PROGRAMME

and

ABSTRACTS

for the

TWELFTH SYMPOSIUM

on

"ADVANCES IN THE STUDY OF THE SYDNEY BASIN AND THE NEW ENGLAND FOLD BELT"

DEPARTMENT OF GEOLOGY
THE UNIVERSITY OF NEWCASTLE
N.S.W. 2308

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TWELFTH SYMPOSIUM

ON

"ADVANCES IN THE STUDY OF THE SYDNEY BASIN AND THE NEW ENGLAND FOLD BELT"

5 to 7 May, 1978

CONVENER:

DR. R. OFFLER,
DEPARTMENT OF GEOLOGY,
THE UNIVERSITY OF NEWCASTLE.

Advances in the study of the Sydney Basin; abstracts of the symposia: (annual) 1st symposium 1966 to 4th symposium 1969. Newcastle, University of Newcastle, Department of Geology. Published as one volume with individual title pages. From 5th symposium 1970 title changed to Advances in the study of the Sydney Basin; programme and abstracts, which see also.

Geology - N.S.W. - Congresses
University of Newcastle - Department of Geology
Symposium on Advances in the study of the Sydney Basin, University of Newcastle (s)

Advances in the study of the Sydney Basin; programme and abstracts of the symposia: (annual) 5th symposium 1970 to date. Newcastle, University of Newcastle, Department of Geology. Previously known as Advances in the study of the Sydney Basin; abstracts of the symposia, which see also.

Geology - N.S.W. - Congresses
University of Newcastle - Department of Geology
Symposium on Advances in the study of the Sydney Basin, University of Newcastle (s)

FOREWORD

Welcome to the Twelfth Newcastle Symposium!

You will have noted that the theme of this Twelfth Symposium has been extended to include the New England Fold Belt. At this stage this is intended as a "once-off exercise" but much will depend on the interest generated by the extended theme. Therefore, at the end of the Symposium I would welcome your comments on whether the usual theme "Advances in the Study of the Sydney Basin" should be extended or changed. In fact, any comments that you believe could lead to more beneficial and enjoyable Symposia in the future would be appreciated.

This year a record number of papers has been received. The staff and I hope that much useful discussion will be generated by them and that you will be sufficiently enthused to return in 1979.

B. NASHAR

Head of Department

PREFACE

The programme and abstract volume of the TENTH NEWCASTLE SYMPOSIUM contains an author and locality index for the first ten Symposia. The next index will appear in the volume of the Thirteenth Symposium.

This year twenty papers and a keynote address will be given. Fifteen of these papers deal with various aspects of the Sydney Basin, the remaining papers are concerned with geological phenomena from the New England Fold Belt.

The material for this year's excursion did not lend itself to the format of this volume and will be issued separately.

K.H.R. MOELLE

R. OFFLER

PROGRAMME

FRIDAY, 5th MAY 1978

		HOURS
REGISTRATION	in the Foyer of the Geology Building The University of Newcastle	9.00 a.m. - 5.00 p.m.
EXCURSION:	Newcastle Coal Measures Leader:- Professor C.F.K. Diessel	1.30 p.m. - 5.00 p.m.
INFORMAL GATHERING	at "Stan's Bar" University Union	After 8 p.m.

SATURDAY, 6th MAY 1978

REGISTRATION	in the Foyer of the Geology Building The University of Newcastle	8.30 a.m. - 9.00 a.m.

MORNING TECHNICAL SESSION

Geology/Physics Lecture Theatre E01
(beside the Geology Department)
The University of Newcastle

Chairman: Dr. D. SWAINE
Division of Mineralogy
C.S.I.R.O.

OPENING OF 12TH NEWCASTLE SYMPOSIUM — 9.00 a.m. - 9.05 a.m.

Professor D.W. GEORGE
Vice Chancellor
The University of Newcastle

		HOURS
1.	THE OCCURRENCE AND SIGNIFICANCE OF A COKING COAL DYKE WITHIN THE SINGLETON COAL MEASURES OF N.S.W. G.H. TAYLOR, C.S.I.R.O. Fuel Geoscience Unit and R.A. BRITTEN, Joint Coal Board	9.05 a.m. - 9.35 a.m.
2.	THE APPLICATION OF GEOLOGY IN LONGWALL MINING AT SOUTH BULLI COLLIERY F. BOS and B. AGRALI Bellambi Coal Co. Ltd.	9.35 a.m. - 10.05 a.m.
3.	PREDICTION OF BAD COAL MINING CONDITIONS IN SYDNEY BASIN COALFIELDS J. CREASEY, J. HUNTINGTON and J. SHEPHERD C.S.I.R.O. Division Mineral Physics	10.05 a.m. - 10.35 a.m.
	Morning Tea in Geology Department	10.35 a.m. - 11.05 a.m.
4.	GEOCHEMICAL EVIDENCE FOR MARINE INFLUENCED SEDIMENTATION IN THE NEWCASTLE COAL MEASURES P. WARBROOKE The Broken Hill Proprietary Co. Ltd.	11.05 a.m. - 11.35 p.m.
5.	THE ROLE OF CONSULTANTS IN THE COAL GEOLOGY OF THE SYDNEY BASIN R.C. NOLAN Esso Australia Ltd.	11.35 a.m. - 12.05 p.m.
	<u>KEYNOTE ADDRESS</u> Mr. K.A. RICHARDS Esso Australia Ltd. WHAT IS A RESERVE?	12.05 p.m. - 12.45 p.m.
	SUMMARY AND VOTE OF THANKS BY CHAIRMAN	12.45 p.m. - 12.50 p.m.

Lunch at the University Union

AFTERNOON TECHNICAL SESSION

Geology/Physics Lecture Theatre E01
(beside the Geology Department)
The University of Newcastle

Chairman: Professor A. COOK
Department of Geology
The University of Wollongong

		HOURS
6.	CLINOHYPERSTHENE AND HYPERSTHENE FROM A COAL FIRE BUCHITE NEAR RAVENSWORTH, N.S.W. B. HENSEN and D.R. GRAY University of N.S.W.	2.10 p.m. - 2.40 p.m.
7.	NEW ENGLAND TECTONICS IN A WORLD PERSPECTIVE F.S. JEFFRIES Esso Australia Ltd.	2.40 p.m. - 3.10 p.m.
8.	WRENCH FAULTING IN THE NORTHERN SYDNEY BASIN I. BLAYDEN Earth Resources Australia Pty. Ltd.	3.10 p.m. - 3.40 p.m.
	Afternoon Tea in the Geology Department	3.40 p.m. - 4.10 p.m.
9.	DATING OF EXTRUSIVE AND INTRUSIVE IGNEOUS ROCKS OF THE SOUTHERN SYDNEY BASIN P.F. CARR and R.A. FACER University of Wollongong	4.10 p.m. - 4.40 p.m.
10.	UNWRAPPING LITTLE BAY OR AN EARLY MIOCENE ESTUARINE DEPOSIT AT LITTLE BAY, SYDNEY A.D. PARTRIDGE, Esso Australia Ltd. J.M. BENSON and D. BELL University of N.S.W.	4.40 p.m. - 5.10 p.m.
11.	PERMIAN PALAEOGEOGRAPHY OF WESTERN NEW ENGLAND J.W. BROWNLOW Geological Survey of N.S.W.	5.10 p.m. - 5.40 p.m.
	SUMMARY AND VOTE OF THANKS BY CHAIRMAN	5.40 p.m. - 5.45 p.m.

END OF SESSION

Sherry followed by Symposium Dinner at the UNIVERSITY UNION	7.00 p.m. - 7.30 p.m.

SUNDAY, 7th MAY 1978

Two concurrent sessions will be held

TECHNICAL SESSION I - CLAYSTONES ("TUFFS")

Geology/Physics Lecture Theatre E01

Chairman: Dr. R.A. BRITTEN
Joint Coal Board

		HOURS
12.	THE REID'S MISTAKE FORMATION AT SWANSEA HEADS F.C. LOUGHNAN and A.S. RAY University of New South Wales	9.30 a.m. - 10.00 a.m.
13.	CLAYSTONES OF THE ERARING AREA: ENGINEERING PERFORMANCE J.P. MACGREGOR and G. BRISCOE Electricity Commission of N.S.W.	10.00 a.m. - 10.30 a.m.
14.	CLAYSTONES OF THE SOUTHERN LAKE MACQUARIE AREA - EFFECTS ON UNDERGROUND MINING P.P. WOOTON Coal & Allied Industries Ltd.	10.30 a.m. - 11.00 a.m.
	Morning Tea in the Geology Department	11.00 a.m. - 11.30 a.m.
15.	SWELLING CLAYSTONES FROM THE ERARING AREA (NEWCASTLE COAL MEASURES); CHEMICAL AND MINERALOGICAL PROPERTIES J.L. ANDERSON, N.S.W. Department of Mines E. SLANSKY, Geological Survey of N.S.W.	11.30 a.m. - 12.00
	DISCUSSION	12.00 - 12.30 p.m.
	SUMMARY AND VOTE OF THANKS BY CHAIRMAN	12.30 p.m. - 12.35 p.m.

END OF SESSION

TECHNICAL SESSION II - NEW ENGLAND FOLD BELT

Physics Lecture Theatre DG08

Chairman: Dr. R.A. BINNS
Division of Mineralogy
C.S.I.R.O.

		HOURS
16.	ASPECTS OF THE GEOLOGY OF THE WOODSREEF SERPENTINITE R. GLEN Geological Survey of N.S.W.	9.30 a.m. - 10.00 a.m.
17.	STRUCTURAL ANALYSIS OF SERPENTINITES, PEEL FAULT ZONE, GLENROCK STATION, N.S.W. A. WILLIAMS University of Newcastle	10.00 a.m. - 10.30 a.m.
18.	CHEMISTRY AND TECTONIC SETTING OF L. DEVONIAN AND ORDOVICIAN-SILURIAN (?) META-VOLCANICS, GLENROCK STATION, N.S.W. R. OFFLER University of Newcastle	10.30 a.m. - 11.00 a.m.
	Morning Tea in the Geology Department	11.00 a.m. - 11.30 a.m.
19.	A STRATIGRAPHIC BASIS FOR THE MAPPING OF THE HASTINGS BLOCK N. MORRIS University of Newcastle	11.30 a.m. - 12 noon
20.	DEVONIAN TETRACORAL FAUNAS FROM NEW ENGLAND A.J. WRIGHT University of Wollongong	12 noon - 12.30 p.m.
	SUMMARY AND VOTE OF THANKS BY CHAIRMAN	12.30 p.m. - 12.35 p.m.

END OF SESSION

FAREWELL LUNCHEON - UNIVERSITY UNION	12.35 p.m. - 2.00 p.m.

THE OCCURRENCE AND SIGNIFICANCE OF A COKING COAL DYKE WITHIN THE SINGLETON COAL MEASURES OF NEW SOUTH WALES

R.A. Britten
Joint Coal Board

and

G.H. Taylor
CSIRO Fuel Geoscience Unit

In April, 1977, at the invitation of the Manager of Foybrook Open Cut, Mr. Gordon Turner, a dyke of coal exposed in the worked face of the Pikes Gully Seam at Foybrook was examined and sampled. Features of the occurrence were received and from field and petrographic evidence an interpretation has been made of the likely mode of occurrence and origin of the dyke. Laboratory tests of the dyke coal indicated it to have coking properties and a proximate analysis rather similar to the Pikes Gully and Liddell Seams of the locality.

The strike of the dyke was (N16.5°E) parallel to sub-parallel to prominent joints, faults, and minor igneous intrusions in the locality. The dyke extended in a straight line across the floor of the open-cut in the Pikes Gully Seam. It was again located along its line of strike in underground workings in the underlying Liddell Seam within an adjacent colliery. Its thickness was consistently of the order of 25cm; its depth, from the base of the Liddell Seam to the top of the highwall in the Pikes Gully Seam, was at least 120m; and its lateral extent was at least 0.5km. The dyke, therefore, contained not less than about 25,000 tonnes of coal, the emplacement of which must have been engendered by a set of very special conditions.

The interfaces of the coal dyke with the intruded strata were quite sharp with no significant distortion and with no obvious sign of heat effect on the intruded coal adjacent to the dyke. The intruded strata included the Pikes Gully Seam together with its floor rocks and overlying mudstones, siltstones and coarse grained massive sandstones. The total absence of both horizontal and vertical distortion of either the coal dyke or the coal seams intruded by it suggests that the intruded coal was mature at the time of the dyke emplacement.

Petrographic examination of samples from the dyke and adjacent coal disclosed some interesting and significant features. The dyke coal is microscopically quite distinctive. None of the layering, typical of coal, occurs. Instead the texture is one in which vitrinite-like material forms a groundmass within which other materials, especially inertinite macerals, occur randomly distributed. There is no banding or preferred orientation nor are any vesicles present. The vitrinite-like groundmass is not homogeneous but contains innumerable fine, rounded inclusions of highly anisotropic carbonaceous material, interpreted as being mesophase bodies - an incipient stage of coke formation. The development of mesophase is related to the rank of a coal which has been subsequently heated and it is inferred that the dyke coal must have been at about its present stage of maturity at the time the dyke was emplaced. Since mesophase formation was no more than incipient, the chilled dyke coal retains coking properties.

The petrographic evidence suggests that emplacement of the dyke probably occurred contemporaneously with (Tertiary) igneous intrusions in the vicinity. A basaltic plug is known to occur nearby and this has severely affected parts of the Liddell Seam together with the underlying Barrett and Hebden Seams of the area. It is inferred that the interaction of igneous intrusion within these seams produced the reservoir of fluid coal which fed the dyke; brecciated coal from the Barrett Seam, noted in the course of petrographic analysis of a nearby bore core (Smyth 1968) may also have been related to this interaction.

A further occurrence of a coal dyke was encountered in two major splits of the Liddell Seam at Liddell Colliery approximately 1.5km south south east from the coal dyke at Foybrook. This occurrence, although probably related to the coal dyke at Foybrook, was separated from it by an igneous dyke up to 50m thick. The sub-parallel orientation and close proximity of these coal dykes to the igneous dyke separating them strongly suggests the coal dykes were commonly derived from coal mobilised through interaction with the igneous dyke between them.

It is concluded that emplacement of the coal dyke resulted from rapid extrusion from a very large reservoir of highly fluid coal produced at temperatures of the order of 450°C. Under the influence of high confining pressures the loss of volatile components was inhibited.

Under this high pressure, the very fluid coal was able to form a sheet-like body in rocks already stressed by igneous intrusions. Injection took place with great rapidity and was accompanied by almost instant "freezing" or resolidification that left little or no mark upon the rocks through which the dyke was emplaced.

References: Smyth, M. Petrography of Permian Coals from Tomago Measures. Proc. Aust. A.I.M.M., No.226, March, 1968.

THE APPLICATION OF GEOLOGY IN LONGWALL MINING AT SOUTH BULLI COLLIERY

F. Bos and B. Agrali
The Bellambi Coal Company Limited

Longwall mining was introduced by The Bellambi Coal Company Limited at South Bulli Colliery in 1965 and at present two longwall units are in operation in the Bulli Seam and one in the Balgownie Seam. Longwall mining is more productive than any other method available under the difficult mining conditions experienced. Moreover, longwall mining is safer and higher extraction percentages can be achieved.

Initially the available equipment proved to be inadequate for the local conditions which are mainly controlled by the presence of massive sandstones above the seams. After numerous technical changes and especially after greatly improving the roof supports, the extraction by the retreating longwall method is now operating successfully.

The role of geology is comparatively minor, but nevertheless it forms an indispensable part in long and short term mine planning and budgeting. In unworked areas the usual techniques of drilling, field work and airphoto interpretation are employed to ensure as far as possible the consistency in structure, coal quality and seam thickness. The interpretations are continually checked by observations and samples in the most advanced underground workings enabling improved forecasts for the next two to three years production.

Detailed mapping is carried out in the development headings for each longwall block. This mapping consists of recording the seam composition and thickness, extraction height, roof falls, ribside conditions, small faults, joints, "leaners", roof and floor types, stone rolls, dykes and cinder. Strip samples are taken at regular intervals for float and sink tests and the determination of the crucible swelling number. As soon as the development workings have surrounded a block of coal for extraction by the longwall method a geological report is prepared. Depending on the experience in previous longwall blocks and the equipment to be used, recommendations are made for the extraction height in several subsections of the block, and predictions are made of washery recovery and the amount of roof and floor stone to be expected in the run of mine product. Predictions are also made of clean coal properties and attention is drawn to any geological disturbance that may hamper the extraction of the coal.

PREDICTION OF BAD COAL MINING CONDITIONS IN SYDNEY BASIN COALFIELDS

J. Creasey, J.F. Huntington and J. Shepherd
CSIRO Division of Mineral Physics

For the past two years the Division of Mineral Physics has been engaged in research to improve the geological understanding of adverse coal seam conditions that hinder underground coal extraction. Such conditions examined have included roof failure, floor lift and instantaneous outbursts of coal and gas. Using underground structural/engineering mapping, statistical analysis, structural photointerpretation and surface mapping the following structures have been identified which are associated with bad working conditions: minor fault swarms, particularly clusters of oblique and strike-slip faults; zones of high frequencey jointing underground; surface fracture zones visible on air photographs and in outcrops which are often departures from the regional structural pattern. The spatial association of these structures with bad working conditions in historically-located zones has permitted the development of short, medium and long term prediction techniques for identifying certain classes of structural zones likely to be deleterious to mining. These techniques can be applied to new development immediately ahead of coal faces, in new panel development and in the layout of completely new collieries. These findings are based on investigations carried out in seven collieries. Future research will be aimed at verifying their use in other situations, and integrating them with roof control and out-burst engineering studies.

GEOCHEMICAL EVIDENCE FOR MARINE INFLUENCED SEDIMENTATION IN THE NEWCASTLE COAL MEASURES

P.R. Warbrooke
The Broken Hill Proprietary Co. Ltd.

Geochemical trends in sediments have often been used to help distinguish between marine and non-marine depositional environments. This approach can be used to illustrate the gradation from a marine or semi-marine environment in Tomago Coal Measure time to non-marine fluvial environment in upper Newcastle Measure time. Swaine (1962), using variations in the boron content of coals, suggested the Tomago Coal Measures were deposited in brackish or intermittent marine conditions and the Newcastle Coal Measures represent a transition between brackish and fresh water conditions.

In this present study only analyses from coals with an ash content of less than 35% were used. The elements considered were sulphur, phosphorus, iron, calcium and magnesium.

Most sulphur is deposited in the peat swamps in the form of sulphide minerals by sulphur reducing bacteria and as organic sulphur in plant material. The bacteria thrive best in neutral or weakly alkaline conditions which exist where swamp water (pH 3 to 6) and sea water (pH 8) mix. Sea water is the major source of sulphur, containing about 250 times more than river water. The total sulphur content gradually decreases from 1.13% in the Tomago Coal Measures to 0.36% in the Victoria Tunnel seam of the Newcastle Coal Measures. Above this seam the sulphur content is erratic but averages at 0.36%. The decrease in sulphur content can be explained by the decreasing pH and available sulphur associated with a retreating sea. Lateral variation of sulphur within the

Yard and Victoria Tunnel seam horizons suggest the Permian sea was situated to the east or south east of the study area.

The geochemistry of phosphorus is more complex than sulphur. River water is the major source of the phosphorus brought into the peat swamp. Removal of phosphorus from solution is increased with increasing temperature, pH and salinity. The phosphorus content increases from 0.022% in the Tomago Coal Measures to 0.120% in the Yard seam (Newcastle Coal Measures). Low values are due to removal of phosphorus from river water before it can reach these areas. The Yard seam occupies the position where phosphorus supply and chemical conditions are favourable for maximum deposition. Above the Yard seam the phosphorus gradually decreases due to the gradual decrease in pH and salinity associated with a retreating sea.

Iron, calcium and magnesium contents of coal ash all decrease from the Tomago to the top of the Newcastle Coal Measures. The three elements are usually present as carbonate minerals which form in weakly acid to alkaline conditions. These conditions exist in a marine influenced peat swamp. Sea water is the dominant source of calcium and magnesium and river water the major source of iron.

Intense bioturbation in the upper Tomago Coal Measures is evidence of its marine or semi-marine origin. Recently the author has located bioturbation in the Waratah Sandstone underlying the Borehole seam and the Tighes Hill Formation overlying the Borehole seam suggesting brackish conditions.

Geochemical trends suggest the upper Tomago and lower Newcastle Coal Measures were deposited under the influence of a receding Permian sea situated somewhere to the east or south east of the present coast line.

Reference: Swaine, D.J., 1962, Boron in New South Wales Permian Coals. Aust. J. Sci., 25, 265-266.

THE ROLE OF CONSULTANTS IN THE COAL GEOLOGY OF THE SYDNEY BASIN

R.C. Nolan
Esso Australia Ltd.

Geologists of the N.S.W. Geological Survey and the Joint Coal Board were the initial "advisers" on the coal geology of the Sydney Basin. The need to ensure that coal exploration results were adequately documented required them to provide assistance to private industry. As universities became more specialised in coal geology and the coal research organisations developed their programmes, they were consulted for their specialised knowledge. Independent consultants and consulting groups only became available to the industry in the early 1970's.

This paper discusses the activities of a consulting group to illustrate how it must operate in order to conform to the Aus. I.M.M. Code of Ethics and Code of Consultants. A consulting group is a service company and as such must maintain some office facilities, remain informed of new developments, maintain contact with potential clients and train junior personnel in addition to the main task of providing a service for a fee. Adherence to a minimum fee schedule is required to provide reasonable remuneration and to prevent unfair competition. The basis for a scale of fees and the reasons why tendering is not permissible are outlined. Consultant-client relationships are most important and the client's responsibilities under the Codes are discussed.

In the absence of a separate Professional Association, the Aus. I.M.M. Codes provide the only guidelines for coal geology consultants. The Codes' provisions, relative to the current situation, are discussed and compared with those of an overseas association. Additional guidelines are recommended.

WHAT IS A RESERVE?

Keynote Address

Mr. K.A. Richards
Esso Australia Ltd.

Reserves are never found; reserves are only developed. Reserve estimation should be categorised so that the user can readily identify the category most applicable to his requirements. Presentation of reserves should clearly illustrate the variability and speculation inherent in their estimation. This is best accomplished by the use of probability distribution curves, which have the advantage of defining the entire range of reserve variability and speculation in one visual presentation. Construction of these curves imposes a discipline on the geologist which is so often lacking in more traditional methods. The use of such curves is becoming accepted in the oil industry and would be of particular benefit to the Australian coal industry.

CLINOHYPERSTHENE AND HYPERSTHENE FROM A COALFIRE BUCHITE NEAR RAVENSWORTH, N.S.W.

B.J. Hensen
University of New South Wales

and

D.R. Gray
Virginia Polytechnical Institute

Clinohypersthene, $Fe_{1.02}Mg_{0.88}Ca_{0.04}Al_{0.05}(Si_{1.93}Al_{0.06})O_6$, space group $\underline{P}2_1/\underline{c}$ and hypersthene occur in two separate, partly glassy rocks a few feet apart in a buchite 'chimney' associated with a burned coal seam. The clinohypersthene occurs as phenocrysts and is accompanied by plagioclase (An_{80}), cordierite [$Mg/(Mg + Fe^{2+}) = 0.65$], spinel ($Mt_{52}Uv_{26}Hc_{22}$) and brown glass. The hypersthene has the same Wo-content but is more magnesian [$Mg/(Mg + Fe^{2+}) = 0.50\text{–}0.52$] than the nearby clinohypersthene [$Mg/(Mg+ Fe^{2+}) = 0.30-0.46$]. The data suggest that the two phase region marking the orthopyroxene to pigeonite transition in the system $CaO-MgO-FeO-SiO_2$ intersects the enstatite-ferrosilite join. The clinohypersthene probably crystallised at a temperature of 1050 - 1100°C.

NEW ENGLAND TECTONICS IN A WORLD PERSPECTIVE

F.S. Jeffries
Esso Australia Ltd.

Using coloured Landsat photographs from the thrust belts around the world it can be suggested that the New England Fold Belt and Sydney Basin is typical of a widespread tectonic and stratigraphic couplet. Re-interpreted seismic data from the Hunter Valley supports this concept. Economic implications of this approach suggest that coal resources in the Hunter Valley will have to be heavily discounted because mining conditions will be much more difficult than currently imagined. Also a tenuous case can be made for the possible occurrence of hydrocarbons in fracture porosity within the thrust sequence.

WRENCH FAULTING IN THE NORTHERN SYDNEY BASIN

I.D. Blayden
Earth Resources Australia Pty. Ltd.

The Hunter Valley Region of the Sydney Basin is structurally complex compared to other parts of the Basin. The rocks are affected by a number of major faults and folds which in general trend in a northerly direction. An adequate interpretation of the tectonic events which produced these structures has yet to be presented due largely to poor outcrop and the occurrence of a number of unconformities in the sequence which obscure prior structuring.

A reassessment of the region has been undertaken which incorporates an interpretation of key seismic lines as well as surface structural and stratigraphic data. This study indicates that the major faults in the Hunter Valley are wrench faults with a right lateral sense of displacement. They probably represent splays off the main "Hunter Thrust" structure which is also considered to be primarily a wrench feature.

The principal episode of wrenching occurred during deposition of the widespread upper Permian Singleton Coal Measures and equivalent units. Presence of the wrench faults and subsidiary features in the rocks has already seriously disrupted mining in some areas and the available data would suggest that further significant disruptions will be encountered. In order to minimise future problems a major structural investigation is required incorporating geological and geophysical techniques to define the location, nature and extent of likely troublesome areas.

DATING OF EXTRUSIVE AND INTRUSIVE IGNEOUS ROCKS OF THE SOUTHERN SYDNEY BASIN

P.F. Carr and R.A. Facer
University of Wollongong

The southern Sydney Basin contains extensive areas of extrusive and intrusive igneous rocks which have been regarded as ranging in age from Upper Permian to Tertiary. Very few of these igneous rocks have been dated isotopically, especially in the Southern Coalfield, so that most ages have been inferred from stratigraphic relationships, palaeomagnetic data and chemical and petrographic similarity to dated rocks.

Extrusive igneous rocks in the Wollongong - Kiama area are interbedded with a series of marine sandstones. The Upper Permian age indicated by the abundant fauna in these sedimentary rocks is supported by palaeomagnetic and radiometric data for the igneous rocks. Good stratigraphic control on the other igneous rocks in the southern Sydney Basin is lacking and hence ages of rocks not dated isotopically are not as well defined.

Weathering and alteration of many of the igneous rocks of the Southern Coalfield has made radiometric dating difficult, but careful sample collection procedures have made it possible to obtain K-Ar isotope data on 11 samples. The ages obtained fall into two groups: middle to late Permian and middle to late Tertiary. Comparison of these newly-determined ages with other radiometric data from the southern Sydney Basin confirms Permian and Tertiary groups of ages.

The available radiometric age data indicates well-defined periods of igneous activity in the Southern Coalfield during the middle to late Permian and middle to late Tertiary. As yet there are no known Mesozoic igneous rocks from the Southern Coalfield of the Sydney Basin.

UNWRAPPING LITTLE BAY

(An Early Miocene Esturine Deposit at Little Bay, Sydney)

A.D. Partridge, Esso Australia Ltd.
J.M. Benson, University of New South Wales
D. Bell, University of New South Wales

Early Miocene sands, peats and clays have been recognised in two bores and in outcrop at Little Bay, a coastal suburb of Sydney. The deposit lies in a linear channel or ravine formed in the Hawkesbury Sandstone and strikes north-west south-east. This ravine is located on the seaward side of the northern headland of Botany Bay and is approximately 400 metres from the coast where the ground surface is 25 metres above sea level. The known extent of the deposit is 250 metres by 80 metres.

An Early Miocene age for the deposit is proposed on the basis of palynological assemblages which can be referred to the upper subdision of the *Proteacidites tuberculatus* Zone described from the Gippsland Basin. The assemblages which are dominated by *Nothofagus* pollen, are of rather low diversity and show little compositional variation in the bore sections.

The deposit is interpreted as an esturine valley fill similar to the upper reaches of the many bays and coves in present day Port Jackson and Port Hacking. Marine fossils in the deposit include dinoflagellates and microforaminifera in the palynological preparations and badly exfoliated specimens of calcareous foraminifera which were observed in freshly broken sections of core from Bore No.1.

Lithologically, the Little Bay deposit is indistinguishable from the sands, peats and clays underlying Botany Bay and Port Jackson. It is likely that some of these deposits are also of Tertiary age. This implies that the cutting of the classic drowned river valleys, such as Port Jackson, which are characteristic of this part of the Sydney Basin, commenced at least as far back as the early Tertiary; probably during major eustatic low stands of sea level. Partial filling of the valleys then occurred at eustatic high stands of sea level. The Little Bay deposit represents the latest Oligocene to Early Miocene high stand of sea level recognised everywhere around Australia.

LATE CARBONIFEROUS AND PERMIAN PALAEOGEOGRAPHY OF WESTERN NEW ENGLAND

J.W. Brownlow
Geological Survey of New South Wales

The following major geographical changes occurred during the Late Carboniferous and Permian in western New England and the adjacent Gunnedah Basin between the Nandewar and Liverpool Ranges.

Stage 1 ** (Late Carboniferous)

On the western margin of the Gunnedah Basin was a glaciated mountainous range with acid volcanism (Rylstone and Boggabri Volcanics) on its eastern flank. Sediment transport was predominantly eastward into the Tamworth Trough. This range was largely removed by the end of the Carboniferous by a combination of block faulting, erosion and regional subsidence.

Stage 2 (?Early Permian)

Western New England was a region of generally low relief with local sedimentation (Temi Formation) around sporadic relict acid volcanic massifs. Basaltic volcanism (Werrie Basalt) occurred which was associated with widespread subsidence and restricted marine transgression.

Stage 3 (Early Permian)

Minor subsidence may have occurred in the Gunnedah Basin after the cessation of volcanism. Fine grained lithic sediments were deposited in restricted seas. Emergent areas had low relief and were well drained, leading to intense weathering.

Lower Stage 4 (Early Permian)

Uplift on fault systems in Western New England (e.g. Hunter-Mooki, Peel) produced a series of high NNW trending ridges on their eastern sides. Erosion of mainly Late Carboniferous acid volcanics on the ridge adjacent to the Hunter-Mooki Fault System probably produced the first major westward transport of sediment into the Gunnedah Basin. Flint clay sediments (Leard Formation) were derived from a palaeosol on this ridge, and later, lithic sediments (Nandewar Formation) were derived from below the palaeosol (Brownlow, 1977b). Drainage from the ridge produced coal swamps in the depositional area.

Upper Stage 4 (? Late Permian)

Widespread marine transgression occurred west of the Hunter-Mooki Fault System and possibly locally to the east during regional subsidence. Erosion continued in the moderate relief terrain in western New England.

Lower Stage 5 (? Late Permian)

Relief was probably low to moderate in western New England and pronounced gaps probably existed in the NNW trending ridges. The Gunnedah Basin had probably reached its greatest depth and was filling up with sediment.

Upper Stage 5 (Late Permian)

Uplift occurred in the western part of central New England and acid volcanism commenced on the eastern flank of the elevated region. Drainage into a slightly elevated Gunnedah Basin took place through gaps in intervening ridges, producing coal swamps and mixed provenance sediments interbedded with acid tuffs (Black Jack Coal Measures). Cessation of volcanism and regional subsidence in central New England was accompanied by termination of sedimentation and drainage of the coal swamps.

This interpretation is consistent with the tectonic model of Brownlow (1977a) and further demonstrates that for the Late Carboniferous and Permian, the (western) New England tectonics are clearly recorded in the Gunnedah Basin.

** The Palynological time scale of Evans (1967) as modified by Paten (1969).

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THE REID'S MISTAKE FORMATION AT SWANSEA HEADS

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The Reid's Mistake Formation was named by McKenzie (1964) to denote the stratigraphic interval separating the Lower and Upper Pilot Coals within the Boolaroo Sub-Group of the Newcastle Coal Measures. The type section was taken from the B.H.P. Stockton Borehole No.3 Shaft where the formation has a thickness of 27m and contains in addition the Seahampton Sandstone Member, "material largely of tuffaceous origin". However, in the exposure at the cliff face at Swansea Heads, considered by McKenzie as the standard section for the formation, the Seahampton Sandstone Member is not recognisable and the succession, which is reduced in thickness to 10.5m, comprises for the most part interbedded claystones and "cherts".

The claystones are composed primarily of regular and random mixed layer clay minerals and quartz with or without minor amounts of kaolinite, analcite, feldspar and discrete montmorillonite and, as such, they differ little from fine-grained sediments found elsewhere within the Newcastle Coal Measures (Hamilton, 1968).

On the other hand, the "cherts", which are particularly hard and brittle, contain abundant chalcedonic quartz and analcite, the latter constituting as much as 40% of the rock, with the accessory minerals being mainly mixed layer clays, biotite and less frequently, feldspar. In thin section they have an apparent vitroclastic texture with the shards and matrix replaced by chalcedony and analcite. Similar rocks have been described previously from the Newcastle Coal Measures by Loughnan (1966), who believed that they had formed through the reaction of volcanic glass with soda-rich solutions in an arid lacustrine or floodplain environment. However, more recently the pyroclastic origin of these "cherts" have been questioned on the basis that (a) in places they are crossbedded and have other sedimentological features inconsistent with volcanic fall-out and (b) there is little independent evidence to substantiate the concept of widespread vulcanicity in the Sydney Basin during the Later Permian.

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CLAYSTONES OF THE ERARING AREA; ENGINEERING PERFORMANCE

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The "tuff(?)" (or claystone) units of the Permian Newcastle Coal Measures in the Eraring area contain smectite and mixed layer clays which exhibit swelling and/or slaking characteristics with changing moisture conditions and water composition.

Sampling and testing of drill core has indicated the widespread lateral and vertical occurrence of the claystone within the Coal Measures. The term claystone is used here to include siltstone and clayey sandstone of the "tuff(?)" members. In addition to grainsize variations, the claystone exhibits extremely variable composition and clay content.

The claystone has caused slope stability and erosion problems during construction of the Eraring Power Station and has been responsible for severe floor heave and roof falls in collieries in the western Lake Macquarie area.

Treatment of the claystone has not been attempted on a large-scale in the Eraring area but methods which have been successful in other areas include lime stabilization and control of moisture content. Protection of the claystone by coverings such as gunite and asphalt has also been used successfully.

CLAYSTONES OF THE SOUTHERN LAKE MACQUARIE AREA
EFFECTS ON UNDERGROUND COAL MINING

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Underground mining in Chain Valley and Wallarah Collieries has encountered adverse working conditions resulting from clay-rich strata underlying the Wallarah and overlying the Great Northern Seams.

This material has caused major floor heave problems in Wallarah Seam workings in Chain Valley Colliery and roof instability in parts of the Great Northern Seam workings in both collieries.

Geological investigations have met with mixed success in predicting such conditions which have been controlled to varying degrees in mining operations.

This contribution will describe these features, the methods used to predict them and the means adopted to reduce their affects on mining.

SWELLING CLAYSTONES FROM THE ERARING AREA (NEWCASTLE COAL MEASURES); CHEMICAL AND MINERALOGICAL PROPERTIES

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and

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Floor heave in coal mines of the Eraring area is caused by swelling clay minerals in claystones of the Moon Island Beach Sub Group of the Newcastle Coal Measures. Mixed-layer mica-smectite or smectite, and kaolinite make up the clay fraction of the claystones. Mica-smectite and smectite are the swelling components.

The intensity of swelling is mainly related to the nature of the swelling mineral, their cation exchange capacity, the original state of hydration of the rocks and the nature of the exchangeable cations. Exchangeable sodium is the most important, its concentration being directly related to the swelling capacity. High concentrations of sodium have been found in mine waters taken from Awaba State Coal Mine in the vicinity of areas affected by floor heave.

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ASPECTS OF THE GEOLOGY OF THE WOODSREEF SERPENTINITE

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The Woodsreef Serpentinite differs from other ultramafics associated with the Peel Fault because it is a bifurcated rather than a lenticular body, and because it is host to an economic asbestos deposit. These two features are related.

All the ultramafics are derived from a harzburgite and although no completely unserpentinised harzburgite is present, an original composition of 65% olivine (Fa_9) + 30% orthopyroxene (En_{94}) + 5% chrome spinel is estimated.

Serpentinisation of this harzburgite results in massive serpentinite and schistose serpentinite and at least two generations of schistosity formation are present. The alteration of partially serpentinised harzburgite to a chrysotile + lizardite massive serpentinite involves both chemical change and volume increase, and expansion cracks around kernels of harzburgite may contain fibrous chrysotile.

Fibre growth is accompanied by a volume increase in an environment of directed stress, excess water and slightly elevated temperatures. This growth is thus restricted to developing cracks which can accommodate the volume increase and fibre growth,takes place in the manner of Durney and Ramsay (1973). Most of these cracks are structurally controlled in orientation and can be related to movement on the Peel Fault or to the late stage remobilisation of part of the Woodsreef Serpentinite during folding of the Woolomin Beds which results in the bifurcated shape of the ultramafic.

Tectonic blocks of dolerite, gabbro and trondhjemite may represent disrupted dykes. The more mafic blocks undergo alteration to rodingite during serpentinisation.

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STRUCTURAL ANALYSIS OF SERPENTINITES, PEEL FAULT SYSTEM, GLENROCK STATION, N.S.W.

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The Peel Fault System has long been recognised as a major structural element of the New England Region and has been the subject of much speculation in the many tectonic theories which have been proposed for the region.

Despite its importance, few factual data pertaining to its extent, geometry, timing and nature of movements are presently available.

A detailed structural analysis of the serpentinites contained within faults of this system may help to elucidate this problem. The serpentinites have been intimately associated with faults of the system from its inception to the present. Consequently, they may be reasonably expected to contain abundant structural data awaiting appraisal.

Preliminary work within the Glenrock area has shown that this is the situation.

Mesoscopically, at least three generations of foliation may be recognised. The earliest (S_1) is a fine schistosity believed to have originated under ductile conditions. This is crenulated by a close-spaced cleavage (S_2) which is penetrative on the microscale. A third, much wider spaced cleavage (S_3) which crenulates S_2 is penetrative on the mesoscale but is not, generally, microscopically developed. The two cleavages S_2 and S_3 were formed under brittle-ductile to brittle conditions and are demonstrably shear planes.

Folds in both S_1 (F_2) and S_2 (F_3) are recognised but, as yet, their full significance has not been determined. They exhibit variable style and orientation and, in general, are sparsely distributed throughout the serpentinite belts.

In addition to these structural elements a pre-existing (primary?) foliation in the form of a mineralogical layering is observed in some massive serpentinite bodies.

Finally, post- S_3 brittle deformation has been extensive resulting in several generations of faults and joints. Some of the latter were filled with opaline material, magnesite or clinochrysotile while undergoing extension.

Further work, involving a comparison of the structural deformation within the serpentinites with that in the adjacent country rocks, is required to enable some control to be placed on the extent and timing of the deformational events.

CHEMISTRY AND TECTONIC SETTING OF L. DEVONIAN AND ORDOVICIAN-SILURIAN (?) META-VOLCANICS, GLENROCK STATION, N.S.W.

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The volcanic rocks of the Glenrock Station area are associated with sediments of varying age and composition which occur in a series of thrust slices of the Peel Fault Zone. The upper thrust slices contain rocks lithologically similar to the Woolomin Beds (Crook, 1961), the lower slices, Lower to Upper Middle Devonian (A. Wright, N. Morris pers. comm.) rocks belonging to the Tamworth Group (Crook, 1961). A wedge of Upper Carboniferous (N. Morris pers. comm.) rocks occurs between the two main thrust sheets.

Major and trace element analyses have been carried out and the discriminant diagrams of Pearce and Cann (1973), Pearce (1975) and Winchester and Floyd (1977) used in an attempt to determine the magmatic affinity and tectonic setting of these volcanic rocks.

These diagrams show:

(1) tholeiitic (subalkaline) basalts and calc-alkaline andesites-dacites occur in the Devonian sequence and that the basalts have island arc and ocean floor affinities.

(2) tholeiitic basalts, with a chemistry similar to abyssal tholeiites, and alkali basalts erupted during intra plate activity, are associated with cherts of the Woolomin Beds.

(3) tholeiitic basalts with island arc and ocean floor affinities are intercalated with sediments of the Woolomin Beds.

Microprobe analyses of pyroxenes confirm the tholeiitic nature of the basic volcanic rocks, but also indicate that those of the Devonian sequence are geochemically transitional between tholeiitic and alkaline magmas.

Field and laboratory studies suggest that the volcanic rocks intercalated with sedimentary rocks in the upper and lower thrust sheets are island arc in origin.

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A STRATIGRAPHICAL BASIS FOR THE MAPPING OF THE HASTINGS BLOCK

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The sediments of the Hastings Block apparently range in age from Early Carboniferous to about the middle of the Permian. They consist predominantly of lutites - a monotonous succession of thousands of metres of blue-grey to black mudstones and siltstones containing few reliable marker horizons. Only a small part of the Block has been mapped in detail. Areas near Taree and Kempsey were mapped by Voisey in the nineteen thirties but little intensive work has been done outside these two areas since that time. Nevertheless, a geological map of the entire Block is in existence and has been used, perhaps a little prematurely, as the basis for a tectonic interpretation.

It is unlikely that the Hastings Block will ever be mapped with the same degree of precision as, for example, the contiguous region between the Hunter and the Manning. The Block is severely faulted but few of the faults, even the large-scale ones, have been recognised and mapped. There is a small number of useful widespread fossil horizons but they are separated by great thicknesses of barren sediment and long time gaps. Fortunately, there were a number of changes in the Carboniferous and Permian, which in addition to profoundly affecting the composition and distribution of the flora and fauna, produced recognisable changes in the sediments. These changes affected the composition and sedimentation rate of the fine-grained sediments and controlled the distribution in time and space of some rarer lithotypes in the area, particularly the conglomerates, both fluvial types and diamictites, the limestones and the coal. These changes - change in the climate, uplift and progradation of the shoreline, change in the composition of the volcanics, constitute an event stratigraphy. The time at which they occurred is known from work in the region between the Hunter River and the Manning River, where the sediments are for the most part richly fossiliferous.

When all the presently available criteria are used there still remain some sediments of unassignable age. Such is the confusion at present, however, that a system which can distinguish Carboniferous rocks from Permian, and Early Carboniferous rocks from Late Carboniferous rocks most of the time, is of considerable value.

SOME DEVONIAN TETRACORAL FAUNAS FROM NEW ENGLAND

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Poorly known tetracoral faunas, one from west of Keepit Dam, and the other from Glenrock Station are discussed.

The Keepit coral faunas were first recorded by Jenkins (1969) who assigned them a Frasnian age on the basis of conodont faunas. The lowest exposed limestones yield abundant Synaptophyllum with a variety of other tetracorals. Higher horizons yield a different fauna dominated by Hexagonaria, "Billingsastrea".

The Glenrock tetracoral fauna is derived from limestones near the Peel Thrust and apparently overlain by sandy beds containing in places abundant shells. Both faunas are early Devonian. Brachiopods from the latter unit include abundant Gypidula and Taemostrophia. Tetracorals from the limestones include ?Pseudamplexus, Xystriphyllum spp., Hexagonaria, Thamnophyllum and "Billingsastrea". Polygnathid conodont elements have been recovered from the limestones.