1985).

In the Lolworth-Ravenswood Block in northern Queensland, the initial intrusions of the Ravenswood Granodiorite Complex (470±30 Ma) were synchronous with regional deformation and metamorphism. Deformation and syntectonic plutonic activity also occurred at this time in the Anakie Inlier to the south (Day & others, 1983). In the Broken River Province further north, quartz-rich turbidites, volcaniclastic sediments and tholeiitic volcanics (Judea and Carriers Well Formations) were deposited in an extensional back-arc basin which developed on the edge of the craton behind a volcanic arc represented by the Everetts Creek Volcanics (Withnall & others, 1988). Metamorphosed volcanics and possible clastics (Lucky Creek and Paddys Creek Formations) present in the Georgetown Inlier to the west (Withnall, 1982) may be of similar age.

TIME SLICE 4: GISBORNIAN-BOLINDIAN (469-438 Ma)

During the Late Ordovician the sea retreated from most of the craton. The Larapintine Sea, which was such a prominent feature of Ordovician Time Slices 2 and 3, no longer existed, although the possibility of a tenuous connection between the Canning and the Amadeus Basins cannot be completely ruled out. Time Slice 4 sediments are absent from many of the cratonic basins, but there is evidence that at least part of the Carribuddy Group, which consists of dolomite, mudstone and evaporites, is of Late Ordovician age (Legg, 1987; Nicoll & others, 1988). This unit was deposited under hypersaline conditions, suggesting little or no connection to the open ocean. It is unclear whether any connection of the Canning Basin to the open sea was to the west, or to the east through the Amadeus Basin; the former is favoured. This is supported by the fact that the most saline conditions and the thickest evaporites are found in the southeast corner of the basin, however, there is considerable debate about how much of the Carribuddy Group is Ordovician in age. In the Amadeus Basin, Time Slice 4 sediments are represented by the upper part of the Stokes Siltstone and the Carmichael Sandstone. For at least part of this time, conditions were hypersaline; abundant casts of halite crystals occur in the Stokes Siltstone. Nicoll and others (1988) have suggested that this phase of hypersalinity is the consequence of eustatic sea level fall combined with tectonic uplift at the eastern end of the Amadeus Basin. The Carmichael Sandstone was probably mainly a non-marine unit, and the clastic material may have been derived from this uplifted area, although isopach maps for this unit (Wells & others, 1970) suggest a southerly source area. Kennard and others (1986) suggested that a marine facies, derived from both the north and the south may also be present within the Carmichael Sandstone. During Time Slice 4, the connection between the Amadeus and Georgina Basins may have been rather tenuous. Whilst biostratigraphic control is not good it is likely that both the Mithaka Formation and Ethabuka Sandstone occur within this time slice. The lower part of the Ethabuka Sandstone is partly marine (Draper, 1980b) but the environment became progressively more paralic (in part deltaic) and non-marine. The depositional conditions of the Carmichael and Ethabuka Sandstones may therefore have been similar at times. There is no evidence of Time Slice 4 sediments in the Warburton Basin, although it is possible that the Dullingari Group sedimentation continued into the Late Ordovician. Similarly, the Cartu Beds of the Officer Basin, which contain no diagnostic fossils, may extend into the Upper Ordovician.

In contrast to the craton, Time Slice 4 rocks are widely distributed throughout southeastern Australia, although no sediments of this age are known from the Gnalta Shelf. In western Tasmania, deposition of the Gordon Group limestones and shales continued on a broad, stable shelf. Deep, quiet water facies predominate throughout Victoria and New South Wales, with extensive turbidite deposition both in the Wagga Trough and further east in the forearc areas ("eastern zone" of Powell, 1984). The Coolac Serpentinite and Honeysuckle beds, which crop out to the east of the Jindalee beds in southern New South Wales, are of (?)uppermost Ordovician-Lower Silurian age. These mafic-ultramafic rocks are probably related to the initiation of the Tumut Trough (Basden, 1974, 1982), possibly as a back-arc or marginal basin (Scheibner & Pearce, 1978; Stuart-Smith, 1987).

Thick sequences of Upper Ordovician mafic to intermediate volcanics occur extensively in New South Wales. Mafic volcanics are present at Louth and Mt Dijou in the northwest and mafic-intermediate volcanics (e.g., Goonumbla Volcanics, Oakdale Group, Angullong Tuff, Cheesemans Creek Formation, Rockley and Sofala Volcanics) are widespread in the central eastern part of the state (Stanton, 1956; Sherwin, 1973; Webby, 1976; Pickett, 1978). Dominantly mafic volcanics (Gooandra and Nine Mile Volcanics) also occur further south near Kiandra (Owen & Wyborn, 1979). The Upper Ordovician volcanics are often associated with limestones (Louth, Parkes, and the Wellington-Molong area), and some include pillow lavas (Mt Dijou, and Gooandra Volcanics), suggesting deposition at shallow to emergent levels in a volcanic island or pedestal environment (Cas, 1983). The Sofala Volcanics, on the other hand, appear to have been deposited by mass-flow mechanisms in deep, quiet water (Cas, 1983). Similarly, the association of the Rockley Volcanics with the quartz-rich greywackes and slates of the Triangle Group may indicate a relatively deep marine environment of deposition (Cas & others, 1980). Deep water submarine fan deposits (Nungar and Adaminaby beds, Pittman Formation) continued to accumulate to the east of the volcanic arc (Owen & Wyborn, 1979), as did the accretionary prism deposits of the Wagonga beds and the overlying greywacke-slate unit (Jenkins & others, 1982; Bischoff & Prendergast, 1987).

The inter-arc rifting model of Scheibner (1973a, 1976, 1985) considered the Parkes volcanic belt, the Molong volcanic belt and the Sofala Volcanics to have been contiguous during the Ordovician, forming a single north-south trending arc which was rifted apart during Ordovician and Silurian-Devonian interarc basin formation. However, Cas & others (1980) suggested that the original palaeogeographic trend of the arc was northwesterly with the arc extending over 800km from Louth (north of Cobar), through the Wellington-Bathurst area, southwards to Kiandra, and partially enclosing the marginal basin (Wagga Trough) to the west. An arc of this size would have been comparable to modern arcs such as the Andaman-Nicobar arc, which has been proposed as a palaeogeographic and tectonic analogue (Cas & others, 1980; Cas, 1983; Powell, 1984). Cas and others (1980) have speculated that the I-S line in the Siluro-Devonian granites, separating I-type granites to the east from dominantly S-type granites to the west, could correspond with the eastern edge of the volcanic arc.

Limestones of Upper Ordovician age (Trelawney and Uralba beds) are found in fault blocks along the Peel Fault System in the Tamworth Terrane. The Trelawney beds may possibly be allochthonous blocks within the Devonian sequence. They contain a rich, well-preserved coral fauna and were deposited under shallow marine conditions. The Uralba beds contain allochthonous blocks of shallow marine limestones within a deeper water sequence of bedded cherts and mudstones (Cawood, 1976; Philip, 1966). The faunas contained in the limestones show some affinities with North American faunas, so their palaeogeographic significance is uncertain. They may represent displaced portions of the Ordovician arc to the southwest, however Webby (1987) believes that the biogeographic evidence does not wholly support this idea.

In central eastern Queensland (near Clermont), siltstones and limestones (Fork Lagoons beds and possible correlatives in the Anakie Inlier to the west) were deposited under shallow marine conditions (Anderson & Palmieri, 1977; Day & others, 1983). In the Broken River Province, craton-derived quartz-rich turbidites and arc-derived volcaniclastics (Judea beds and equivalents), continued to be deposited in the back-arc basin (Withnall & others, 1988).

ORDOVICIAN MINERAL AND ENERGY RESOURCES

OIL AND GAS

Sediments of Ordovician age are of considerable economic significance. In both the Amadeus and Canning Basins they provide the source and potential source respectively, for commercial quantities of hydrocarbons, and are the target of continuing exploration programs. Elsewhere, for example in the Warburton Basin, there are indications of Ordovician oil and gas, though to date not in commercial quantities.

Ordovician source rocks are widespread, particularly in Time Slices 2 and 3. In the Amadeus and Canning Basins there is strong evidence to show that the good source rock qualities of the Horn Valley Siltstone (up to 2.75% TOC - Gorter, 1984) and the Goldwyer Formation (up to 6.4% TOC - Foster & others, 1986) respectively, are a direct result of the presence of the alga *Gloeocapsamorpha prisca* (Foster & others, 1986; Hoffmann & others, 1987), which has also been identified as the source for hydrocarbons in several North American Ordovician basins. Foster and others (1986) suggested that *G. prisca* flourished in low latitude, warm, shallow epeiric seas. Its development in the Canning and Amadeus Basins may have been enhanced by the presence of the transcratonic seaway, in which upwelling systems produced areas of high organic productivity. The phosphogenic conditions associated with the Stairway Sandstone in the Amadeus Basin were also responsible for the development of relatively widespread organic rich shales. This is significant in view of the fact that phosphatic sediments constitute major petroleum source rocks in many parts of the world.

Reservoir rocks of Ordovician age are also widespread. Sandstones such as the Pacoota Sandstone have good reservoir properties. They appear to be most widespread during Ordovician Time Slice 1. Nicoll and others (1988) have suggested that Ordovician reservoir sands were preferentially formed during times of low sea level. Carbonates are even more widespread, with potential carbonate reservoirs present in the Canning and Georgina Basins. However, the only Ordovician carbonate reservoirs of real economic significance to have been recognised are those in the Nita Formation of the Canning Basin.

Potential caprocks also occur in the Ordovician section. The Horn Valley Siltstone of the Amadeus Basin (Time Slice 2) is particularly notable in that not only does it constitute an important source rock but it also provides a caprock for the oil and gas trapped in the underlying Pacoota Sandstone. Perhaps the most important caprocks occur within the Carribuddy Formation and the upper part of the Stokes Formation, both of which contain evaporites. All the known Ordovician evaporites occur within sediments of Time Slice 4 age.

Within the Canning Basin there are a number of significant Ordovician oil shows mostly in the vicinity of the Broome Platform (Brown & others, 1984), with some oil being recovered from the Nita Formation in Great Sandy No. 1 (Alexander & others, 1984) and from the Goldwyer Formation in Dodonea No. 1 and Acacia No. 1 (Woodhouse, 1982). In all cases these oils were sourced from the algal-rich kerogen of the Goldwyer Formation. It is estimated that under optimum maturation conditions, the Goldwyer Formation in the Canning Basin would be capable of generating 61×10^9 barrels of liquid hydrocarbons (Foster & others, 1986).

In the Amadeus Basin, the Horn Valley Siltstone constitutes the major source rock. Whilst the formation is over-mature on the northern margin of the basin, significant parts of the unit to the south are within the oil window (Gorter, 1984). The black phosphatic shales of the Stairway Sandstone also constitute an important potential source rock. Commercial quantities of gas (with some oil) are produced from the Pacoota Sandstone of the Mereenie and Palm Valley structures and minor shows have been reported from the Stairway Sandstone in a number of areas (Jackson & others, 1984; Ozimic & others, 1986). Whilst most of the obvious major structures in the Amadeus Basin have now been tested, there are undoubtedly many more subtle structural and stratigraphic traps still waiting to be tested.

In the Warburton Basin, lower Palaeozoic (mainly Ordovician) sediments were the initial target for petroleum exploration in the 1960's. Although the oil staining encountered in Gidgealapa No. 1 (Delhi Australian Petroleum Ltd & Santos Ltd, 1966) was in Cambrian sediments (Gatehouse, 1986), a number of the shows in other wells may be from the Ordovician section. The Ordovician of the Warburton

Basin is therefore regarded as having some petroleum potential, although it must be regarded as much less prospective than the Canning and Amadeus Basins.

Wells and Moss (1983) suggested that the Ordovician Djagamara Formation in the Ngalia Basin may contain some poor quality petroleum source rocks; this unit also contains some sands with possible reservoir potential. However, the Ordovician of the Ngalia Basin has generally poor petroleum prospectivity. The same is probably true for the relatively thin Ordovician sequences of the nearby Wiso Basin, although Kennewell and Huleatt (1980) suggested that the Hanson River Beds may be the most prospective section in the Lander Trough with possible source, reservoir and caprocks all located within the formation. Within the trough the section may be sufficiently thick for oil and gas to be generated but in most parts of the basin the section is thin and immature.

There is no hydrocarbon production from the Georgina Basin but Draper and others (1978) documented a number of oil and gas occurrences in Ordovician sediments, including gas in the Coolibah Formation in Ethabuka No. 1 (Alliance Oil Development, 1975) and bitumen in the Ninmaroo Formation and the Toko Group in various drill holes. In general, however, the Ordovician sediments of the Georgina Basin have poor source rock characteristics (Green & Balfe, 1980). There are good Cambrian source rocks in the basin, however, and this, coupled with the good reservoir characteristics of the Carlo Sandstone, the Kelly Creek Formation, and to a lesser extent the Ninmaroo Formation, suggests that the Ordovician of the Georgina Basin has some prospectivity, especially in the southeastern corner of the basin where the section is relatively thick.

In conclusion, the hydrocarbon prospectivity of the Ordovician can be closely related to palaeogeography. The best source rocks are found in Time Slice 2 and 3 when sea level was relatively high and a well-defined transcratonic seaway extended conditions of high organic productivity across the craton. Some of the best clastic reservoir rocks were deposited during Time Slice 1 when sea level was relatively low. Caprocks occur throughout the sequence, although evaporitic caprocks were deposited only during Time Slice 4 when sea level was very low and evaporites were widespread.

METALLIFEROUS DEPOSITS

There are minor metalliferous deposits hosted in rocks of Ordovician age on the craton. For example, small secondary copper deposits have been reported from the Djagamara Formation in the Ngalia Basin (Wells & Moss, 1983), and sphalerite occurs in the Ordovician Ninmaroo, Kelly Creek and Nora Formations of the Georgina Basin (Green & Balfe, 1980). There are minor occurrences in other basins but no deposits of commercial significance are known and the metal potential of Ordovician cratonic rocks is considered to be very minor.

By contrast, Ordovician mineralization is widespread in the Tasman Fold Belt System, and is generally related to volcanic activity along the convergent margin and to periods of orogenesis. Ordovician mineralization in the Lachlan Fold Belt was largely restricted to the areas of volcanism along the island arc (Degeling & others, 1986). Three distinct metalliferous associations occur within both the Lower-Middle and Upper Ordovician volcanics: 1) disseminated copper sulphide and native copper mineralization; 2) stratabound disseminated to semi-massive copper sulphides; and 3) vein and stratiform gold and copper-gold deposits (Bowman & others, 1983 - the reader is referred to this reference, from which much of the following is derived, for a more complete discussion of mineralization within the island arc successions of the Lachlan Fold Belt). All of these mineralization types are believed to have been associated with volcanic complexes which were partly emergent at some stage. Type 1 mineralization appears to have been related to late-stage fumarolic activity towards the emergent tops of the volcanoes (Manto deposits). Deposits of this type occur in Lower-Middle Ordovician rocks at Walli and Woodstock near Cowra and at Narragal near Wellington, and in Upper Ordovician andesites north of Wellington. Type 2 deposits form the most important deposits of Late Ordovician age. These stratiform deposits formed in the tuffs and sediments which accumulated in the craters of andesitic stratovolcanoes and within the tuffaceous sediments in the surrounding lagoons. Deposits of this type are found in the area around Blayney (e.g. the Blayney, Cadia and Browns Creek mines). Lower-Middle Ordovician deposits of this type occur in the Bowan Park gold-copper district. Type 3 stratiform deposits were probably derived from volcanogenic hydrothermal solutions and accumulated within fine-grained tuffaceous sediments in quiet shallow-water marine environments adjacent to the volcanic centres. The vein deposits appear to be related to late-stage epithermal activity and formed in fracture zones around the subsiding volcanic pile. Type 3 deposits occur within Lower-Middle Ordovician rocks near Cowra, and in Upper Ordovician rocks near Wellington. The origin of the major gold (with lesser copper) mineralization in the Upper Ordovician Sofala Volcanics is unclear, however regional metamorphism has been suggested as the mechanism for its concentration and deposition. Porphyry copper-gold mineralization near Parkes (the Goonumbla deposits), which was previously considered to be of Middle Silurian age (Jones, 1985), has recently been dated as latest Ordovician (439±1 Ma) (Perkins & others, 1990). The host rocks for the mineralization are quartz monzonite pipes that intrude a sequence of comagmatic intermediate volcanics (Krynen & others, 1987; Perkins & others, 1990). The deposits are believed to have formed in the central part of a large collapse caldera (Jones, 1985). Stratabound iron lenses in sediments overlying Lower-Middle Ordovician volcanics at Carcoar, south of Orange, are believed to have been deposited by submarine hot springs. Stratabound copper-uranium-molybdenum lenses in the same area were probably formed during early diagenesis, with some of the metals derived from nearby intrusions.

Ordovician mineral deposits are also found elsewhere in the Lachlan Fold Belt. Minor gold mineralization at Mt Dijou in northwestern New South Wales is associated with mafic volcanics of Upper Ordovician (Time Slice 4) age (Gilligan, 1974). Significant copper mineralization occurs in the Cambro-Ordovician Girilambone Group at Tottenham, Girilambone-Hermidale and Canbelego in western New South Wales (Glen & others, 1985). These deposits are associated with mafic volcanics, mafic and ultramafic rocks, and chlorite schists, respectively. Small, auriferous quartz veins also occur throughout the Girilambone Group. The Cambro-Ordovician Jindalee beds, near Cootamundra in southern New South Wales, contain syngenetic manganese deposits in association with a mafic volcanic sequence (Fitzpatrick, 1974). Chromite, gold, and various sulphide minerals occur in the Coolac region in ultramafic rocks of possible Upper Ordovician age (Ashley, 1974).

Tin-tungsten granitoid-hosted mineralization in northern Victoria commenced during the latest Ordovician-Early Silurian Benambran Orogeny; these deposits are generally small (Ramsay & Vandenberg, 1986). In Tasmania, the Gordon Limestone (Time Slices 2-4) at Zeehan is host to stratabound disseminated and veined base metal (lead-zinc) sulphides. Collins and Williams (1986) believe that this may represent a minor Ordovician phase of metallogenesis and thermal activity. Mineralization in the Kanmantoo Trough is largely Cambrian, however there is some evidence that copper, and to a lesser extent silver, lead, zinc and gold, were locally remobilised during the Late Cambrian-Early Ordovician Delamerian Orogeny (Parker, 1986).

Syngenetic copper and gold mineralization is present in the ?Cambro-Ordovician Anakie Metamorphics in central-eastern Queensland; at Peak Downs the copper mineralization occurs within a banded-iron formation (Murray, 1986). In the Lolworth-Ravenswood Block in northern Queensland, some gold mineralization near Charters Towers is related to the intrusion of the Ravenswood Granodiorite Complex (Day & others, 1983); isotopic age determinations give a Time Slice 3 (470±30 Ma) age for the earliest intrusions (Webb, 1969; Day & others, 1983). Further north in the Mount Windsor Subprovince, stratiform massive sulphide bodies (copper, lead, zinc) of submarine exhalative origin are found at the base of, and within, the Trooper Creek Formation of the Seventy Mile Range Group, at several localities including Thalanga and Liontown (Henderson, 1986). In the Georgetown Inlier, base metal sulphide deposits (copper, silver-lead-zinc, gold) have recently been discovered in the Cambrian-?Ordovician Balcooma metavolcanics, and small gold and copper deposits occur in possible Late Ordovician volcanics of the Lucky Creek and Paddys Creek Formations (Murray, 1986).

NON-METALLIFEROUS DEPOSITS

Ordovician phosphorites are present in the Amadeus and Georgina Basins and occur predominantly in sediments deposited during Time Slice 3. Those of the Amadeus Basin are the most widespread, although generally their grade is relatively low and the beds thin. For this reason they are unlikely to be of commercial interest for the foreseable future. The occurrences show few lithological similarities with the economically more important Cambrian deposits of the Georgina Basin, however the overall depositional setting of the Cambrian and the

Ordovician deposits is strikingly similar in that both were deposited during a time of high sea level, within an elongate transcratonic seaway. The phosphorites occur within organic-rich sediments that contain abundant fossils and were probably deposited under relatively shallow marine conditions with high organic productivity (Cook, 1972). The Ordovician was a time of fairly widespread phosphogenesis in many parts of the world (Cook & McElhinny, 1979) either as a consequence of changes to global seawater chemistry, or the location of continental margins with the right configuration and palaeolatitude to produce oceanic upwelling. It is likely that the Ordovician of the Australian craton has further potential for discovering major phosphate resources but for the present there is little incentive to undertake phosphate exploration programs in view of the fact that massive phosphate resources of Cambrian age have already been delineated in the Georgina Basin.

Ordovician sediments of Time Slice 4 also have some potential for containing potash salts. In general the potential is low because the evaporites are typically thin and discontinuous. The important exception to this is the Canning Basin where the Carribuddy Formation contains abundant evaporites. At least the lower part of this unit is believed to be Ordovician (Time Slice 4) in age. Although potash exploration programs have been undertaken in the Canning Basin, little information has yet been released on the results. Other Ordovician intracratonic basins may contain evaporites of Time Slice 4 age but their potential for potash is likely to be very minor, with most of the known evaporites (generally occurring as pseudomorphs) having fairly strong marine affinities.

DISCUSSION

The palaeogeographic maps shown in this volume summarize the results that large scale processes such as sealevel change, climatic change, variations in the chemistry and circulation of the oceans, and tectonism, have had on the region of Gondwana that now constitutes the Australian continent. These large scale processes are not independent of each other; plate tectonic movements can lead to changes in oceanographic circulation patterns and ultimately to changes in climate. Similarly, climate change can lead to variations in eustatic sea level. For the present, many of these interactions are imperfectly understood; further back in time they are both poorly understood and poorly documented. The Ordovician Period lasted approximately 70 million years. Because of the lack of biochronological precision for this Period it is difficult to recognize more than the gross changes. For example, from the four Ordovician maps a first order relative sea level curve can be delineated; an intermediate relative sea level during Time Slice 1 was followed by a high sea level during Time Slice 2. Sea level reached a maximum during Time Slice 3 before falling to a low point during Time Slice 4. Superimposed on this pattern are other changes that are probably equivalent to second and third order sea level curves. Preliminary Ordovician onlap and relative sea level curves determined by Nicoll and others (1988) for the Canning, Amadeus and Georgina Basins provide an indication of the scale of these changes, demonstrating that superimposed on the major cycle, with a periodicity approximately equivalent to the whole of the Ordovician (70 million years), were four or five second order cycles of sea level change. The extent to which these changes were eustatic is not clear, although Nicoll and others (1988) related some of the more major changes to global eustasy rather than regional tectonic events. For example, the major sea level fall in Time Slice 4 may well be a reflection of low global sea levels associated with a late Ordovician phase of glaciation (Sheehan, 1988).

Tectonism in the Australian region inevitably had an important effect on change of relative sea level. In the latest Cambrian to Early Ordovician the Delamerian Orogeny, in particular, elevated much of the southeastern corner of the craton. This area was to remain high throughout the remainder of the Ordovician and beyond. More localized uplifts, such as the Rodingan Movement in the Amadeus

Basin region during Time Slice 4, had an important local effect on patterns of deposition and erosion.

One of the most striking features of Ordovician palaeogeography is the Larapintine Sea, a well-defined yet quite narrow feature through which marine conditions were able to extend across a large portion of the craton. Initiation of the seaway was the result of a rise in relative sealevel (Nicoll & others, 1988). Nevertheless, it is possible that within the seaway, and particularly on its margins, tectonism had some effect on relative sea level changes. Similarly, the onset of the Rodingan Movement in the eastern part of the Amadeus Basin may have not only produced local changes in relative sea level, but may also have partly closed off the eastern end of the Larapintine Sea resulting in the development of hypersaline conditions during Time Slice 4.
The whole question of sea level change has been a controversial one in recent years, with the significance of the changes, their magnitude, and the driving processes all a matter of much debate. As noted previously, the Australian Ordovician record has the potential for providing at least first and second order relative sea level curves, which reflect the interplay of tectonics and eustasy; determining the relative importance of these two components is difficult. During the Ordovician in Australia, sea level change exerted a fundamental influence on the existence or absence of the Larapintine Sea and on the nature and distribution of sediments. These in turn had a profound effect on the distribution of resources, particularly organic-rich sediments and phosphorites, the occurrence of potential reservoir rocks and the existence of evaporites.

It is likely that throughout the Ordovician, the Australian craton was located on the margins of Gondwana at low latitudes (Fig. 1) (Scotese & others, 1979; Scotese, 1986, in press). Ziegler and others (1981) and Parrish (1982) have proposed models for atmospheric and oceanic circulation during the Ordovician based on the continental reconstructions of Scotese and others (1979), and sediment distribution patterns. During Time Slices 2 and 3, when the Larapintine Sea was well established, the currents flowed predominantly from east to west (consistent with a low latitude position). These currents are likely to have produced upwelling in the narrow seaway as a result of entrainment of coastal waters and interaction with bathymetric highs. This was probably responsible for the development of organic-rich and phosphatic sediments. Upwelling would have also accentuated the aridity of the coastal climate thus minimizing the input of clastic sediments from the adjacent hinterland. There is also some evidence of high productivity conditions in the Fold Belt, with organic-rich sediments found on some of the palaeo-bathymetric highs.

The warm arid climatic conditions evident during the Ordovician are consistent with a low palaeolatitude. The maximum input of clastic sediments into cratonic basins was during Time Slice 1. This may have been a response to a higher rate of precipitation, however the maturity of sandstones such as the Pacoota Sandstone is consistent with a mature and fairly arid landscape. Clastic sediments may have been derived from nearby areas uplifted during the Delamerian Orogeny. During Time Slice 2 and 3 there was no prolonged period of clastic input, and overall conditions were probably fairly arid and warm. As noted previously, upwelling within the seaway would have resulted in enhanced aridity in the coastal zone. The most arid part of the Ordovician was during Time Slice 4 when the evaporites of the Stokes Formation and particularly those of the lower part of the Carribuddy Formation were deposited. This also appears to have been a time of low sea level possibly associated with glaciation in other parts of Gondwana. Therefore at the close of the Ordovician, conditions were probably slightly cooler but more arid.

SELECTED BIBLIOGRAPHY

ADAMS, C.J., BLACK, L.P., CORBETT, K.D., & GREEN, G.R., 1985 - Reconnaissance isotopic studies bearing on the tectonothermal history of Early Palaeozoic and Late Proterozoic sequences in western Tasmania. *Australian Journal of Earth Sciences*, 32, 7-36.

ADRIAN, J., 1971 - Stratigraphic units in the Molong district, New South Wales. *Geological Survey of New South Wales, Record* 13(4), 179-198.

ALEXANDER, R., CUMBERS, M., & KAGI, R.I., 1984 - Geochemistry of some Canning Basin crude oils. *In* PURCELL, P.G. (Editor) - THE CANNING BASIN, WA. *Proceedings of the GSA/PESA Canning Basin Symposium, Perth 1984*, 353-358.

ALLIANCE OIL DEVELOPMENT N.L., 1975 - Well completion report - Ethabuka No. 1, ATP 160P, Queensland. *Unpublished report held by Department of Mines, Brisbane.*

ANDERSON, J.C., & PALMIERI, V., 1977 - The Fork Lagoons beds, an Ordovician unit of the Anakie Inlier, central Queensland. *Queensland Government Mining Journal*, 78, 260-263.

ASHLEY, P.M., 1974 - Lachlan Fold Belt - southern serpentinite belts. *In* MARKHAM, N.L., & BASDEN, H. (Editors) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales*, 184-194.

BAKER, C.J., 1978 - Geology of the Cobar 1:100 000 sheet 8035. *Geological Survey of New South Wales.*

BAKER, C.J., SHERWIN, L., & SCHMIDT, B.L., 1975 - Revised stratigraphy of the Cobar-Gunderbooka area. *Geological Survey of New South Wales, Quarterly Notes* 20, 1-14.

BALKE, B., PAGE, C., HARRISON, R., & ROUSSOPOULOS, G., 1973 - Exploration in the Arafura Sea. *The APEA Journal*, 13(1), 9-12.

BANKS, M.R., 1962 - The Ordovician system. *In* SPRY, A.H. & BANKS, M.R. (Editors) - The geology of Tasmania. *Journal of the Geological Society of Australia*, 9, 147-176.

BANKS, M.R., 1988 - The base of the Silurian System in Tasmania. *In* COCKS, L.R.M., & RICKARDS, R.B. (Editors) - A global analysis of the Ordovician-Silurian boundary. *Bulletin British Museum (Natural History) Geology Series*, 43, 191-194.

BANKS, M.R., & BAILLIE, P.W., 1988 - Late Cambrian to Devonian. *In* BURRETT, C.F., & MARTIN, E.L. (Editors) - Geology and mineral resources of Tasmania. *Geological Society of Australia, Special Publication* 15, 182-237.

BANKS, M.R., & BURRETT, C.F., 1980 - A preliminary Ordovician biostratigraphy of Tasmania. *Journal of the Geological Society of Australia*, 26, 363-375.

BANKS, M.R., & SMITH, E.A., 1968 - A graptolite from the Mathinna Beds, northeastern Tasmania. *Australian Journal of Science*, 31(3), 118-119.

BARNES, R.G., 1975 - Tibooburra-Wonominta Block. *In* MARKHAM, N.L., & BASDEN, H. (Editors) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales.*

BARRIE, J., 1965 - Natural phosphates. *In* McLEOD, I.R. (Editor) - Australian mineral industry: the mineral deposits. *Bureau of Mineral Resources, Australia, Bulletin* 72, 479-486.

BARRON, B.J., 1976 - Recognition of the original volcanic suite in altered mafic volcanic rocks at Sofala, New South Wales. *American Journal of Science*, 276, 604-636.

BASDEN, H., 1974 - Preliminary report on the geology of the Cootamundra 1:100 000 sheet. *Geological Survey of New South Wales, Quarterly Notes*, 15, 7-18.

BASDEN, H., 1982 - Preliminary report on the geology of the the Tumut 1:100 000 sheet area, southern New South Wales. *Geological Survey of New South Wales, Quarterly Notes*, 46, 1-18.

BASDEN, H., ADRIAN, J., CLIFT, D.S.L., & WINCHESTER, R.E., 1978 - Geology of the Cootamundra 1:100 000 sheet 8528. *Geological Survey of New South Wales.*

BATTERSBY, D.G., 1974 - Cooper Basin gas and oil fields. *In* LESLIE, R.B., EVANS, H.J. & KNIGHT, C.L. (Editors) - Economic geology of Australia and Papua New Guinea. 3. Petroleum. *Australasian Institute of Mining and Metallurgy, Monograph* 7, 321-351.

BEAVIS, F.C., 1962 - The geology of the Kiewa area. *Royal Society of Victoria, Proceedings*, 72, 95-100.

BEAVIS, F.C., 1967 - Structures in the Ordovician rocks of Victoria. *Royal Society of Victoria, Proceedings*, 80, 147-182.

BEAVIS, F.C., 1976 - Ordovician. *In* DOUGLAS, J.G. & FERGUSON, J.A. (Editors) - Geology of Victoria. *Geological Society of Australia, Special Publication* 5, 25-44.

BEMBRICK, C.S., 1975 - Bancannia Synclinorial Zone. *In* MARKHAM, N.L., & BASDEN, H., (Editors) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales, Department of Mines.*

BENBOW, D.D., 1968 - Case history-Mereenie field. *The APEA Journal*, 8(2), 114-119.

BISCHOFF, G.C.O., & PRENDERGAST, E.I., 1987 - Newly-discovered Middle and Late Cambrian fossils from the Wagonga Beds of New South Wales, Australia. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 175(1), 39-64.

BLACK, L.P., & ADAMS, C.J., 1980 - Radiometric dating studies bearing on the Late Proterozoic - Early Paleozoic evolution of Western Tasmania.

Geological Society of Australia, 4th Australian Geological Convention, Abstracts and Programs, 24.

BLISSET, A.H., 1962 - Zeehan, geological atlas - one mile series. *Geological Survey of Tasmania, Explanatory Report* 7/5.

BMR AUTHORS, 1976 - The structure of Australia and variations in tectonic style. Symposium 103.3 International Geological Congress, Sydney, 1976. *Bureau of Mineral Resources Australia, Record* 1976/72 (unpublished).

BOWEN, K.G., 1975 - Potassium-Argon dates - determinations carried out by the Geological Survey of Victoria. *Geological Survey of Victoria, Report* 1975/3.

BOWMAN, H.N., RICHARDSON, S.J., & PATERSON, I.B.L. (Editors), 1983 - Palaeozoic island arc and arch mineral deposits in the central west of New South Wales. *Geological Survey of New South Wales, Records*, 21(2), 329-406.

BRADLEY, J., 1954 - Geology of the West Coast Range of Tasmania, Part I. *Royal Society of Tasmania, Papers and Proceedings*, 88, 193-243.

BRADLEY, J., 1956 - The Geology of the West Coast Range of Tasmania, Part II. *Royal Society of Tasmania, Papers and Proceedings*, 90, 65-130.

BRADY, T.J., JAUNCEY, W., & STEIN, C., 1966 - The geology of the Bonaparte Gulf Basin. *The APEA Journal*, 7-11.

BRANAGAN, D.F., 1969 - Palaeovolcanology in New South Wales: a stratigraphic summary. *Geological Society of Australia, Special Publication* 2, 155-161.

BROOKS, C., 1966 - The rubidium-strontium ages of some Tasmanian igneous rocks. *Journal of the Geological Society of Australia*, 13, 457-469.

BROOKS, C., & LEGGO, M.D., 1972 - The local chronology and regional implications of a Rb/Sr investigation of granitic rocks from Corryong District, southeastern Australia. *Journal of the Geological Society of Australia*, 19, 1-20.

BROWN, C.M., TUCKER, D.H., & ANFILOFF, V., 1988 - An interpretation of the tectonostratigraphic framework of the Murray Basin region of southeastern Australia, based on an examination of airborne magnetic patterns. *Tectonophysics*, 154, 309-333.

BROWN, D.A., CAMPBELL, K.S.W., & CROOK, K.A.W., 1968 - THE GEOLOGICAL EVOLUTION OF AUSTRALIA AND NEW ZEALAND. *Pergamon Press, Sydney*.

BROWN, S.A., BOSERIO, I.M., JACKSON, K.S., & SPENCE, K.W., 1984 - The geological evolution of the Canning Basin - implications for petroleum exploration. *In* PURCELL, P.G. (Editor) - THE CANNING BASIN, WA. *Proceedings of the GSA/PESA Canning Basin Symposium, Perth, 1984*, 85-96.

BROWNE, W.R., (Editor), 1950 - GEOLOGY OF THE COMMONWEALTH OF AUSTRALIA. *Arnold, London.*

BRUNKER, R.L., 1968 - Cobham Lake 1:250 000 Geological Sheet. *Geological Survey of New South Wales, Explanatory Notes* SH/54-11.

BURNE, R.V., GORTER, J.D., & SAXBY, J.D., 1979 - Source rocks and hydrocarbon potential of the Paleozoic in the onshore Canning Basin, Western Australia. *BMR Journal of Australian Geology & Geophysics* 5, 4, 125-133.

BURNS, K.L., 1964 - Devonport, Geological atlas - one mile series. *Geological Survey of Tasmania, Explanatory Report*, K/55-6-29.

BURNS, K.L., 1974 - Aspects of the early history of the southern Tasman Orogenic Zone: discussion. *In* DENMEAD, A.K., TWEEDALE, G.W., & WILSON, A.F. (Editors) - THE TASMAN GEOSYNCLINE - A SYMPOSIUM. *Geological Society of Australia, Queensland Division*, 46.

BURRETT, C.F., 1979 - Middle-Upper Ordovician conodonts and stratigraphy of the Gordon Limestone Sub-group, Tasmania. *Ph.D. thesis, University of Tasmania* (unpublished).

BURRETT, C.F., & STAIT, B., 1985 - South East Asia as part of an Ordovician Gondwanaland - a palaeobiogeographic test of a tectonic hypothesis. *Earth and Planetary Science Letters*, 75, 184-190.

BURRETT, C.F., & STAIT, B., 1987 - China and southeast Asia as part of the Tethyan margin of Cambro-Ordovician Gondwanaland. *In* McKENZIE, K.G. (Editor) - Shallow Tethys 2. Proceedings of the International Symposium on Shallow Tethys 2, Wagga Wagga, September 1986. *A.A. Balkema, Rotterdam*, 65-77.

BURRETT, C.F., STAIT, B., & LAURIE, J., 1983 - Trilobites and microfossils from the Middle Ordovician of Surprise Bay, southern Tasmania, Australia. *Association of Australasian Palaeontologists, Memoir* 1, 177-193.

BURRETT, C.F., STAIT, B., SHARPLES, C., & LAURIE, J., 1984 - Middle-Upper Ordovician shallow platform to deep basin transect, southern Tasmania, Australia. *In* BRUTON, D.L. (Editor) - Aspects of the Ordovician System. *Palaeontological Contributions from the University of Oslo* 295, *Universitetsforlaget*, 149-157.

CAMPANA, B., 1954 - The structure of the eastern South Australian Ranges: the Mount Lofty-Olary Arc. *Journal of the Geological Society of Australia*, 2, 47-61.

CAMPANA, B., & KING, D., 1963 - Palaeozoic tectonism, sedimentation and mineralization in West Tasmania. *Journal of the Geological Society of Australia*, 10, 1-53.

CAREY, S.W., 1953 - Geological structures of Tasmania in relation to mineralization. *In* EDWARDS, A.B. (Editor) - Geology of Australian Ore Deposits. *5th Empire Mining and Metallurgical Congress, Australia and New Zealand, Publications*, 1, 1108-1128.

CAREY, S.W., & BANKS, M.R., 1954 - Lower Palaeozoic unconformities in Tasmania. *Royal Society of Tasmania, Papers*, 88, 295-369.

CAS, R.A.F., 1983 - A review of the palaeogeographic and tectonic development of the Palaeozoic Lachlan Fold Belt of southeastern Australia. *Geological Society of Australia, Special Publication* 10.

CAS, R.A.F., POWELL, C.McA., & CROOK, K.A.W., 1980 - Ordovician palaeogeography of the Lachlan Fold Belt: a modern analogue and tectonic constraints. *Journal of the Geological Society of Australia*, 27(1), 19-31.

CAS, R.A.F., & VANDENBERG, A.H.M., 1988 - Ordovician. *In* DOUGLAS, J.G., & FERGUSON, J.A. (Editors) - GEOLOGY OF VICTORIA. *Geological Society of Australia, Victorian Division*, 63-102.

CASEY, J.N., & WELLS, A.T., 1964 - The geology of the north-east Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Report* 49.

CAWOOD, P.A., 1976 - Cambro-Ordovician strata, northern New South Wales. *Search*, 7, 317-318.

CAWOOD, P.A., & LEITCH, E.C., 1985 - Accretion and dispersal tectonics of the southern New England Fold Belt, eastern Australia. *In* HOWELL, D.G. (Editor) - Tectonostratigraphic terranes of the circum-Pacific. *Circum-Pacific Council, Earth Sciences Series* 1, 481-492.

CHALKER, L.E., & BEMBRICK, C.S., 1977 - Geology of the Narooma 1:100 000 Sheet. *Geological Survey of New South Wales*, 8925.

CHAPPELL, B.W., & WHITE, A.J.R., 1974 - Two contrasting granite types. *Pacific Geology*, 8, 173-174.

CHAPPELL, B.W., WHITE, A.J.R., & HINE, R., 1988 - Granite provinces and basement terranes in the Lachlan Fold Belt, southeastern Australia. *Australian Journal of Earth Sciences*, 35, 505-521.

CHEWINGS, C., 1935 - The Pertatataka series in central Australia with notes on the Amadeus Sunkland. *Royal Society of South Australia, Transactions*, 59, 141-163.

COHEE, G.V., GLAESSNER, M.F., & HEDBERG, H.D., (Editors), 1978 - Contributions to the geologic time scale. Papers given at the Geological time scale symposium 106.6, 25th International Geological Congress Sydney, Australia. *American Association of Petroleum Geologists, Studies in Geology* 6.

COLLINS, P.L.F., & WILLIAMS, E., 1986 - Metallogeny and the tectonic development of the Tasman Fold Belt System in Tasmania. *Ore Geology Reviews*, 1, 153-201.

COMBAZ, A., & PENIGUEL, G., 1972 - Etude palynostratigraphique de l'Ordovicien dans quelques sondages du Basin de Canning (Australie Occidentale). *Bulletin du Centre de Recherches de Pau-SNPA*, 6(1), 121-167.

COMPSTON, W., 1979 - The place of isotopic age determinations in stratigraphy. *Episodes: Geological Newsletter, Ottawa, International Union of Geological Sciences*, 1979/1, 10-13.

COMPSTON, W., & CHAPPELL, B.W., 1979 - Sr-isotope evolution of granitoid source rocks. *In* McELHINNY, M.W. (Editor) - THE EARTH: ITS ORIGIN, STRUCTURE AND EVOLUTION. *Academic Press, London*, 377-426.

CONEY, P.J., 1988 - The Tasman orogenic system and the Pacific margin of Gondwana. *In* KLEEMAN, J.D. (Editor) - New England Orogen - tectonics and metallogenesis. *Department of Geology and Geophysics, University of New England*, 11-19.

COOK, P.J., 1963 - The geology of the Yuendumu native reserve, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1963/37.

COOK, P.J., 1972 - Sedimentological studies on the Stairway Sandstone of central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 95.

COOK, P.J., 1988 - Palaeogeographic atlas of Australia. Volume 1 - Cambrian. *Bureau of Mineral Resources, Australia.*

COOK, P.J., & McELHINNY, 1979 - A re-evaluation of the spatial and temporal distribution of sedimentary phosphate deposits in the light of plate tectonics. *Economic Geology*, 74, 315-330.

COOK, P.J., & SCOTT, I.F., 1967 - Reconnaissance geology and petrography of the Ngalia Basin, Northern Territory. *Bureau of Mineral Resources, Report* 125.

COOPER, B.J., 1981 - Early Ordovician conodonts from the Horn Valley Siltstone, central Australia. *Palaeontology*, 24/1, 147-184.

COOPER, B.J., 1986 - A record of Ordovician conodonts from the Warburton Basin, South Australia. *Department of Mines and Energy, South Australia, Geological Survey, Report Book* 86/12 (unpublished).

COOPER, J.A., WELLS, A.T., & NICHOLAS, T., 1971 - Dating of glauconite from the Ngalia Basin, Northern Territory, Australia. *Journal of the Geological Society of Australia*, 19(2), 97-106.

COOPER, R.A., & GRINDLEY, G.W. (Editors), 1982 - Late Proterozoic to Devonian sequences of southeastern Australia, Antarctica and New Zealand and their correlation. *Geological Society of Australia, Special Publication* 9.

CORBETT, K.D., 1964 - Geology of the Florentine Valley area. *B.Sc.(Hons.) Thesis, University of Tasmania* (unpublished).

CORBETT, K.D., 1970 - Sedimentology of an Upper Cambrian Flysh-paralic sequence (Denison Group) of the Denison Range, south-west Tasmania. *Ph.D. Thesis, University of Tasmania* (unpublished).

CORBETT, K.D., 1975a - The Late Cambrian to Early Ordovician sequence on the Denison Range, south-west Tasmania. *Royal Society of Tasmania, Papers and Proceedings*, 109, 111-120.

CORBETT, K.D., 1975b - Preliminary report on the geology of the Red Hills-Newton Creek area, West Coast Range, Tasmania. *Tasmania, Department of Mines, Technical Report*, 19, 11-25.

CORBETT, K.D., & BANKS, M.R., 1974 - Ordovician stratigraphy of the Florentine Synclinorium, southwest Tasmania. *Royal Society of Tasmania, Papers and Proceedings*, 107, 207-238.

CORBETT, K.D., & BANKS, M.R., 1975 - Revised terminology of the Late Cambrian-Ordovician sequence of the Florentine-Denison Range area, and the significance of the Junee Group. *Royal Society of Tasmania, Papers and Proceedings*, 109, 121-126.

CORBETT, K.D., BANKS, M.R., & JAGO, J.B., 1972 - Plate tectonics and the Lower Palaeozoic of Tasmania. *Nature, Physical Science*, 240, 9-11.

CORBETT, K.D., GREEN, G.R., & WILLIAMS, P.R., 1977 - The geology of central western Tasmania. *In* BANKS, H.R., & KIRKPATRICK, J.B. (Editors) - LANDSCAPE AND MAN: THE INTERACTION BETWEEN MAN AND ENVIRONMENT IN WESTERN TASMANIA. *Royal Society of Tasmania.*

CORBETT, K.D., REID, K.O., CORBETT, E.G., GREEN, G.R., WELLS, K., & SHEPPARD, N.W., 1974 - The Mount Read Volcanics and Cambrian-Ordovician relationships at Queenstown, Tasmania. *Journal of the Geological Society of Australia*, 21(2), 173-186.

CRAWFORD, A.R., & CAMPBELL, K.S.W., 1973 - Large-scale horizontal displacement within Australo-Antarctica in the Ordovician. *Nature, Physical Science*, 241, 11-13.

CROOK, K.A.W., 1974 - Kratonisation of West Pacific-type geosynclines. *Journal of Geology*, 82, 24-36.

CROOK, K.A.W., 1980 - Fore-arc evolution in the Tasman Geosyncline: the origin of the southeast Australian continental crust. *Journal of the Geological Society of Australia*, 27(2), 215-232.

CROOK, K.A.W., & FELTON, E.A., 1975 - Tasman Geosyncline greenstones and ophiolites. *Journal of the Geological Society of Australia*, 22(1), 117-131.

CROOK, K.A.W., HUGHES, R.J., SCOTT, P.A., & BEIN, J., 1973 - Ordovician and Silurian history of the southeastern part of the Lachlan Geosyncline. *Journal of the Geological Society of Australia*, 20(2), 133-138.

CROOK, K.A.W., & POWELL, C.McA., 1976 - The evolution of the southeastern part of the Tasman Geosyncline. *25th International Geological Congress, Sydney, Excursion Guide* 17A.

DAILY, B., 1963 - Appendix 3B. *In* HARRISON, J., CAMPBELL, I.R., & HIGGINBOTHAM, G.T. - Delhi-Santos Pandieburra 1 well completion report. *Bureau of Mineral Resources, Australia, File* 63/1002 (unpublished).

DAILY, B., JAGO, J.B., & MILNES, A.R., 1973 - Large-scale horizontal displacements within Australo-Antarctica in the Ordovician. *Nature, Physical Science*, 244, 61-64.

DAY, R.W., WHITAKER, W.G., MURRAY, C.G., WILSON, I.H., & GRIMES, K.G., 1983 - Queensland geology : a companion volume to the 1:250,000 scale geological map (1975). *Geological Survey of Queensland, Publication* 383.

DEGELING, P.R., GILLIGAN, L.B., SCHEIBNER, E., & SUPPEL, D.W., 1986 - Metallogeny and the tectonic development of the Tasman Fold Belt System in New South Wales. *Ore Geology Reviews*, 1, 259-313.

DELHI AUSTRALIAN PETROLEUM LTD & SANTOS LTD, 1966 - Delhi-Santos Gidgealpa No. 1 well, South Australia. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 73.

DELHI AUSTRALIAN PETROLEUM LTD & SANTOS LTD, 1967 - Kalladeina No. 1 well completion report. *Bureau of Mineral Resources, Australia, File* 67/4244 (unpublished).

DENMEAD, A.K., TWEEDALE, G.W., & WILSON, A.F., 1974 - THE TASMAN GEOSYNCLINE - A SYMPOSIUM. *Geological Society of Australia, Queensland Division.*

DEVINE, S.B., & YOUNGS, B.C., 1975 - Review of the Palaeozoic stratigraphy and petroleum potential of northern South Australia. *The APEA Journal*, 15(1), 45-54.

DICKINSON, S.B., & SPRIGG, R.C., 1953 - Geological structures of South Australia in relation to mineralization. *In* EDWARDS, A.B. (Editor) - Geology of Australian Ore Deposits. *Fifth Empire Mining and Metallurgy Congress, Melbourne*, 426-448.

DOUGLAS, J.G., & FERGUSON, J.A. (Editors), 1976 - Geology of Victoria. *Geological Society of Australia, Special Publication* 5.

DOUGLAS, J.G., & FERGUSON, J.A. (Editors), 1988 - GEOLOGY OF VICTORIA. *Geological Society of Australia, Victorian Division.*

DRAPER, J.J., 1977 - Environment of deposition of the Carlo Sandstone, Georgina Basin, Queensland and Northern Territory. *BMR Journal of Australian Geology & Geophysics*, 2, 97-110.

DRAPER, J.J., 1980a - *Rusophycus* (Early Ordovician ichnofossil) from the Mithaka Formation, Georgina Basin. *BMR Journal of Australian Geology & Geophysics*, 5(1), 57-62.

DRAPER, J.J., 1980b - Ethabuka Sandstone, a new Ordovician unit in the Georgina Basin, and a redefinition of the Toko Group. *Queensland Government Mining Journal*, 81(947), 469-475.

DRAPER, J.J., SHERGOLD, J.H., & HEIGHWAY, K.A., 1978 - A review of petroleum exploration and prospects in the Georgina Basin. *Bureau of Mineral Resources, Australia, Record* 1978/10.

DREW, M.G., & EVANS, G.R., 1975 - Recent geological and geophysical results in the northeastern Canning Basin. *The APEA Journal*, 1, 11.

DRUCE, E.C., & JONES, P.J., 1971 - Cambro-Ordovician conodonts from the Burke River Structural Belt, Queensland. *Bureau of Mineral Resources, Australia, Bulletin* 110, 1-158.

ELLISTON, J., 1954 - Geology of the Dundas district Tasmania. *Royal Society of Tasmania, Papers*, 88, 161-183.

ETHERIDGE, M.A., RANSOM, D.M., WILLIAMS, P.F., & WILSON, C.J.L., 1973 - Structural evidence of the age of folded rocks on the south coast of New South Wales. *Journal of the Geological Society of Australia*, 19, 465-470.

EVANS, T.G., 1972 - Napperby, Northern Territory- 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* SF/53-9.

EVANS, T.G., & GLIKSON, A.Y., 1969 - Geology of the Napperby Sheet area, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1969/85 (unpublished).

EVERNDEN, J.R., & RICHARD, J.R., 1962 - Potassium-argon ages in eastern Australia. *Journal of the Geological Society of Australia*, 9, 1-50.

FELTON, E.A., 1974 - Molong-South Coast Anticlinorial Zone: northern section. *In* MARKHAM, N.L., & BASDEN, H. (Editors) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales*, 232-244.

FINDLAY, R.H., 1987 - A review of the problems important for interpretation of the Cambro-Ordovician paleogeography of northern Victoria Land (Antarctica), Tasmania, and New Zealand. *In* McKENZIE, G.D. (Editor) - Gondwana six: structure, tectonics, and geophysics. *American Geophysical Union, Geophysical Monograph* 40, 49-66.

FINUCANE, K.J., 1932 - Preliminary report on the geological survey of the Rosebery district - I,II. *Chemical Engineering Mining Review*, 25, 5-7, 43-46.

FITZPATRICK, K.R., 1974 - Bogan Gate Synclinorial Zone. *In* MARKHAM, N.L., & BASDEN, H. (Editors) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales*, 172-183.

FORMAN, D.J., & WALES, D.W. (Compilers), 1981 - Geological evolution of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 210.

FOSTER, C.B., O'BRIEN, G.W., & WATSON, S.T., 1986 - Hydrocarbon source potential of the Goldwyer Formation, Barbwire Terrace, Canning Basin, Western Australia. *The APEA Journal*, 26, 142-155.

FREEMAN, R.N., 1965 - Geological appraisal of productive potential, P.E.L. 114, New South Wales. *Geological Survey of New South Wales, Petroleum File, Geology* 1965/1 (unpublished).

FROELICH, A.J., KRIEG, E.A., & HOPKINS, R.M., 1968 - Recent geophysical results, northern Amadeus Basin. *The APEA Journal*, 8, 104-113.

GATEHOUSE, C.G., 1983 - Stratigraphic units in the Warburton Basin in South Australia. *Geological Survey of South Australia, Quarterly Geological Notes* 86, 5-8.

GATEHOUSE, C.G., 1986 - The geology of the Warburton Basin in South Australia. *Australian Journal of Earth Sciences*, 33(2), 161-180.

GEE, C.E., 1966 - The geology and mineral deposits of the Moina-Lorinna area. *B.Sc.(Hons.) Thesis, University of Tasmania* (unpublished).

GEE, R.D., & LEGGE, P.J., 1974 - Beaconsfield. One mile geological map series. *Geological Survey of Tasmania, Explanatory Notes* 8215N.

GIBBINS, S., 1974 - The geology of the Coolac-Gobarralong districts. *B.Sc. (Hons.) Thesis, Australian National University* (unpublished).

GILFILLAN, M.A., 1976 - Stratigraphy and structure of the Sofala Volcanics. *Bulletin of the Australian Society of Exploration Geophysicists*, 7(1), 28-29.

GILLIGAN, L.B., 1974 - Cobar and Mineral Hill Synclinorial Zone. *In* MARKHAM, N.L., & BASDEN, H. (Editor) - THE MINERAL DEPOSITS OF NEW SOUTH WALES. *Geological Survey of New South Wales*, 146-171.

GILLIGAN, L.B., & SCHEIBNER, E., 1978 - Lachlan Fold Belt in New South Wales. *Tectonophysics*, 48, 217-266.

GLAESSNER, M.F., & PARKIN, L.W., 1958 - The geology of South Australia. *Journal of the Geological Society of Australia*, 5(2), 28-45.

GLEADOW, A.J.W., & LOVERING, J.F., 1978 - Thermal history of granitic rocks from western Victoria: a fission-track dating study. *Journal of the Geological Society of Australia*, 25(6), 323-340.

GLEN, R.A., MacRAE, G.P., POGSON, D.J., SCHEIBNER, E., AGOSTINI, A., & SHERWIN, L., 1985 - Summary of the geology and controls of mineralization in the Cobar region. Cobar field conference, December 1985. *Geological Survey of New South Wales, Report* GS 1985/203.

GLENISTER, B.F., LINDNER, A.W., BALME, B.E., PLAYFORD, P.E., & McWHAE, J.R.H., 1958 - The stratigraphy of Western Australia. *Journal of the Geological Society of Australia*, 4(2).

GLOVER, J.E., 1973 - Petrology of the halite-bearing Carribuddy Formation, Canning Basin, Western Australia. *Journal of the Geological Society of Australia*, 20(3), 343-359.

GORTER, J.D., 1984 - Source potential of the Horn Valley Siltstone, Amadeus Basin. *The APEA Journal*, 24, 66-90.

GORTER, J.D., in press - Palaeogeography of Late Cambrian-Early Ordovician sediments in the Amadeus Basin, central Australia. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the

Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

GORTER, J.D., RASIDI, J.S., TUCKER, D.H., BURNE, R.V., PASSMORE, V.L., WALES, D.W., & FORMAN, D.J., 1979 - Petroleum geology of the Canning Basin. *Bureau of Mineral Resources, Australia, Record* 1979/32 (unpublished).

GOSTIN, V.A., 1973 - Geology of the Mornington Peninsula. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY (2nd edition). *School of Geology, University of Melbourne*, 46-52.

GREEN, D.C., & WEBB, A.W., 1974 - Geochronology of the northern part of the Tasman Geosyncline. *In* DENMEAD, A.K., TWEEDALE, G.W., & WILSON A.F. (Editors) - THE TASMAN GEOSYNCLINE - A SYMPOSIUM. *Geological Society of Australia, Queensland Division*, 275-291.

GREEN, D.H., 1959 - Geology of the Beaconsfield district, including the Andersons Creek Ultramafic Complex. *Record of the Queen Victoria Museum, Tasmania* 10.

GREEN, P.M., & BALFE, B.E., 1980 - Stratigraphic drilling report - G.S.Q. Mt. Whelan 1 and 2. *Queensland Government Mining Journal*, 81(941), 162-178.

GUPPY, D.J., LINDNER, A.W., RATTIGAN, J.R., & CASEY, J.N., 1958 - The geology of the Fitzroy Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 36.

HALL, G., & SOLOMON, M., 1962 - Metallic mineral deposits. *In* SPRY, A., & BANKS, M.R. (Editors) - The geology of Tasmania. *Journal of the Geological Society of Australia*, 9(2), 285-309.

HALL, R.L., 1975 - Late Ordovician coral faunas from north-eastern New South Wales. *Royal Society of New South Wales, Journal and Proceedings*, 108, 75-93.

HALL, T.S., 1895 - The geology of Castlemaine, with a subdivision of part of the Lower Silurian rocks of Victoria, and a list of minerals. *Royal Society of Victoria, Proceedings*, 7, 55-88.

HALL, T.S., 1899 - The graptolite-bearing rocks of Victoria, Australia. *Geological Magazine*, 46, 439-451.

HALL, T.S., 1912 - Reports on graptolites. *Geological Survey of Victoria, Record* 3, 188-211.

HALL, T.S., 1914 - Reports on graptolites, No. 11. *Geological Survey of Victoria, Record* 3, 290-300.

HALLAM, A., 1984 - Pre-Quaternary sea-level changes. *Annual Reviews of Earth and Planetary Science*, 12, 205-243.

HARLAND, W.B., COX, A.V., LLEWELLYN, P.G., PICKTON, C.A.G., SMITH, A.G., & WALTERS, R., 1982 - A geologic time scale. *Cambridge University Press, Cambridge*.

HARRINGTON, H.J., BURNS, K.L., & THOMPSON, B.R., - Gambier-Beaconsfield and Gambier-Sorell fracture zones and the movement of plates in the Australia-Antarctica-New Zealand region. *Nature, Physical Science*, 245(146), 109-112.

HARRIS, W.J., 1916 - The palaeontological sequence of the Lower Ordovician rocks of the Castlemaine district, Part I. *Royal SocietysandVictoria, Proceeomics*, 29, 50-70, 5"^H^G59^H^G^H^G^059^H^G^H^G^0^D

ILLS, 1933 - *IsograD.E. caduceus* andtyts allies in Vice gra. *Royal Socin V of Victoria, ournaldingthe Geol, 79-114.*

HARRIS, W.J., 1935 - The graptolite succession of Bendigo East, with suggested zoning. Royal Society of Victoria, Proceedings, 47, 314-337.

HARRIS, W.J., & KEBLE, R.A., 1932 - Victorian graptolite zones with correlations and description of species. *Royal Society of Victoria, Proceedings*, 44, 25-48.

HARRIS, W.J., & THOMAS, D.E., 1938a - Notes on the geology of the Howqua Valley. *Mining and Geological Journal of Victoria*, 1(2), 81-84.

HARRIS, W.J., & THOMAS, D.E., 1938b - A revised classification of the Ordovician graptolite beds of Victoria. *Mining and Geological Journal of Victoria*, 1, 62-72.

HARRIS, W.J., & THOMAS, D.E., 1940 - Notes on the geology of the Upper Goulburn Basin. Part 1 - The Jamieson Valley. *Mining and Geological Journal of Victoria*, 2, 191-197.

HARRIS, W.J., & THOMAS, D.E., 1954 - Notes on the geology of the Wellington-Macalister area. *Mining and Geological Journal of Victoria*, 5(3), 34-49.

HENDERSON, G.A.M., 1981 - Geology of Canberra, Queanbeyan, and environs: notes to accompany the 1980 1:50 000 geological map. *Bureau of Mineral Resources, Australia.*

HENDERSON, R.A., 1980 - Structural outline and summary geological history for northeastern Australia. *In* HENDERSON, R.A., & STEPHENSON, P.J. (Editors) - THE GEOLOGY AND GEOPHYSICS OF NORTHEASTERN AUSTRALIA. *Geological Society of Australia, Queensland Division*, 1-26.

HENDERSON, R.A., 1982 - Notes on the stratigraphy of the Mount Windsor Subprovince. *In* WITHNALL, I.W. (Editor) - 1982 Field Conference, Charters Towers-Greenvale area. *Geological Society of Australia, Queensland Division*, 7-11.

HENDERSON, R.A., 1983 - Early Ordovician faunas from the Mount Windsor Subprovince, northeastern Queensland. *Association of Australasian Palaeontologists, Memoir* 1, 145-175.

HENDERSON, R.A., 1986 - Geology of the Mt Windsor Subprovince - a lower Palaeozoic volcano-sedimentary terrane in the northern Tasman Orogenic Zone. *Australian Journal of Earth Sciences*, 33(3), 343-364.

HENDERSON, R.A., & STEPHENSON, P.J. (Editors) 1980 - THE GEOLOGY AND GEOPHYSICS OF NORTHEASTERN AUSTRALIA. *Geological Society of Australia, Queensland Division.*

HILL, D., 1960 - Geological structure. *In* HILL, D., & DENMEAD, A.K. (Editors) - The geology of Queensland. *Journal of the Geological Society of Australia*, 7, 1-19.

HILLS, E.S., & THOMAS, D.E., 1945 - On fissuring in sandstones. *Economic Geology*, 40, 51-62.

HILLS, E.S., & THOMAS, D.E., 1954 - Turbidity currents and the graptolite facies in Victoria. *Journal of the Geological Society of Australia*, 1, 119-133.

HOFFMANN, C.F., FOSTER, C.B., POWELL, T.G., & SUMMONS, R.E., 1987 - Hydrocarbon biomarkers from Ordovician sediments and fossil alga *Gloeocapsamorpha prisca* Zalessky 1917. *Geochimica et Cosmochimica Acta*, 47, 1151-1156.

HOPWOOD, T.P., STEPHENS, M.B., & O'CONNOR, B., 1977 - The structure of a small complexly-deformed area within Ordovician rocks near Mansfield, Victoria. *Journal of the Geological Society of Australia*, 24, 219-233.

HORSTMAN, E.L., LYONS, D.A., NOTT, S.A., & BROAD, D.S., 1976 - Canning Basin, onshore. *In* LESLIE, R.B., EVANS, H.J., & KNIGHT, C.L. (Editors) - Economic geology of Australia and Papua New Guinea - 3. Petroleum. *Australasian Institute of Mining and Metallurgy, Monograph* 7, 170-184.

HUTTON, L.J., RIENKS, I.P., & WYBORN, D., 1990 - A reinterpretation of the Ravenswood Batholith, north Queensland. *Australasian Institute of Mining and Metallurgy Pacific Rim Congress 90, Proceedings*, 3, 179-185.

JACKSON, K.S., McKIRDY, D.M., & DECKELMAN, J.A., 1984 - Hydrocarbon generation in the Amadeus Basin, central Australia. *The APEA Journal*, 24, 42-65.

JACKSON, M.J., & VAN DE GRAAFF, W.J.E., 1981 - Geology of the Officer Basin. *Bureau of Mineral Resources, Australia, Bulletin* 206.

JAGO, J.B., 1973 - Paraconformable contacts between Cambrian and Junee Group sediments in Tasmania. *Journal of the Geological Society of Australia*, 20, 373-377.

JAGO, J.B., COOPER, J.A., & CORBETT, K.D., 1977 - First evidence for Ordovician igneous activity in the Dial Range Trough, Tasmania. *Journal of the Geological Society of Australia*, 24, 81-86.

JELL, P., BURRETT, C.F., STAIT, B., & YOCHELSON, E., 1984 - The Early Ordovician bellerophontid *Peelerophon oehlerti* (Bergeron) from Argentina, Australia and Thailand. *Alcheringa*, 8, 169-176.

JENKINS, C.J., 1982 - Darriwilian (Middle Ordovician) graptolites from the Monaro trough sequence east of Braidwood, New South Wales. *Linnean Society of New South Wales, Proceedings*, 106(2), 173-179.

JENKINS, C.J., KIDD, P.R., & MILLS, K.J., 1982 - Upper Ordovician graptolites from the Wagonga Beds near Batemans Bay, New South Wales. *Journal of the Geological Society of Australia*, 29(3), 367-373.

JENNINGS, I.B., 1963 - Middlesex. One mile geological map series. *Geological Survey of Tasmania, Explanatory Report* K/55-6-45.

JENNINGS, I.B., 1975 - Sheffield. Geological atlas 1 mile series. *Geological Survey of Tasmania, Explanatory Report* 37.

JOHNSON, N.E.A., 1966 - WAPET Kidson No.1 well completion report. *Bureau of Mineral Resources, Australia, File* 65/4177 (unpublished).

JOHNSTONE, M.H., 1961 - West Australian Petroleum Pty Ltd Samphire Marsh No.1 well completion report. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 5.

JOHNSTONE, M.H., LOWRY, D.C., & QUILTY, P.G., 1973 - The geology of southwestern Australia: a review. *Royal Society of Western Australia, Journal*, 56(1), 5-15.

JONES, D.K., & PEARSON, G.R., 1972 - Tectonic elements of the Perth Basin. *The APEA Journal*, 12(1), 17-22.

JONES, G.J., 1985 - The Goonumbla porphyry copper deposits, New South Wales. *Economic Geology*, 80, 591-613.

JONES, P.J., 1971 - Lower Ordovician conodonts from the Bonaparte Gulf Basin and the Daly River Basin, northwestern Australia. *Bureau of Mineral Resources, Australia, Bulletin* 117.

JONES, P.J., SHERGOLD, J.H., & DRUCE, E.C., 1971 - Late Cambrian and Early Ordovician stages in western Queensland. *Journal of the Geological Society of Australia*, 18, 1-32.

KANTSLER, A.J., & McKIRDY, D.M., 1980 - Oil geochemistry and potential source rocks of the Officer Basin, South Australia. *The APEA Journal*, 20(1), 68-86.

KAULBACK, J.A., & VEEVERS, J.J., 1969 - Cambrian and Ordovician geology of the southern part of the Bonaparte Gulf Basin, Western Australia. *Bureau of Mineral Resources, Australia, Report* 109.

KEBLE, R.A., 1950 - The Mornington Peninsula. *Geological Survey of Victoria, Memoir* 17.

KEBLE, R.A., & BENSON, W.N., 1939 - Graptolites of Australia: bibliography and history of research. *National Museum, Melbourne, Memoirs* 11, 11-99.

KEMEZYS, K.J., 1976 - Geology and mineralization between West Wyalong and Condoblin, New South Wales. *Bulletin of the Australian Society of Exploration Geophysicists*, 7, 34-36.

KEMEZYS, K.J., 1978 - Ordovician and Silurian lithofacies and base-metal deposits of the Lachlan Fold Belt. *Journal of the Geological Society of Australia*, 25, 97-107.

KENNARD, J.M., NICOLL, R.S., & OWEN, M. (Editors), 1986 - Late Proterozoic and Early Palaeozoic depositional facies of the northern Amadeus Basin. *12th International Sedimentological Congress, Field Excursion 25B. Bureau of Mineral Resources, Canberra.*

KENNEWELL, P.J., & HULEATT, M.B., 1980 - Geology of the Wiso Basin, Northern Territory. *Bureau of Mineral Resources, Australia, Bulletin* 205.

KILPATRICK, D.J., & FLEMING, P.D., 1980 - Lower Ordovician sediments in the Wagga Trough: discovery of early Bendigonian graptolites near Eskdale, north-east Victoria. *Journal of the Geological Society of Australia*, 27(1), 69-73.

KNIGHT, C.L. (Editor), 1975 - Economic geology of Australia and Papua New Guinea - 1. Metals. *Australasian Institute of Mining and Metallurgy, Monograph* 5.

KOOP, W.J., 1966 - Recent contributions to Palaeozoic geology in the South Canning Basin, Western Australia. *The APEA Journal*, 6, 105-109.

KORSCH, R.J., & KENNARD, J.M. (Editors), in press - Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

KORSCH, R.J., & LINDSAY, J.F., 1989 - Relationships between deformation and basin evolution in the intracratonic Amadeus Basin, central Australia. *Tectonophysics*, 158, 5-22.

KRIEG, G.W., 1973 - Everard, South Australia - 1:250 000 geological series. *Geological Survey of South Australia, Explanatory Notes* SG/53-13.

KRIEG, G.W., & JACKSON, M.J., 1973 - The geology of the Officer Basin. *Bureau of Mineral Resources, Australia, Record* 1973/44 (unpublished).

KRYNEN, J.P., CLARKE, I., & SHERWIN, L., 1987 - Geological setting of gold and copper mineralization in the Parkes area. *Geological Survey of New South Wales, Report* GS1986/059 (unpublished).

KURYLOWICZ, L.E., OZIMIC, S., McKIRDY, D.M., KANTSLER, A.J., & COOK, A.C., 1976 - Reservoir and source rock potential of the Larapinta Group, Amadeus Basin, central Australia. *The APEA Journal*, 16, 49-66.

LAIRD, M.G., COOPER, R.A., & JAGO, J.B., 1977 - New data on the lower Palaeozoic sequence of northern Victoria Land, Antarctica, and its significance for Australian-Antarctic relations in the Palaeozoic. *Nature*, 265, 107-110.

LAMBECK, K., 1984 - Structure and evolution of the Amadeus, Officer and Ngalia Basins of central Australia. *Australian Journal of Earth Sciences*, 31(1), 25-48.

LAWRENCE, C.R., 1975 - Geology, hydrodynamics and hydrochemistry of the southern Murray Basin. *Geological Survey of Victoria, Memoir* 30.

LEGG, D.P., 1976 - Ordovician trilobites and graptolites from the Canning Basin, Western Australia. *Geologie et Palaeontologie*, 10, 1-58.

LEGG, D.P., 1978 - Ordovician biostratigraphy of the Canning Basin, Western Australia. *Alcheringa*, 2, 321-334.

LEGG, D.P., 1987 - The Ordovician palaeogeography of the Canning Basin. *In* McKENZIE, K.G. (Editor) - Shallow Tethys 2. Proceedings of the International Symposium on Shallow Tethys 2, Wagga Wagga, September 1986. *A.A. Balkema, Rotterdam*, 527-528.

LEGGO, P.J., & McDOUGALL, I., 1965 - Isotopic age determinations on granitic rocks from Tasmania. *Journal of the Geological Society of Australia*, 12, 295-332.

LESLIE, R.B., EVANS, H.J., & KNIGHT, C.L. (Editors), 1976 - Economic geology of Australia and Papua New Guinea - 3. Petroleum. *Australasian Institute of Mining and Metallurgy Monograph 7.*

LINDSAY, J.F., & KORSCH, R.J., 1989 - Interplay of tectonics and sea-level changes in basin evolution: an example from the intracratonic Amadeus Basin, central Australia. *Basin Research*, 2, 3-25.

LINDSAY, J.F., & KORSCH, R.J., in press - The evolution of the Amadeus Basin, central Australia. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

LINDSAY, J.F., KORSCH, R.J., & WILFORD, J.R., 1987 - Timing the breakup of a Proterozoic supercontinent: evidence from Australian intracratonic basins. *Geology*, 15, 1061-1064.

LINDSTRÖM, M., & VORTISCH, W., 1983 - Indications of upwelling in the Lower Ordovician of Scandinavia. *In* SUESS, E., & THIEDE, J. (Editors) - COASTAL UPWELLING: ITS SEDIMENT RECORD. PART 2 - SEDIMENTARY RECORDS OF ANCIENT COASTAL UPWELLING. *Plenum Publishing Co., New York*, 535-552.

LOWRY, D.C., JACKSON, M.J., KENNEWELL, P.J., & VAN DE GRAAFF, W.J.E., 1972 - Preliminary results of geological mapping in the Officer Basin, Western Australia, 1971. *Geological Survey of Western Australia, Annual Report for 1971*, 50-56.

LUDBROOK, N.H., & JOHNS, R.K., 1970 - Geology of South Australia. IN South Australian Year Book 1970. *South Australian Department of Mines*, 4-9, 12.

MADIGAN, C.T., 1932 - The geology of the western MacDonnell Ranges, central Australia. *Quarterly Journal of the Geological Society of London*, 88(3), 672-711.

MARSDEN, M.A.H., 1967 - East-central Victoria. *In* McANDREW, J. & MARSDEN, M.A.H. (Editors) - 3. *39th ANZAAS Congress, Section C, Excursion Handbook, Melbourne*, 87-115.

MARSDEN, M.A.H., 1973 - Palaeozoic evolution of east-central Victoria. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY (2nd edition). *School of Geology, University of Melbourne*, 175-201.

MATTHEWS, W.L., 1975 - Lake River. Geological atlas 1:50 000 series. *Geological Survey of Tasmania*, 8314S.

MAYNE, S.J., 1976 - Australian platform-cover correlation charts - Adelaidean to Recent. *Bureau of Mineral Resources, Australia, Bulletin* 183.

McCLATCHIE, L., 1971 - Base metal mineralization at Mineral Hill, Central Western N.S.W. *Geological Survey of New South Wales, Memoirs* 11.

McCULLOCH, M.T., & CHAPPELL, B.W., 1982 - Nd isotopic characteristics of S- and I-type granites. *Earth and Planetary Science Letters*, 58, 51-64.

McTAVISH, R.A., 1973 - Prioniodontacean conodonts from the Emanuel Formation (Lower Ordovician) of Western Australia. *Geologica et Palaeontologica*, 7, 27-58.

McTAVISH, R.A., & LEGG, D.P., 1972 - Middle Ordovician correlation - conodont and graptolite evidence from Western Australia. *Neues Jahrbuch für Geologie und Palaontologie Monatshefte*, 8, 465-474.

McTAVISH, R.A., & LEGG, D.P., 1976 - The Ordovician of the Canning Basin, Western Australia. *In* BASSETT, M.G. (Editor) - THE ORDOVICIAN SYSTEM. *University of Wales Press and National Museum of Wales, Cardiff*, 447-478.

McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F., & BALME, B.E., 1958 - The stratigraphy of Western Australia. *Journal of the Geological Society of Australia*, 4(2).

MEEN, J.K., & EGGLER, D.H., 1987 - Petrology and geochemistry of the Cretaceous Independence volcanic suite, Absaroka Mountains, Montana: clues to the composition of the Archean sub-Montanan mantle. *Geological Society of America, Bulletin*, 98, 238-247.

MILLER, J.F., 1984 - Cambrian and earliest Ordovician conodont evolution, biofacies and provincialism. *Geological Society of America, Special Paper* 196, 43-68.

MILLIGAN, E.N., SMITH, K.G., NICHOLS, R.A.H., & DOUTCH, H.F., 1966 - Geology of the Wiso Basin, N.T. *Bureau of Mineral Resources, Australia, Record* 1966/47 (unpublished).

MILLS, K.J., 1973 - The structural geology of the Warren National Park and the western portion of the Mount Crawford State Forest, South Australia. *Royal Society of South Australia, Transactions*, 97(4), 281-315.

MILNES, A.R., COMPSTON, W., & DAILY, B., 1977 - Pre- to syn-tectonic emplacement of Early Palaeozoic granites in southeastern South Australia. *Journal of the Geological Society of Australia*, 24, 87-106.

MORGAN, C.M., SWEET, I.P., MENDUM, J.R., & PONTIFEX, I.P., 1970 - The geology of the Cape Scott, Port Keats, Ferguson River and Delamere 1:250 000 sheet areas, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1970/3 (unpublished).

MORRISON, G.W., 1980 - Characteristics and tectonic setting of the shoshonite rock association. *Lithos*, 13, 97-108.

MOYE, D.G., SHARP, K.R., & STAPLEDON, D.H., 1963 - Geology of the Snowy Mountains Region. *Snowy Mountains Hydro-Electric Authority, Australia.*

MURRAY, C.G., 1975 - Tasman Geosyncline in Queensland - regional geology. *In* KNIGHT, C.L. (Editor) - Economic Geology of Australia and Papua New Guinea - 1. Metals. *Australasian Institute of Mining and Metallurgy, Monograph* 5.

MURRAY, C.G., 1986 - Metallogeny and the tectonic development of the Tasman Fold Belt System in Queensland. *Ore Geology Reviews*, 1, 315-400.

MURRAY, C.G., & KIRKEGAARD, A.G., 1978 - The Thomson Orogen of the Tasman Orogenic Zone. *Tectonophysics*, 48, 299-325.

MURRAY, C.G., SCHEIBNER, E., & WALKER, R.N., 1989 - Regional geological interpretation of a digital coloured residual Bouguer gravity image of eastern Australia with a wavelength cut-off of 250 km. *Australian Journal of Earth Sciences*, 36, 423-449.

NICHOLAS, T., 1969 - The geology of the Lake Mackay Sheet area, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1969/89 (unpublished).

NICHOLAS, T., 1972 - Lake Mackay, Northern Territory - 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* SF/52-11.

NICOLL, R.S., 1980 - Middle Ordovician conodonts from the Pittman Formation, Canberra, A.C.T. *BMR Journal of Australian Geology & Geophysics*, 5(2), 150.

NICOLL, R.S., GORTER, J.D., & OWEN, M., in press - Ordovician sediments in the Waterhouse Range Anticline, Amadeus Basin, central Australia: their interpretation and tectonic implications. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

NICOLL, R.S., OWEN, M., SHERGOLD, J.H., LAURIE, J.R., & GORTER, J.D., 1988 - Ordovician event stratigraphy and the development of a Larapintine Seaway, central Australia. *In* Palaeogeography, sea level, & climate: implications for resource exploration. Extended abstracts, 1988 BMR Research Symposium. *Bureau of Mineral Resources, Australia, Record* 1988/42.

OFFLER, R., & FLEMING, P.O., 1968 - A synthesis of folding and metamorphism in the Mt. Lofty Ranges, South Australia. *Journal of the Geological Society of Australia*, 15(2), 245-266.

OLIVER, R.L., 1972 - Some aspects of Antarctic-Australian geological relationships. *In* ADIE, R.J. (Editor) - ANTARCTIC GEOLOGY AND GEOPHYSICS. *Universitetsforlaget, Oslo*, 859-864.

OVERSBY, B., 1971 - Palaeozoic plate tectonics in the southern Tasman Geosyncline. *Nature, Physical Science*, 234(46), 45-47, 60.

OVERSBY, B.S., WITHNALL, I.W., & BAKER, E.M., 1976 - Revision of Pre-Mesozoic geology in the Woogar River, Stawell River and Glenlath areas, Gilberton 1:250 000 sheet area, north Queensland. *Queensland Government Mining Journal*, 77(900), 473-479.

OWEN, M., GARDNER, D.E., WYBORN, D., SALTET, J., & SHACKLETON, M.S., 1974 - Geology of the Tantangara 1:100 000 sheet area, A.C.T. and N.S.W. *Bureau of Mineral Resources, Australia, Record* 1974/176 (unpublished).

OWEN, M., & WYBORN, D., 1979 - Geology and geochemistry of the Tantangara and Brindabella 1:100 000 sheet areas, N.S.W. and A.C.T. *Bureau of Mineral Resources, Australia, Bulletin* 204.

OZIMIC, S., PASSMORE, V.L., PAIN, L., & LAVERING, I.H., 1986 - Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Petroleum Accumulations Report* 1.

PACKHAM, G.H., 1960 - Sedimentary history of part of the Tasman Geosyncline in south eastern Australia. *Proceedings of the Twenty-first International Geological Congress, Copenhagen*, 12, 74-83.

PACKHAM, G.H., 1968 - The Lower and Middle Palaeozoic stratigraphy and sedimentary tectonics of the Sofala-Hill End-Euchareena region. *Proceedings of the Linnean Society of New South Wales*, 93, 111-163.

PACKHAM, G.H., 1969 - The geology of New South Wales. *Journal of the Geological Society of Australia*, 16(1).

PACKHAM, G.H., 1973 - A speculative Phanerozoic history of the south-west Pacific. *In* COLEMAN, P.J. (Editor) - THE WESTERN PACIFIC: ISLAND ARCS, MARGINAL SEAS, AND GEOCHEMISTRY. *University of Western Australia Press, Perth*, 369-388.

PARKER, A.J., 1986 - Tectonic development and metallogeny of the Kanmantoo Trough in South Australia. *Ore Geology Reviews*, 1, 203-212.

PARKIN, L.W. (Editor), 1969 - HANDBOOK OF SOUTH AUSTRALIAN GEOLOGY. *Geological Survey of South Australia, Adelaide*.

PARRISH, J.T., 1982 - Upwelling and petroleum source beds, with reference to Paleozoic. *American Association of Petroleum Geologists, Bulletin*, 66(6), 750-774.

PERKINS, C., McDOUGALL, I., CLAOUÉ-LONG, J., & HEITHERSAY, P., 1990 - ^{40}Ar-^{39}Ar and U-Pb geochronology of the Goonumbla copper-gold and Gidginbung gold deposits, NSW. *In* Gondwana: terranes and resources. Tenth Australian Geological Convention, February 4-9, 1990, University of Tasmania, Hobart. *Geological Society of Australia, Abstracts* 25.

PHILIP, G.M., 1966 - The occurrence and palaeogeographic significance of Ordovician strata in northern New South Wales. *Australian Journal of Science*, 29(4), 112-113.

PHILLIPS, B.J., JAMES, A.W., & PHILIP, G.M., 1985 - The geology and hydrocarbon potential of the north-western Officer Basin. *The APEA Journal*, 25, 52-61.

PICKETT, J., 1978 - Further evidence for the age of the Sofala Volcanics. *Geological Survey of New South Wales, Quarterly Notes* 31, 1-4.

PITT, G.M., BENBOW, M.C., & YOUNGS, B.C., 1980 - A review of recent geological work in the Officer Basin, South Australia. *The APEA Journal*, 20(1), 209-220.

PLAYFORD, P.E., COPE, R.N., COCKBAIN, G.H., LOW, G.H., & LOWRY, D.C., 1975 - Phanerozoic. *In* The geology of Western Australia. *Geological Survey of Western Australia, Memoir* 2, 223-431.

PLUMB, K.A., & VEEVERS, J.J., 1971 - Cambridge Gulf, Western Australia - 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* SD/52-14.

POGSON, D.J., 1975 - The Tasman Mobile Zone in New South Wales - geology and tectonic history. *In* KNIGHT, C.L. (Editor) - Economic geology of Australia and Papua New Guinea - 1. Metals. *Australasian Institute of Mining and Metallurgy, Monograph* 5, 667-676.

POGSON, D.J., & FELTON, E.A., 1978 - Reappraisal of geology, Cobar-Canbelego-Mineral Hill region, central western New South Wales. *Geological Survey of New South Wales, Quarterly Notes* 33, 1-14.

POGSON, D.J., SUPPEL, D.W., GILLIGAN, L.B., SCHEIBNER, E., BAKER, C., SHERWIN, L., BROWN, R., FELTON, E.A., & FAIL, A.P., 1976 - Recent studies of the tectonics, stratigraphy and mineralization of the Cobar-Mineral Hill region. *Bulletin of the Australian Society of Exploration Geophysicists*, 7(1), 31-34.

POWELL, C.McA., 1976 - Geology of the Hill End Trough Molong High: a critical appraisal of the tectonic history of the Hill End Trough and its margins. *Bulletin of the Australian Society of Exploration Geophysicists*, 7(1), 14-18.

POWELL, C.McA., 1983 - Tectonic relationship between the Late Ordovician and Late Silurian palaeogeographies of southeastern Australia. *Journal of the Geological Society of Australia*, 30(3), 353-373.

POWELL, C., McA., 1984 - Ordovician to earliest Silurian: marginal sea and island arc. *In* VEEVERS, J.J. (Editor) - PHANEROZOIC EARTH HISTORY OF AUSTRALIA. *Clarendon Press, Oxford*, 290-309.

POWELL, D.E., 1976 - The geological evolution of the continental margin off northwest Australia. *The APEA Journal*, 16(1), 13-23.

PREISS, W.V., 1987 - The Adelaide Geosyncline: Late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics. *Geological Survey of South Australia, Bulletin* 53.

PRENDERGAST, E.I., 1987 - An Early Palaeozoic subduction complex on the New South Wales south coast. *In* International Conference on Deformation of Crustal Rocks, Mt Buffalo, Australia. *Geological Society of Australia, Abstracts* 19, 4-5.

PRICHARD, C.E., & QUINLAN, T., 1962 - The geology of the southern half of the Hermannsberg 1:250 000 Sheet. *Bureau of Mineral Resources, Australia, Report* 61.

QUILTY, P., 1971 - Cambrian and Ordovician dendroids and hydroids of Tasmania. *Journal of the Geological Society of Australia*, 17(2), 171-189.

RADKE, B.M., 1980 - Epeiric carbonate sedimentation of the Ninmaroo Formation (Upper Cambrian-Lower Ordovician), Georgina Basin. *BMR Journal of Australian Geology & Geophysics*, 5(3), 183-200.

RADKE, B.M., & DUFF, P., 1980 - A potential dolostone reservoir in the Georgina Basin: the Lower Ordovician Kelly Creek Formation. *BMR Journal of Australian Geology & Geophysics*, 5(2), 160-163.

RAMSEY, W.R.H., & VANDENBERG, A.H.M., 1986 - Metallogeny and tectonic development of the Tasman Fold Belt Sysem in Victoria. *Ore Geology Reviews*, 1, 213-257.

RANDALL, M.A., 1973 - Groundwater in the Wiso Basin and environs, Northern Territory. *Bureau of Mineral Resources, Australia, Bulletin* 123.

RANDALL, M.A., & BROWN, M.C., 1967 - Geology of the northern part of the Wiso Basin, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1967/110 (unpublished).

RICHARDS, J.R., & SINGLETON, O.P., 1981 - Palaeozoic Victoria, Australia: igneous rocks, ages and their interpretation. *Journal of the Geological Society of Australia*, 28(4), 395-421.

ROBERTS J., & VEEVERS, J., 1973 - Summary of BMR studies of the onshore Bonaparte Gulf Basin 1963- 1971. *Bureau of Mineral Resources, Australia, Bulletin* 139, 29-58.

ROSE, G., 1966 - White Cliffs. 1:250 000 geological series. *Geological Survey of New South Wales, Explanatory Notes* SH/54-12.

ROSE, G., & BRUNKER, R.L., 1969 - The Upper Proterozoic and Phanerozoic geology of northwestern New South Wales. *Australasian Institute of Mining and Metallurgy, Proceedings*, 299, 105-120.

RUBENACH, M., 1974 - The origins of the Serpentine Hill Complex, western Tasmania. *Journal of the Geological Society of Australia*, 21, 91-106.

RUSSELL, R.T., & TRUEMAN, N.A., 1971 - The geology of the Duchess phosphate deposits, northwest Queensland, Australia. *Economic Geology*, 66, 1186-1214.

RUTLAND, R.W.R., 1976 - Orogenic evolution of Australia. *Earth Science Reviews*, 12, 161-196.

SADLER, D.R., 1972 - Geology of Cadia, N.S.W. *B.Sc.(Honours) Thesis, Australian National University* (unpublished).

SCHEIBNER, E., 1972a - A model of the Palaeozoic tectonic history of N.S.W. *Abstracts for Joint Specialists Groups Meetings, Geological Society of Australia, Canberra* F12-F16.

SCHEIBNER, E., 1972b - The Kanmantoo Pre-Cratonic Province in New South Wales. *Geological Survey of New South Wales, Quarterly Notes* 7, 1-10.

SCHEIBNER, E., 1972c - Actualistic models in tectonic mapping. *Twenty-fourth International Geological Congress, Montreal*, 3, 405-422.

SCHEIBNER, E., 1972d - Tectonic concepts and tectonic mapping. *Geological Survey of New South Wales, Records* 14(1), 37-83.

SCHEIBNER, E., 1973a - A plate tectonic model of the Palaeozoic tectonic history of N.S.W. *Journal of the Geological Society of Australia*, 20, 405-426.

SCHEIBNER, E., 1973b - Geology of the Taralga 1:100 000 Sheet 8829. *Geological Survey of New South Wales.*

SCHEIBNER, E., 1976 - Explanatory notes on the tectonic map of New South Wales, scale 1:1 000 000. *Geological Survey of New South Wales.*

SCHEIBNER, E., 1978 - Tasman Fold Belt system in New South Wales - general description. *Tectonophysics*, 48, 207-216.

SCHEIBNER, E., 1985 - Suspect terranes in the Tasman Fold Belt System, eastern Australia. *In* HOWELL, D.G. (Editor) - Tectonostratigraphic terranes of the circum-Pacific. *Circum-Pacific Council, Earth Sciences Series* 1, 481-492.

SCHEIBNER, E., 1989 - The tectonics of New South Wales in the second decade of application of the plate tectonics paradigm. *Royal Society of New South Wales, Journal and Proceedings*, 122, 35-74.

SCHEIBNER, E., & PEARCE, J.A., 1978 - Eruptive environments and inferred exploration potential of metabasalts from New South Wales. *Journal of Geochemical Exploration*, 10, 63-74.

SCOTESE, C.R., 1986 - Phanerozoic reconstructions: a new look at the assembly of Asia. *University of Texas Institute for Geophysics, Technical Report* 66 (unpublished).

SCOTESE, C.R., in press - Ordovician plate tectonic reconstructions. Sixth International Symposium on the Ordovician System, Sydney, 1991.

SCOTESE, C.R., BAMBACH, R.K., BARTON, C., VAN DER VOO, R., & ZEIGLER, A.M., 1979 - Paleozoic base maps. *Journal of Geology*, 87, 217-277.

SEDIMENTARY BASINS STUDY SECTION, PETROLEUM EXPLORATION BRANCH BMR, 1974 - Summary of Phanerozoic sedimentary basins of Australia and adjacent regions, 1974. *Bureau of Mineral Resources, Australia, Record* 1974/178 (unpublished).

SELLEY, R.C., 1985 - ANCIENT SEDIMENTARY ENVIRONMENTS AND THEIR SUB-SURFACE DIAGNOSIS (third edition). *Chapman and Hall, London.*

SEMENIUK, V., 1970 - The Lower-Middle Palaeozoic stratigraphy of the Bowan Park area, central western New South Wales. *Royal Society of New South Wales, Journal and Proceedings*, 103, 15-30.

SEMENIUK, V., 1972 - The stratigraphy of the Bowan Park Group, New South Wales. *Royal Society of New South Wales, Journal and Proceedings*, 105, 77-85.

SEMENIUK, V., 1973 - Nearshore to offshore facies and depositional history of the Ordovician Daylesford Limestone, New South Wales. *Journal of the Geological Society of Australia*, 20, 449-463.

SEMENIUK, V., & BYRNES, J.G., 1971 - Occurrence and significance of *Ischadites* Murchison in Ordovician limestones at Bowan Park, New South Wales. *Journal of the Geological Society of Australia*, 18, 235-241.

SHAW, R.D., in press - The tectonic development of the Amadeus Basin, central Australia. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

SHAW, R.D., & WELLS, A.T., 1983 - Alice Springs, Northern Territory - 1:250 000 geological series (second edition). *Bureau of Mineral Resources, Australia, Explanatory Notes* SF/53-14.

SHAW, S.E., FLOOD, R.H., & RILEY, G.H., 1982 - The Wologorong Batholith, New South Wales, and the extension of the I-S line of Siluro-Devonian granitoids. *Journal of the Geological Society of Australia*, 29(1), 41-48.

SHEEHAN, P.M., 1988 - Late Ordovician events and the terminal Ordovician extinction. *New Mexico Bureau of Mines & Mineral Resources, Memoir* 44, 405-415.

SHELL DEVELOPMENT (AUSTRALIA), 1971 - Money Shoal-1 well completion report. *Shell Development (Australia) report* (unpublished).

SHERGOLD, J.H., 1971 - Resume of data on the base of the Ordovician in northern and central Australia. Colloque Ordovician-Silurien, Brest, Septembre 1971. *Mémoires de Bureau de Recherches géologique et minière*, 73, 391-402.

SHERGOLD, J.H., 1986 - Review of the Cambrian and Ordovician palaeontology of the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Report* 276.

SHERGOLD, J.H., & DRUCE, E.C., 1980 - Upper Proterozoic and Lower Palaeozoic rocks of the Georgina Basin. *In* HENDERSON, R.A., & STEPHENSON, P.J., (Editors) - THE GEOLOGY AND GEOPHYSICS OF NORTHEASTERN AUSTRALIA. *Geological Society of Australia, Queensland Division.*

SHERGOLD, J.H., DRUCE, E.C., RADKE, B.M., & DRAPER, J.J., 1976 - Cambrian and Ordovician stratigraphy of the eastern portion of the Georgina Basin, Queensland and eastern Northern Territory. *25th International Geological Congress, Australia, 1976, Field Excursion Guidebook* 4C.

SHERGOLD, J.H., ELPHINSTONE, R., LAURIE, J.R., NICOLL, R.S., WALTER, M.R., YOUNG, G.C., & WENLONG ZANG, in press - Late Proterozoic and Early Palaeozoic palaeontology and biostratigraphy of the Amadeus basin. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the Amadeus Basin. *Bureau of Mineral Resources, Australia, Bulletin* 236.

SHERRARD, K., 1954 - The assemblages of graptolites in New South Wales. *Royal Society of New South Wales, Journal and Proceedings*, 87, 73-101.

SHERRARD, K., 1962 - Further notes on assemblages of graptolites in New South Wales. *Royal Society of New South Wales, Journal and Proceedings*, 95, 167-178.

SHERWIN, L., 1971 - Stratigraphy of the Cheesemans Creek district, New South Wales. *Geological Survey of New South Wales, Records* 13(4), 199-237.

SHERWIN, L., 1973 - Stratigraphy of the Forbes-Bogan Gate district. *Geological Survey of New South Wales, Records* 15, 47-101.

SHERWIN, L., 1976 - The Secrets section through the Cotton beds north of Parkes. *Geological Survey of New South Wales, Quarterly Notes* 24, 6-10.

SHERWIN, L., 1979 - Age of the Nelungaloo Volcanics near Parkes. *Geological Survey of New South Wales, Quarterly Notes* 35, 15-18.

SHERWIN, L., 1983 - New occurrences of Ordovician graptolites from central New South Wales. *Geological Survey of New South Wales, Quarterly Notes* 53, 1-4.

SHERWIN, L., CLARKE, I., & KRYNEN, J.P., 1987 - Revision of stratigraphic units in the Forbes-Parkes-Tomingley district. *Geological Survey of New South Wales, Quarterly Notes* 67, 1-23.

SINGLETON, O.P., 1965 - Geology and mineralization of Victoria. *In* McANDREW, J. (Editor) - Geology of Australian Ore Deposits. *Eighth Commonwealth Mining and Metallurgy Congress, Melbourne*, 440-449.

SINGLETON, O.P., 1973 - Geology of south Gippsland. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY (Second Edition). *School of Geology, University of Melbourne*, 129-138.

SKWARKO, S.K., 1967 - Some Ordovician graptolites from the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 92, 171-183.

SMITH, K.G., 1967 - Stratigraphic drilling in the Georgina Basin, N.T. *Bureau of Mineral Resources, Australia, Report* 124.

SMITH, K.G., 1972 - Stratigraphy of the Georgina Basin. *Bureau of Mineral Resources, Australia, Bulletin* 111.

SOLOMON, M., 1958 - Palaeozoic sedimentation, tectonics and mineralization in the Mt Lyell area (Tasmania). *M.Sc. Thesis, University of Tasmania, Hobart* (unpublished).

SOLOMON, M., 1965 - Geology and mineralization of Tasmania. *In* McANDREW, J. (Editor) - Geology of Australian ore deposits. *Eighth Commonwealth Mining and Metallurgy Congress, Melbourne*, 464-477.

SOLOMON, M., 1979 - Delamerian unconformities in Tasmanian: discussion. *Journal of the Geological Society of Australia*, 26(8), 435-436.

SOLOMON, M., 1981 - An introduction to the geology and metallic ore deposits of Tasmania. *Economic Geology*, 76(2), 194-208.

SOLOMON, M., & GRIFFITHS, 1972 - Tectonic evolution of the Tasman Orogenic Zone, eastern Australia. *Nature, Physical Science*, 237(70), 3-6.

SOLOMON, M., & GRIFFITHS, J.R., 1974 - Aspects of the early history of the southern Tasman Orogenic Zone. *In* DENMEAD, A.K., TWEEDALE, G.W., & WILSON, A.F. (Editors) - THE TASMAN GEOSYNCLINE - A SYMPOSIUM. *Geological Society of Australia, Queensland Division, Brisbane*, 19-46.

SOLOMON, M., & GRIFFITHS, J.R., 1975 - Aspects of the early history of the southern part of the Tasman Orogenic Zone of eastern Australia. *Australasian Institute of Mining and Metallurgy, Proceedings* 24, 242, 9-24.

SPENCER-JONES, D., 1965 - The geology and structure of the Grampians area, western Victoria. *Geological Survey of Victoria, Memoir* 25.

SPENCER-JONES, D., & VANDENBERG, A.H.M., 1975 - The Tasman Geosyncline in Victoria - regional geology. *In* KNIGHT, C.L. (Editor) - Economic geology of Australia and Papua New Guinea - 1. Metals. *Australasian Institute of Mining and Metallurgy, Monograph* 5, 637-646.

SPRY, A.H., & BANKS, M.R., 1962 - Geology of Tasmania. *Journal of the Geological Society of Australia*, 9.

STAIT, B., & BURRETT, C.F., 1987 - Biogeography of Australian and southeast Asian Ordovician nautiloids. *In* McKENZIE, G.D. (Editor) - GONDWANA SIX: STRATIGRAPHY, SEDIMENTOLOGY, AND PALEONTOLOGY. *American Geophysical Union, Geophysical Monograph* 41, 21-28.

STANTON, R.L., 1956 - The Palaeozoic rocks of the Wiseman's Creek-Burraga area, N.S.W. *Royal Society of New South Wales, Journal and Proceedings*, 89, 131-145.

STEWART, I.R., & GLEN, R.A., 1986 - An Ordovician age for part of the Girilambone Group at Yanda Creek, east of Cobar. *Geological Survey of New South Wales, Quarterly Notes* 64, 23-25.

STRUCKMEYER, H.I.M., & BROWN, P.J., 1990 - Australian sealevel curves. Part 1: Australian inundation curves. *Bureau of Mineral Resources, Australia, Record* 1990/11.

STRUSZ, D.L., 1989 - Australian Phanerozoic timescales: 3. Silurian - biostratigaphic chart and explanatory notes. *Bureau of Mineral Resources, Australia, Record* 1989/33

STRUSZ, D.L., & HENDERSON, G.A.M., 1971 - Canberra City A.C.T. - 1:50000 geological map and explanatory notes. *Bureau of Mineral Resources, Australia.*

STRUSZ, D.L., & NICOLL, R.S., 1973 - Palaeozoic fossils from the Tarago region, New South Wales. *Bureau of Mineral Resources, Australia, Record* 1973/15 (unpublished).

STUART, W.J., & VON SANDEN, A.T., 1972 - Palaeozoic history of the St Vincent Gulf region, South Australia. *The APEA Journal*, 12, 9-16.

STUART-SMITH, P.G., 1987 - Extensional structures in the Tumut Trough, southern New South Wales, Australia. *In* Applied extension tectonics. Extended abstracts, 1987 BMR Research Symposium. *Bureau of Mineral Resouces, Australia, Record* 1987/51, 62-63.

TALENT, J.A., 1969 - The geology of East Gippsland. *Proceedings of the Royal Society of Victoria*, 82, 37-60.

TALENT, J.A., & THOMAS, D.E., 1967 - Central Victoria. *39th ANZAAS Congress, Section C, Excursion Handbook, Melbourne*, 25-42.

TALENT, J.A., & THOMAS, D.E., 1968 - Excursion No. 7, central Victoria. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY. *School of Geology, University of Melbourne* 24, 25-42.

TALENT, J.A., & THOMAS, D.E., 1973 - Stratigraphy and structure of the Palaeozoic of west-central Victoria. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY (second edition). *School of Geology, University of Melbourne*, 65-82.

TANNER, J.J., 1966 - Distribution of Palaeozoic rocks beneath the Great Artesian Basin, Queensland. *The APEA Journal*, 6, 116-120.

TATTAM, C.M., 1976 - Petrology of igneous rocks. *In* DOUGLAS, J.G., & FERGUSON, J.A. (Editors) - Geology of Victoria. *Geological Society of Australia, Special Publication* 5, 349-374.

TATE, R., 1896 - Palaeontology. *In* SPENCER, B. (Editor) - REPORT ON THE WORK OF THE HORN SCIENTIFIC EXPEDITION TO CENTRAL AUSTRALIA. *Melbourne, Melville, Mullen & Slade, London*, 3, 97-116.

THOMAS, D.E., 1935 - Ordovician. *In* SKEATS, E.W. (Editor) - Outline of the physiography and geology of Victoria. *ANZAAS Handbook for Victoria, Melbourne University Press*, 96-105.

THOMAS, D.E., 1939 - The structure of Victoria with respect to the Lower Palaeozoic rocks. *Mining and Geological Journal of Victoria*, 1, 59-64.

THOMAS, D.E., 1940 - Geological parish maps of Heathcote, Knowsley East. *Geological Survey of Victoria.*

THOMAS, D.E., 1959 - The geological structure of Victoria. *Royal Society of New South Wales, Journal and Proceedings*, 92, 182-190.

THOMAS, D.E., 1960 - The zonal distribution of Australian graptolites. *Royal Society of New South Wales, Journal and Proceedings*, 24, 94, 1-58.

THOMAS, D.E., & KEBLE, R.A., 1933 - The Ordovician and Silurian rocks of the Bulla-Sunbury area, and discussion of the sequence of the Melbourne area. *Royal Society of Victoria, Proceedings*, 45, 33-84.

THOMSON, B.P., 1953 - Geology and ore occurrence in the Cobar district. *In* EDWARDS, A.B. (Editor) - GEOLOGY OF AUSTRALIAN ORE DEPOSITS. *Fifth Empire Mining and Metallurgical Congress, Melbourne*, 863-869.

THOMSON, B.P., 1965 - Geology and mineralization of South Australia. *In* McANDREW, J. (Editor) - GEOLOGY OF AUSTRALIAN ORE DEPOSITS. *Eighth Commonwealth Mining and Metallurgy Congress, Melbourne*, 270-284.

THOMSON, B.P., 1969 - The Kanmantoo Group and Early Palaeozoic tectonics. *In* PARKIN, L.W. (Editor) - HANDBOOK OF SOUTH AUSTRALIAN GEOLOGY. *Government Printer, Adelaide*, 97-108.

TOWNER, R.R., & GIBSON, D.L., 1983 - Geology of the onshore Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 215.

TOWNSON, W.G., 1985 - The subsurface geology of the western Officer Basin - results of Shell's 1980-1984 petroleum exploration campaign. *The APEA Journal*, 25, 34-51.

TRAVES, D.M., 1955 - The geology of the Ord-Victoria region, northern Australia. *Bureau of Mineral Resources, Australia, Bulletin 27.*

TRAVES, D.M., CASEY, J.N., & WELLS, A.T., 1956 - The geology of the southwestern Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Report* 29.

TURNER, S., FODEN, J., & COOPER, J., 1989 - Post Delamerian magmatism: tectonic controls on magma chemistry and evidence for post Delamerian extension. *In* Australasian tectonics. *Geological Society of Australia, Abstracts* 24.

VAIL, P.R., MITCHUM, R.M., Jr, THOMPSON, S., III, 1977 - Seismic stratigraphy and global changes of sea level. Part 4: global cycles of relative changes of sea level. In PAYTON, C.E. (Editor) - Seismic stratigraphy - applications to hydrocarbon exploration. *American Association of Petroleum Geologists, Memoir* 26, 83-97.

VANDENBERG, A.H.M., 1973 - Geology of the Melbourne district. *In* McANDREW, J., & MARSDEN, M.A.H. (Editors) - REGIONAL GUIDE TO VICTORIAN GEOLOGY. *School of Geology, University of Melbourne*, 14-30.

VANDENBERG, A.H.M., 1976 - The Tasman Fold Belt in Victoria. *Geological Survey of Victoria, Report* 1976/3.

VANDENBERG, A.H.M., 1978 - The Tasman Fold Belt System in Victoria. *Tectonophysics*, 48, 267-298.

VANDENBERG, A.H.M., 1981 - Victorian stages and graptolite zones. *In* WEBBY, B.D. (Editor) - The Ordovician System in Australia, New Zealand and Antarctica. *International Union of Geological Sciences, Publication* 6, 2-7.

VANDENBERG, A.H.M., & WEBBY, B.D., 1988 - Ordovician-Silurian boundary in Victoria and New South Wales, Australia. *In* COCKS, L.R.M., & RICKARDS, R.B. (Editors) - A global analysis of the Ordovician-Silurian boundary. *Bulletin British Museum (Natural History) Geology Series*, 43, 183-190.

VEEVERS, J.J., 1967 - The Phanerozoic geological history of northwest Australia. *Journal of the Geological Society of Australia*, 14, 253-272.

VEEVERS, J.J., 1971 - Phanerozoic history of Western Australia related to continental drift. *Journal of the Geological Society of Australia*, 18, 87-96.

VEEVERS, J.J., 1976 - Early Phanerozoic events on and alongside the Australasian- Antarctic platform. *Journal of the Geological Society of Australia*, 23, 183-206.

VEEVERS, J.J. (Editor), 1984 - PHANEROZOIC EARTH HISTORY OF AUSTRALIA. *Clarendon Press, Oxford*.

VEEVERS, J.J., JONES, J.G., & POWELL, C.McA., 1982 - Tectonic framework of Australia's sedimentary basins. *The APEA Journal*, 22(1), 283-300.

VEEVERS, J.J., & WELLS, A.T., 1961 - The geology of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 60.

VOISEY, A.H., 1969 - The New England Region. *In* PACKHAM, G.H. (Editor) - The Geology of New South Wales. *Journal of the Geological Society of Australia*, 16(1), 229-231.

VON DER BORCH, C.C., 1980 - Evolution of Late Proterozoic to Early Paleozoic Adelaide Foldbelt, Australia: comparisons with post-Permian rifts and passive margins. *Tectonophysics*, 70, 115-134.

WALL, V.J., & CEPLECHA, J.C., 1976 - Deformation and metamorphism in the development of gold-quartz mineralization in slate belts. *25th International Geological Congress, Sydney, Abstracts* 1, 142-143.

WALLEY, A.M., 1987 - Notes to accompany a 1:5 000 000 Silurian structural history map, 1987. *Bureau of Mineral Resources, Australia, Record* 1987/54.

WALLEY, A.M., & COOK, P.J. (Compilers), in press - The Palaeozoic palaeogeography of the Amadeus Basin. *In* KORSCH, R.J., & KENNARD, J.M. (Editors) - Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 236.

WALLEY, A.M., STRUSZ, D.L., & YEATES, A.N., in press - Palaeogeographic atlas of Australia. Volume 3 - Silurian. *Bureau of Mineral Resources, Australia.*

WALPOLE, B.P., DUNN, P.R., & RANDALL, M.A., 1968 - Geology of the Katherine-Darwin region, Northern Territory. *Bureau of Mineral Resources, Australia, Bulletin* 82.

WARREN, R.G., 1983 - Metamorphic and tectonic evolution of granulites, Arunta Block, central Australia. *Nature*, 305, 300-303.

WASS, R., & DENNIS, D.M., 1977 - Early Palaeozoic faunas from the Warwick-Stanthorpe region, Queensland. *Search*, 24, 8(6), 207-208.

WEBB, A.W., 1969 - Metallogenic epochs in eastern Queensland. *Australasian Institute of Mining and Metallurgy, Proceedings*, 230, 29-37.

WEBB, A.W., 1976 - The use of the potassium-argon method to date a suite of granitic rocks from southeastern South Australia. *AMDEL Bulletin* 21, 25-36.

WEBB, A.W., & McDOUGALL, I., 1968 - The geochronology of the igneous rocks of eastern Queensland. *Journal of the Geological Society of Australia*, 15, 313-346.

WEBB, B.P., 1960 - Diapiric structures in the Flinders Ranges, South Australia. *Australian Journal of Science*, 22, 9.

WEBBY, B.D., 1969 - Ordovician stromatoporoids from New South Wales. *Palaeontology*, 12, 637-662.

WEBBY, B.D., 1972 - The rugose coral *Palaeophyllum* Billings from the Ordovician of central New South Wales. *Linnean Society of New South Wales, Proceedings*, 97, 150-157.

WEBBY, B.D., 1974 - Lower Palaeozoic rocks of the craton of Australia. *University of Sydney, Report* 1974/3 (unpublished).

WEBBY, B.D., 1975 - Succession of Ordovician coral and stromatoporoid faunas from central-western New South Wales, Australia. *In* SOKOLOV, B.S. (Editor) - Drevniye Cnidaria, Volume II. *Nauka, Novosibirsk*, 57-68.

WEBBY, B.D., 1976 - The Ordovician system in southeastern Australia. *In* BASSETT, M.G. (Editor) - THE ORDOVICIAN SYSTEM. *University of Wales Press, Cardiff*, 417-446.

WEBBY, B.D., 1978 - History of the Ordovician continental platform shelf margin of Australia. *Journal of the Geological Society of Australia*, 25, 41-63.

WEBBY, B.D., 1979 - Delamerian unconformities in Tasmania: reply. *Journal of the Geological Society of Australia*, 26, 436-437.

WEBBY, B.D., 1987 - Biogeographic significance of some Ordovician faunas in relation to east Australian Tasmanide suspect terranes. *In* LEITCH, E.C., & SCHEIBNER, E. (Editors) - Terrane accretion and orogenic belts. *American Geophysical Union, Geodynamics Series* 19.

WEBBY, B.D., & NICOLL, R.S. (Compilers), 1989 - Australian Phanerozoic timescales: 2. Ordovician. *Bureau of Mineral Resources, Australia, Record* 1989/32.

WEBBY, B.D., VANDENBERG, A.H.M., COOPER, R.A., BANKS, M.R., BURRETT, C.F., HENDERSON, R.A., CLARKSON, P.D., HUGHES, C.P., LAURIE, J., STAIT, B., THOMSON, M.R.A., & WEBERS, G.F., 1981 - The Ordovician system in Australia, New Zealand and Antarctica: correlation chart and explanatory notes. *International Union of Geological Sciences, Publication* 6.

WELLS, A.T., 1972 - Mount Doreen, Northern Territory - 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* SF/52-12.

WELLS, A.T., 1976a - Ngalia Basin. *In* LESLIE, R.B., EVANS, H.J., & KNIGHT, C.L. (Editors) - Economic geology of Australia and Papua New Guinea - 3. Petroleum. *Australasian Institute of Mining and Metallurgy, Monograph* 7, 226-230.

WELLS, A.T., 1976b - Geology of the Late Proterozoic-Palaeozoic Amadeus Basin. *25th International Geological Congress, Sydney, Australia, Excursion Guide* 48A

WELLS, A.T., EVANS, T.G., & NICHOLAS, T., 1968 - The geology of the central part of the Ngalia Basin, Northern Territory. *Bureau of Mineral Resources, Australia, Record* 1968/38 (unpublished).

WELLS, A.T., FORMAN, D.J., RANFORD, L.C., & COOK, P.J., 1970 - Geology of the Amadeus Basin, central Australia. *Bureau of Mineral Resources, Australia, Bulletin* 100.

WELLS, A.T., & MOSS, F.J., 1983 - The Ngalia Basin, Northern Territory: stratigraphy and structure. *Bureau of Mineral Resources, Australia, Bulletin* 212.

WELLS, A.T., MOSS, F.J., & SABITAY, A., 1972 - The Ngalia Basin, Northern Territory - recent geological and geophysical information upgrades petroleum prospects. *The APEA Journal*, 12(1), 144-151.

WELLS, B.E., 1956 - The geology of the Casterton district. *Royal Society of Victoria, Proceedings*, 68, 85-100.

WHITE, A.J.R., COMPSTON, W., & KLEEMAN, A.W., 1967 - The Palmer Granite - a study of a granite within a regional metamorphic environment. *Journal of Petrology*, 8, 29-50.

WHITE, A.J.R., WILLIAMS, I.S., & CHAPPELL, B.W., 1976 - Jindabyne Thrust and its tectonic, physiographic and petrogenetic significance. *Journal of the Geological Society of Australia*, 23, 105-112.

WILFORD, G.E., 1983 - Phanerozoic palaeogeography. *BMR Earth Science Atlas of Australia.*

WILKINSON, H.E., 1972 - Lower Ordovician (Castlemanian) shelly fossils at Castlemaine. *Mining and Geological Journal*, 7(2), 21.

WILKINSON, H.E., 1974 - Bendigo 1:100,000 Geological Map. *Department of Mines, Victoria.*

WILLIAMS, E., 1978a - Tasman Fold Belt in Tasmania. *Tectonophysics* 48, 159-206.

WILLIAMS, E., 1978b - Delamarian unconformities in Tasmania: reply. *Journal of the Geological Society of Australia*, 26, 438.

WILLIAMS, E., SOLOMON, M., & GREEN, G.R., 1975 - Tasman Geosyncline in Tasmania: the geological setting of metalliferous ore deposits in Tasmania. *In* KNIGHT, C.L. (Editor) - Economic Geology of Australia and Papua New Guinea - 1. Metals. *Australasian Institute of Mining and Metallurgy, Monograph* 5, 567-581.

WILLIAMS, G.E., 1973 - Simpson Desert Sub-basin - a promising Permian target. *The APEA Journal*, 13, 33-40.

WILLIAMS, G.E., 1975 - Northern extent of the Delamerian Orogeny. *Search*, 6(10), 435-436.

WILLIAMS, P.R., 1975 - The relationship between the Cambrian rocks and the correlate of the Junee Group at Misery Hill, near Zeehan. *Technical Report of the Department of Mines, Tasmania*, 18, 36-39.

WILSON, C.J.L., 1968 - Geology of the Narooma area, N.S.W. *Royal Society of New South Wales, Journal and Proceedings*, 101, 147-157.

WILSON, J.L., 1975 - CARBONATE FACIES IN GEOLOGIC HISTORY. *Springer-Verlag, Berlin.*

WILSON, R.B., 1966 - Geological appraisal of P.E.L. 78 Mootwingee area, New South Wales, Beach Petroleum N.L. *Geological Survey of New South Wales, Petroleum File, Geology* 1966/7 (unpublished).

WITHNALL, I.W., 1982 - The geology of the Greenvale-Balcooma area. *In* WITHNALL, I.W. (Editor) - 1982 Field Conference Charters Towers - Greenvale area. *Geological Society of Australia, Queensland Division, Brisbane*, 31-46.

WITHNALL, I.W., 1985 - Pre-Devonian geology of the Graveyard Creek Subprovince, Broken River Province (Embayment), North Queensland. *Geological Survey of Queensland, Record* 1985/32.

WITHNALL, I.W., LANG, S.C., JELL, J.S., McLENNAN, T.P.T., TALENT, J.A., MAWSON, R., FLEMING, P.J.G., LAW, S.R., MACANSH, J.D., SAVORY, P., KAY, J.R., & DRAPER, J.J., 1988 - Stratigraphy, sedimentology, biostratigraphy and tectonics of the Ordovician to Carboniferous, Broken River Province, north Queensland. *Geological Society of Australia, Australasian Sedimentologists Group Field Guide Series* 5.

WOLF, K.H., FLUGEL, E., & KEMEZYS, K.J., 1968 - Ordovician calcareous algae from a bioherm, Blathery Creek Volcanics, New South Wales. *Review of Palaeobotany and Palynology*, 6, 147-153.

WOODHOUSE, G., 1982 - Geochemical evaluation of Acacia No. 1 (Canning Basin). *Western Mining Corporation report* (unpublished).

WOOLLEY, D.R., & ROCHOW, K.A., 1965 - Mineral deposits in central Australia. *In* McANDREW, J. (Editor) - Geology of Australian Ore Deposits. *Eighth Commonwealth Mining and Metallurgy Congress, Melbourne*, 186-190.

WOPFNER, H., 1967 - Cambro-Ordovician sediments from the north-eastern margin of the Frome Embayment (Mt. Arrowsmith), N.S.W. *Royal Society of New South Wales, Journal and Proceedings*, 100, 163-178.

WOPFNER, H., 1972 - Depositional history and tectonics of South Australian sedimentary basins. *South Australian Mineral Resources Review* 133, 32-50.

WYATT, D.H., PAINE, A.G.L., CLARKE, D.E., GREGORY, C.M., & HARDING, R.B., 1971 - Geology of the Charters Towers 1:250 000 Sheet area, Queensland. *Bureau of Mineral Resources, Australia, Report* 137.

WYBORN, D., 1988 - Ordovician magmatism, gold mineralisation, and an integrated tectonic model for the Ordovician and Silurian history of the Lachlan Fold Belt in NSW. *BMR Research Newsletter* 8, 13-14.

WYBORN, L.A.I., & CHAPPELL, B.W., 1979 - Geochemical evidence for the existence of a pre-Ordovician sedimentary layer in south-eastern Australia. *In* DENHAM, D. (Compiler) - Crust and upper mantle of southeast Australia. *Bureau of Mineral Resources, Australia, Record* 1979/2, 104.

YEATES, A.N., CROWE, R.W.A., TOWNER, R.R., WYBORN, L.A.I., & PASSMORE, V.L., 1975 - Notes on the geology of the Gregory Sub-basin and adjacent areas of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Record* 1975/77 (unpublished).

YEATES, A.N., GIBSON, D.L., TOWNER, R.R., & CROWE, R.W.A., 1984 - Regional geology of the onshore Canning Basin. *In* PURCELL, P.G. (Editor) - THE CANNING BASIN, WA. *Proceedings of the GSA/PESA Canning Basin Symposium, Perth 1984*, 23-55.

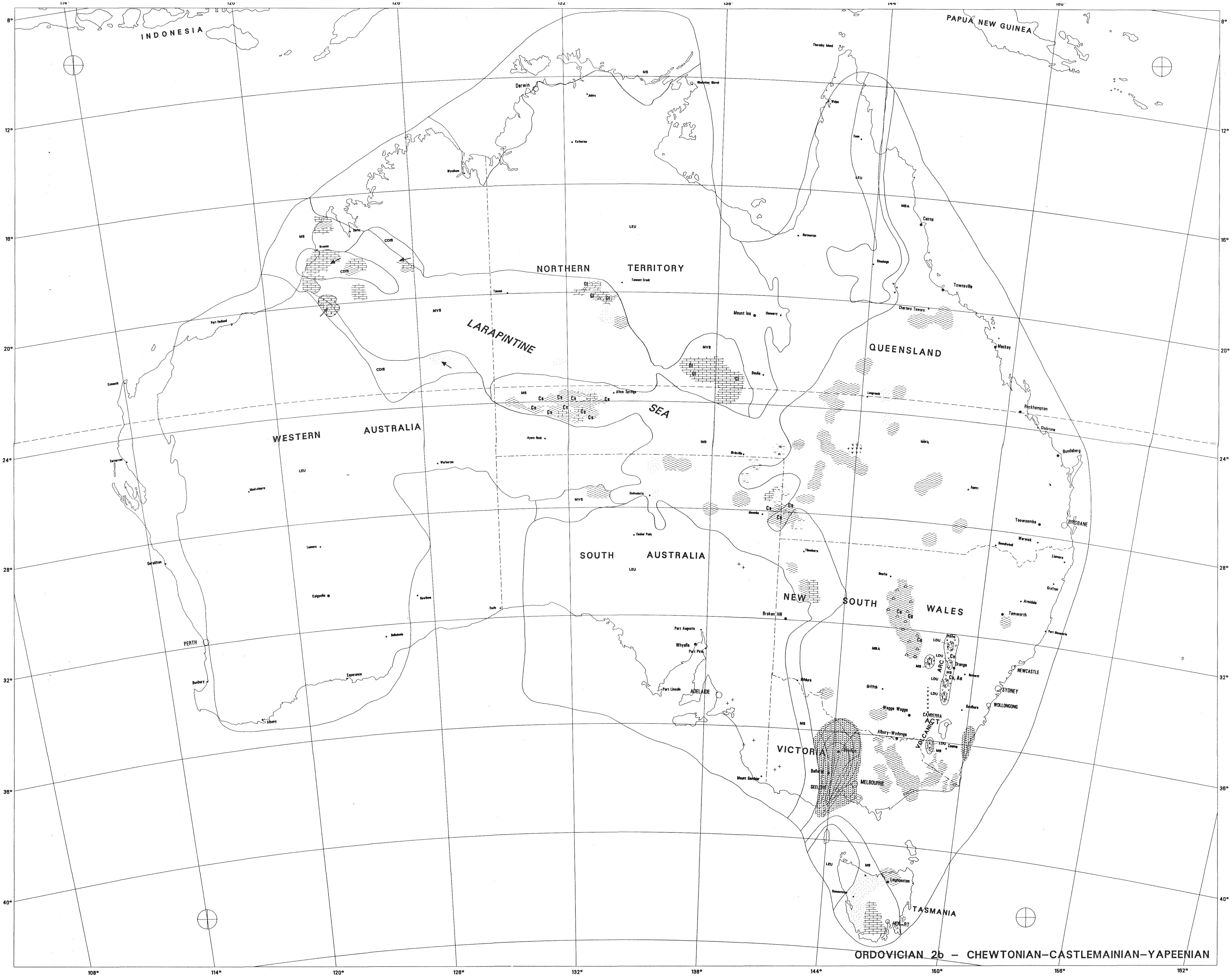
YOUNG, R.J.B., 1972 - Barbwire No 1 well completion report (North West Petroleum Pty. Ltd.). *Bureau of Mineral Resources, Australia, File* 72/2001 (unpublished).

YOUNGS, B.C., 1973 - Pedirka Basin. *In* LESLIE, R.B., EVANS, J.H., & KNIGHT, C.L. (Editors) - Economic Geology of Australia and New Guinea - 3. Petroleum. *Australasian Institute of Mining and Metallurgy, Monograph* 7, 372-373.

YOUNGS, B.C., 1978 - Stratigraphic drilling in the eastern Arrowie Basin, 1975-76. *Geological Survey of South Australia, Quarterly Geological Notes* 66, 16-20.

ZIEGLER, A.M., BAMBACH, R.K., PARRISH, J.T., BARRETT, S.F., GIERLOWSKI, E.H., PARKER, W.C., RAYMOND, A., & SEPKOSKI, J.J. Jr, 1981 - Paleozoic biogeography and climatology. *In* NIKLAS, K.J. (Editor) - PALEOBOTANY, PALEOECOLOGY, AND EVOLUTION. Volume 2. *Praeger Publishers, New York*, 231-266.

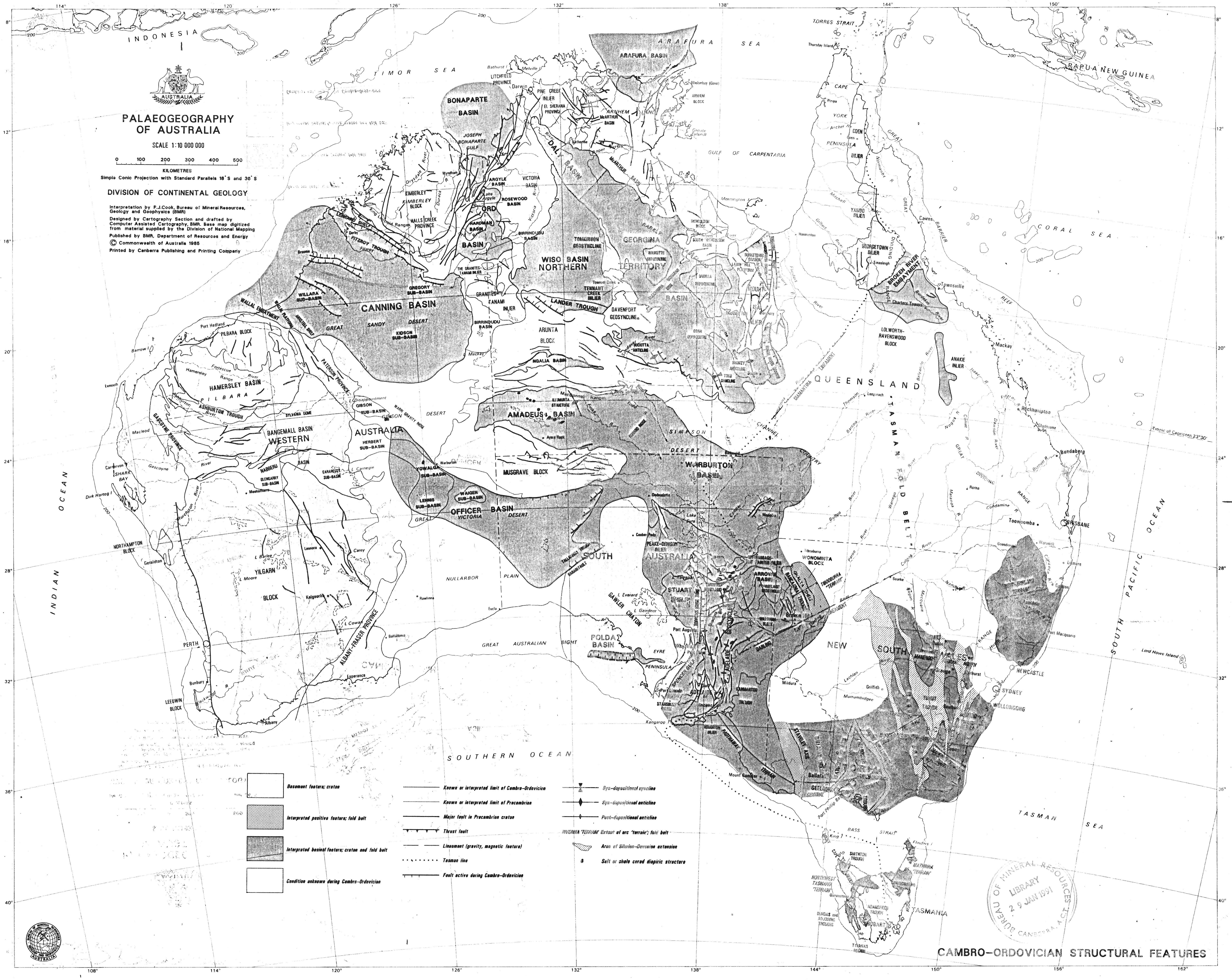
ORDOVICIAN 1b – DATSONIAN–LANCEFIELDIAN–BENDIGONIAN



ORDOVICIAN 2b – CHEWTONIAN–CASTLEMAINIAN–YAPEENIAN

INDONESIA
PAPUA NEW GUINEA
NORTHERN TERRITORY
LARAPINTINE
SEA
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
TASMANIA
HIGHLANDS
VOLCANIC
ACT
Darwin
Cairns
Townsville
Mount Isa
Alice Springs
Rockhampton
Bundaberg
Toowoomba
BRISBANE
Broken Hill
Port Augusta
Whyalla
ADELAIDE
PERTH
Kalgoorlie
NEWCASTLE
SYDNEY
WOLLONGONG
MELBOURNE
GEELONG
Ballarat
Launceston
HOBART
LEU
MS
MBA
CDIS
LDU
ORDOVICIAN 3b – DARRIWILIAN

ORDOVICIAN 4b – GISBORNIAN–EASTONIAN–BOLINDIAN


PALAEOGEOGRAPHY OF AUSTRALIA
SCALE 1:10 000 000
0 100 200 300 400 500
KILOMETRES
Simple Conic Projection with Standard Parallels 18° S and 36° S
DIVISION OF CONTINENTAL GEOLOGY
Interpretation by P.J.Cook, Bureau of Mineral Resources, Geology and Geophysics (BMR)
Designed by Cartography Section and drafted by Computer Assisted Cartography, BMR. Base map digitized from material supplied by the Division of National Mapping
Published by BMR, Department of Resources and Energy
© Commonwealth of Australia 1985
Printed by Canberra Publishing and Printing Company
AUSTRALIA
INDONESIA
TIMOR SEA
ARAFURA SEA
TORRES STRAIT
PAPUA NEW GUINEA
CORAL SEA
GULF OF CARPENTARIA
INDIAN OCEAN
SOUTH PACIFIC OCEAN
SOUTHERN OCEAN
TASMAN SEA
GREAT AUSTRALIAN BIGHT
BASS STRAIT
ARAFURA BASIN
BONAPARTE BASIN
DALY BASIN
McARTHUR BASIN
GEORGINA BASIN
WISO BASIN
CANNING BASIN
ORD BASIN
AMADEUS BASIN
WARBURTON BASIN
OFFICER BASIN
ARROWIE BASIN
POLDA BASIN
HAMERSLEY BASIN
BANGEMALL BASIN
PILBARA BLOCK
YILGARN BLOCK
MUSGRAVE BLOCK
ARUNTA BLOCK
GAWLER CRATON
STUART SHELF
ALBANY-FRASER PROVINCE
PATERSON PROVINCE
LANDER TROUGH
FITZROY TROUGH
KIMBERLEY BLOCK
TASMAN FOLD BELT
BROKEN RIVER EMBAYMENT
ANAKIE INLIER
QUEENSLAND
NEW SOUTH WALES
SOUTH AUSTRALIA
WESTERN AUSTRALIA
NORTHERN TERRITORY
TASMANIA
Basement feature; craton
Interpreted positive feature; fold belt
Interpreted basinal feature; craton and fold belt
Condition unknown during Cambro-Ordovician
Known or interpreted limit of Cambro-Ordovician
Known or interpreted limit of Precambrian
Major fault in Precambrian craton
Thrust fault
Lineament (gravity, magnetic feature)
Tasman line
Fault active during Cambro-Ordovician
Syn-depositional syncline
Syn-depositional anticline
Post-depositional anticline
RIVERINA 'TERRAIN' Extent of arc 'terrain'; fold belt
Area of Silurian-Devonian extension
Salt or shale cored diapiric structure
CAMBRO-ORDOVICIAN STRUCTURAL FEATURES

REFERENCE : ORDOVICIAN

Conglomerate

Quartz sandstone

Lithic sandstone

Undifferetiated sandstone

Feldspathic sandstone

Quartz–rich greywacke

Evaporites

Mudstone

Limestone

Dolomite

Chert

Pyroclastics

Sedimentary breccia

Felsic extrusives

Mafic extrusives

Felsic intrusives

Mafic intrusives

Inferred subcrop

Ultramafic

LAND

UNCLASSIFIED ENVIRONMENT

LEU

DEPOSITIONAL ENVIRONMENT

LDU *Undifferentiated*

LDF *Fluvial*

COASTAL

DEPOSITIONAL ENVIRONMENT

CDIS *Intertidal–supratidal*

CDD *Deltaic*

CDP *Paralic*

SEA

MARINE ENVIRONMENT

MVS *Very shallow (0–20m)*

MS *Shallow (0–200m)*

MBA *Bathyal–abyssal (>200m)*

Geological boundary

Fault

Isopach, thickness in metres

Where location of boundaries, faults and isopachs is approximate, line is broken; where inferred, queried

Bore or data point locality with reference number

Radiometric age in millions of years

Oil occurrence within this time slice

Thickness in metres

Approximate minimum thickness in metres

Cs *Mineral occurrence; Au – Gold, Cr – Chromium, Cs – Carbonaceous sediments, Cu – Copper, Gl – Glauconite, Gp – Gypsum, Mn – Manganese, Na – Halite and other chlorides, Pb – Lead, Ph – Phosphate, Py – Pyrite, Su – Sulphate, Zn – Zinc*

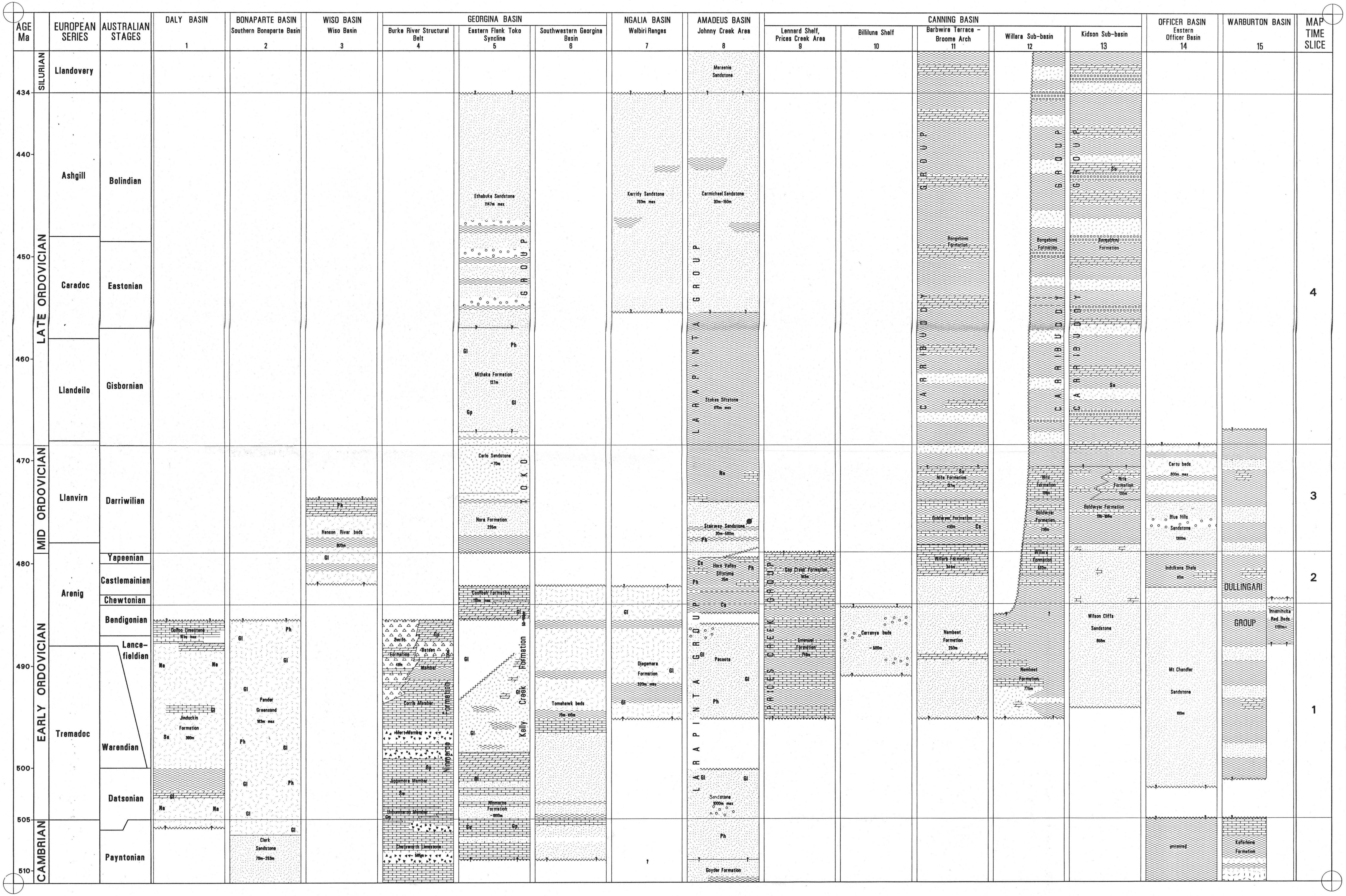
Measured palaeocurrent direction

Zone of crustal extension

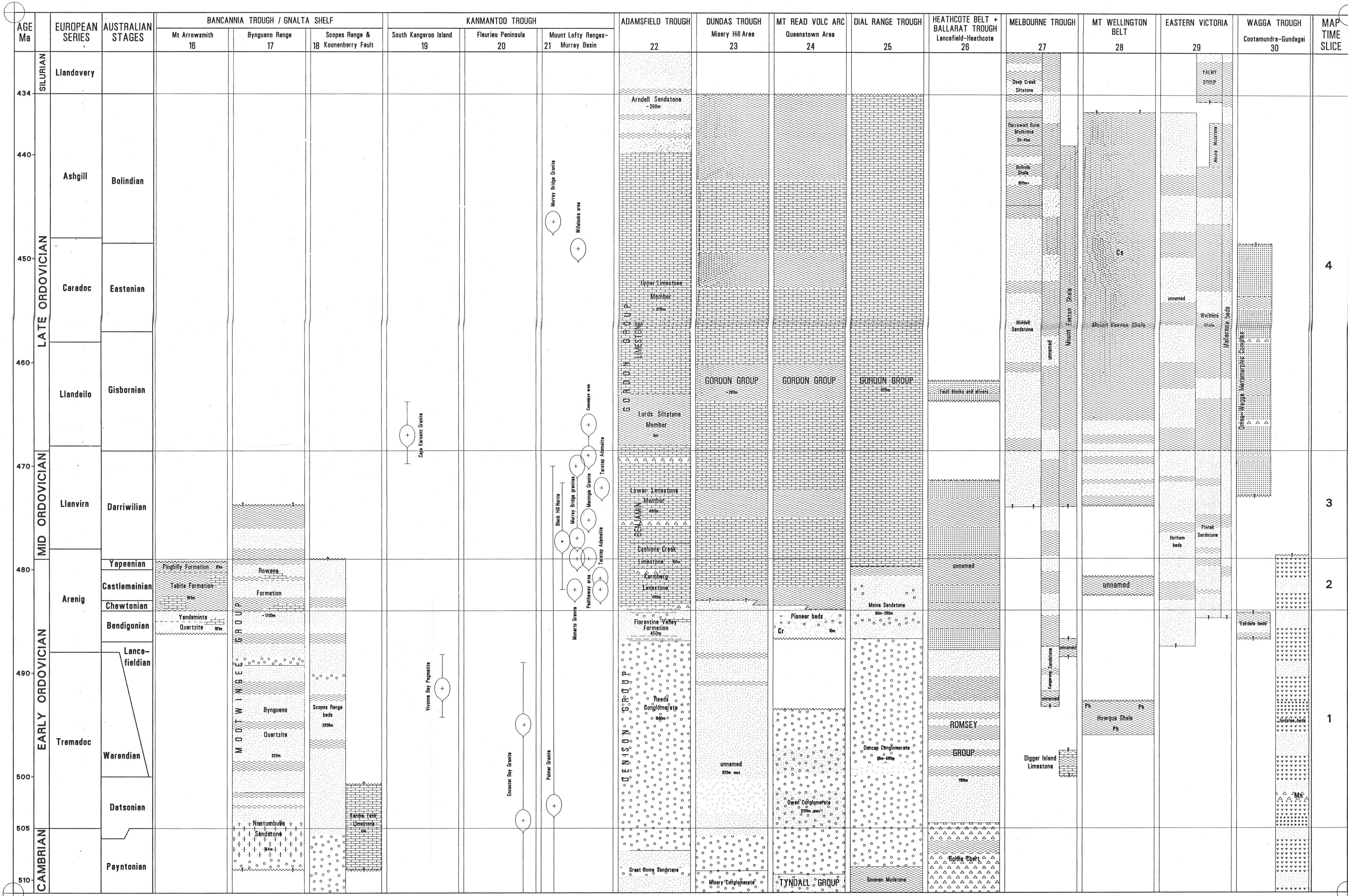
Fan

Volcanoes, inferred

Diagrammatic stream

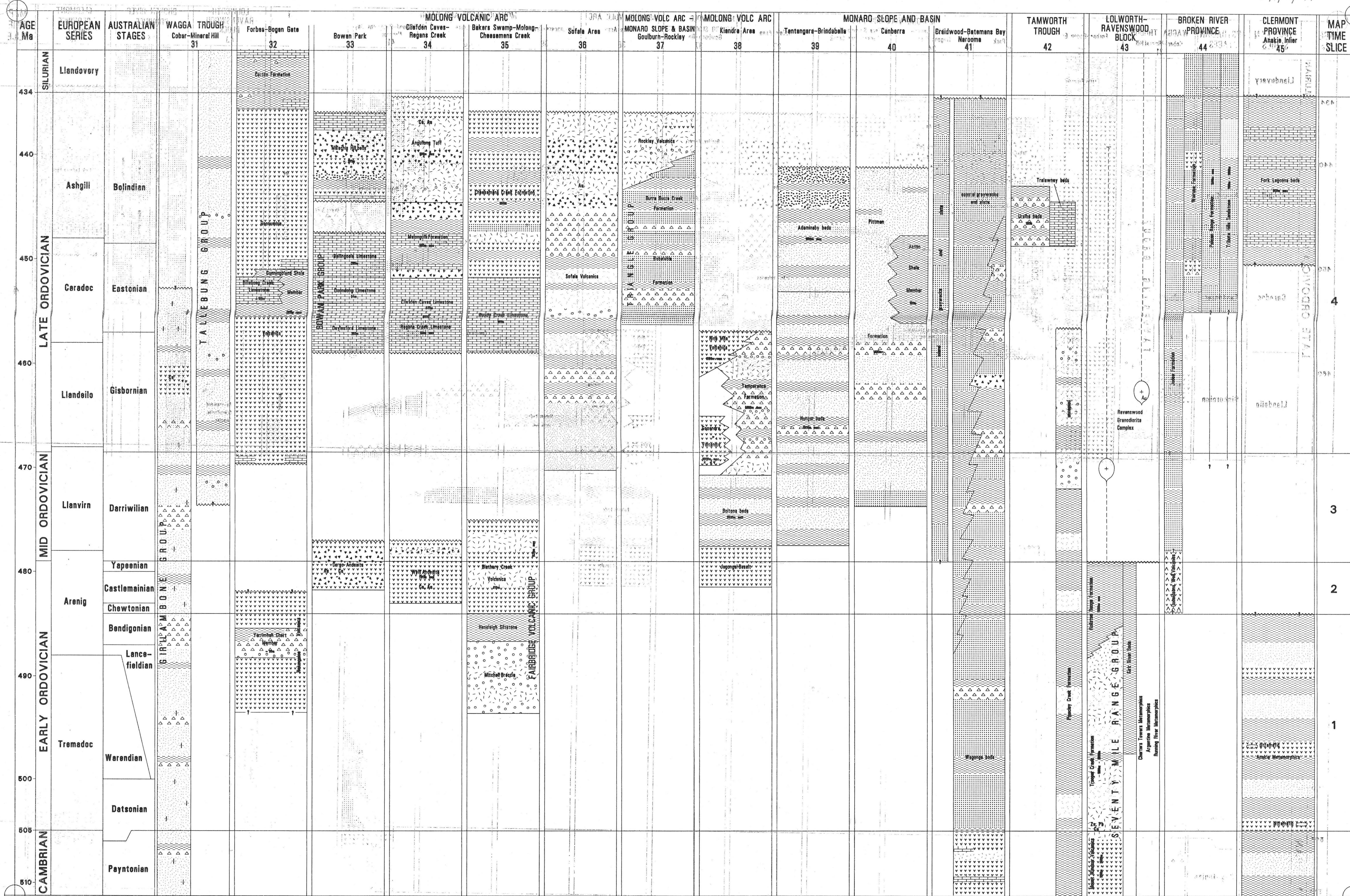


02-OCT-1990 10:33 PAI:[I0002]ORDICLITH.DGN;I

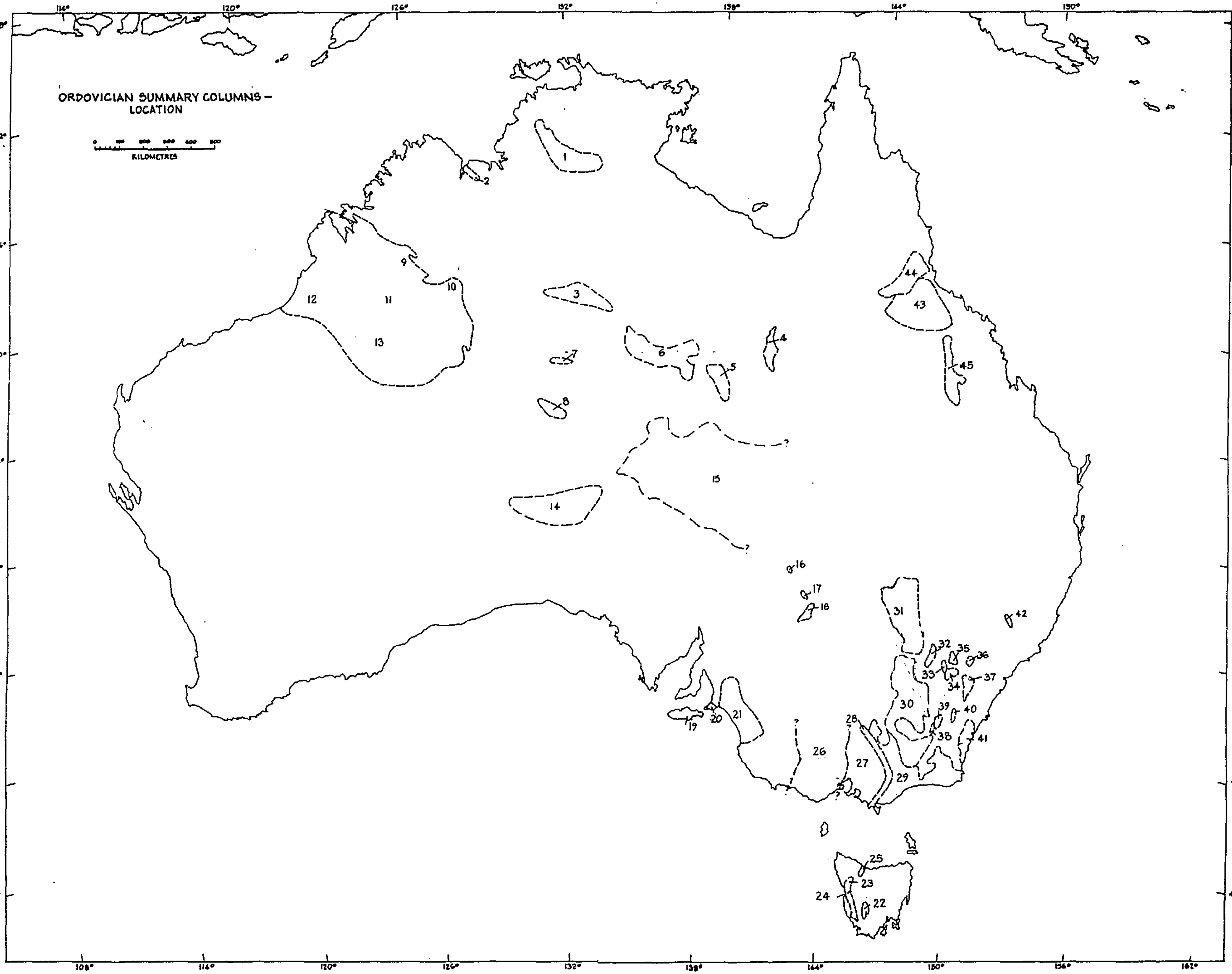


AGE Ma
EUROPEAN SERIES
AUSTRALIAN STAGES
BANCANNIA TROUGH / GNALTA SHELF
Mt Arrowsmith 16
Byngueno Range 17
18 Scopes Range & Koonenberry Fault
KANMANTOO TROUGH
South Kangaroo Island 19
Fleurieu Peninsula 20
21 Mount Lofty Ranges– Murray Basin
ADAMSFIELD TROUGH 22
DUNDAS TROUGH Misery Hill Area 23
MT READ VOLC ARC Queenstown Area 24
DIAL RANGE TROUGH 25
HEATHCOTE BELT + BALLARAT TROUGH Lancefield–Heathcote 26
MELBOURNE TROUGH 27
MT WELLINGTON BELT 28
EASTERN VICTORIA 29
WAGGA TROUGH Cootamundra–Gundagai 30
MAP TIME SLICE
434
440
450
460
470
480
490
500
505
510
SILURIAN
LATE ORDOVICIAN
MID ORDOVICIAN
EARLY ORDOVICIAN
CAMBRIAN
Llandovery
Ashgill
Caradoc
Llandeilo
Llanvirn
Arenig
Tremadoc
Bolindian
Eastonian
Gisbornian
Darriwilian
Yapeenian
Castlemainian
Chewtonian
Bendigonian
Lancefieldian
Warendian
Datsonian
Payntonian
Pingbilly Formation
Tabita Formation
Yandeminta Quartzite
Rowena Formation
~1700m
MOOTWINGEE GROUP
Byngueno Quartzite
320m
Nootumbulla Sandstone
Scopes Range beds
2830m
Kandie Tank Limestone
Cape Kersaint Granite
Vivonne Bay Pegmatite
Encounter Bay Granite
Murray Bridge Granite
Willalooka area
Coonalpyn area
Taratap Adamellite
Black Hill Norite
Murray Bridge granites
Marcollat Granite
Meningie Granite
Padthaway area
Monarto Granite
Palmer Granite
Arndell Sandstone
~250m
Upper Limestone Member
Lords Siltstone Member
Lower Limestone Member
Cashions Creek Limestone
Karmberg Limestone
GORDON GROUP LIMESTONE
BENJAMIN
Florentine Valley Formation
450m
Reeds Conglomerate
DENISON GROUP
Great Dome Sandstone
GORDON GROUP
Pioneer beds
Cr
unnamed
Owen Conglomerate
Misery Conglomerate
TYNDALL GROUP
Moina Sandstone
Duncan Conglomerate
Gnomon Mudstone
Fault blocks and slivers
unnamed
ROMSEY GROUP
Goldie Chert
Deep Creek Siltstone
Darraweit Guim Mudstone
Bolinda Shale
Riddell Sandstone
unnamed
Mount Easton Shale
Kangaroo Sandstone
unnamed
Digger Island Limestone
Cs
Mount Easton Shale
unnamed
Ph
Howqua Shale
YALMY GROUP
Ahaina Mudstone
unnamed
Warbisco Shale
Mallacoota beds
Pinnak Sandstone
Hotham beds
Ordovician Wagga Metamorphic Complex
Eakdale beds
Jindalee beds
Mn
1
2
3
4

1990/41



16-OCT-1990 11:08 PAI:[11002]ORD3CLITH.DGN;1


ORDOVICIAN SUMMARY COLUMNS — LOCATION
KILOMETRES
0 100 200 300 400 500
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
108°
114°
120°
126°
132°
138°
144°
150°
156°
162°
8°
12°
16°
20°
24°
28°
32°
36°
40°