PALAEOGEOGRAPHY

NOTES TO ACCOMPANY A [illegible] SCALE

D[illegible]

S. [illegible]

R8904901

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

ONSHORE SEDIMENTARY & PETROLEUM GEOLOGY

RECORD 1989/49

BMR RECORD 1989/49

NOTES TO ACCOMPANY A 1:5 000 000 SCALE DEVONIAN STRUCTURE MAP OF AUSTRALIA

BY

S. OLISSOFF

BUREAU OF MINERAL RESOURCES/AUSTRALIAN PETROLEUM INDUSTRIES RESEARCH ASSOCIATION

PALAEOGEOGRAPHIC MAPS PROJECT

CONTENTS

LIST OF FIGURES

SUMMARY

Major structures and structural events affecting the Australian continent during the Devonian are depicted on the accompanying 1:5 000 000 scale map, and are briefly described in these notes.

Major orogenic events (Bowning, Tabberabberan and Late Devonian orogenesis), and movements sympathetic with and consequent to these periods of orogenesis has meant that the continent, during Devonian times, has been in a state of perpetual motion. At no time, has the continent as a whole been demonstrably quiescent.

Tectonism has resulted in the following:

- reactivation of basement structures continent-wide
- extremely rapid downwarping, transfering **hundreds of cubic kilometres** of sediment into relatively narrow deep basins;
- large scale rotations
- large scale uplift culminating in the development of highland areas;
- major episodic igneous intrusions and plutonism;
- continental collision and both island arc and continental arc volcanism;
- crustal extension and compression; and
- salt tectonics.

Orogenesis has had a "stepping" effect across the continent. The nature and consequences of this tectonism in Western and Central Australia was of a very different nature to that in Eastern Australia. This may be due in part, to the nature of the basement, which was a fundamental influence on the entire Devonian structural history.

INTRODUCTION

The data in this Record were assembled during the preparation of a series of palaeogeographic maps of the Devonian, as part of the joint BMR/APIRA Phanerozoic Palaeogeographic Maps Project. As only a summary account of the structures will accompany the published notes to the palaeogeographic maps a more complete version is given here.

This compilation is based on extensive literature research, supplemented by information derived from geologists of BMR, State Geological Surveys and Universities. The structural features are described below by area.

WESTERN AND CENTRAL AUSTRALIA

Introduction

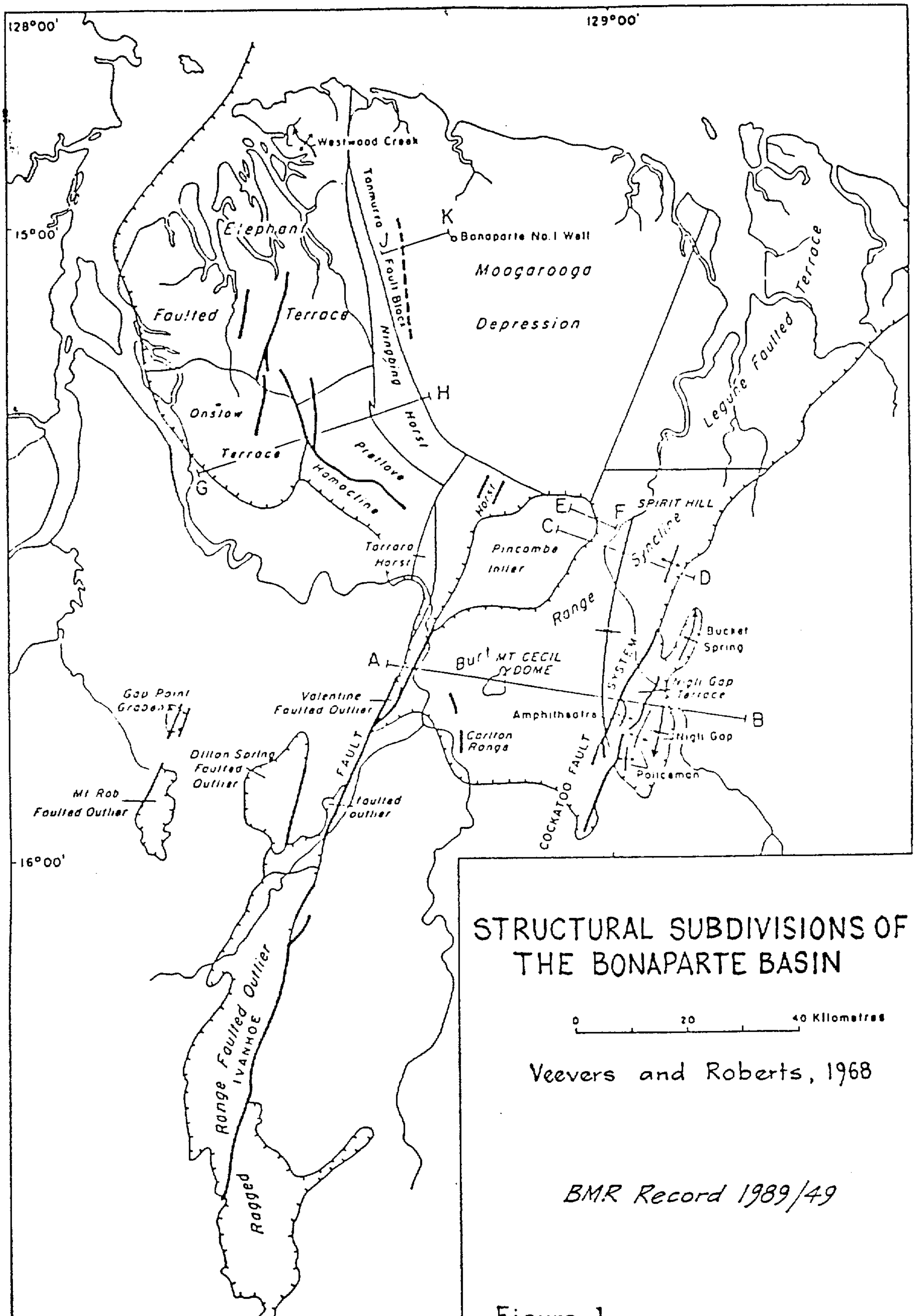
Devonian sediments were deposited in intracratonic basins of Western and Central Australia. The three basins adjacent to the present Western Australian coast were embayments of sea lying to the northwest of Australia, and contain mostly marine sediments, whereas those of Central Australia were filled primarily with continental, freshwater sediments. Devonian sediments occur in outcrop in all the basins, except the Officer and Arafura Basins where they are present only in subcrop.

Until late Middle Devonian time, this region of the continent was relatively stable (cratonic); subsequent epeirogenic activity set in motion accelerated downwarping (particularly in the Western basins), concomitant marine incursions and reactivation of basement elements generally. The consequences were low to moderately dipping strata cut by high-angle faults. Metamorphism is evident only in the Arunta Inlier (north of the Amadeus Basin) close to fault zones, such as the Redbank Deformed Zone.

The most significant epeirogenic movements are probably related to the Tabberabberan Orogeny; these caused block rotation linking the structural development of the Western and Central Basins. For instance, Smith (1984) has suggested that the Tabberabberan Orogeny triggered the Alice Springs Orogeny, hence, the two may be partly coeval. The significant movement affecting both Western and Central regions is the clockwise rotation of Central Australia and the southern Canning Basin relative to the Kimberley Block. The zones of mobility for rotation, are located at junctions such as, the axis of the Gregory Sub-basin, Eastern Basin Margin Fault System, and the edge of the Halls Creek Mobile Zone. The overall effect of the rotational movement was to cause compressional and dextral tectonics and uplift in the Amadeus Basin and Arunta Block, general uplift in the Ngalia and Wiso Basins and wrenching and rifting movements in the west (Austin & Williams, 1978).

Bonaparte Basin

The intracratonic Bonaparte Basin is the northernmost basin containing outcrop of Devonian sediments. Sedimentation occurred primarily onshore. Minor offshore sedimentation has been revealed in drillhole intersections. Devonian structural movements in the Bonaparte Basin began in the Frasnian, relating directly to Tabberabberan and Alice Springs orogenies, and coinciding with a clearly defined regional marine transgression commencing in the earliest *asymmetricus* to *praesulcata* zones (Talent & Yolkin, 1987). Movement along faults caused renewed deposition in the basin and uplift in the Precambrian source areas along the south-



STRUCTURAL SUBDIVISIONS OF THE BONAPARTE BASIN

0 20 40 Kilometres

Veevers and Roberts, 1968

BMR Record 1989/49

Figure 1

ern margin. These movements continued with diminishing intensity throughout the remainder of the Upper Devonian and Lower Carboniferous.

The Early Frasnian movements initiated deposition of the Bonaparte Beds. Deposition continued into the Carboniferous. During this time, the axis of the basin changed from a northwest direction in the Early Frasnian to an east-northeast direction in the Late Frasnian to Visean (Roberts & Veevers, 1973). Frasnian movements also caused uplift and subsequent erosion of the Pincombe Inlier, and the area along the Cockatoo Fault System; significant subsidence occurred in the Moogarooga Depression (indicated by two depoaxes on the map) and in the Tanumurra Fault Block, which lies along the western edge of the Moogarooga Depression (Fig. 1); intermittent faulting and subsidence occurred along the Burt Range Syncline (expressed as a major syncline and minor depocentre on the map) the Mount Robb and Dillon Springs Outliers, the Gap Point Graben (expressed as normal faults), and along the Legune Faulted Terrace.

During the Fammenian, the southeastern platform was uplifted, probably along faults, and eroded. Little faulting occurred but subsidence continued through from the Frasnian (subsidence represented by the depocentre in the Moogarooga Depression and along the Pretlove Homocline).

Diapirism, both onshore and offshore is a conspicuous feature and is well evidenced in seismic records. Salt (139m thick) in Sandpiper 1 Well is believed to be equivalent in age to the Ningbing Group onshore (Fammenian). The salt (190m) in Pelican Island 1 Well is thought to be Devonian or older (Wells, 1980).

Canning Basin

The Canning Basin is a large intracratonic basin bounded by the Precambrian Kimberley Block to the north and the Pilbara Block to the south. The basin is nearly colinear with the Amadeus Basin to the southeast (Horstman *et al.*, 1976).

The structural development and sedimentation in the Basin was controlled by a number of pre-existing structural trends. For example (a) the Halls Creek Mobile Zone, a NNE-trending left lateral transcurrent fault system, was intermittently very active during the late Middle Devonian equivalent of the Tabberabberan Orogeny and to the Late Devonian-Early Carboniferous Alice Springs Orogeny; (b) the NW-SE-trending conjugate set of dextral strike-slip faults of the Fenton, Stansmore and Tina Springs Faults show intermittent growth throughout the Palaeozoic. This fault system is parallel to the King Leopold Mobile Zone in the Kimberley Block and is probably related to it (Smith, 1984); (c) an Early Frasnian event caused anti-regional tilting of fault blocks basin-wide e.g. Blackstone High, Barbwire Terrace. The movement of the Beagle Bay Fault is also directly related to this event (Lehmann, 1984).

During the Early Devonian, growth faulting occurred along the Pender Bay Fault. This movement initiated the proto-Pender Embayment as a half-graben deepening to the north. This area became a major depocentre with sedimentation continuing until the early Middle Devonian. Farther south, in the Kidson and Willara Sub-Basins, uneven downwarping and subsidence took place. With subsequent sedimentation, the two sub-basins merged across the Munro Arch. Renewed subsidence, gentle downwarping and sedimentation occurred from the Givetian to the Middle Frasnian. These NW-SE trending basins became a major depocentre. Both sub-basins are characterised by limited contemporaneous en-echelon faults creating half-grabens. The regions of deposition became confined to the north and east during the Late Devonian. Deposits are preserved in the Fitzroy and Gregory Sub-basins of the Fitzroy Graben (Yeates *et al.*, 1984).

The Fitzroy Graben developed as a major half graben (W.A. Geol. Surv., written comm 1987) bounded by listric normal faults, and downfaulted back-tilted blocks along its flanks (Brown *et al.*, 1984). This coincides with the main rifting phase in the Canning Basin occurring from the Early Givetian to the Tournasian (Brown *et al.*, 1984).

The Gregory Sub-basin is controlled, along its northeastern boundary by the dextral strike-slip Hinge Fault, and along the southwestern margin by the Fenton, Tina Springs and Dummer Range Fault Systems. The Sub-basin becomes narrower to the southeast but was probably connected to the Kidson Sub-Basin until the Alice Springs Orogeny. The dominant Devonian structural features in the Gregory Sub-basin are the en-echelon folds controlled by NW-SE trending sets of conjugate dextral strike-slip faults (Smith, 1984).

The adjacent Balgo Terraçe (also known as the Betty Terrace) underwent continuous growth faulting throughout the Palaeozoic with maximum growth during Devonian to Early Carboniferous time. A series of NW-SE and N-S trending normal faults, some listric at depth, are evident. The throws on individual faults can be in excess of 4000m. The fault pattern on the Terrace is interpreted to be related to a large delta complex that developed during the Late Devonian and which culminated in the Early Carboniferous (Smith, 1984). The northeastern side of the Terrace is controlled by the Mueller Fault System and the southwest side by the Hinge and Stansmore Fault Systems.

The Billiluna Shelf and adjacent Balgo Terrace comprise the northeastern part of the Canning Basin adjoining the Halls Creek Mobile Belt and Granites-Tanami Province. The southwestern margin of the Billiluna Shelf is controlled by the NW-SE trending Mueller Fault System of down-to-the-basin faults which show strong Palaeozoic growth and sole out at depth (Smith, 1984). The Shelf is cut by a series of normal faults which are either parallel to the Mueller Fault and are listric, or which trend east-west and north-south. The east-west fault along the northern margin shows continuous Palaeozoic growth (Smith, 1984).

A N-S sinistral strike-slip fault is interpreted along the eastern margin of the Canning Basin (W.A. Geol. Surv; written comm., 1987).

Basement highs occur in the northern Canning Basin in the region of the Oscar Range, the May River Langoora High and the Beagle Bay reef complex.

Amadeus Basin

Basin configuration and structural elements of the intracratonic Amadeus and nearby Ngalia, and southwest Georgina Basins (M. J. Freeman; written comm. 1986) were probably controlled by the tectonic framework of the underlying Arunta Complex. Major controlling structures included the latitudinal shears of the Redbank and Harry Creek Deformed Zones, and the Oolera Fault Zone, the former being active during the Devonian. The timings are on the map. Uplift of the Arunta Complex therefore occurred north of the present Amadeus Basin margin.

It seems likely that movement was occurring in the Amadeus Basin throughout most of the Devonian. This activity was possibly cumulative, hence, the difficulty to "pinpoint" specific structural events. There was however, considerable localised uplift, rapid deposition and erosion which is in evidence for example, east of Ellery Creek, and in the Ross River Syncline (R. S. Nicoll, pers comm 1986; Jones, 1972). Salt tectonics in the basin began in the late Proterozoic, and continued to the end of the Palaeozoic, the rate of doming increasing with onset of the Alice Springs Orogeny. Salt domes occupy the cores of the Ooraminna and Waterhouse Anticlines (J. F. Lindsay pers comm, 1986) possibly intruding during folding and extension (J. Bradshaw, pers comm, 1987). The growth of the Goyder Pass salt structure, however, continued during deposition of the Mereenie Sandstone but ceased prior to the deposition of the basal Pertnjara Group (Wells, 1980).

Devonian structural changes are related to two major tectonic events, the Pertnjara Movement and the Alice Springs Orogeny.

The Middle to Late Devonian **Pertnjara Movement** probably originated as a regional epeirogenic uplift similar to the earlier Rodingan Movement. The Pertnjara Movement has been attributed (Jones, 1972) to a disconformity existing between the Mereenie Sandstone and the Pertnjara Group in the northeastern part of the Amadeus Basin. Recent evidence (M. Owen, pers comm. 1987) suggests that the contact between the Mereenie Sandstone and the overlying Parke Siltstone of the Pertnjara Group is in part gradational, and in part disconformable. This may suggest that, similarly to the Tabberabberan Event in Eastern Australia, the Pertnjara Movement was variable across the basin. The unconformity beneath the Mt Eclipse Sandstone in the Ngalia Basin and the disconformity in the Georgina Basin are also attributable to the Pertnjara Movement (Jones, 1972). The Pertnjara sequence is synorogenic (Wells *et al.*, 1970).

On the northern margin of the Amadeus Basin, uplift continued until the Alice Springs Orogeny. This uplift culminated in the rapid deposition of the Brewer Conglomerate which lies in a major depocentre along the northern margin of the Basin in its easternmost sector. The uplifts to the south in the Finke area, possibly correspond to the "pre-Brewer" uplift, and resulted in the deposition of the conglomeratic Finke Group sediments directly onto the Proterozoic basement (Wells *et al.*, 1970). Later tilting occurred during the Alice Springs Orogeny.

The **Alice Springs Orogeny** (400Ma-300Ma) as defined by Shaw *et al.* (1984) was confined to the latest Devonian and is recognised throughout much of the Arunta Inlier and the Amadeus Basin. Its effect was widespread, and has been recognised in the Harts Range area, along the southern margin and extending to the south of the Redbank Deformed Zone, and in widely separate parts of the region to the north bounding the Ngalia Basin, and bounded by the Granites-Tanami Province and Birrindudu, Wiso and Georgina Basins. (Shaw *et al.*, 1984). (Fig. 2).

The Orogeny was characterised by:

a) thrust faulting which was particularly intense along the Redbank Deformed Zone and Delny-Mount Sainthill Fault Zone and was accompanied by greenschist metamorphism. The Delny-Mount Sainthill Fault Zone is a reactivated high-angle reverse fault up to 5 km wide (Freeman, 1986). The Gardner Fault, striking east-west with at least 6000m of vertical displacement and in excess of 10 km of strike-slip movement (J. Bradshaw, pers comm. 1987) occurred during the Late Devonian due to compressional forces acting from the NNE. During the latest Famennian or Early Carboniferous time, movement along the Oomoomilla Fault caused verti-

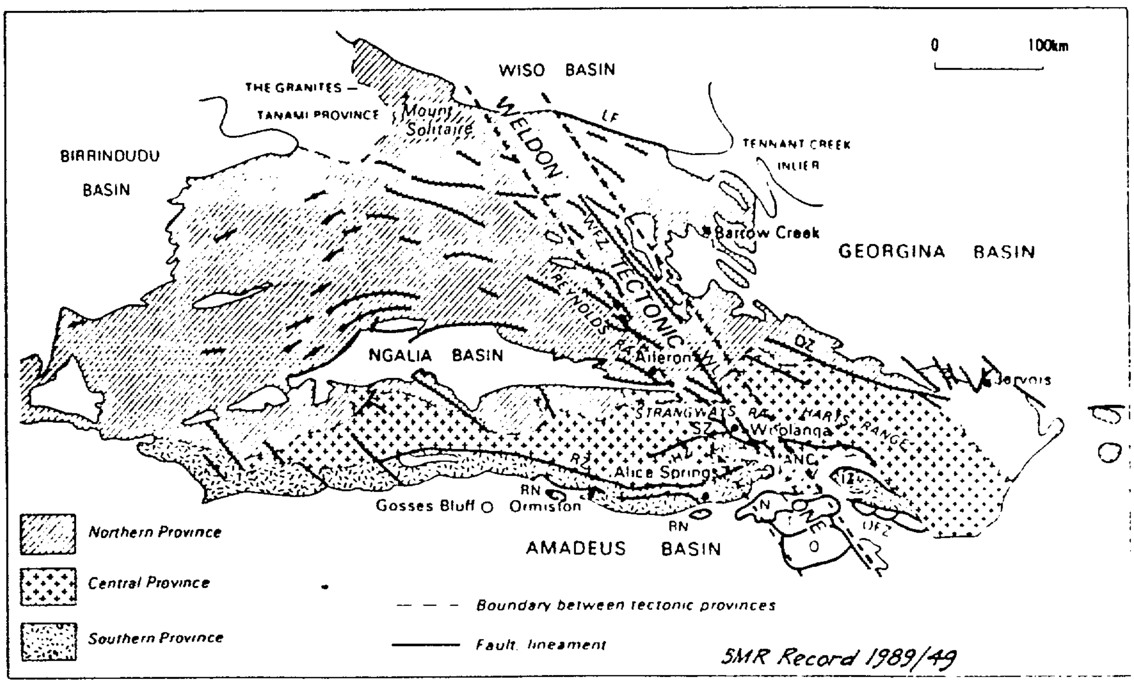


Figure 2 Tectonic provinces and structural features of the Arunta Inlier (Shaw et al., 1984)

cal displacement of at least 3.5 km with possible stress directed from between the NNE and SSE (Freeman, 1986).

b) local pegmatite formation occurred in the Harts Range in the Devonian; this is the only known magmatic activity during the Alice Springs Orogeny (Shaw *et al.*, 1984).

c) Late Devonian deposition along the north-central portion of the Amadeus Basin which can be interpreted as a depocentre of lacustrine sedimentation in the Mereenie Anticlinal zone.

Granites-Tanami Region

Five major tectonic phases have been recognised in the Granites-Tanami region. The last of these occurred during the Devonian. It has been recognised in the southwest of the Region by faulting and folding of the Pedestal Beds. This phase was probably part of the Alice Springs Orogeny (Blake, 1978).

Georgina Basin

There was little tectonic movement in the Georgina Basin during the Devonian. Activity along the Toomba Fault caused uplift prior to Devonian times providing the slope for deposition of the Cravens Peak Beds as an alluvial fan. Subsequent activity on the Fault occurred much later, thrusting Upper Proterozoic and crystalline basement rocks over Paleozoic rocks.

Wiso Basin

The only evidence of possible deformation during Devonian times are the large slump structures of the Lake Surprise Sandstone (Kennewell & Huleatt, 1980).

Ngalia Basin

The Ngalia Basin was subjected to two major Devonian tectonic events. The earlier event was the poorly constrained Kerridy Movement which had a basinwide effect during the Middle Devonian, causing basement reactivation, folding, faulting and thrusting. Later movement was associated with the Alice Springs Orogeny.

During the Kerridy Movement, the Kerridy Sandstone was uplifted and eroded producing a major unconformity of Late Devonian to Late Carboniferous Mount Eclipse Sandstone age. The Mount Doreen Fault was probably initiated by the Kerridy Movement, which was also responsible for the reactivation of the Yuendumu Thrust which was also responsible for the reactivation of the Ngalia Basin; its greatest displacement is on the southern edge of the Mount Doreen Salient. The thrust intersects progressively younger formations westwards from Yuendumu (Wells & Moss, 1983).

The Alice Springs Orogeny was responsible for either initiating or reactivating the Waite Creek Fault and for the deposition of the Mount Eclipse Sandstone which is concentrated primarily in a depocentre close to the present northern margin of the Ngalia Basin (Wells & Moss, 1983).

Arafura Basin

Intracratonic Palaeozoic sediments occur in the Arafura Basin beneath thick Mesosoic and Tertiary cover (Smith & Ross, 1986). Little is known of the structural development of the Basin.

Devonian sediments similar to those of the Bonaparte Beds in the Bonaparte Basin have been intersected in Money Shoal 1 Well, located within the Money Shoal Graben (Smith & Ross, 1986). The Graben is northwest-trending and was formed by bounding normal faults. The Devonian sediments may well extend beyond the limits of the Graben, on to the Aru and Merauke Ridges, and to the east as far as Wessel Island.

EASTERN QUEENSLAND AND NORTHEAST NEW SOUTH WALES

Introduction

The eastern Queensland and northeast New South Wales regions comprise three major fold belt systems; the Hodgkinson-Broken River and Thomson Fold Belts in Queensland and the New England Fold Belt of southeast Queensland and northeast New South Wales. These fold belts comprise the eastern and northern parts of the Tasman Fold Belt System (Fig. 3).

Tectonism and metamorphism in pre-Devonian times appear to have formed a relatively stable continental crust over most of the Tasman Fold Belt existing at that time (Murray, 1986). During the Devonian, the eastern part of Australia was subjected to "a pattern of orogenic and epeirogenic events alternating with protracted periods of relative quiescence" (Talent & Yolkin, 1987), the latter occurring primar-

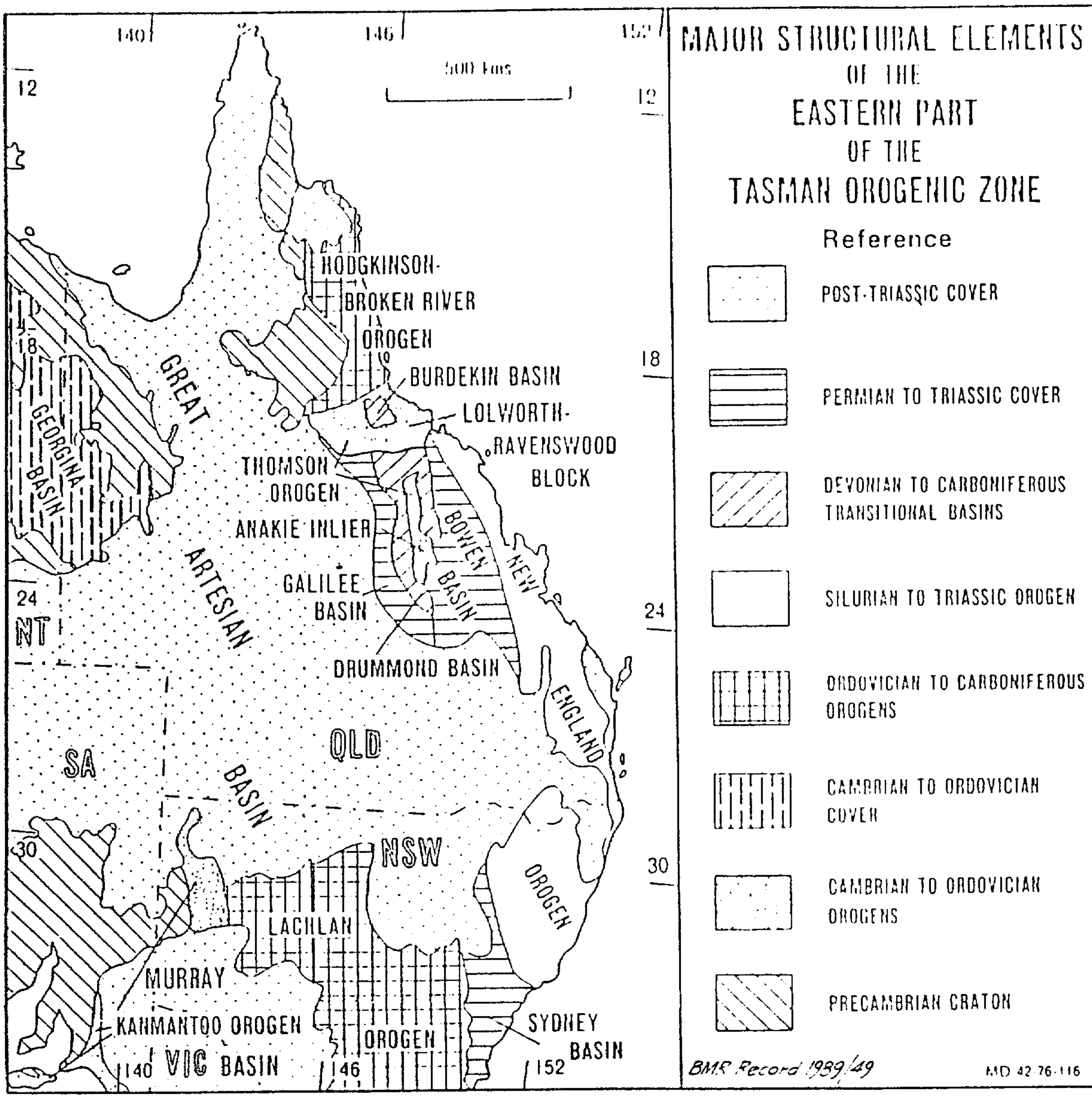


Figure 3 Location of the Hodgkinson - Broken River, Thomson and New England Orogens (Day et al., 1978)

ily in the Lower to Middle Devonian. Orogenic and epeirogenic events are more closely associated with the Tabberabberan movements commencing in the late Givetian or post-middle *varcus* Zone (Talent & Yolkin, 1987).

The tectonic evolution of the Thomson and Hodgkinson-Broken River Fold Belts still remains uncertain. The largely concealed Thomson Fold Belt is considered to have been a rifted continental margin during Precambrian or early Paleozoic time, which evolved (by Early-Middle Devonian time) to a convergent "Pacific-type" continental margin (Murray, 1986). Forearc, backarc (Fawckner, 1978; Arnold & Fawckner, 1980; Gregory, 1977; Gregory et al., 1980), rifted margin (Fawckner, 1981; cited in Murray, 1986) and accretionary wedge settings have been proposed for the Hodgkinson-Broken River Fold Belt. In the New England Fold Belt Early Devonian sequences were derived from a volcanic island arc setting whereas sequences of Late Devonian age are derived from a continental margin volcanic arc setting (Murray, 1986).

Hodgkinson-Broken River Fold Belt (H-BRFB)

The Hodgkinson Province is separated from the Precambrian Georgetown and Yambo Inliers to the west by the Palmerville Fault. The Precambrian Georgetown Inlier is separated from the Broken River Province by the Burdekin River Fault (Murray, 1986). The Palmerville Fault is a reactivated Late Devonian thrust fault, with associated mylonite in zones of significant crustal weakness (Shaw et al., 1987). The major movements along the fault are interpreted to be caused by thrusting from the west to the northeast (Fawckner, 1980; Shaw *et al.*, 1987). Similarly, the Mitchell Fault, to the east of the Palmerville Fault, is due to Late Devonian thrusting (Shaw *et al.*, 1987).

Possible extensions of the Palmerville Fault are the Burdekin River and Clarke River Fault Systems of the Broken River Province which lie directly south. The Burdekin Fault, which was active throughout the Silurian and Early Devonian (Swarbrick, 1976), is possibly a continuation of the zone of thrusting associated with the Palmerville Fault. The Clarke River Fault appears to have been controlled by basement structures (Withnall *et al.*, 1985). Arnold (1975) has suggested that large-scale sinistral movements have occurred along the fault. The sense of movement, however, has not been "conclusively determined" (Withnall *et al.*, 1985). The Clarke River Fault was possibly active during the Middle Devonian and was still active throughout the Frasnian (Swarbrick, 1976). Movement of the NNE-trending Gray Creek Fault occurred during the Frasnian (Withnall *et al.*, 1985). Post-dating these faults are trend lines of slaty-cleavage deformation which occurred throughout the Hodgkinson & Broken River Provinces and the Townsville hinterland.

A number of hypotheses have been proposed for the H-BRFB:-

a) the Fold Belt represents an arc-trench gap assemblage associated with an Andean-type continental margin volcanic arc on the Precambrian craton to the west. (Arnold, 1975; Arnold & Fawckner, 1980; Cooper *et al.*, 1975; Day *et al.*, 1978; 1983; Henderson, 1980). No evidence for the existence of the arc is available although it is speculated (by the above authors) that the Late Silurian to Middle Devonian granitoids lying to the west and elongated N-S may represent the former arc site. These predominantly S-type granites, however, are not what one would expect in a volcanic arc, and hence, the theory is not favoured here;

b) the Fold Belt represents a back-arc basin, whereby rocks "accumulated in an incipient marginal sea which formed behind a volcanic arc in the region of the Barnard Metamorphics" (Fawckner, 1981; Gregory *et al.*, 1980);

c) the Fold Belt represents a rifted continental margin (Fawckner, 1981);

d) the Fold Belt represents an accretionary wedge succession.

Imbricate thrust slices with dominant westward facings and eastward younging i.e., sedimentary structures on individual beds indicate facings are to the west, whereas, each thrust packet becomes progressively younger to the east (Arnold, 1975). Arnold (1975) opposes model (d) above because the greywacke compositions "fall outside the field of sandstones of magmatic arc provenance defined by Dickinson & Suczek (1979)". This assumes a direct relationship between the tectonics of sediment source areas and of associated depositional basins. However, sandstones can be transported "across boundaries of sedimentary-tectonic provinces and can thus occur in sedimentary or tectonic settings petrogenetically unrelated to the tectonics of the sediment source area".

Vebel (1985), Kasper & Lance (1986), and Thornberg & Kulm (1987) cite cases where sands petrogenetically unrelated to the arc-trench system have been introduced into accretionary prisms by sedimentary or tectonic processes e.g., Nias, Barbados, Chile Trench, thus the greywacke composition of the H-BRFB can be accommodated in an accretionary model and it was adopted as such during compilation of a correlation chart that was a forerunner to the structural map (Olissoff *et al.*, in prep.).

Thomson and New England Fold Belts (TFB & NEFB)

The oldest rocks in the NEFB in Queensland are calc-alkaline volcanics, volcanoclastic sediments and limestones of Late Silurian to Middle Devonian age which form a series of fault blocks grouped together as the Calliope Isand Arc (Day *et al.*, 1978; 1983; Murray, 1986). The arc may have been separated from the Australian continent (represented by the Anakie Inlier) by a marginal sea - the Murruin Basin (Marsden, 1972). Veevers *et al.*, (1982) have suggested that the arc may have been a suspect or exotic terrain which originally lay to the east of a wide ocean basin. Henderson (1980) suggested that the Late Silurian to Middle Devonian sequence of both the NEFB and the H-BRFB formed a "continuous NNW-trending belt along the northeastern edge of the Australian Continent which was an active Andean-type continental margin" (Murray, 1986). The island-arc model is preferred here.

The rocks of the Calliope Island Arc were folded along NNW axes at the end of the Middle Devonian (Marsden, 1972). The deformation extended as far west as the Anakie Inlier and appears to have accompanied either the closure of, or caused partial cratonization and uplift of, the marginal sea to the west of the Calliope Island Arc (Day *et al.*, 1978; 1983; Murray, 1986).

East of the Arc are deep water sediments **comprising bathyal, tectonic and trench assemblages**. These represent a typical ocean floor assemblage and are referred to as the Wandilla Slope and Basin sequence by Murray (1986) and as the Wandilla Accretionary Wedge Sequence in this compilation. The forearc basin sequence associated with this Early Devonian Arc is evident only to the very north of the NEFB towards Rockhampton (H. J. Harrington pers. comm., 1986) and is referred to here as the Tamworth Forearc Equivalent.

During the Middle Devonian (and probably associated with the Tabberabberan Orogeny), significant fault movements occurred in what is now the Yarrol Basin. The N-S trending Boyne River-Tungamull-Broad Sound Fault is possibly a high-angle easterly-dipping reverse fault (Kirkegaard *et al.*, 1970).

During the Middle Devonian orogeny, the Gracemere Block was stabilized by mild deformation and the Mount Morgan Tonalite intruded. An east-dipping fracture cleavage developed parallel to the axial planes of folds in suitable lithologies of the Mt Holly-Mt Larcom Blocks (Kirkegaard *et al.*, 1970). Farther to the west, movement along the Eungella-Cracow Mobile Belt may have commenced from the beginning of the Middle Devonian.

By the beginning of the Late Devonian most of Queensland appears to have evolved into a single tectonic entity, with the exception of the Gympie Block and possibly the Beenleigh Block.

In the Late Devonian-Early Carboniferous the NEFB is interpreted to have been an active Andean-type continental margin (Day *et al.*, 1978; 1983). A continental-margin volcanic arc, the Connors-Auburn Volcanic Arc, developed to the west of the present position of the Calliope Island Arc. To the east, the volcaniclastic Yarrol Forearc Basin developed unconformably over the deformed rocks of the Calliope Island Arc. Work by Cawood (1983) indicates that the arc (in NSW) changed from andesitic-dacitic composition in the Early Devonian to basaltic-andesitic composition in the Middle Devonian, and supplied sediments to a fore-arc basin called the Tamworth Belt. To the east of the Tamworth Belt lay a deepwater slope-trench sequence or accretionary wedge. To the east of it the approximate positions of the trench and ocean floor have been inferred.

Throughout the Late Devonian and Early Carboniferous, the New England Fold Belt exhibited remarkably similar palaeogeographic conditions and tectonic settings. It consisted essentially of:-

1. a western volcanic arc
2. a central unstable forearc basin
3. an eastern accretionary wedge

possibly with a trench farther to the east, related to a west dipping subduction zone. The accretionary wedge deposits have accreted as a stack of thrust sheets. It is likely that the Fold Belt as a whole was continuous.

The reason for the offset between the Yarrol and the Tamworth Provinces of the Fold Belt has not been resolved. One suggestion is that the offset is due to large-scale dextral transform motion. Another hypothesis is that these two provinces are continuous, but the sequence was subject to later oroclinal bending. Recent geophysical work suggests the latter for the accretionary wedge, but that the arc and forearc basin were much less deformed (R. Korsch, pers. comm., 1986).

The inferred positions of the Trench-Ocean Floor, (time-slices 1-4 and 5-9) on the structural map indicate a relative migration eastward of the trench with growth of the wedge during the Devonian.

The Anakie Inlier lies to the west of the volcanic arc sequences, and if the arc was of island-arc character, it had to be separated from the Inlier by a marginal sea. The Inlier is a north-northwesterly trending basement ridge, upon which Middle Devonian volcanics and sediments have been deposited. It evolved as a ridge during the Tabberabberan Orogeny, and the Drummond Basin formed immediately to the west and east of it (Olgers, 1972). The marginal sea separating the Calliope Island Arc from the Anakie Inlier closed or was uplifted at the beginning of the Late Devonian.

The Drummond Basin has all the attributes of a continental foreland basin, related to the Connors-Auburn continental margin volcanic arc (Murray, 1986). It has a large subsurface Devonian extent, reaching beneath the Permo-Triassic Galilee Basin.

The Adavale Basin Lies southwest of the Drummond Basin, and is concealed beneath Permian and Mesozoic sediments of the Galilee, Cooper and Eromanga Basins (Passmore & Sexton, 1984). They have suggested that the Adavale Basin existed as an erosional remnant of a more extensive depositional basin. The Adavale Basin was initiated in the Early Devonian as a foreland basin.

A NNE-trending hingeline occurs through the centre of the Adavale Basin, immediately east of which a rift developed and thick continental volcanic sequences were erupted. Subsidence occurred immediately east of the hingeline probably in response to deposition of volcanics and to tectonic activity farther east; this induced a major depocentre in the Middle Devonian. Uplift may also have occurred in the early part of the Middle Devonian. Thrusting along the eastern edge of the basin during deposition of the Log Creek Formation probably marked the onset of the Tabberabberan Orogeny or its equivalent (Auchincloss, 1976; and Wiltshire, 1981; both cited in Passmore & Sexton, 1984).

TRANSITIONAL PROVINCE TO EASTERN AUSTRALIA

Introduction

The Transitional Province encompasses the entire Darling Basin, and is composed of (a) the Bancannia Trough located above the western edge of the Darling basin, and (b) the Darling Basin, where structures are best expressed in the western and easternmost portions of the basin. For the purpose of this compilation, the discussion focuses on the Bancannia Trough West-Darling Basin (extending from the centre of the Basin to its western edge) and on the East Darling Basin (extending as far as the Kopyje Shelf (Fig. 4)). The Province is considered to be transitional in character between the more stable intracratonic units of Western and Central Australia, and the more mobile Syn-Post Orogenic Trough-Ridge Province (Lachlan Fold Belt) to the east.

The Darling Basin is a poorly defined intracratonic basin. It developed from a pre-existing basin, termed the Amphitheatre Continental Basin by Scheibner (1976), which started to collapse and sink following the Late Silurian to earliest Devonian Bowning Orogeny. The Darling Basin was formed by a resurgence of fault activity along the Darling River Lineament (Scheibner, 1976).

Bancannia Trough and Western Darling Basin

During the Early Devonian, this region was subject to crustal extension and basin formation within a broad fracture zone. The northwesterly segment of the Darling Basin formed along pre-existing zones of weakness.

At the beginning of the Middle Devonian, regional adjustments affected depositional sites and a widespread unconformity resulted. Subsidence in the Bancannia Trough was greatest along its northeast boundary fault system and subsequent sedimentation onlapped westwards towards the stable Broken Hill Block.

The onset of renewed tectonic activity in the Late Devonian (primarily wrenching) caused uplifting of the Scopes Range High and reactivated uplift of the Lake Wintlow High (which had previously formed segments of the basement) effectively creating and isolating the Bancannia, Menindee and Blantyre Troughs from each other. The effects of this activity appear to be confined to the western half of the Darling Basin (Evans, 1977).

The intramontane Bancannia Trough is bound to the south by the Darling Basin and to the west by the paratectonic Adelaide Fold Belt (Scheibner, cited in Degeling *et al.*, 1986). The Trough is a NW-trending fault-bounded graben situated between the Broken Hill and Wonominta Blocks. It contains up to 7000m of principally Devonian sediments (Evans, 1977). The faults which bound the Bancannia Trough were active during the Late Devonian and en-echelon flexures formed in association with the fault movements suggesting a left-lateral wrench motion (Evans, 1977). The faults may have existed during the Early Devonian.

The Bancannia Trough is separated from most of the Darling Basin by a northeasterly-trending horst at the southern end of the trough, the Scopes Range High. It represents a post-depositional uplifted and faulted barrier. It did not, therefore, serve as an original depositional barrier as faulting took place mainly during Frasnian time. Gravity data suggest that a right lateral convergent wrench couple may have been responsible for the uplift (Evans, 1977).

Similarly, during the early Late Devonian, the NE-trending, fault-bounded Menindee Trough (which contains about 6000m of Devonian sediments) was formed primarily by uplift of the flanking Scopes Range and Early Devonian Lake Wintlow Highs rather than by subsidence of the graben centre alone. Negligible expression of the trough existed prior to this time. The Menindee Trough is parallel to the Tarrara and Renmark Troughs, all of which, during the Early Devonian were possibly connected to the cross-trending Bancannia Trough. The presence of relatively thick Devonian sequences in these two latter Troughs has been confirmed by drilling. Seismic data suggest the Devonian sediments have been faulted into the Trough (M. Brown pers. comm., 1987).

The Lake Wintlow High, which separates the Menindee Trough from the Blantyre Trough, was probably forming during the Early Devonian (as evidenced by onlap against the eastern flank of the High). Its evolution, however, is thought to be similar to that of the Scopes Range High (Evans, 1977).

The Blantyre Trough is fault-bounded to the north and west. Gravity and seismic data suggests that at least two highs within the Trough are elevations of basement-involved, partly faulted anticlines (Evans, 1977).

Eastern Darling Basin

In the eastern part of the Darling Basin, from the Cobar Trough to the Mouramba Shelf, a series of fault-bounded shelf-trough sequences is present (Fig. 4). Across the Darling Basin as a whole sedimentology and environment appear to be sequential from West to East; the structural elements of the western and central parts appear related to NNE and NNW-trending regions of uplift and basement reactivation; the eastern region is probably related to extensional tectonism partly similar to that of the trough-ridge sequence of the Lachlan Fold Belt and comagmatic Early Devonian granites.

During the Early Devonian, basement faults were reactivated which are now seen primarily as lineaments or cross-faults (Fig. 4). The Winduck Lineament occurs along a WNW-trending zone of local unconformities between the Cobar Supergroup and the overlying Mulga Downs Group. Glen (1982) suggested that folding and truncation of the Winduck Group in this zone reflects vertical movement on a WNW-trending basement fault reactivated at this time. Some strike-slip movement may also have taken place (Glen *et al.*, 1985).

To the east, the similarly-trending Crowl Creek Lineament separates the Cobar and Mount Hope Troughs. This lineament coincides with a major north to south sediment thinning (e.g. 1200-1300m of the Shume Formation) in a block west of the Woorara Fault. Also directly to the north, the WNW-trending Buckambool Lineament coincides with a northward widening of the Cobar Trough (Glen *et al.*, 1985).

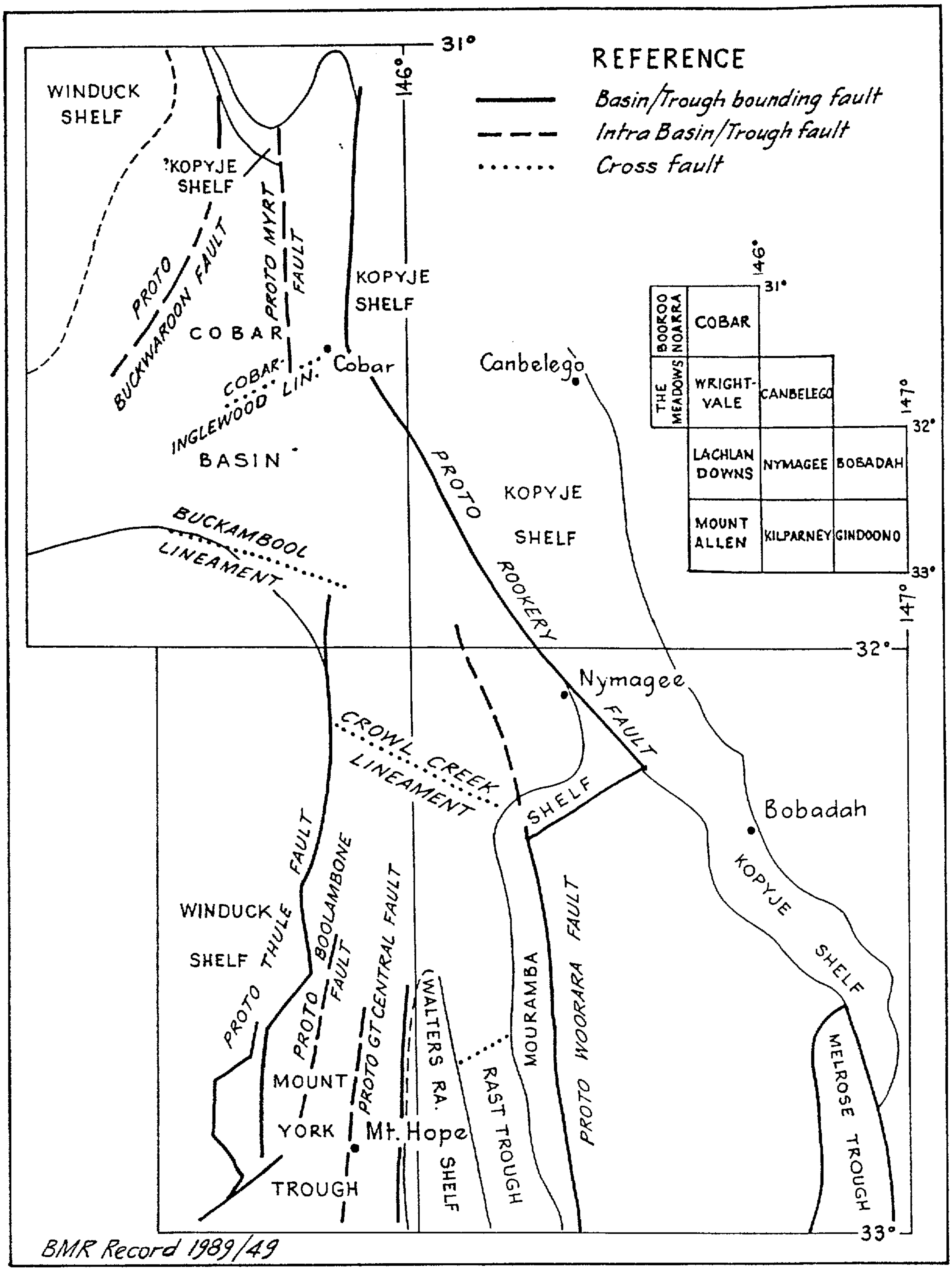


Figure 4 Structural features of the eastern Darling Basin (after Glen et al., 1984)

The Mount Hope Lineament trends northeast and extends across shelf and trough sequences. It separates volcanics in the Rast Trough from sediments in the Mount Hope Trough, and also "separates different shelf sequences of different thicknesses e.g. the Mouramba Group from the Boothumble Formation" (Glen *et al.*, 1985).

Basement-derived faulting delineates shelf and trough sequences. The two most significant faults which delineate the eastern boundary of the Transition Zone are the north-trending normal Woorara Fault and the NNW-trending normal Rookery Fault. Both faults controlled initial basin subsidence and were probably connected by a NE-trending cross-fault south of Nymagee.

"During initial [Early Devonian] sedimentation, the Woorara Fault Scarp separated land on the east from the Mouramba Shelf to the west" (Glen *et al.*, 1985); the southern end of the Rookery Fault (expressed as a hinge line) marked a distinct facies change between the Kopyje Group sediments and the Mouramba Shelf sediments, whereas to the north, the fault was a scarp which separated the Kopyje Shelf to the east from the Cobar Trough to the west (Glen *et al.*, 1985). Extension along the Rookery Fault occurred in the earliest Devonian. The area immediately west of the Rookery Fault and confined by the Woorara Fault, Rookery Fault and linking cross-fault is characterised by an abrupt east to west increase in sediment thickness (1.2-2 km) reflecting subsidence, and which is expressed as a depocentre on the map.

The normal Thule Fault delineates the western edge of the Mt Hope Trough. It separated the short-lived Mount Kennan Shelf from land to the west. The Fault probably extends northwards to form the southwestern margin of the Cobar Trough.

The intrabasin normal Boolahbone Fault of the Mount Hope Trough was active in the early Devonian localising both volcanic centres and sites of A-type granitoid intrusions. The normal, probably west-dipping Great Central Fault, active during the Pragian to lowermost Eifelian marked the western extent of the Broken Range Block to the east. To the north, the westernmost fault in the Cobar Trough, the Buckwaroon Fault, marks an abrupt change in sediment thickness (7 km in the west to 4.5 km in the east) across the fault. East of the Buckwaroon Fault, lies the Myrt Fault which is probably a normal fault, west of which there is greater extension and subsidence than to the east of the fault. The Walters Range Shelf is bounded on its eastern and western sides by fault scarps separating it from deeper water troughs in Pragian time. Similarly, fault scarps partly isolate the Winduck Shelf. During the late Early Devonian general uplift and limited faulting occurred during the post-Cobar Supergroup hiatus.

SYN-POST OROGENIC TROUGH-RIDGE PROVINCE (LACHLAN FOLD BELT), SOUTHEAST AUSTRALIA

Introduction

The Syn-Post Orogenic Trough-Ridge Province (Lachlan Fold Belt) is an early Palaeozoic complex orogenic zone characterised primarily by flysch sedimentation and silicic magmatism. By Devonian times a mostly extensional tectonic regime was operative with multiple meridionally-trending basins with possible rift margins separated by narrow highs and platforms in which granitoids continued to be emplaced (Powell, 1983). This trough-ridge palaeogeography was well established by the beginning of Devonian time (Packham, 1960; 1969).

Deformation in the Province was principally attributed to:-

(a) the Bowning Orogeny of earliest Devonian time which mainly produced dextral transcurrent movement associated with the closure of the Tumut Trough (Powell, 1983) and major folding in the southeast. The orogeny was, however, limited in areal extent, and produced relatively weak deformation elsewhere. Thus, in the Hill End and Melbourne Troughs, there is no evidence for Bowning movements (Veevers, 1984);

(b) the more widespread Tabberabberan Orogeny of Middle Devonian time had similarly variable effects throughout the Province. Deformation was most intense in intergranite areas (D. Wyborn, pers. comm., 1987). "The Tabberabberan deformation represents an east-west shortening" and "is associated with large conjugate transcurrent faults of both dextral and sinistral effect" (Wyborn, 1977; Veevers, 1984), tight and open folding, and cleavage. The beginning of the Tabberabberan orogenic events occurred at the late Emsian (*serotinus* zone) in southeast Australia and early Eifelian (post-*costatus* zone) times in central NSW (Talent & Yolkin, 1987).

Basement to the Trough-Ridge Province is unknown but most likely to be continental crust (Compston & Chappell, 1979). This is suggested by the occurrence of widespread silicic volcanism and intrusions of Siluro-Devonian granitoids (Cas, 1983) and the thickness of its continental crust revealed by deep seismic data (Finlayson *et al.*, 1979).

The broad east-west extent of the Province during Siluro-Devonian times remains an enigma. Cas (1983) has suggested that the (magmatic) province appears to have been "a single very broad, magmatic domain containing intraprovince basins" of limited extensional and graben-subsidence origin, "developed within a continental-type crust." Cas (1983) has also suggested that "in terms of modern tectono-magmatic settings, two possibilities exist - a) a convergent plate margin arc setting, or b) a rift setting". The latter was advocated by Wyborn (1977) and has been adopted on the map because of the widespread development of ridges and troughs.

The evolution of the Trough-Ridge Province changes markedly through the Devonian. For example during Late Silurian to Middle Devonian times, and owing primarily to the effects of the Bowning Orogeny, contemporaneous sedimentation, volcanism and crustal movements occurred variably at local and regional scales. During the late Middle Devonian (386-380Ma) the Tabberabberan Orogeny caused contemporaneous uplift and deformation resulting in a fairly extensive area of highlands. Several A-type granites postdate this deformation near Captains Flat and intrude into the deformed Wyangala Batholith (D. Wyborn, pers. comm., 1987). During Late Devonian times, there occurred a resurgence of rifting during which bimodal (though dominantly silic) lavas and coeval sediments accumulated in the Comerong Rift Zone due to intense faulting (due to crustal extension) and block subsidence. This was accompanied by emplacement of A-type granitoids within the rift zone and its adjacent highs (White & Chappell, 1983).

Tumut and Cowra Troughs

The Tumut Trough stretches from north of Bogan Gate southwards towards Cootamundra and Tumut. It partially merges with the Cowra Trough to the east.

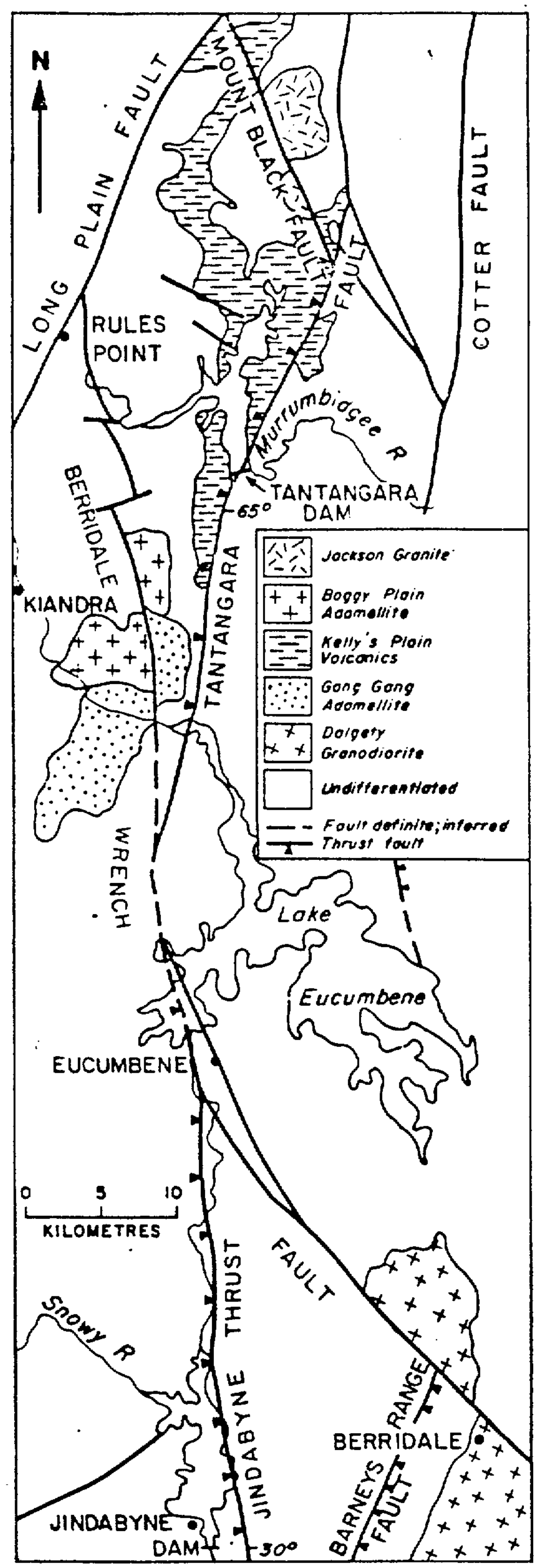
To the north, Early Devonian sediments were deposited in a constricted depression with an axis along the line between Trundle and Bogan Gate. A depoaxis (Trundle

Syncline) in this region has been inferred on the map since Early Devonian marine sediments exceeds 5 km in thickness. These sediments were subsequently folded during a late Bowning or, more likely, early Tabberabberan orogenic phase. A depocentre has also been inferred for the Tullamore Syncline to the east where 1.5 km of Upper Devonian sediments were deposited in an existing depression with suspected contemporaneous subsidence (Sherwin, 1973).

The eastern boundary of the Tumut Trough follows the Mooney Mooney Thrust System - a high angle thrust with superimposed subvertical components which terminate near Yarrongobilly farther south. To the west of the Mooney Mooney Thrust, there is the east-dipping high-angle reverse Cootamundra Fault, and to the east, the Jugiong shear zone which is possibly also a high-angle thrust.

This major thrusting movement, which was associated with folding in the Tumut and Cowra Troughs, occurred in the earliest Devonian (Basden *et al.*, 1978). Some instability along the Coolac Serpentinite/Bogong Granite contact in post-early Middle Devonian time has been interpreted by Ashley (1973; cited in Basden *et al.*, 1978). The Cowra Trough, interpreted by Scheibner (1973) as having been a marginal sea, closed in the Middle Devonian (dated by the 393 Ma Bogong Granite; Ashley *et al.*, 1971).

East of the Long Plain Fault in the Tantangara-Brindabella region, the Cotter Fault was probably reactivated in the earliest Devonian in response to the Bowning event (Fig. 5). As all of the above mentioned faults were reactivated during the intense Early Carboniferous deformation it is suspected that this deformation overprinted Tabberabberra-related movement, particularly as **major disconformities directly related to the latter occur.**



BMR Record 1989/49

Fig.5 Major faults in the Berridale Tantangara region. Geology after Owen et al., 1974 and White et al., 1976

The Boggy Plain Fault is of probably Early Devonian age as it displaces the 406±1 Ma Boggy Plain Adamellite (Wyborn, 1977) by 5 km through left-lateral wrench faulting. Similarly the Mount Black Fault displaces the Lower Devonian Mountain Creek Volcanics and Jackson Granite by 3.5 km of left-lateral movement (Wyborn, 1977).

During the Tabberabberan Orogeny an episode of horizontal compression caused folding of the Lower Devonian Mountain Creek Volcanics and Murrumbidgee Group, and the Middle Devonian Hatchery Creek Conglomerate. "During this episode the Young Batholith and Lower Devonian Burrinjuck Granite were thrust over the Hatchery Creek Conglomerate along the Long Plain Fault. The wrench faulting in the Berridale and other batholiths to the south, probably took place at this time. Earlier Siluro-Devonian intrusion took place in a tensional wrench-faulting regime (where direction of wrenching is reversed)" (Wyborn, 1977).

The Early Devonian Tantangara Fault has displaced the base of the Kelly's Plain volcanics vertically by approximately 300m, though not all of this movement occurred during the Devonian. Much of it is attributed to Cainozoic movements. This thrusting is unrelated to major post-early Devonian wrench faulting on the Berridale Fault. "The Berridale Wrench Fault, the master fault in the Berridale region had its major movements after Middle Devonian times, possibly during latitudinal horizontal compression in the Tabberabberan deformation" (Wyborn, 1977).

The Devils Pass Fault in the Yass-Black Range area is inferred to be a result of the Tabberabberan event.

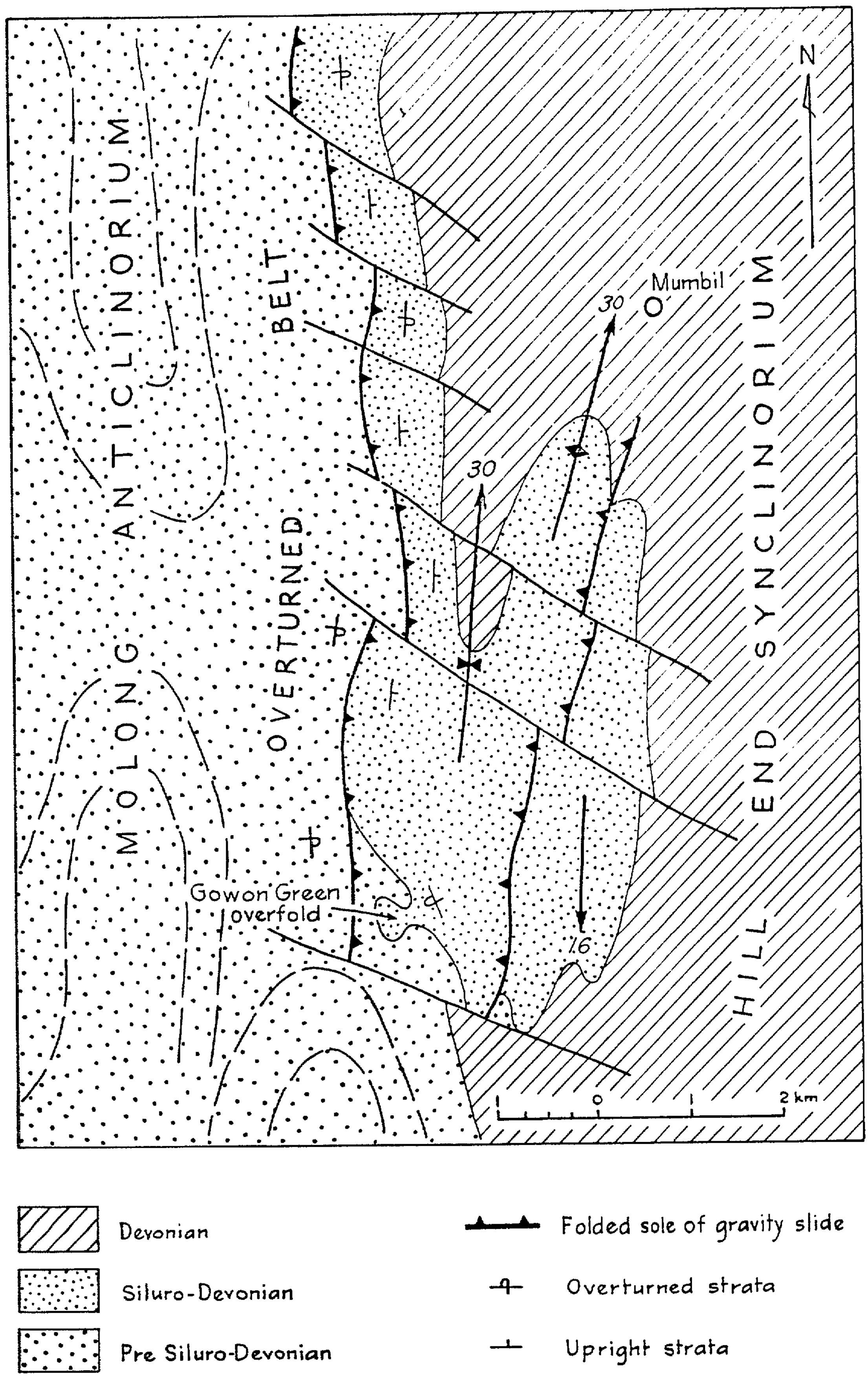
Molong High/Hill End Trough/ Capertee High

The Hill End Trough is flanked to the west by the Molong High and to the east by the Capertee High (Anticlinoria). The depositional history of the Trough is thought to have begun in the Middle Silurian and ended in the Middle Devonian. Its fill was deformed during the Early Carboniferous Kanimblan Orogeny (Powell *et al.*, 1976).

In Early Devonian time the Cuga Burga Volcanics were erupted into the Hill End Trough possibly to a thickness of about 1 km. The axis of the Trough lay nearby to Hill End. The western side of the Trough had a gentle slope towards the axis (Packham, 1968). During deposition of the Merrions Tuff which was erupted within the Trough to the end of the Cunningham Formation sedimentation (4 km thick) the axis of the Trough migrated eastwards about 12 km. Depocentres have been inferred from the thicknesses of deposits within the Trough. Cas (1976) has suggested that the Hill End Trough is an embryonic inter-arc basin, with a basement of sialic or intermediate character.

During the Middle Devonian, uplift and broad folding (as a result of the Tabberabberan Orogeny) occurred on the Molong and Capertee Highs reducing and terminating sedimentation (Powell *et al.*, 1976). The initial uplift may have triggered the syntaphral movement of sediment cover on the Molong High into the Hill End Trough following the Early to Middle Devonian uplift (Fig. 6). This differential eastward movement was accommodated by tear-faulting resulting in alternation of upright and overturned beds with lobate and arcuate trends (Russell, 1976). Rocks involved in the gravity slide are of Ludlovian to Pragian age.

On the eastern margin of the Hill End Trough a structural and stratigraphic boundary, the Wiagdon Fault Zone, separates the Hill End Trough from the Capertee



BMR Record 1989/49

Figure 6 Structure in the Molong High (after Russell, 1976)

High. The southern portion of the fault changes character to a series of thrusts, each constituting the overturned limb of an east-facing anticline.

Though a facies change is evident across the Fault Zone, the amount of displacement is not large and may "simply represent dislocations developed on the overturned limbs of folds that were no longer able to accommodate deformation by bedding-plane slip" (Powell *et al.*, 1976).

Regional deformation of the Hill End Trough occurring in Latest Devonian and/or Early Carboniferous time is characterised by slaty cleavage parallel to the axial planes of the regional meridional folds; the cleavage is absent however, from the flanking Highs. This event may have overprinted possible diastrophism of Tabberabberan age. That tectonism occurred at this time is revealed by the low-angle unconformity between the Lower Devonian rocks and the Upper Devonian Catombal Group (Powell *et al.*, 1976).

Though the Molong Capertee Highs were both loci for some Devonian sedimentation they acted as basement highs relative to their flanking troughs.

Captains Flat Region

a) Ngunawal Basin:

The Ngunawal Basin, formerly known as the Captains Flat Trough (Bain *et al.*, 1987) was formed during late Silurian times. The basin is bounded to the east by the Capertee High and to the west by the Canberra High and Canberra-Yass Magmatic Belt (Fig. 7). Devonian effects in the basin were entirely deformational.

Previous hypotheses of this region suggested that it "represented a graben-like structure, possibly developed as a volcanic rift, bounded by faults (Scheibner, 1976; Gilligan, et al., 1979)". Bain *et al.* (1987) have since interpreted it to be "an area of relatively minor volcanism compared to the adjacent non-marine areas". "Emplacement into shallow crustal positions probably contributed to the emergence of the land surface above the batholiths and consequent formation of a relatively shallow basin in the inter-batholith region". Chappell *et al.* (1987) ascribe such a possibility to "granite tectonics".

The first period of deformation and metamorphism in the basin occurred during the mid-Devonian as revealed by Rb-Sr dating of metamorphic biotite and sericite in volcaniclastic sediments near Captains Flat. Ordovician and Silurian sediments were folded into upright positions with prominent N-S axial-plane cleavage (Bain *et al.*, 1987). Later, a second regional event produced N-S folding, local re-folding and broad antiforms. Tight synformal structures occurred along the margins of the Silurian sequence (Bain *et al.*, 1987).

These folding events, faulting and subsequent erosion reduced the width of the basin in excess of 50% resulting in "an elongate zone of small fault bounded erosional remnants corresponding to high and low strain areas" (Bain *et al.*, 1987; Fig. 7).

b) Capertee High

Along part of the eastern margin of the Ngunawal Basin in earliest Devonian time lay the Bindook Porphyry Complex which originated as a cauldron subsidence. Near the northeastern margin of the Complex, the Myall Ridge Fault probably developed in response to broad up-doming of the Yerranderie area as a prelude to the local eruptions from the Yerranderie volcano whose centre is preserved in the present-

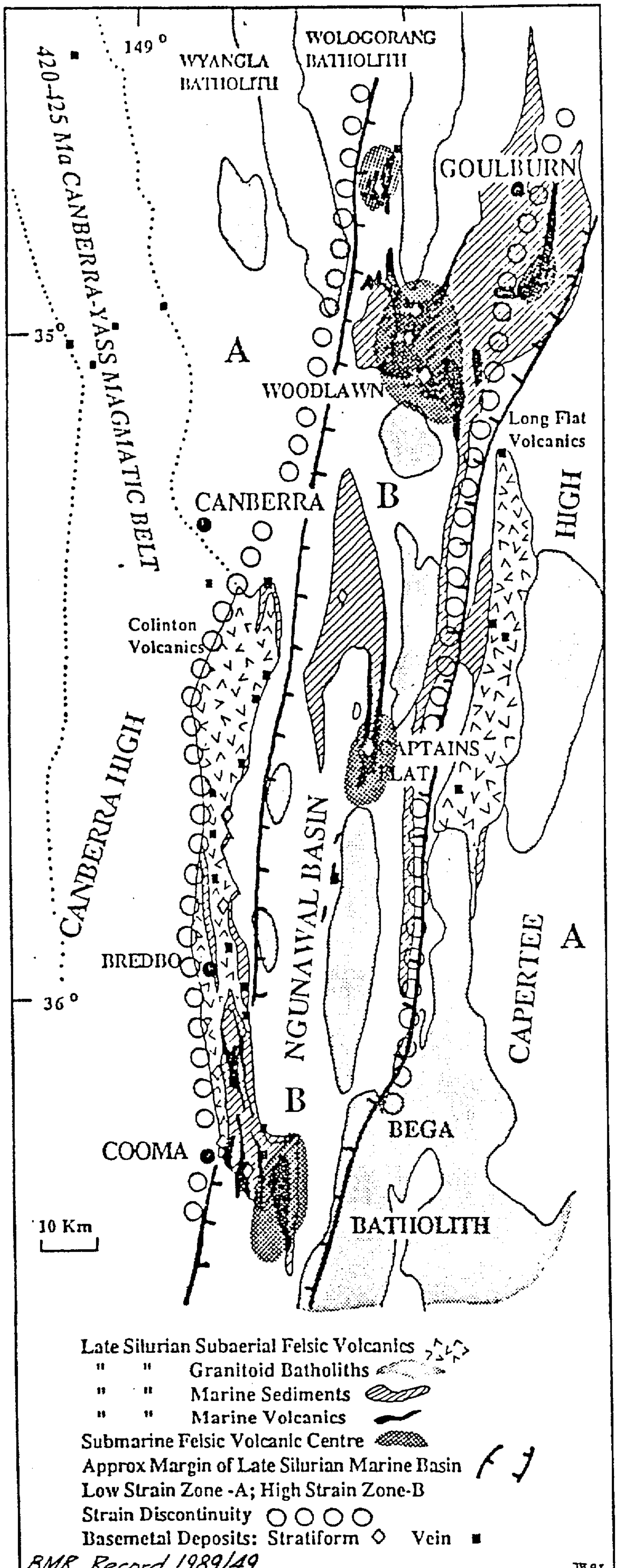


Figure 7 Structure in the Captains Flat region (Bain et al., 1987)

day landscape (Fergusson, 1980). Displacement on the fault diminishes to the southwest (Fergusson, 1980); the northwestern side is downthrown.

Close by to the south of the Complex are the Yarralaw and Jaqua faults (Jones *et al.*, 1984). The Yarralaw Fault separates on upthrown block of Late Silurian sediments to the west from the downthrown block of Early Devonian Tangerang Formation (minimum throw of 1.5 km). Some of the movement is post-Devonian. The Jaqua Fault terminates the southward extension of the Tangerang Formation. Its eastern boundary is cut by numerous small faults; some of these are probably growth structures; others have displaced the basal units of the Tangerang Formation, but as they predate some of the volcanic units, they are therefore Early Devonian in age (Jones *et al.*, 1984).

South Coast Anticlinorial Zone

The South Coast of NSW is the eastern-most known part of the Trough Ridge Province. During the Early Devonian Bowning deformation, this region was strongly compressed. Tight meridional to NE-trending folds developed in the sedimentary strata whilst open NE-trending folds developed in Silurian volcanics (Wyborn & Owen, 1986). Powell (1983) has suggested that between Middle and earliest Late Devonian times there was an interchange of principal stress directions. "Latitudinal compression in the Eifelian to Givetian (Tabberabberan compression), gave way to latitudinal extension in the late Givetan or early Frasnian" (Powell, 1983).

In the late Givetian to early Frasnian, the narrow meridionally-trending continental Comerong Rift was formed as a result of extensional faulting, and monoclinal flexing of folded Ordovician strata (Wyborn & Owen 1986; Powell, 1983). Rifting occurred along major fractures such as the Mongarlowe, Donovan and Buckenbowra Faults. These movements were accompanied by the extrusion of basalt and rhyolitic lavas.

Similarly, in the late Givetian or Early Frasnian, the Boyd Volcanic Complex (Fergusson *et al.*, 1979) was initiated. This Complex is the southern extension of the Comerong Rift Zone, thus the entire volcanic graben has exposed dimensions of about 20-30 km in width and 300 km in length.

The Boyd Volcanic Complex was probably short-lived. Its age is constrained by plates of the fish *Bothriolepis and Phyllolepis* which indicate a Givetian age (Young, 1983). The Complex is intruded by the Gabo Island Granite which has a date of 363±12Ma (Powell, 1983).

Throughout much of the South Coast Region, the Bega and Moruya Batholiths were emplaced probably during the Lochkovian (D. Wyborn pers comm.). Large transcurrent faults, such as the NE-trending Burragate Fault were initiated during a deformation (D2) event that offset plutons in the Bega Batholith. This fault cuts the Early Devonian Kameruka Granodiorite offsetting it dextrally with a 24 km displacement. This movement probably pre-dates the Tantowangalo Fault (to the north) which offsets the Kameruka Granodiorite dextrally for a further 16 km. Sinistral offsets are present in NW-trending faults, such as the Berridale Wrench which offsets the Berridale Batholith by 11 km. The D2 event is overprinted by the contact aureole of the Givetian-Frasnian A-type Mumbilla Granite so that it is tightly constrained to the Middle Devonian.

Both the Burragate and Edrom Faults are transcurrent. Their activity during the Devonian is constrained by the overlying, undeformed Late Devonian Merrimbula Group.

Volcanism in the Comerong Rift Zone ceased in the early Frasnian. Subsidence, however, continued and the rift was filled with widespread fluviatile, deltaic and shallow marine sediments by the late Frasnian (Powell, 1983).

TASMAN FOLD BELT SYSTEM IN VICTORIA

Victoria, in part, comprises the southern part of the Syn-Post Orogenic Trough-Ridge Province. During the Devonian the region has been variously affected by three main tectonic episodes.

a) The Bowning Orogeny (Earliest Devonian)
b) The Tabberabberan Orogeny (Middle Devonian)
c) The Late Devonian to Early Carboniferous episode

Events of the **Bowning Orogeny** produced widespread block faulting and some granite emplacement (405-395Ma) (Ramsey & VandenBerg, 1986), the latter always having associated aureoles. For example, in the Molong Zone, a cluster of foliated granitoids is associated with the Kuark Metamorphics and other granites have hornfels aureoles (VandenBerg *et al.*, 1976). while in the Melbourne Trough, thrusting occurred along the Moormbool faults and the Waratah Bay Axis was uplifted.

In Eastern Victoria, the Wombat Creek Graben is bounded by the Wombat and Morass Creek Faults with throws in excess of 3000m. These faults were active during deposition of Silurian to Devonian sequences in the Graben (Bolger, 1983). Closely following these movements, the "Bindi Deformation" (Bowning equivalent - which antedates the *dehiscens* Zone transgression-development, (Talent & Yolkin, 1987)) caused tight to isoclinal folding, cleavage development, minor open folding and greenschist metamorphism. These effects are also evident in the Limestone Creek Graben (Ramsay & VandenBerg, 1986).

Following the "Bindi Deformation", in the middle Early Devonian, crustal extension gave rise to the Buchan Rift, into which a thick volcanic sequence was erupted. Subsidence was accompanied by initial volcanism, and there was renewed rifting in the Wombat Creek Graben.

During the Early to Middle Devonian, sedimentation was confined primarily to the Buchan and Melbourne Troughs. The axis of the Melbourne Trough migrated eastwards. In the Wagga Zone the strike-slip Kiewa Fault, and the Baranduda Fault were activated by both Bowning and Tabberabberan movements. The Kiewa Fault, a steeply-dipping dextral strike-slip movement with offset of 50 km (Morand & Gray, 1987) displaced the Early Devonian Yackandandah Basin Granite. The Baranduda Fault was probably active in the earliest Devonian, and it later cut the Kiewa Fault.

The **Tabberabberan Orogeny** coincided with the *serotinus* Zone. It was a regional event affecting all areas of Silurian and Devonian deposition in southeastern Australia.

The Grampians Group sediments of the Grampians Trough were faulted and folded into broad open structures. Intraformational faulting is evident in the Black and southern Wonderland Ranges region.

Tabberabberan folding may have been responsible for the anticlinorial synclinorial pattern in the Ararat-Bendigo Zone (VandenBerg, 1978). The Kerrie Conglomerate was folded into a simple asymmetric v-shaped syncline, and faults, the largest being the Whitelaw Fault (displacement of up to 3.5 km) are meridionally steep west-dipping reverse faults. In the Melbourne Trough during late Eifelian to early Givetian time, sediments were folded, faulted, and intruded by dykes and granite.

The most intensive tectonic deformation occurred along the tectonic axes of the Trough especially in its eastern part. This activity also further enhanced the existing NNW structural parallelism of the basement rocks. Faults were active during both the Bowning and Tabberabberan movements. The Mt. William reverse Fault lies along the western side of the trough with a known stratigraphic offset of 13 km. The real offset may be much larger. Similarly, the Enochs Point Thrust of the Mt. Easton Axis located near the eastern margin has displaced strata by 2.5 km.

The Mt. Easton, Waratah Bay, Barkly River, Mt. Wellington and Heathcote Belts existed as structural highs (VandenBerg *et al.*, 1976). The Woods Point Dyke Swarm intruded after the Tabberabberan event and prior to subaerial Late Devonian volcanism. Most of the high level granites in Central Victoria (Strathbogie, Cobaw, Gembook and Baw Baw Batholiths) intruded after the Tabberabberan Orogeny.

Eastern Victoria was more complexly deformed by the Tabberabberan movements. Pronounced faulting occurred along the Indi-Long Plain Fault (Buchan Zone) the transcurrent movements producing intense shearing and cleavage. Thrusting along the major Wombat-Indi Fault enabled translocation to occur. Movements on the west dipping Indi Fault have a reverse fault motion with a sinistral strike-slip component (Morand *et al.*, 1987). The Bindi Fault, is a low-angle SW-dipping reverse or thrust fault, and forms part of the system of large scale faults. The Emu Egg Fault dips east and is probably a reactivated Bindian structure.

The Tabberabberan faulting modified the original margins of the Buchan Rift (VandenBerg *et al.*, 1984). Sediments in the Buchan Rift and Bindi Half Graben were gently folded. Both are synclinal basins; the Buchan Rift has a NNW-trending axis, and the Bindi Half-Graben trends N-S, the synclinal axis being located beneath the Bindi Fault (VandenBerg *et al.*, 1984). Minor displacement occurred along the Yalmy Fault and Combienbar Wrench.

During the **Late Devonian to earliest Carboniferous** episode, further tectonism of decreasing intensity occurred, after which there was stability. High level granites were intruded in the Ballarat and Melbourne Troughs, often culminating in the extrusion of thick volcanic piles in cauldron subsidences. Cauldron subsidence and block faulting occurred contemporaneously. The Howitt Trough was formed during this period, the Howqua-Rose High was uplifted, and the sediment cover mildly to moderately folded.

TASMAN FOLD BELT SYSTEM IN TASMANIA

Tasmania comprises the southernmost known part of the Tasman Fold Belt System. Early Devonian rocks of Tasmania were deformed by the mid-Devonian Tabberabberan Orogeny. Consistent with the remainder of the Trough-Ridge Province, many of the fold patterns of Tasmania are controlled by basement structures. Subsequent to this major deformation, granite intrusion within the folded rocks occurred between 375-335 Ma (Collins & Williams, 1986).

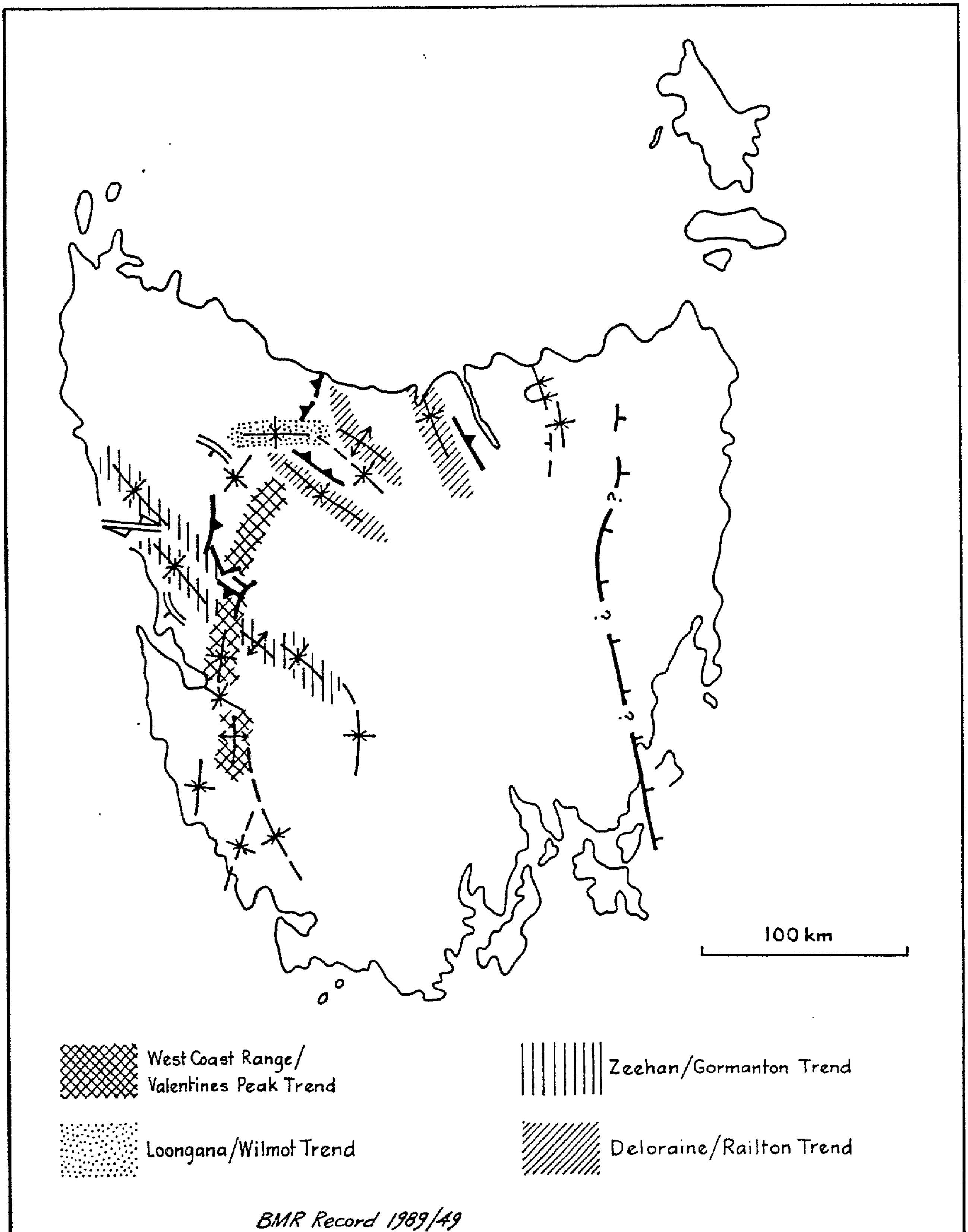


Figure 8 Structural trends of the Devonian in Tasmania

In Western Tasmania, Devonian deformation is expressed as two main phases. The earlier phase produced the West Coast Range/Valentines Peak trend of north-trending folds "developed in zones of closure between converging blocks" (Collins & Williams, 1986), and the east-trending folds of the Loongana/Wilmot trend, located to the north (Fig. 8). The later phase produced arcuate northwesterly to northerly folds in the Deloraine/Railton trend, and the northwesterly aligned trend Zeehan/Gormanston.

The earlier folds of the West Coast Range/Valentine Peak trend have west dipping axial planes and associated reverse faults and thrusts. They are thought to have been caused by tectonic transportation from the west. Folds of the Loongana/Wilmot trend are symmetrical. The later folds of the Deloraine/Railton trend have north-easterly dipping axial surfaces, associated cleavage and thrusts, and resulted from tectonic transportation from the northeast (Collins & Williams, 1986).

Folds in the Mathinna Beds in the northeast, developed from tectonic transportation from the southwest. The folds trend NW with axial surfaces dipping to the SW.

Devonian granitoids are generally younger in Western Tasmania (335-367 Ma) than in Eastern Tasmania (348-389 Ma) (McDougall & Leggo, 1965; Cocker, 1982; Brooks & Compston, 1965; Brooks, 1966; cited in Collins & Williams, 1986).

The granites of northeastern Tasmania caused local folding in places, but generally, were passively emplaced by diapiric intrusion and roof-lifting (Collins & Williams, 1986).

ACKNOWLEDGEMENTS

I am grateful to J. Bradshaw, C. Brown, L. Harrington, R. Korsch, J. F. Lindsay, R. S. Nicoll, V. Passmore, A. Wells, D. Wyborn, A. N Yeates, and staff of States Surveys and Universities for discussions and advice. Financial assistance for this study was provided through the Australian Petroleum Industry Research Association.

REFERENCES

ARNOLD, G.O., 1975—A structural and tectonic study of The Broken River Province, north Queensland. *Ph D. Thesis, James Cook University* (unpubl.).

ARNOLD, G.O. and FAWKNER, J.F., 1980—The Broken River and Hodgkinson Provinces. *In* HENDERSON, R.A. and STEPHENSON, P.J. (Editors) - The geology and geophysics of northeastern Australia. *Geological Society of Australia Inc., Queensland Division*, 175-189.

ASHLEY, P.M., 1973—Ultramafic and associated rocks near Tumut, New South Wales. *Ph D. thesis, Macquarie University* (unpubl.)

ASHLEY, P.M., CHENHALL, B.E., CREMER, P.L., & IRVING, A.J., 1971—The geology of the Coolac Serpentinite and adjacent rocks east of Tumut, New South Wales. *Journal and Proceedings Royal Society of New South Wales*, 104, 11-29.

AUCHINCLOSS, G., 1976—Adavale 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 Series*, 7, 309-315.

AUSTIN, P.M., and WILLIAMS, G.E., 1978—Tectonic development of Late Precambrian to Mesozoic Australia through plate motions possibly influenced by the earth's rotation. *Journal of the Geological Society of Australia*, 25(1), 1-21.

BAIN, J.H.C., WYBORN, D., HENDERSON, G.A.M., STUART-SMITH, P.G., ABELL, R.S., and SOLOMON, M., 1987—Regional geological setting of the Woodlawn and Captains Flat massive sulphide deposits, New South Wales, Australia. *Pacific Rim Congress 87, extended abstracts*, 25-28.

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

BLAKE, D.H., 1978—The Proterozoic and Palaeozoic rocks of the Granites-Tanami Region, Western Australia and Northern Territory, and interregional correlations. *BMR Journal of Australian Geology and Geophysics*, 3, 35-43.

BLAKE, D.H., HODGSON, I.M., and MUHLING, P.C., 1979—Geology of the Granites-Tanami Region. *Bureau of Mineral Resources, Australia, Bulletin*, 197.

BOLGER, P.F., THORNE, H.R., WOOD, P.D., COOK, C.E., and ROGERSON, R.J., 1983—Palaeozoic geology of the Dartmouth Dam area, northeastern Victoria. *Proceedings of the Royal Society of Victoria*, 95, 259-271.

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

CAS, R.A.F., 1976—The Hill End Trough - an empirical approach. *Bulletin of the Australian Society of Exploration Geophysics*, 7, 1.

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, Inc., Special Publication No.* 10.

CAWOOD, P.A., 1983—Modal composition and detrital clinopyroxene geochemistry of lithic sandstones from the New England Fold Belt (east Australia): A Palaeozoic forearc terrane. *Geological Society of America, Bulletin*, 94, 1199-1214.

CHAPPELL, B.W., WHITE, A.J.R., and WYBORN, D., 1987—The importance of residual source material (restite) in granite petrogenesis. *Journal of Petrology*, 28, 1111-1138.

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

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

COOPER, J.A., WEBB, A.W., and WHITAKER, W.G., 1975—Isotopic measurements in the Cape York Peninsula area, north Queensland. *Journal of the Geological Society of Australia*, 22, 285-310.

DAY, R.W., MURRAY, C.G., and WHITAKER, W.G., 1978—The eastern part of the Tasman orogenic zone. *Tectonophysics*, 48, 327-364.

DAY, R.W., WHITAKER, W.G., MURRAY, C.G., WILSON, I.H., and GRIMES, K.G., 1983—Queensland geology. A companion volume to the 1:2 500 000 scale geological map (1975). *Geological Survey of Queensland, Publication* 383.

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

DICKENSON, W.R., and SUCZEK, C.A., 1979—Plate tectonics and sandstone compositions. *Bulletin of the American Association of Petroleum Geologists*, 63, 2164-2182.

EVANS, P.R., 1977—Petroleum geology of western New South Wales. *The APEA Journal*, 17, 1, 42-49.

FAWCKNER, J.F., 1975—Geology of the O.K. mines area, north Queensland. *B Sc. (Hons) Thesis, James Cook University* (unpubl.).

FAWCKNER, J.F., 1978—The O.K. - a cupreous pyrite volcanogenic massive sulphide deposit formed in a marginal sea setting? *In North Queensland Conference Australian Institute of Mining and Metallurgy Conference Series*, 7, 43-55.

FAWCKNER, J.F., 1980—A deformational model for the western Hodgkinson Province. *In Recent Developments in far north Queensland. Australasian Institute of Mining and Metallurgy*, 17-19 October.

FAWCKNER, J.F., 1981—Structural and stratigraphic relations and a tectonic interpretation of the western Hodgkinson Province, northwest Australia. *Ph D. Thesis, James Cook University, Townsville* (unpubl.).

FERGUSSON, J., 1980—Yerranderie Crater: a Devonian silicic eruptive centre within the Bindook Complex, New South Wales. *Journal of the Geological Society of Australia*, 27, 75-82.

FERGUSSON, C.L., CAS, R.A.F., COLLINS, W.J., CRAIG, G.Y., CROOK, K.A.W., POWELL, C.McA., SCOTT, P.A., and YOUNG, G.C., 1979—The Upper Devonian Boyd Volcanic Complex, Eden, New South Wales. *Journal of the Geological Society of Australia*, 26, 87-105.

FINLAYSON, D.M., PRODEHL, C., and COLLINS, C.D.N., 1979—Explosion seismic profiles, and implications for crustal evolution, in southeastern Australia. *BMR Journal of Australian Geology and Geophysics*, 4(3), 243-252.

FREEMAN, M.J., 1986—Huckitta, Northern Territory. *Geological Survey of the Northern Territory 1:250 000 Geological Series, Explanatory Notes* SF 53-11.

GILLIGAN, L.B., FELTON, E.A., and OLGERS, F., 1979—The Regional setting of the Woodlawn deposit. *Journal of the Geological Society of Australia*, 26, 135-140.

GLEN, R.A., 1982—The Amphitheatre Group, Cobar, New South Wales : preliminary results of new mapping and implications for ore search. *Geological Survey of New South Wales Quarterly Notes*, 49, 1-14.

GLEN, R.A., MACRAE, G.P., POGSON, D.J., SCHEIBNER, E., AGOSTINI, A., and SHERWIN, L., 1985—Summary of the geology and controls of mineralization in the Cobar Region. *Geological Survey of New South Wales Report*, 1985/203.

GREGORY, P.W., 1977—Geology of the Mt. Malloy and Dianne massive sulphide deposits, Hodgkinson Province, north Queensland. *Ph D. Thesis, James Cook University* (unpublished).

GREGORY, P.W., TAYLOR, R. G., and WHITE, A.H., 1980—Mineralization in the Broken River and Hodgkinson Provinces. *In* HENDERSON, R.A., and STEPHENSON, P.J., (Editors). The Geology and Geophysics of Northeastern Australia. *Geological Society of Australia, Queensland Division, Brisbane*, 191-200.

HENDERSON, R.A., 1980—Structural outline and summary geological history for northeastern Australia. *In* HENDERSON, R.A., and STEPHENSON, P.J. (Editors). The Geology and Geophysics of Northeastern Australia. *Geological Society of Australia, Queensland Division, Brisbane*, 1-21.

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

JONES, B.G., 1972—Upper Devonian to Lower Carboniferous stratigraphy of the Pentnjara Group, Amadeus Basin, central Australia. *Geological Society of Australia, Journal*, 19, 229-251.

JONES, B.G., CARR, P.F., and HALL, C.G., 1984—The Early Devonian Tangerang Formation of the Marulan - Windellama Region, New South Wales - definition and palaeo-environmental significance. *Australian Journal of Earth Science*, 31, 75-90.

KASPUR, D.C., and LANCE, D.K., 1986—Palaeogeography and tectonic implications of quartzose sandstones of Barbados. *Tectonics*, 5, 837-854.

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

KIRKEGAARD, A.G., SHAW, R.D., and MURRAY, C.G., 1970—Geology of the Rockhampton and Port Clinton 1:250 000 Sheet areas. *Geological Survey of Queensland, Report* 38.

LAMBECK, K., 1984—Structure and evolution of the Amadeus, Officer, and Ngalia Basins of Central Australia. *Australian Journal of Earth Sciences*, 31, 25-38.

LEHMANN, P.R., 1984—The stratigraphy, palaeogeography and petroleum potential of the Lower to lower Upper Devonian sequence in the Canning Basin. *In* PURCELL, P. G. (Editor) - The Canning Basin, W.A. *Proceedings of the GSA/PESA Canning Basin Symposium, Perth, 1984*, 253-275.

MARSDEN, M.A.H., 1972—The Devonian history of northeastern Australia. *Journal of the Geological Society of Australia*, 19, 125-162.

MORAND, V.J., and GRAY, D.R., 1987—Tectonic evolution of the Omeo Metamorphic Complex, northeast Victoria. *International Conference on Deformation of Crustal Rocks, Mt. Buffalo, Australia, Abstracts* 19, 1-2a.

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

MURRAY, C.G., FERGUSSON, C.L., FLOOD, P.G., WHITAKER, W.G., and KORSCH, R.J., 1987—Plate tectonic model for the Carboniferous evolution of the New England Fold Belt. *Australian Journal of Earth Sciences*, 34, 213-236.

OLGERS, F., 1972—Geology of the Drummond Basin, Queensland. *Bureau of Mineral Resources, Australia, Bulletin*, 132.

OWEN, M., and WYBORN, D., 1979—Geology and geochemistry of the Tantangara and Brindabella area. *Bureau of Mineral Resources, Australia, Bulletin*, 204.

PACKHAM, G.H., 1960—Sedimentary history of the Tasman Geosyncline in southeastern Australia. *International Geological Congress*, 21, 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, 654pp.

PASSMORE, V.L., and SEXTON, M.J., 1984—The structural development and hydrocarbon potential of Palaeozoic source rocks in the Adavale Basin region. *APEA Journal*, 24, 393-411.

POWELL, C.McA., 1983—Geology of the New South Wales South Coast. *Geological Society of Australia (Inc.) Specialist Group in Tectonics and Structural Geology. Field guide # 1.*

POWELL, C.McA., EDGECOMBE, D.R., HENRY, N.M., and JONES, J.C., 1976—Timing of Regional Deformation of the Hill End Trough ; a reassessment. *Journal of the Geological Society of Australia*, 23, 407-421.

POWELL, C.McA., HORDERN, M.J., and WILLIS, I.L., 1976—Multiple deformation associated with the Wingdon Fault Zone along the Turon River, near Sofala. *Australian Society of Exploration Geophysicists Bulletin*, 7, 26-27.

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

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

RUSSELL, H.Y., 1976—The geometry of the Gowen Green Overfold and its relationship to the regional deformational history. *Australian Society of Exploration Geophysicists, Bulletin*, 7.

SCHEIBNER, E., 1973—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.*

SHAW, R.D., FAWCKNER, J.F., and BULTITUDE, R.J., 1987—The Palmerville Fault System: a major imbricate thrust system in the Northern Tasmanides, North Queensland. *Australian Journal of Earth Sciences*, 34, 69-93.

SHAW, R.D., STEWART, A.J., and BLACK, L.P., 1984—The Arunta Inlier: a complex ensialic mobile belt in central Australia. Part 2: tectonic history. *Australian Journal of Earth Sciences*, 31, 457-484.

SHERWIN, L., 1973—Stratigraphy of the Forbes-Bogan Gate district. *Geological Survey of New South Wales, Record*, 15, 1, 47-101.

SMITH, G., 1984—The tectonic development of the Gregory Sub-Basin and adjacent areas, northeastern Canning Basin. *In* PURCELL, P.G. (Editor) - The Canning Basin, W.A. *Proceedings of the GSA/PESA Canning Basin Symposium, Perth, 1984*, 109-120.

SMITH, M.R., and ROSS, J.G., 1986—Petroleum exploration of the Northern Australian continental shelf. *The American Association of Petroleum Geologists Bulletin* 70, 11, 1700-1712.

SWARBRICK, C.F.J., 1976—Hodgkinson Basin. *In* LESLIE, R.B., EVANS, H.J., and KNIGHT, C.L., (Editors). Economic geology of Australia and Papua New Guinea 3. Petroleum. *Australasian Institute of Mining and Metallurgy Monograph Series* 7, 384-386.

TALENT, J.A., and YOLKIN, E.A., 1987—Transgression-regression patterns for the Devonian of Australia and southern West Siberia. *Cour. Forsch. Inst. Senckenberg*, 92, 235-249.

THORNBURG, T.M., and KULM, L.D., 1987—Sedimentation in the Chile Trench: depositional morphologies, lithofacies and stratigraphy. *Geological Society of America Bulletin* 98, 33-52.

VANDENBERG, A.H.M., 1978—The Tasman Fold Belt in Victoria. *Tectonophysics*, 48, 267-297.

VANDENBERG, A.H.M., BOLGER, P.F., and O'SHEA, P.J., 1984—Geology and mineral exploration of the Limestone Creek area, northeast Victoria. *Geological Survey of Victoria, Report* 72.

VANDENBERG, A.H.M., GARRATT, M.J., and SPENCER-JONES, D., 1976—Silurian - Middle Devonian. *In* DOUGLAS, J.G., and FERGUSSON, J.A. (Editors) - Geology of Victoria. *Geological Society of Australia. Special Publication* 5, 4, 45-76.

VEBEL, M.A., 1985—Mineralogically mature sandstones in accretionary prisms. *Sedimentary petrology* 55, 685-690.

VEEVERS, J.J. (Editor), 1984—Phanerozoic earth history of Australia. *Clarendon Press, Oxford.*

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

VEEVERS, J.J., and ROBERTS, J., 1968—Upper Palaeozoic rocks, Bonaparte Gulf Basin of northwestern Australia. *Bureau of Mineral Resources, Australia, Bulletin* 97.

WELLS, A.T., 1980—Evaporites in Australia. *Bureau of Mineral Resources, Australia, Bulletin*, 198.

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

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

WHITE, A.J.R., and CHAPPELL, B.W., 1983—Granitoid types and their distribution in the Lachlan Fold Belt, southeastern Australia. *Geological Society of America Memoir* 159, 21-34.

WILTSHIRE, M.J., 1981—Paroo No. 1 company well completion report. *Australian Aquitaine Petroleum Ltd.* (unpubl.).

WITHNALL, I.W., LANG, S.C., WARNICK, J.V., SCOTT, M., McLENNAN, T.P.T., LAW, S.R., and HUTTON, L.J., 1985—Summary of results from the 1984 field season in the Einasleigh and Clarke River 1:250 000 Sheet areas - RGMP Progress Report. *Geological Survey of Queensland, Record* 1985/30.

WYBORN, D., 1977—The Jindabyne Thrust and its tectonic, physiographic and petrogenetic significance. *Journal of the Geological Society of Australia*, 24, 233-236.

WYBORN, D., and OWEN, M., 1986—Araluen, New South Wales. 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Australia.*

YEATES, A.N., GIBSON, D.L., TOWNER, R.R., and CROWE, R.W.A., 1984—Regional geology of the onshore Canning basin, W.A. *In* PURCELL, P.G. (Editor) - The Canning basin, W.A. *Proceedings of the GSA/PESA Canning basin Symposium, Perth*, 1984, 23-55.

YOUNG, G.C., 1983—A new Antiarchan fish (Placodermi) from the Late Devonian of southeastern Australia. *BMR Journal of Australia Geology and Geophysics*, 8, 71-81.