STRUCTURAL ANALYSIS AND GEOLOGICAL EVOLUTION OF THE ROCKVALE - COFFS HARBOUR REGION, NORTHERN NEW SOUTH WALES

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PREFACE

Some preliminary field observations on the structure of overturned sediments at Rockvale for an undergraduate project (Korsch 1967), and on the sediments and structure of some coastal headlands in the Woolgoolga region as part of a Bachelor of Science (Honours) course at the University of New England (Korsch 1968), led to the involvement in the present work.

Detailed studies on the Rockvale - Coffs Harbour region were commenced in February, 1970 and, except where mentioned in the text, this thesis includes only work carried out since that time.

Two supporting papers published in the Journal and Proceedings of the Royal Society of New South Wales (Korsch 1971, 1973) are included in the Map Folder. These papers represent the main results of the Honours work but were written during the period of candidature for this thesis and include some ideas developed during this time.

I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

TABLE OF CONTENTS

(A detailed list of contents is included in the Map Folder.)

SUMMARY

Purpose: Three major structural blocks have been recognised in the Rockvale - Coffs Harbour region of central New England and their evolution has been studied in terms of sediment deposition, metamorphism, deformation, igneous activity and tectonics, with an emphasis on structural analysis.

Analysis of Folds: Theoretical structural models have been developed, mainly in response to data collected in the field, to explain some systematic changes in the morphology of mesoscopic folds in the Coffs Harbour Block. Equations for determining the wavelength, amplitude and percent shortening in both symmetrical and periodic asymmetrical folds have been derived using the parameters of interlimb angle, chord length and halflength of a fold. Graphs comparing interlimb angles with the amplitude and wavelength ratios of individual form surfaces allow comparisons of the fold styles produced by different deformational episodes. Theoretical fold profiles have been developed to simulate systematic changes in interlimb angles and chord ratios. The fold train inflection surfaces of theoretical symmetrical fold profiles are always normal to the axial surfaces but the fold stack inflection surfaces can be normal, oblique or parallel to the axial surfaces. For asymmetrical folds, these conditions need not apply.

Origin of Steeply-plunging Folds: The origin of steeply-plunging folds is a geological problem difficult of solution. A systematic change from horizontal to steeply-plunging D1 fold axes from north to south in the Woolgoolga district has been explained geometrically as follows. If the strike of the marker horizon is constantly at an angle other than zero to the strike of the axial surface, then, as deformation proceeds the dip of the marker horizon becomes steeper and the plunge of the fold axis changes from 0^{o} towards 90^{o}. Even a difference of 1^{o} in the strikes of the marker surface and axial surface causes remarkable changes in the plunge of the fold axis, when the dip of the marker horizon is close to the dip of the axial surface.

Geometry and Origin of Cleavages: Fracture cleavage patterns in the Coffs Harbour Block show many cleavage traces diverging to both sides of a dominant set of cleavage traces. These patterns approximate closely

to those predicted by a theoretical model, and were produced by a deformation of lower intensity than that which produced slaty cleavage. In places where more intense deformation has occurred, the fracture cleavage grades into slaty cleavage.

Successive Deformations

(i) Coffs Harbour Block: Within the Coffs Harbour Block three deformational episodes have been identified, two being expressed on the mesoscopic scale and the third being obvious only on the macroscopic scale. There is a progressive increase in the intensity of the first deformation towards the south of the block, and it is accompanied by an increase in the grade of regional metamorphism. The second deformation was not widespread, its effects being observed only in isolated localities. The distribution of lithological units suggests that the Coffs Harbour Block as a whole could be a complex macroscopic syncline, which developed at a late stage after the two mesoscopic deformations. The mechanism for its formation is postulated to be the rotation of a small lithospheric plate.

(ii) Rockvale Block: Most beds are overturned in the Rockvale Block which is complexly deformed and contains at least three recognisable deformations on the mesoscopic scale. The intensity of the deformations increases eastwards, the western part of the study area being dominated by features produced by Deformation 1 (D1), but D2 and D3 features become progressively more common eastwards and are eventually associated with regional metamorphism of the amphibolite facies. A macroscopic fold (the Rockvale Anticlinal Synform) plunges steeply to the east and consists mainly of overturned strata. The existence of overturned strata over a large region is puzzling, but is attributed to the diapiric intrusion of the Abroi Granodiorite.

(iii) Dyamberin Block: This unit has been affected by two episodes of mesoscopic deformation which ceased prior to the emplacement of the Round Mountain Leucoadamellite in the Early Triassic.

Sedimentation, Paired Metamorphic Belt and Plutonism: Within the southern part of the New England Geosyncline seven stratigraphic associations and four plutonic suites are recognised. Two zones of intermediate and low pressure metamorphic rocks are interpreted as a paired metamorphic belt associated with a subduction zone.

Tectonic Analysis: A new plate tectonic model has been developed with the recognition of several plates and plate boundaries within New England, and the model utilizes the geometry of triple junctions to place constraints on possible analyses of this inactive system. A theoretical model of a small plate rotating between two larger plates is used to explain the complex structural and lithological picture in the Thangetti Zone, which at the existing level of geological knowledge is a "zone of forbidden analysis". Three, or possibly four, major orogenic events associated with plate movements and interactions have been recognised in New England as a whole, and are partially overlapping in space and time.

The first orogeny lasted for most of the Devonian and Carboniferous and was associated with the migration of the Peel trench eastwards from the Peel Fault, and with the production of a volcanic arc and the Bundarra Plutonic Suite.

Rotation of the small Ngamba plate and its subduction along the Wollomombi plate boundary are regarded as the cause of the second orogeny which in the Permian produced a vortex pattern in southern New England.

The third orogeny, also of Permian age, occurred during the evolution of the Demon Fault as a trench-trench transform accompanied by southwards movement of the Coffs Harbour plate.

A fourth orogeny, possibly simultaneous with or overlapping the previous orogenies, involved relative movement of the "Pacific" plate northwards and the rotation of small plates between the "Pacific" and "Australian" plates. The direct effects of this orogeny are preserved only at a few isolated coastal localities, and therefore not much is known about it but it probably lasted for at least most of the Permian.

Appendices: A volume of appendices accompanying the thesis includes detailed descriptions of the stratigraphy, sedimentary petrography, sedimentation, metamorphism and igneous intrusions of the Rockvale - Coffs Harbour region, and of the methods used in the computer analysis of the geological data.

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Technical assistance was provided by Mr. D.G. Cameron and the technical staff of the Department of Geology, University of New England. Many of the figures and maps are the result of meticulous draughtsmenship by Mr. K.C. Cross and Mr. M.R. Bone. The final copy of this thesis was patiently typed by Miss M. Willick and the captions to the figures were typed by Mrs. R.K. Vivian.

INTRODUCTION

This thesis presents a detailed structural analysis of three tectonic blocks in northern New South Wales, and their geological setting within the southern part of the New England Geosyncline. The aim has been to correlate the depositional history, metamorphism, intrusion of the granitic rocks and deformation in the Rockvale - Coffs Harbour region, and to produce a tectonic synthesis. Some theoretical aspects of folding have been developed, because a satisfactory explanation was sought for a systematic change in the morphology of folds from the Coffs Harbour region.

The thesis is in two sections. Section I describes theoretical aspects of folding, along with a detailed structural analysis and deformational history for the three tectonic blocks. One aspect of the theoretical work involves a rotation in the plunge of fold axes with increasing intensity of deformation. This has been done without invoking complex situations such as a rotating or heterogeneous stress field. Another aspect attempts to explain fracture cleavage. Both models have been applied to selected field localities within the Rockvale - Coffs Harbour region. An attempt to explain the large area of overturned sediments at Rockvale has also been made.

The second section provides a description of the major structural units in the New England Geosyncline. Several authors have recently published tectonic models of eastern Australia and some have discussed the New England region. In this thesis the published models are examined and a new tectonic model for the New England region is proposed.

Three appendices are included. Appendix I describes the stratigraphy, sedimentation and metamorphism for the three tectonic blocks in the Rockvale - Coffs Harbour region. Brief descriptions of previously undescribed granitic intrusions are also included. Appendix II outlines techniques used in the computer analysis of the geological data, and Appendix III describes laboratory techniques.

The Rockvale - Coffs Harbour region occupies an area of over 8000 sq. km within the New England Geosyncline (Fig. 1A). It is bounded on the east by the Pacific Ocean; to the south by the Bellinger Fault; to the north-east

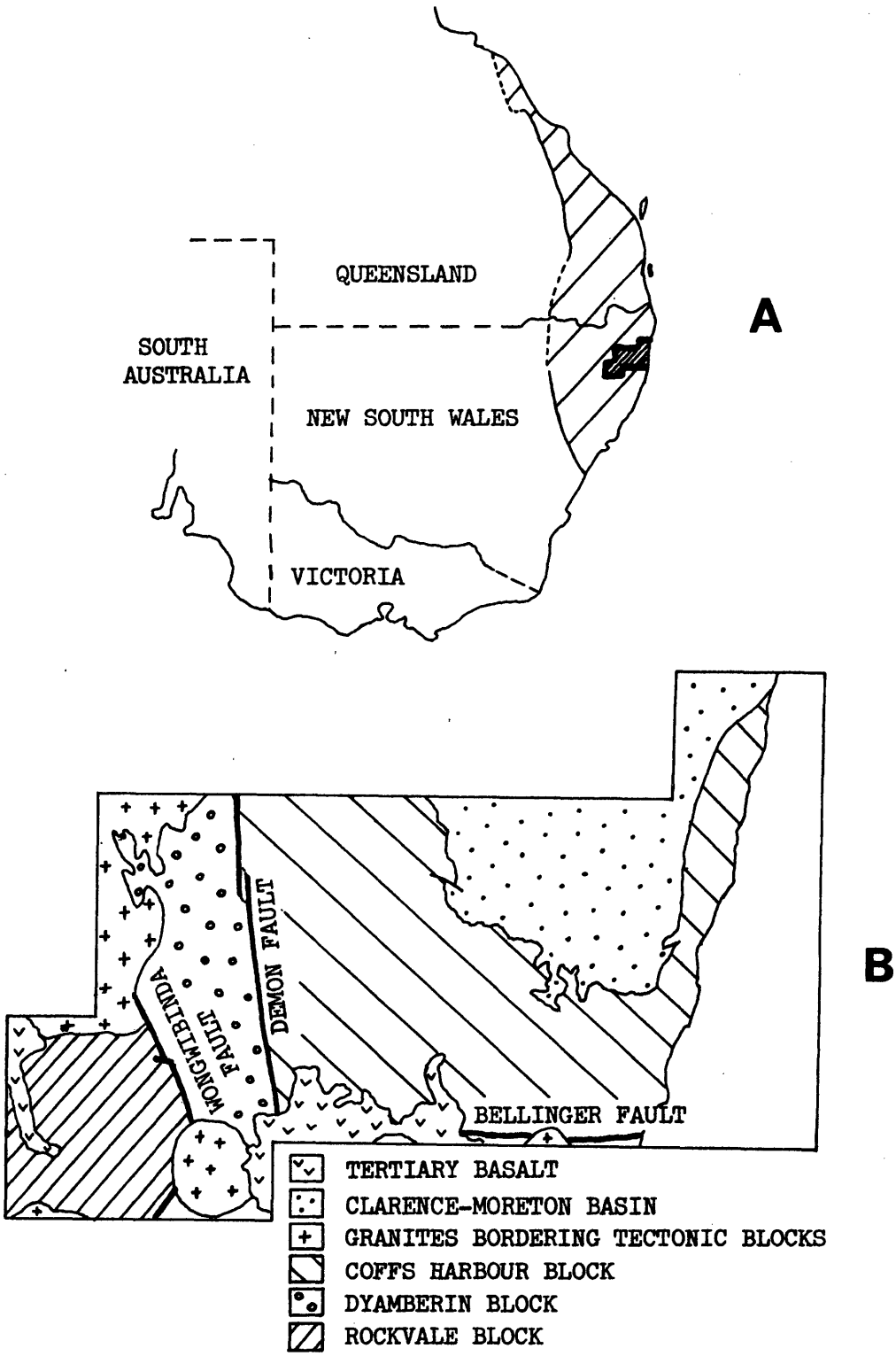

Fig. 1: A. Location of Rockvale-Coffs Harbour Region with respect to the New England Geosyncline in Eastern Australia.

B. Tectonic units of the Rockvale-Coffs Harbour Region.

by the overlying Mesozoic Clarence - Moreton Basin; and, to the north-west by granitic rocks of the New England Batholith. The region has been subdivided on the basis of stratigraphy and depositional history into three distinct tectonic units which are mainly fault bounded (Fig. 1B). The Rockvale Block, to the west, is separated from the central Dyamberin Block by the Wongwibinda Fault, and the Dyamberin Block is separated from the eastern Coffs Harbour Block by the Demon Fault.

Earlier Work

Although previous workers have given broad outlines of the geology of the Rockvale - Coffs Harbour region, this thesis presents the first detailed account of the geology of the Coffs Harbour and Dyamberin Blocks and part of the Rockvale Block. Korsch (1968, 1971, 1973) has published a detailed account of the coastal headlands of part of the Coffs Harbour Block. The only detailed account of rocks from the Rockvale Block is by Binns (1966) for the Wongwibinda Complex. Other work on the Rockvale - Coffs Harbour region is mentioned below.

Clarke (1853) traversed the region from Ebor to Grafton and briefly listed the geological units he encountered, including granite, basalt, greenstone, feldspathic rocks, schist and trap. Wilkinson and Slee (1889) briefly mentioned the sediments (slates to sandstones) and postulated a Devonian age for them.

The sediments at Coffs Harbour were examined cursorily by Denmead (1928) who termed them "schists" and likened them to the Brisbane Schists. Voisey (1934) published an account of the coastal area south from Coffs Harbour in which he noted the distinction between the rocks of the Coffs Harbour Block and those of the Nambucca Fold Belt. This break was also noted by Kenny (1936). Voisey (1942a) also described the geology east of Armidale and in 1950 noted that Permian fossils had been found in Kangaroo Creek in the Dyamberin Block. A summary of the stratigraphic succession was given by Voisey (1957) when he revised his earlier stratigraphic nomenclature.

The map of Binns and others (1967) outlines the geological boundaries of the western part of the field area and provides a brief summary of the geology of the southern half of the New England tablelands. The gross regional setting of the Rockvale - Coffs Harbour region has been considered by Voisey (1953, 1959, 1965), Packham (1969), Leitch (1972), Scheibner (1972, 1973) and by authors in Denmead *et al.* (1974). Most of the recent authors have presented plate tectonic models for the geological evolution of New England.

Palaeontological investigations have been concerned with the rare isolated occurrences of fossils, mainly of Permian age. McKelvey and Gutsche (1969) listed the principal fossil localities and all known occurrences have been summarised by Runnegar (1970).

Korsch (1971) described the Emerald Beach Leucoadamellite, and Leitch (1972) described the Glenifer Adamellite and the Dorrigo Mountain Complex from the Coffs Harbour Block. The intrusions from the Rockvale Block and surrounding areas have been treated in more detail by previous workers. Greaves (1960) and Ransley (1964) reported on the Rockvale Adamellite-Granodiorite and Binns (1966) and Collerson (1967) examined the Abroi Granodiorite and Round Mountain Leucoadamellite. Granitic rocks north of the Rockvale area have been comprehensively treated by Neilson (1965, 1970). Potassium-argon radiometric dates for some of the intrusions were listed by Binns and Richards (1965).

The Tertiary basaltic rocks have received little petrographic attention apart from brief descriptions by Browne (1933), McDougall and Wilkinson (1967), Wilkinson (*in* Packham 1969) and Collerson (1967).

Numerous small mineral deposits occur in the Rockvale - Coffs Harbour region and there are detailed published descriptions of some of them. Production figures are recorded in the Annual Reports of the N.S.W. Department of Mines. Kenny (1926) described the economic deposits at Rockvale and these have been further considered by Lawrence and Chand (1962), Suppel and McClatchie (1970) and McClatchie and Sylvester (1970).

Stibnite deposits of the Magword Mine at Fishington were investigated by Harrison (1952), and by Relph (1959a) who also examined the Gulf Copper Mine at Dyamberin (1959b). Hanlon (1942) described the stibnite at Wild Cattle Creek, and the setting of this deposit was discussed by McManus *et al.* (1965). The mineral prospects of the Tyringham district were examined by Kenny (1932) and Kennedy (1964) inspected a tin-lead-zinc prospect near Ebor.

Gold mines at Coramba were described by Carne (1895) who recorded a mass of granite intruding the "Devonian formation". Kenny (1936) believed that the Coramba granite was an "intrusive tuff". McClatchie (1962) examined the area of the Evening Star Gold Mine at Coramba and concluded that the rocks there are a part of a sedimentary succession and are not granites or intrusive tuffs as previous authors had thought.

An area of exploration interest at the present time is the Karangi Copper Mine (GR 6146 2510). Also of interest is an area about 5 km west of Woolgoolga (GR 6286 2710) where native mercury occurs along joint planes in

a siliceous mudstone.

Investigations of possible quarry sites for breakwater construction material at Wooli have led to accounts of the geology of that area by Chesnut and Bowman (1968) and Roy and Bowman (1968).

The Mesozoic Clarence - Moreton Basin has been described by McElroy (1956, 1962) and more recently by students of the University of New England, whose reports sometimes include a brief mention of the Palaeozoic "basement".

Studies of the Quaternary deposits and physiography of the region include the pioneering work of Voisey (1935, 1942b). Warner (1971) discussed the evolution of the landscape of much of the Rockvale - Coffs Harbour region.

Third-year geology students at the University of New England have done project essays on small areas within the Rockvale - Coffs Harbour region and they are mentioned at relevant places in the text.

Outline of the geology of the Rockvale - Coffs Harbour region

Coffs Harbour Block

This block is bounded on the south and west by the Bellinger and Demon Faults respectively, and the area where these faults should intersect is covered by a thick sequence of Cainozoic basaltic rocks. Three stratigraphic units, younging from south to north, are recognised in the Upper Palaeozoic deformed clastic sediments of the Coffs Harbour Block. The sediments consist of massive to well-bedded greywackes (Plate 1A), siltstones, mudstones, cherts and jaspers. Bedding is distinct in the north but in a southerly direction is progressively less distinct, until it is nearly obliterated by increasing deformation and metamorphism.

A low-grade regional metamorphic event of prehnite-pumpellyite to greenschist facies has been overprinted on the southern portion of the block by a static thermal event which caused the growth of randomly-oriented biotite. One major episode of deformation produced mesoscopic folding with an axial plane cleavage, and there has been subsequent minor folding of a localised nature. Both syntectonic and post-tectonic granitic intrusions have been emplaced into rocks of this block.

Dyamberin Block

The Dyamberin Block is divided into two stratigraphic units, one of which is of early Permian or latest Carboniferous age. Clastic rocks

predominate but differ from those of the other two blocks in that conglomerates, diamictites, sandstones and slates are the main lithologies. Rare basic and acid volcanic rocks occur also.

Deformation is similar to that in the Coffs Harbour Block, and low-grade regional metamorphism occurred, but there is no evidence of a later static thermal event. Granitic rocks occur along the boundaries of the block in some places, and there is also a small dioritic mass which is possibly related to the New England Batholith. The absence of batholithic rocks inside the block might account for the lack of thermal metamorphism, similar to that of the Coffs Harbour Block.

Rockvale Block

The Rockvale Block extends westwards beyond the thesis area to the vicinity of Armidale, and consists of Permian and older sediments of a turbidite origin. In the field area greywackes and mudstones are the most common lithologies and no basic or acid volcanics have been observed. The western part of the thesis area has suffered low-grade regional metamorphism which increases in intensity eastwards to the Wongwibinda Complex which consists of high-grade schists of amphibolite facies, migmatites and gneissose granitic rocks.

Deformation over much of this block has been severe. Even the least metamorphosed sediments have suffered possibly three deformations, and a large area of sediments at Rockvale has been overturned. Numerous igneous dykes truncating the sediments are probably related to the stressed granitic bodies which occur in this block. To the north younger post-tectonic granitic rocks are found.

Specimen Numbers, Base Maps and Grid References

All rock specimens and thin sections are housed in the collection of the Department of Geology, University of New England. When referred to in the text, numbers for thin sections are prefixed with an S (e.g. S32828) and rock specimens with an R (e.g. R32856).

Large maps are placed in a separate folder. The base for those covering the Rockvale - Coffs Harbour region is an enlargement of parts of the following 1:250,000 sheets of the Royal Australian Survey Corps : Maclean, Coffs Harbour, Dorrigo, Grafton. Grid references throughout the text refer to the national grid (in yards) of the 1:250,000 sheets and are prefixed by the abbreviation GR (e.g. GR 5712 2684). Geological maps on a scale of

1:250,000 have been published by the N.S.W. Department of Mines (Rose 1968; Brunker *et al.* 1969; Leitch *et al.* 1969).

PLATE 1

A. Topographic depression defining position of Demon Fault in the Guy Fawkes River area (GR 5354 2933).

B. Well-bedded and massive units from Coramba Beds at Look-at-me-now, Coffs Harbour Block (GR 6308 2611).

C. Conglomeratic unit from the Sara Beds, Dyamberin Block (GR 5365 2776).

D. Diamictite boulder incorporated in a conglomerate from the Sara Beds, Dyamberin Block (GR 5317 2900).

E. Folds and quartz veins in migmatites from the Zone of Migmatites, Rockvale Block (GR 5184 2470).

F. Granitic clast in conglomerate from Coramba Beds, Coffs Harbour Block (R32362, GR 5643 3014).