ISSN 0727-0097

PROGRAMME

and

ABSTRACTS

for the

SIXTEENTH SYMPOSIUM

on

"ADVANCES IN THE STUDY OF THE SYDNEY BASIN"

DEPARTMENT OF GEOLOGY
THE UNIVERSITY OF NEWCASTLE
NSW 2308

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PROGRAMME

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SIXTEENTH SYMPOSIUM

ON

ADVANCES IN THE STUDY OF THE

SYDNEY BASIN

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30TH APRIL, 1ST & 2ND MAY, 1982

CONVENER:

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

PREFACE

A warm welcome to the Sixteenth Newcastle Symposium is extended to you by the staff of the Department of Geology. In particular, we wish to thank our Keynote Speaker, Professor H.J. Harrington, Bureau of Mineral Resources, Canberra, for his participation.

On Saturday, a series of papers covering sedimentological, structural and other aspects of the Sydney Basin will complement our Keynote Address which is entitled "Tectonics and the Sydney Basin".

In the latter part of the afternoon a Special Topic Session dealing with the Greta Coal Measures will run concurrently with the Technical Session.

On Sunday, two concurrent sessions will be held, one emphasising the sedimentological and stratigraphic aspects of rocks in the northern Sydney Basin; the other, petrographic and other characteristics of coal.

We look forward to your participation again in our annual gathering.

R. Offler

B.A. Engel

PROGRAMME

FRIDAY 30th APRIL, 1982

REGISTRATION in the OFFICE (1st Floor) of the Geology Department, The University of Newcastle — 9:00am-5:00pm

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EXCURSION — 1:30pm-5:00pm

Inspection of the Greta Coal Measures in the Muswellbrook area. The excursion will deal with the stratigraphic section which will be the subject of a Special Topic Session on Saturday afternoon.

Assemble at the Bayswater Colliery at 1:30 PM as indicated on the enclosed map.

Participants should bring suitable clothing, footwear and hard hats.

Leader: C.F.K. Diessel

INFORMAL GATHERING at the STAFF HOUSE near the University Union Building — After 8:00pm

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SATURDAY, 1st MAY, 1982

REGISTRATION in the FOYER of the Geology Department, The University of Newcastle	8:00-9:00am

SESSION 1 - 9:00 AM to 12:20 PM
(Geology/Physics Lecture Theatre E01)

Chairman: B. Vitnell,
Coal & Allied Industries, Ltd.

OPENING of the 16th NEWCASTLE SYMPOSIUM by the Vice Chancellor of the University of Newcastle, Professor D.W. George	9:00-9:05am
LACUSTRINE (GILBERT) DELTAS IN THE PERMIAN COAL MEASURES OF EASTERN AUSTRALIA AND INDIA; IMPLICATIONS FOR THE WIDESPREAD HYDROPONIC ORIGIN AND DEEP-WATER DIAGENESIS OF GONDWANAN COALS P.J. Conaghan, Macquarie University	9:05-9:35am
PIEDMONT DEPOSITIONAL REGIMES WITHIN THE RAVENSWORTH ALLUVIAL EMBAYMENT: WITTINGHAM COAL MEASURES, NORTHERN SYDNEY BASIN R.G. Cameron*, P.J. Conaghan# & C.F.R. Parbury+, * Geological Survey of New South Wales # Macquarie University + McElroy Bryan & Associates Pty. Ltd.	9:35-10:05am
FLUVIAL SEDIMENTATION IN THE FOYBROOK FORMATION, WITTINGHAM COAL MEASURES D. Marchioni, Consultant Geologist	10:05-10:35am
MORNING TEA in the Geology Department	10:35-11:00am
COAL QUALITY VARIATIONS FROM THE MARINE-TERRESTRIAL TRANSITION IN PERMIAN COALS FROM THE LOWER HUNTER VALLEY P.R.Warbrooke*, C.K.Baker#, J.C.Day+ & R.H.Jones+, * B.H.P. Steel Division Collieries # Layton and Associates + B.H.P. Central Research Laboratories	11:00-11:30am

*** KEYNOTE ADDRESS ***

TECTONICS AND THE SYDNEY BASIN H.J. Harrington, Bureau of Mineral Resources, Geology & Geophysics	11:30am-12:15pm
SUMMARY AND VOTE OF THANKS BY THE CHAIRMAN	12:15-12:20pm
LUNCH in the STAFF HOUSE of the University	12:20-1:45pm

SATURDAY 1st MAY, 1982

SESSION 2 - 1:45 PM to 3:50 PM
(Geology/Physics Lecture Theatre E01)

Chairman: F.S. Jeffries,
Esso Australia Ltd.

THE SURFACE CHARACTERISTICS OF THREE MERIDIONAL FAULT AND JOINT ZONES OF THE SYDNEY BASIN A.J.Mauger*, A.A.Findlayson#, J.F.Huntington* & J.Shepherd+, C.S.I.R.O.Institute of Energy and Earth Resources * Division of Mineral Physics # Division of Geomechanics + A.C.I.R.L.	1:45-2:10pm
ON A COMPARISON BETWEEN FRACTURE PATTERNS IN THE ULAN AND HOME RULE AREAS, N.S.W. K.H.R.Moelle, The University of Newcastle	2:10-2:35pm
THE LOCHINVAR STRUCTURE; NOT JUST AN ANTICLINE C.D.Rawlings* and K.H.R.Moelle+, * T.A.T.S.Group, C.S.R. Ltd. + The University of Newcastle	2:35-3:00pm
THE LAPSTONE STRUCTURES - ONCE AGAIN D.F.Branagan and H.Pedram, The University of Sydney	3:00-3:25pm
SUMMARY AND VOTE OF THANKS BY CHAIRMAN	3:25-3:30pm

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AFTERNOON TEA in the Department of Geology 3:30-3:50pm

SATURDAY 1st MAY, 1982

CONCURRENT SESSIONS - 3:50 PM TO 5:10 PM

SPECIAL TOPIC SESSION 3A (Lecture Theatre E01)		TECHNICAL SESSION 3B (Physics Lecture Theatre DG08)
"THE GRETA COAL MEASURES"		
Chairman: R.A. Britten, Joint Coal Board		Chairman: K. Mosher, Consultant
AN INTERPRETATION OF THE STRATIGRAPHY OF THE MUSWELLBROOK AREA W.O. Morris, Joint Coal Board	3:50-4:15pm	WARRAGAMBA WATER FOR SYDNEY -1872, THE YEAR OF DECISION D.F. Branagan, The University of Sydney
GEOLOGY AND EXPLORATION OF THE BAYSWATER No.2 MINE AREA G.N. Sharrock, Caltex Australia Ltd.	4:15-4:40pm	OVERBURDEN ANALYSES FROM THE WITTINGHAM AND GRETA COAL MEASURES M. Pollington, J.B. Croft & Associates
STRATIGRAPHY OF THE GRETA COAL MEASURES IN THE DRAYTON AREA AND ITS INFLUENCE ON MINE DEVELOPMENT S. Butel, Drayton Coal Pty. Ltd. C.Sinclair (Muswellbrook Coal Co) will contribute.	4:40-5:05pm	HYDROGEOMORPHIC IMPACT OF COAL MINING, HUNTER VALLEY D. Day, Australian National Uni.
SUMMARY AND VOTE OF THANKS BY THE CHAIRMAN	5:05-5:10pm	SUMMARY AND VOTE OF THANKS BY THE CHAIRMAN

SYMPOSIUM DINNER in the Great Cask Hall, Rothbury Estate — Buses Depart 6:15 PM

SUNDAY 2nd MAY, 1982

COFFEE in the Geology Department — 8:30-9:00am

CONCURRENT SESSIONS - 9:00 AM to 1:30 PM

Time	TECHNICAL SESSION 4A (Lecture Theatre E01)	TECHNICAL SESSION 4B (Physics Lecture Theatre DG08)
	Chairman: A. McLean, Kembla Coal & Coke Pty.Ltd.	Chairman: D.F. Branagan, The University of Sydney
9:00-9:30am	STRATIGRAPHIC CORRELATION OF THE UPPER COAL MEASURES OF THE SYDNEY BASIN WITH THEIR EQUIVALENTS IN THE BOWEN BASIN A.T. Brakel, Bureau of Mineral Resources	PETROGRAPHY OF COAL - COKE IN THE BLAST FURNACE C.D.A.Coin* & D.P.Crawford+, *B.H.P.Central Research Labs. +B.H.P.Ironmaking Tech.Group, Newcastle Works
9:30-10:00am	A RESERVOIR QUALITY ASSESSMENT OF SOME SYDNEY BASIN SANDSTONES J.Lau, Esso Australia Ltd.	THERMAL ANALYSIS OF COAL,WITH PARTICULAR REFERENCE TO MINERAL CONSTITUENTS S.St.J. Warne & D. French, The University of Newcastle
10:00-10:30am	THE GEOLOGY OF THE MOUNT ARTHUR NORTH AREA, AN IMPORTANT COAL RESOURCE FOR POWER GENERATION IN NEW SOUTH WALES J.K. Bembrick, Electricity Commission of N.S.W.	REACTIVE INERTINITE C.F.K. Diessel The University of Newcastle

MORNING TEA in the Department of Geology — 10:30 - 11:00am

Time	TECHNICAL SESSION 4A	TECHNICAL SESSION 4B
11:00-11:30am	RECENT EXPLORATION IN THE GUNNEDAH BASIN BY THE DEPARTMENT OF MINERAL RESOURCES C.R.Weber,J.Becket & D.Hamilton, Department of Mineral Resources	SLIM CORE TESTING FOR MAXIMUM COAL PRODUCT INFORMATION R.H. Jones, B.H.P.Central Research Labs.
11:30-12:00pm	THE MINING HISTORY AND SEDIMENTATION OF THE TOMAGO COAL MEASURES IN THE EAST MAITLAND AREA B.Preston and P.P.Wotton, R.W.Miller & Co.	AUSTRALASIAN SEAM BULK SAMPLING DOWN A NARROW SHAFT R. Sanders, Newcastle Wallsend Coal Co.
12:00-12:05pm	SUMMARY AND VOTE OF THANKS BY THE CHAIRMAN	SUMMARY AND VOTE OF THANKS BY THE CHAIRMAN

LUNCH at the STAFF HOUSE of the University — 12:05 - 1:30pm

LACUSTRINE (GILBERT) DELTAS IN THE PERMIAN COAL MEASURES OF EASTERN AUSTRALIA AND INDIA: IMPLICATIONS FOR THE WIDESPREAD HYDROPONIC ORIGIN AND DEEP-WATER DIAGENESIS OF GONDWANAN COALS

P.J.Conaghan
Macquarie University

Compelling new implications regarding the origin of many coal accumulations within Gondwanaland stem from the widespread recognition, in at least the Permian Coal Measures of eastern Australia and India, of extensively developed lacustrine (Gilbert) deltas emplaced immediately above major coal seams. Large-scale opencut mine highwalls and coastal clifflines reveal complete vertical sections through these deltas and the underlying coal seams, and, together with information about delta-front palaeoflow patterns preserved within the delta crossbeds, allow accurate reconstructions of the environment in which the coal accumulated.

The minimum water depths in which the coal-generating vegetal accumulations formed were typically in the range 10-50m, commensurate with the range of primary depositional relief exhibited by the giant delta crossbeds. This evidence, together with the potentially basin-wide lateral development and relative uniformity of the related coal seams, demonstrates that the vegetal accumulations formed, for the most part, on the floors of very extensive, deep freshwater lakes or lacustrine mires. That the vast bulk of this vegetal debris was of fully hydroponic origin, analogous to situations which today characterize large primary lacustrine mires, follows from various considerations of the observed character of the coal deposits that formed in this environment together with the likely constraints that attended its accumulation and diagenesis, including: (1) the extreme unlikelihood that more than trivial volumes of the coal-generating vegetal debris were of terrestrial/allochthonous origin; (2) likely absence or subordinance of sessile (lake-bottom root-anchored) hydrophytes because of prohibitive water depths and hostile lake-bottom chemical milieu (explained below); and (3) typically low to moderate content, but highly stratified vertical distribution, of clastic materials within the related coal seams requiring mechanical emplacement via suspension-settling on an <u>even</u>

surface of wide lateral extent.

Lake infill by epiclastic sediment took place predominantly by delta progradation with minimal heraldic accumulation of suspended-load sediments on the lake-floor in advance of the deltas. This evidence, together with the moderately low content and highly-layered stratigraphic arrangement of clastic impurities in the coal, suggests that clastic sediment entry onto the deep lake-floor (other than regionally through occasional air-fall showers of volcanic ash) was controlled and minimized by: (1) climactic expansions of hydroponic vegetation across the entire lake surface; (2) density-controlled water-mixing patterns at the points of epiclastic sediment entry to the lakes that precluded sediment transportation beyond the delta-front, except perhaps for some density-underflow emplacement of suspended-fines. Conditions of sustained vegetal accumulation on the lake-floor through constant fretting, water-logging, and foundering of debris shed from the hydroponic blanket resulted in thicker, cleaner deposits of coal in those areas of the mire remote from the foci of delta construction. Contrastingly, periods of inactivity in delta advance and concomitant foundering through sediment compaction and isostatic/regional subsidence are recorded by similar vegetal mantling of the delta-top and slopes through encroachment of the hydroponc blanket over the delta platform during these intervals. These deposits coalesce downslope with contemporary vegetal accumulations on the deep lake-floor and so give rise to discordant coal plies (seam splits) when subsequently buried by renewed delta advance.

Directional patterns of secondary cross-stratification within the giant delta crossbeds allow reconstruction of the water-mixing patterns on the delta margins where incoming river water entered the deep standing water of the lake. These bottom palaeoflow patterns demonstrate that the river water entering the deep lake underwent predominantly homopycnal (axial-jet) and/or hyperpycnal (density-underflow) mixing, with only rare episodes of hypopycnal mixing (plane surface-jet with large-scale flow-separation over the delta-front). These mixing patterns reflect the relative densities of the two water masses as a function mainly of temperature, and demonstrate that the density of the river water was almost always equal to or greater than that of the water it entered (i.e., equivalent to upper levels of the lake water being of same or higher temperature than incoming river water). These mixing patterns in turn confirm intuitive expectations (from various considerations of the probable evolution of the mire hydrological structure) that the lake water was strongly density-stratified because of: (1) thermal insulation and hence surface-heating of the upper part of the water-column due to the protective blanket of hydroponic vegetation (i.e., surface waters less dense than deep waters); (2) progressive development above the deep lake-floor vegetal accumulation of a dense, highly-concentrated, organoacidic, anaerobic, antiseptic, humic or coal-forming chemical 'soup'; during times of maximum hydroponic cover and minimal clastic influx to the lake, this chemical 'soup' evidently occupied all but the very top of the water-column as indicated by the evident rapid diagenesis and bright-coal characteristics of laterally-contiguous vegetal accumulations that formed contemporaneously during such periods both on the deep lake-floor and as mantles across the shallowly-submerged delta platform (i.e., in the latter case, as seam splits); (3) progressive enhancement of the strong density-stratification brought about by (1) and (2) through additions of incoming cold river water (of possible glacigene/periglacial melt-water origin) to the lake-bottom chemical 'soup'. Development of these hydrological and hydrobotanical characteristics ensured extreme structural stability of the mire, minimized entry of clastic sediment to the deep lake-floor (cf. earlier remarks), and therefore considerably enhanced the relatively ash-poor, bright, vitrinite-rich characteristics of the resulting coals. The upsequence cyclicity or variation of bright and dull plies that characterizes many of these coals presumably reflects episodic or cyclic breakdown of the mire density-stratification (in very large lakes, not necessarily uniform in space and time across the entire mire, depending on causative mechanism), and hence more aerobic (oxygenated) conditions on the lake-floor. Numerous mechanisms that might conceivably engineer such overturn of the lake waters exist; such as systematic and perhaps cyclic change in the trophic structure of the mire leading to progressive deterioration and eventual loss of the protective hydroponic blanket, or major climatic change having the same result.

A most intriguing feature of these coals that has profound implications for their rate of early diagenesis, dewatering, and rapid acquisition of bulk mechanical strength, is the nature of the upper contact between the coal and the epiclastic sediment of the overlying delta. This contact is invariably knife-sharp, planar and wholly undeformed except for rare pressure-folds of minor (decimetre-scale) amplitude that affect the upper few decimetres of the coal seam and that can be demonstrated by structural/textural evidence in the outcrops to have formed at the immediate toe of the advancing delta through differential clastic loading. These relationships presumably indicate that at the time of delta emplacement over the peat/coal, this diagenetic substance already possessed sufficient mechanical strength to resist all but trivial deformation - a most surprising conclusion considering its evident youth and the substantial sediment thicknesses and rapid rates of differential loading that must surely have characterized delta emplacement.

Gondwanan coals are demonstrably not all of deep-water origin because a blanket-mire setting (for example) can be proven for some on the basis of unequivocal sedimentological evidence (e.g., Cameron and others, this volume). The survey of Gondwanan coals on which this paper is based has not yet progressed geographically beyond eastern Australia and India; but it is probable that the majority of Gondwanan (Permo-Triassic) coals will prove to be of deep-lacustrine origin, particularly those of sizeable thickness and relatively clean ash-poor character.

PIEDMONT DEPOSITIONAL REGIMES WITHIN THE RAVENSWORTH ALLUVIAL EMBAYMENT: WITTINGHAM COAL MEASURES, NORTHERN SYDNEY BASIN

R.G. Cameron*, P.J. Conaghan** & C.F.R. Parbury+

* Geological Survey of N.S.W.
** Macquarie University
\+ McElroy Bryan & Associates Pty. Ltd.

The Late Permian coal-bearing Singleton Supergroup and its correlatives along the northern flank of the Sydney Basin accumulated in a proximal piedmont setting in several north/south-aligned depocentres separated by anticlinorial structural highs of subdued topographic relief. These depositional embayments had transverse and longitudinal dimensions in the order of a few tens of kms, and widened southward towards the median axis of the Basin, toward and beyond which the sedimentary fill progressively thins from preserved maxima of 1.25-1.5km in the embayments themselves. In the onshore segment of the Basin, the most conspicuous of these features is that framed by the Muswellbrook Anticline on the west and the Lochinvar Dome Complex on the east; referred to here as the Ravensworth (Alluvial) Embayment (RE). This paper focusses on the stratigraphically lower (Wittingham) coal measure interval of the Singleton Supergroup in the RE and is based on field studies of large-scale exposures revealed by mine high-walls, exploration trenches, etc. throughout the area. Identification of the major palaeoenvironments that characterize the Wittingham succession here - namely, lakes and lacustrine mire complexes, high-relief lacustrine deltas, braidplains, and alluvial fans and associated blanket-mires - allows a generalized time/space reconstruction of the evolving piedmont that accords well with the mid- to Late Permian morphotectonic history of the region recently elaborated by McClung (1980) and Jones and McDonnell (1981). Events in this history relating to the RE include the late mid-Permian initiation of the Hunter Thrust System to the north, the contemporary development of the flanking anticlinoria to the east and west, and the subsequent involvement of the Embayment-fill in the formation of the Hebden Thrust and associated structures. These manifestations of the growth of the Tamworth Mountain Arc (cf. Jones and McDonnell, 1981) were accompanied by radical changes in depositional regime within the Basin itself, involving its transformation from a relatively shallow marine seaway to a non-marine piedmont.

Conversion of the Basin from glacigene marine (Maitland Group) conditions to freshwater conditions (Singleton Supergroup) in the late Kazanian/early Tartarian possibly accompanied regional deglaciation (cf. Booker, 1960) and is recorded by the little-known basal interval (Saltwater Creek Fm.) of the Wittingham succession. The lower half of the immediately overlying interval (Vane Subgroup) is dominated by a succession of high-relief lacustrine deltas and intervening coal seams which show that throughout this time-interval the RE comprised an enormous lacustrine-mire with water depths of 20-50m, deepening northward towards the Tamworth Arc. The locus of delta construction for much of this time (Barrett-Upper Arties interval) was from east to west across the central and southern part of the Embayment thus partially isolating the northern Embayment as a deep mire and focus of more sustained accumulation of economic coal. The upper half of the Vane Subgroup has stratigraphic and sedimentological characteristics that indicate an upsequence trend towards progressively shallowing water depths throughout the mire complex, with approach to regional alluviation at or very close to base level throughout the whole Embayment. This trend culminates in the successive accumulation of two thin stratigraphic units of regional extent: the Archerfield Sandstone (separating the Vane and overlying Jerrys Plains Subgroups); and the Bayswater Coal Member (basal unit of the latter Subgroup), exceptional within the Wittingham succession because of its anomalously dull, durain-rich character and high inherent ash. Various characteristics of these units (particularly the latter) show that they accumulated on a plain that lacked perceptible regional gradient, the major part of the Bayswater Coal reflecting very slow accumulation at the water-table, either under conditions of very shallow ponding and/or blanket-mire.

In the northern half of the Embayment, this featureless moor was then buried by a complex of large alluvial fans and associated proximal braidplains that migrated southwards away from the mountain front - presumably then located northeast of the present trace of the Hunter Thrust. These fans dominate the lower half of the Jerrys Plains Subgroup (Burnamwood Fm.) for a distance of at least 25km immediately south of the Hunter Thrust and are spectacularly exposed in both transverse and longitudinal section in mine highwalls (at Swamp Creek, Ravensworth, and Buchanan-Lemington). The advance of the fan complex across the Bayswater moor was episodic, insofar as clastic alluviation of the fans wholly ceased from time to time, as demonstrated by the extensive complex of coal seams and plies of the Ravensworth Coal Member and upper Bayswater Coal Member that are intercalated within the fan complex. These coals, of variable but generally intermediate brightness, record the growth of blanket-mires that encroached from the surrounding (pro- and inter-fan) Ravensworth moor, and completely covered the fan surfaces, possibly in response to climatic controls that temporarily halted their clastic alluviation.

In the southern part of the Embayment, the correlative stratigraphic interval above the Bayswater Coal as well as the rest of the overlying Wittingham succession records persistence of a complex of lacustrine-mires and distal braidplains that received volcanolithic epiclastic sediment from the Tamworth Arc to the north and northeast, evidently in part across the crest of the Loder Dome (thus precluding much topographic expression of this structural feature at this time).

Few data exist for the upper part of the Wittingham succession in the extreme northern part of the Embayment, but Booker (1960, p.38) has emphasized the major development of conglomerates there, including occurrences that are evidently referrable to the Jerrys Plains Subgroup (though we have no personal knowledge of how much of the upper part of the Jerrys Plains interval is preserved there). The close proximity of this northern part of the Embayment to the Tamworth Arc could be expected to have resulted in the sustained development of large alluvial fans there throughout all of the Jerrys Plains time-interval if not also through the rest of the Late Permian (Wollombi Coal Measures) and into the Early Triassic, commensurate with the duration of tectonic activity and attendant relief in the Arc (cf. Jones and McDonnell, 1981).

The major contrast in depositional regime that characterizes the Vane and Jerrys Plains Subgroups records two distinct phases of piedmont alluviation during which regional aggradation in the preserved portion of the RE took place predominantly below (Vane) and above (Jerrys Plains) regional base level. In gross dynamic terms, this upsequence change records the southerly migration of more proximal piedmont environments (fan/braidplain/shallow lacustrine- and blanket-mire complexes) over more distal ones (deep lacustrine-mires and associated delta complexes). The existence of deep lakes throughout the whole preserved portion of the Embayment (and beyond in the Basin to the south) during the phase of Vane sedimentation pinned-back any proximal environments that may already have been extant at this time (fan complexes, etc.) to areas which must then have been located north of the present trace of the Hunter Thrust, and hence for which there no longer exists a preserved record.

The upsequence change in depositional regime across the Vane/Jerrys Plains boundary can be interpreted in one or more ways: firstly, in terms of outward migration of facies belts with continuing uplift of the Arc but essentially constant clastic supply; secondly, in terms of increased clastic supply in response to enhanced tectonic relief in the Arc; or thirdly, in terms of declining rates of subsidence following initial tectonic loading of the Embayment by the embryonic Hunter overthrust.

References

BOOKER, F.W., 1960: Studies in Permian sedimentation in the Sydney Basin. Tech. Rept. Dept. Mines NSW, 5: 10-62.

JONES, J.G. & McDONNELL, K.L. 1981: Papua New Guinea analogue for the Late Permian environment of northeastern New South Wales, Australia. Palaeogeography, Palaeoclimatology, Palaeoecology, 34: 191-205.

McCLUNG, G. 1980: Permian marine sedimentation in the northern Sydney Basin, in C. Herbert and R. Helby (eds), A guide to the Sydney Basin. Bull. Geol. Surv. NSW, 26: 54-72.

FLUVIAL SEDIMENTATION IN THE FOYBROOK FORMATION, WITTINGHAM COAL MEASURES

D. Marchioni
Consultant Geologist

The Foybrook Formation is the lowest coal-bearing unit of the Wittingham Coal Measures. Seams in the basal portion of the formation are mined in the Foybrook-Liddell area of the Upper Hunter Valley on the northern margin of the Sydney Basin.

Vertical profile analyses of cored boreholes, combined with examination of limited exposures in mines, provided the basis for an interpretation of the depositional environment of the lower portion of the Foybrook Formation.

The vertical profiles and facies distributions indicate deposition by moderate to high sinuosity streams on the upper delta/alluvial plain. Seam splitting was initiated by differential subsidence and developed in response to the encroachment of peat swamps by active channel systems. Elucidation of facies distribution in seam roof and floor, and of the location of seam splits has significant bearing on mining practice.

A quantitative study of the vertical succession of lithologies revealed 1st Order Markov dependence at several scales. The statistically preferred sequences are a product of the fluvial regime.

COAL QUALITY VARIATIONS FROM THE MARINE-TERRESTRIAL TRANSITION IN PERMIAN COALS OF THE LOWER HUNTER VALLEY

P.R. Warbrooke*, C.K. Baker+, J.C. Day** & R.H. Jones**

* B.H.P. Steel Division Collieries
** B.H.P. Central Research Laboratories
\+ Layton & Associates

Interpretation of the geology of the Lower Hunter Valley indicates a regressive fluvial/deltaic environment for coal deposition during the Permian. Significant exploration and commercial development of the Greta, Tomago and Newcastle Coal Measures has provided sufficient coal quality data to allow trends in coal characteristics related to the depositional environment to be studied.

The parameters that describe coal quality may be divided into two groups - those that are rank dependent and those that are rank independent. Most parameters found in both groups are in part influenced by both the original peat-forming and also the associated environments.

It is reasonably well-known from sedimentological and other evidence that a marine to terrestrial transition extends up the stratigraphic sequence in the Sydney Basin. The vertical variation in the concentration of single elements in coal has been previously studied (Swaine, 1962) and the trends found support a marine to terrestrial transition.

In the present study, the variation of rank dependent parameters has been surveyed to ascertain the influence of the transition. The pattern of variation of parameters such as the mean maximum reflectance of vitrinite, the crucible swelling number, the Gray-King coke type, and (on a dry, mineral matter free basis) the carbon, hydrogen, volatile matter and specific energy, has been related to the depositional environment and geological history. Other supportive parameters such as the ash (ex bands), the recovery and ash of the coal that floats at 1.45 RD, the proportion of bright coal, and the maceral distribution, were examined to assist the explanation of the observed trends.

The values of coal quality parameters that result from deposition in different environments have been thereby established. This information may be used in conjunction with broad studies of environments responsible for the deposition of inter seam sediments, to predict variations in coal quality and to contribute to the selection of exploration areas.

Reference

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

*** KEYNOTE ADDRESS ***

TECTONICS AND THE SYDNEY BASIN*

H.J. Harrington
Bureau of Mineral Resources, Geology & Geophysics, Canberra

The first tectonic problem is to work out the exact time of formation of the Sydney Basin. It is argued here that the Dalwood-Werrie-Gunnedah-Boggabri volcanics are bimodal rift volcanics that are quite different from the Kuttung arc volcanics, and the former are usually unconformable on the latter. The unconformity is latest Carboniferous or very early Permian in age (c.305-295 Ma) and is taken to mark a tectonic event that was the birth of the basin.

The origin of the basin is more contentious than the time of its formation. It has been discussed surprisingly little in the past but is attracting attention at present. The main theories of origin are that:

1. The basin was an exogeosyncline or foredeep to the New England Eugeosyncline (Voisey, 1959).
2. In the Late Permian it was a fore-arc trough related to New England

in much the same way as the Aure Trough is related to the Papuan Peninsula (Jones & McDonnell, 1981). Note that this theory finds a possible modern analogue for the Late Permian Sydney Basin but does not consider the origin of the basin or the Early Permian situation. The theory has been extended to the Triassic (Conaghan & others, 1981). It resembles Voisey's model.

3. The overthrust theory is possibly supported by more geologists than any other, but a formal statement of it has not been found in the literature. It is that the New England Orogen was thrust over the Lachlan Orogen depressing its edge and burying most of the Kuttung Volcanic Arc. Possibly most adherents to the theory would say that the main thrusting occurred early in the Permian but systematic analyses of the theory and its consequences are needed.
4. The basin was formed by rifting during earth expansion (Carey, 1969).
5. It was initiated by Late Carboniferous and Early Permian volcanic rifting between the Lachlan and New England regions, but was a foredeep in the Triassic (Scheibner, 1976).
6. It was a failed third arm of a rift system in which the other two arms widened 200 million years later to form the Tasman Sea. There are analogues of this situation on the southern and western coasts of Australia where continental splitting was preceded, for 100 to 200 million years or more, by deposition in narrow precursor rift valleys and failed arms. This theory must surely have been invented several times since the concept of failed arms was postulated fourteen years ago, but again no published statement of it has been found.
7. A long diapir of hot material from the asthenosphere was intruded into the crust in the Late Carboniferous. Subsidence of its eastern part in the Early Permian was accompanied by igneous activity and caused the formation and evolution of the Sydney Basin (Brownlow, 1981). This is a "thermal" theory.
8. The basin was formed as the New England Fold Belt slid past the eastern side of the Lachlan Fold Belt by a strike-slip on the Mooki-Lapstone Fault in the Latest Carboniferous and earliest Permian (Harrington & Korsch, 1979). It is a transform basin like those in California (transforms and major strike-slip faults being the same thing). Basins are formed where some divergence accompanies the strike-slip, and where splay faults leave the main fault.

No matter how it was formed the basin was affected by several later deformations. At first in the Early Permian it existed only east of the "hinge-line" or fault system near the present Lapstone Monocline. East of the hinge there were fold structures trending northwest parallel to the Hunter Thrust System and the Nepean faults. These folds were important features of the palaeogeography, but much more intense folds on the same trend were formed to the northeast in New England, where they are known as D_3 folds (Korsch & Harrington, 1981). Part of western New England formed the emergent Campbell High. The Greta Coal Measures, and other coal measures of much the same age, were deposited on the western margin of the high in the position of the present Hunter Valley and in the Gunnedah Basin, a little higher on the flank of the high at Cranky Corner and possibly in the Gloucester Trough, and on its crest between Ashford and Inverell. The coals at Ashford are of fairly high rank which suggests that originally the coal measures there, plus any later cover, could have been about 2km thick. We do not know whether or not the coal measures covered a considerable part of the Campbell High, or whether they were concentrated in fault angle depressions and synclinal troughs on the high. It is intriguing to consider whether the non-marine portion of the Sydney and Gunnedah basins should be extended to Ashford in the Early Permian. No coal measures have been found on the east flank of the Campbell High but only marine beds with Permian Fauna II.

At about the end of Maitland Group time and in early Tomago time there was a major change in the tectonics of New England and the Sydney Basin. The change was slow at first but it had dramatic effects by the end of the Permian and in the Early Triassic. The trends of folds, which were also depositional troughs and highs, changed from northwest to north in the region east of the Mooki-Lapstone line. To the west of that line the folds had a northeasterly trend, for example the Mt. Coricudgy Anticline. This major change in the tectonics ushered in the Hunter-Bowen Orogeny as originally defined by Carey & Browne (1938). The sediments in the basin had been dominantly marine and now became dominantly coal measures overlain by other non-marine beds. In New England the D_4 folds have the same northerly trend as the Gloucester Trough and were superposed on the D_3 folds with the production of interference patterns which are also prominent in the dome and basin belt of the Hunter Valley. On the New England Tablelands numerous granitic plutons were intruded in association with major outpourings of felsic volcanics. The quite separate Gerringong volcanic ridge extended from the Wollongong district to east of Sydney and perhaps further north. The large quantities of volcanic debris in the coal measures were probably derived therefore from two different sources, one in New England and the other in the Gerringong ridge. We do not know whether the Gerringong ridge was the eastern limit of the Sydney Basin from the Late Permian (Illawarra time) onwards and we do not know whether it caused the Sydney Basin to become a barred basin.

To the east of the Gerringong ridge there were major geosynclinal events and orogenies in the Lord Howe Rise between the Late Triassic and the Cretaceous, if the geologies exposed in New Caledonia and New Zealand are a true guide. In the Sydney Basin there is direct evidence of Jurassic sediments preserved in diatremes. Several authors have provided indirect evidence, from the ranks of Permian coals, that up to 2km of Mesozoic sediments formerly existed above the Permian.

In Queensland there was extensive igneous activity in the northern Bowen Basin and the Whitsunday coastal region between 110 and 90Ma in the late Early Cretaceous (Albian) and early Late Cretaceous (Cenomanian and Turonian). This activity involved granitoid intrusives and great volumes of felsic volcanics, and it immediately preceded the opening of the Tasman Sea. On the Lord Howe Rise rhyolites with an age of about 94Ma (McDougall and van der Lingen, 1974) were found in DSDP hole 207. When the Lord Howe Rise is rotated back to rejoin the mainland that hole is near northeast Tasmania. It is possible that there were two areas of felsic volcanism, one on the Queensland coast and one east of Tasmania. A second possibility is that those two areas were parts of a continuous magmatic belt that was close to the present east coast of Australia and the Sydney Basin; this would account for the enormous quantities of volcanic debris in the Cretaceous of the eastern half of Australia, especially in the Surat and Eromanga basins and in the Victorian coastal region. Ideas about the Cretaceous history of the Sydney Basin would be changed considerably if it could be proved that the Whitsunday magmatic belt really did exist east of the present coastline.

The opening of the Tasman Sea in the last 20 million years of the

Cretaceous might or might not have removed an eastern section of the Sydney Basin.

There are at present three completely different schools of thought about the subsequent Kosciusko "Orogeny" or Uplift. The first is that it occurred in the Pliocene, the second that it occurred before the eruption of Eocene and Oligocene basalts, and the third is that it has been occurring at a constant rate of about 1mm/year since the Late Cretaceous. It is obvious enough from that situation that there is a very imperfect understanding of the tectonics and warping in the Sydney Basin over the last 65 million years, and that much work is waiting to be done.

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THE SURFACE CHARACTERISTICS OF THREE MERIDIONAL FAULT AND JOINT ZONES OF THE SYDNEY BASIN

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CSIRO is engaged in studying the surface fracture patterns of most of the Sydney Basin with special reference to the acquisition of pre-development data for colliery planning and design in the area to the west of the Lapstone Monocline/Kurrajong Fault. It has been shown by Shepherd, Huntington and Creasey (1981) and Shepherd and Huntington (1981) that several meridional swarms of faults and joints that occur in the Western Coalfield are expressed at the surface and at the coal seam level where they create only negligible displacement. Examination of historical records shows that neighbouring coal mines had abandoned corresponding sections of the seam in regions of intense jointing and minor faulting because they were unable to support the roof. These same zones correspond to features identified on satellite imagery, aerial photography and in the surface jointing.

They can be broadly characterized by their length (approx. 25 km), their width (from 100-200m to 1km), their trend (approx. 000-020 degree strike) and their effect on the regional pattern, causing significant systematic variation in a zone of influence around the structure. Three major zones described in this paper are the Blackheath and Clarence lineaments and the Lapstone Monocline/Kurrajong Fault.

The Blackheath lineament, which is a distinct continuous feature of negative relief, lies on the western edge of the Sydney Basin and extends from the Grose Valley in the north, through Blackheath and Blackheath Glen, down the Megalong Valley, crosses the Cox River to the west of Mount Dingo to disappear in the vicinity of the Kowmung River. The stratigraphic sequence it transects along its length includes the Devonian

Lambie Group, the Carboniferous Bathurst Granite, the Permian Illawarra Coal Measures and the Triassic Grose Sandstone. In addition to a fold axis in the Lambie Group, and a fine grained felsic dyke in the Carboniferous granite, there are joints and minor faulting in the Grose Sandstone all parallel to the zone.

The Clarence Lineament is a zone of en-echelon fracture expressed in the Grose Sandstone. This feature is presently mapped from 5km south of the Bell's Line of Road, crossing it half way between Newnes Junction and Bell, extending across the Wollangambe River and the Bungleboori Creek to the vicinity of Mount Cameron. The regional background jointing, particularly of the NNW trend observed on aerial photography and by ground mapping, rotates in a clockwise sense as the zone is approached from either side. The NNW joint set gradually migrates until it is trending nearly north-south adjacent to the zone. The lineament passes through the north-eastern section of the Clarence Colliery holding and it is anticipated that the colliery will encounter similar bad roof conditions experienced by other mines in the coalfield.

The Triassic Hawkesbury Sandstone is the principal stratigraphic host for the surface expression of the Lapstone Monocline/Kurrajong Fault system. It has similar characteristics of length, width and direction to the other two zones and it causes significant rotation of the regional jointing pattern at outcrop scale.

The origin of meridional structures is a contentious problem, but several authors have invoked basement control (Branagan, 1975; Harrington and Brakel, 1981; Shepherd, Creasey and Huntington, 1981; and Shepherd, Huntington and Creasey, 1981) including strike-slip, reverse and normal fault movement. Whatever theory is advanced, the association of faulting and monocline development in the cover rocks possibly requires a linked composite model and its formulation depends on the acquisition of high quality fracture data especially in the vicinity of the Lapstone structure.

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ON A COMPARISON BETWEEN FRACTURE PATTERNS IN THE ULAN AND HOME RULE AREAS, N.S.W.

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Fracture patterns have been measured in Carboniferous granites and Upper Permian Coal Measure sequences in the northwestern marginal zone of the Sydney Basin and in the immediately adjacent "basement" rocks.

Whereas three fracture systems are common to the granite and sedimentary sequence, at least two patterns are unique to either of the respective geological bodies.

The granite shows both primary and diastrophically produced fractures and the sedimentary units display primary, diagenetically produced fractures, and those that can be attributed to tectonic events.

The fracture systems have generated mechanically significant anisotropies in the Upper Permian Coal Measure sequence, containing the Ulan Seam, which influence the design and stability of mine workings in the Ulan area.

The Carboniferous granites to the west and southwest of Ulan have been affected by tectonic events and this is manifested in a well-defined brittle deformation pattern.

This current work attempts to extend structural analyses of brittle deformation patterns commenced by Rudd, 1971, in the Mudgee area.

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THE LOCHINVAR STRUCTURE: NOT JUST AN ANTICLINE

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The Lochinvar Anticline has featured in the literature since late last century, but little is known about the time sequence of deformational events that have led to the present structural configuration of the area. The stratigraphic development of the Lower Permian strata adjacent to the Lochinvar Anticline is very closely related to the sequence of structural events.

Basement faults, trending submeridionally, were first active during Late Carboniferous time and led to onlap deposition during early Dalwood Group time. The northern margin of the embryonic Sydney Basin was most probably dissected by northwest trending horst and graben structures during the deposition of the Greta Coal Measures.

The Lochinvar Anticline, essentially a flexure slip fold, commenced to form during late Maitland Group time as a gentle warp. The deforming forcefield had a horizontally arranged SE-NW directed maximum principal stress and acted over a relatively short time span.

Submeridionally trending basement faults were reactivated during the deposition of the Tomago Coal Measures; this resulted in a series of fault blocks. The downthrown portions acted as depositional basins for Upper Coal Measure sequences. The Lochinvar Anticline became a faultblock situated between the Elderslie and Buchanan faults. Rotation of this faultblock elevated the northern part of the anticline while onlap deposition took place in the southern portion.

Tectonic uplift increased to a maximum amount in the hinterland during late Newcastle-Singleton Coal Measure time, with basement fault movements persisting intermittently into the mid-Triassic.

Two significant conjugate shear features, the Lachnagar and Greta Faults, deformed the northern portion of the Lochinvar Anticline. These faults are regarded as the southeastern extensions of the Hunter-Mooki Thrust System. It is suggested that this event probably commenced during the Late Permian Epoch and persisted to mid-Triassic time.

A westerly directed maximum principal stress, resulting in thrust movements involving steeply dipping brittle rock units and in bedding plane faults in less steeply dipping beds, has deformed existing basins and is seen as the last recognisable deformational event.

THE LAPSTONE STRUCTURES - ONCE AGAIN

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Previous notes (Branagan 1969, 1975) outlined some aspects of the Lapstone Monocline and its associated structures. This paper documents the geology in more detail.

A regional map indicates the extent and character of the monocline between Kurrajong Heights and Wallacia. The northern and southern extensions have yet to be examined in detail.

The variable width and nature (uniform, convex, concave, knee-shaped and anticlinal) of the monoclinal surface have been mapped. One of the most significant features of the structure is its curvature near the Grose River displacing the northern portion westerly some 2km.

Maps and sections (at scales of 1:10000 and 1:5000) show details of the deformation in a number of key areas (particularly Mitchell's Pass, Old Bathurst Road, Hawkesbury Lookout, Patterson's Hill and Cut Rock). A variety of deformation patterns occurs in association with the monocline, including normal and high angle reverse faulting, numerous low angle reverse faults, sedimentary injections, brecciation and possibly strike-slip movements.

The Kurrajong fault system consists of a series of separate faults (as shown in part by Smith, 1979). Although topographically identifiable in places, outcrops of the faults are poor and maximum displacements can only be inferred. All the major faults are essentially hinged and are vertical or dip steeply to the east, possibly with overturning of strata.

The Glenbrook and associated sub-parallel faults show a similar orientation and character to the faults of the Kurrajong area but are separate from them. Almost all of the two sets of faults curve easterly towards the monocline at their southern extremities.

No definite age relationship has yet been established between the formation of the monocline and the faulting. There is evidence that some faults formed contemporaneously with folds while others are younger.

The variations in the Lapstone-Kurrajong structures are probably the result of several factors: a. the presence of broad regional anticlines and synclines within the Sydney Basin prior to the formation of the monocline-fault system; b. the complex CretaceousTertiary history of the region.

While the beginning of deformation can probably be attributed to the stresses imparted during formation of the Tasman Sea, the area has undoubtedly been active since that time. There are three (or more) distinct periods of gravel formation, and lateritised gravels which have been affected by the folding clearly predate the time of major deformation.

The relation between the dykes and necks of the area and the monocline needs to be studied before the geological history of the area can be written with confidence.

While development along the monocline has revealed much interesting geological information, the nature of the region is such that the development has also triggered numerous potential environmental hazards.

Should the whole structure be proclaimed a geological monument for its own safety and that of the local citizens?

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AN INTERPRETATION OF THE STRATIGRAPHY OF THE MUSWELLBROOK AREA*

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Recent drilling in the North Muswellbrook Area has produced results which indicate that the stratigraphy of the area is different from that previously accepted particularly in regard to the Dalwood Group and the Maitland Group.

The major variations are:

a) The marked thinning, to near absence in some areas, of the Skeletar Formation and Gyarran Volcanics below the Rowan Formation (the Greta Coal Measures).

b) The presence beneath the Rowan Formation of marine strata resembling and probably equivalent to the Rutherford Formation.

c) Evidence of terrestrial wedges including coal within both the Branxton Formation and the Mulbring Formation.

The help and co-operation of Mr. C. Sinclair of the Muswellbrook Coal Company and Mr. G. Sharrock of the Alternate Energy Division of Caltex Australia Ltd., for permission to use bore log data which have contributed to the presentation of this paper, is specially acknowledged.

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AN INTERPRETATION OF THE STRATIGRAPHY OF THE MUSWELLBROOK AREA

Previously Published				This Paper		
UNIT	THICKNESS	LITHOLOGY	ENVIRONMENT	THICKNESS	LITHOLOGY	ENVIRONMENT
Mulbring Formation	300 m	dark mudstones, shales, siltstones	marine	300 + m	dark mudstones, shales, siltstones, light coloured sandstones, coal, rare conglomerates	marine and terrestrial, coal swamp, high energy transitional deposits
Branxton Formation	220 m	dark muddy sand-stones, siltstones, minor mudstones and conglomerates	marine	550 m	dark muddy sand-stones, siltstones, minor mudstones, nearly white coarse sandstones, light coloured comglom-erates, coal	marine and terrestrial, coal swamp, high energy transitional deposits
Rowan Formation (Greta Coal Measures)	110 m	sandstones, silt-stones, shales, mudstones, coal, minor conglomerates	terrestrial coal swamp	60-130 m	as previously published	as previously published
Skeletar Formation	120 m	rhyolite, rhyolite breccia, chert, white tuffaceous shales, pelletal claystones	volcanic terrestrial fluvial	0-100 + m	rhyolite, rhyolite breccias, chert, white tuffaceous shales, pelletal claystones, dark shales, light col-oured sandstones and conglomerates	local volcanic centre in north, fluvial sequence thickening south-wards
Gyarran Volcanics	183 m	amygdaloidal basalts, minor felsite	volcanic ? terrestrial	0-40 + m	amygdaloidal basalts, minor felsite	local volcanic centre
Rutherford Formation		not previously recorded in this area		40 + m	dark siltstones, mudstones	marine

GEOLOGY AND EXPLORATION OF THE BAYSWATER NO.2 MINE AREA

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Caltex Australia Limited

Bayswater No.2 opencut mine is one of two opencuts currently working the Greta Coal Measures in the Upper Hunter Valley. The mine, which commenced production in 1968, produces steaming coal, mainly for export, at the rate of 800,000 tonnes per annum. Coal is mined by conventional truck and shovel method. An expansion programme, currently in progress, plans to double output from the mine.

The Greta Coal Measures crop out along the crest of a major regional structure, the Muswellbrook Anticline. The Bayswater No.2 opencut is located on and adjacent to this feature.

In the Bayswater area the Greta Coal Measures are subdivided into two stratigraphic units. The upper unit - the Rowan Formation, contains the economic seams in the area. Six main coal members are mined at Bayswater and most of these are subject to seam splitting. Up to 21 individual coal splits are recognised at Bayswater. Seam thicknesses range from 0.3 to 12 metres. Similar wide variability occurs in the intercoal strata.

The structural setting of the Bayswater Mine has resulted in a number of major and minor faults being present in the area. Dips in the mine area are generally 5 to 10 degrees, but locally steepen to 40 degrees. This complex geology pattern necessitates the employment of versatile mining equipment to enable maximum coal recovery.

Igneous intrusions at Bayswater are widespread and have variably affected most seams. Coal unaffected by intrusion is of high volatile, bituminous rank with relatively high sulphur content and poor coking characteristics. One split, however, does have coking properties. Raw ash values are variable and a proportion of production has to undergo beneficiation prior to marketing. Coals affected by intrusion have a wide range of quality characteristics including unusually hard coal and coal with a high relative density. The proportion of this heat affected coal which may ultimately be mined and marketed is a further geological factor which as yet has not been closely researched. Preparation of this coal for market may require extension of present technology.

The Bayswater Colliery Holding and its surrounding Authorisation have been extensively drilled with over 600 boreholes to date. During 1981 as part of a continuing exploration programme, 57 fully-cored holes were drilled and the first complete interpretation of all geological and analytical data undertaken. This resulted in the proving of additional coal reserves, better quality control of production and improved mine planning.

Future production at Bayswater No.2 mine will be dictated by geological factors, especially the structural setting, variation in seam splitting and the effect of igneous intrusion on coal quality.

STRATIGRAPHY OF THE GRETA COAL MEASURES IN THE DRAYTON AREA AND ITS INFLUENCE ON MINE DEVELOPMENT

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Drayton Coal Pty. Ltd.

Coal at Drayton belongs to the lower or Greta Coal Measures. In the Muswellbrook-Drayton area, these measures outcrop along the approximately north-south trending crest of the Muswellbrook Anticline. They have been further exposed by the existence of a number of large faults situated parallel and at angles to the axis of the anticline. The Drayton mine area lies on the southern end of the outcropping area of Greta Measures. The stratigraphy is characterised by the occurrence of five major coal horizons which split up to a maximum of 22 mining sections. The geology has been complicated by the occurrence of vast areas of igneous sills which have affected all seams and by severe folding and faulting plus seam splitting away from the axis of the anticline. The mine location is dictated by these geological factors.

WARRAGAMBA WATER FOR SYDNEY - 1872, THE YEAR OF DECISION

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The year 1872 saw the culmination of some years of argument on a new scheme for supplying water for the growing metropolis of Sydney. Prodded by the press, the Government set up a commission to consider the alternatives. Among its members was the remarkable Thomas Woore (1804-1878) hydrographer, surveyor and pastoralist.

The Commission considered at least five schemes and others were recommended by self-confessed experts such as 'Aqua' and 'Ecce'. Schemes included up-grading the Botany swamps supply, damming Cook's River, tapping potential artesian sources, barraging and desalinating Georges or Woronora River, damming the Grose River, using more and larger individual house tanks, the upper Nepean scheme and the Warragamba scheme, the last being the brainchild of Woore.

While the other concepts are interesting from both engineering and geological standpoints, Woore's deserves to be remembered for its boldness and ingenuity. It was conceived not only to supply water for Sydney and its suburbs but to irrigate the northern part of the County of Cumberland and to ensure the prevention of flooding on the Hawkesbury River.

Woore's scheme was rejected out of hand by the other commissioners but he did not accept defeat. He promptly issued a pamphlet containing details of his scheme and called a public meeting to explain it, which led to a wide discussion of its merits and deficiencies.

Woore envisaged a rock fill dam 170ft high with a maximum width of 600ft. To replace unavailable clay he proposed a process of cement grouting which he believed would prove adequate.

A short tunnel and a cutting using tributary creeks were intended to provide flow to a gravity canal system at Mulgoa and to allow for flood discharge.

Woore called for a detailed feasibility study of his plans but the commission would not consider it because of the likely cost of the final scheme and the unorthodox character of the technology involved. Was the final result - construction of the Nepean scheme - a victory for conservatism or would Woore's dam have failed anyhow?

OVERBURDEN ANALYSES FROM THE WITTINGHAM AND GRETA COAL MEASURES

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J.B. Croft & Associates Pty. Ltd.

Overburden disturbed during opencut mining operations is a potential source of toxic leachate, in particular acid mine drainage. In addition, some overburden material may need to be utilized as a growing medium in the rehabilitation of the site.

Accordingly, detailed chemical analyses of overburden from proposed opencut mine sites are carried out as part of the process of EIS preparation. The aims of such analytical programmes are:

(a) to identify the nature of leachate generation from the overburden in both the short and long term.

(b) to identify nutrient and trace element deficiencies that may affect the future use of overburden spoil as a growing medium.

Overburden associated with the Wittingham and Greta Coal Measures in the Singleton-Muswellbrook area has been analysed as part of this process.

Leachates from overburden associated with the Wittingham Coal Measures have high pH, high exchangeable sodium percentages and low salinity. Sulphur, phosphorus and nitrogen levels are low and trace elements are not present in toxic levels. Acid mine drainage is not a potential problem but the material is likely to be unstable and liable to clay dispersion on wetting. If used as a growing medium the material will be deficient in phosphorus and nitrogen and the high pH will result in some micronutrients being unavailable to plants.

Leachates from overburden associated with the Greta Coal Measures have variable pH (ranging from strongly acid to very strongly alkaline), high exchangeable sodium percentages and generally low salinity. This material is likely to be unstable and liable to clay dispersion on wetting. Sulphur content is variable (ranging up to 3.5%), some strata having high acid potential relative to their acid neutralizing capacity. Such strata will produce acid mine drainage, releasing toxic elements present, and create problems for plant growth.

HYDROGEOMORPHIC IMPACT OF COAL MINING, HUNTER VALLEY, N.S.W.

D. Day
Australian National University

(Abstract not supplied.)

STRATIGRAPHIC CORRELATION OF THE UPPER COAL MEASURES OF THE SYDNEY BASIN WITH THEIR EQUIVALENTS IN THE BOWEN BASIN*

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To understand the sedimentary and structural evolution of the 1750km long Sydney-Gunnedah-Bowen Basins trough in Late Permian time, it is first necessary to have reliable region-wide stratigraphic control. The normal correlation tools are inadequate for this task, either because they are inapplicable to coal measure sequences, or because their degree of time resolution is not fine enough. The work of Vail and others (1977) established that cycles of relative change of sea level on a global scale have occurred throughout Phanerozoic time, and offers a new means

of correlating between basins. To use this method, marine incursions of considerable extent in each basin are interpreted to represent time lines recording global rises in sea level. Such incursions occur at two levels in both the Sydney and Bowen Basins. The Kulnura Marine Tongue (Sydney Basin) can be correlated with the Arkarula Sandstone (Gunnedah Basin) and the MacMillan Formation (Bowen Basin). The higher Denman Formation and its equivalents in the Sydney Basin can in turn be equated with an unnamed burrowed portion of the Burngrove Formation in the Bowen Basin.

Among the implications of this model are (1) the German Creek Formation is equivalent to the basal portion of the Tomago and Illawarra Coal Measures, and late Permian coal measure deposition started in both basins at about the same time, and (2) the Newcastle Coal Measures are equivalent to the Rangal Coal Measures and the upper tuffaceous section of the Burngrove Formation. No environmental Denman equivalent is known from the Gunnedah region, either because it has not yet been recognised, or because the area stood above sea level at the time of this eustatic high-stand.

It is clear from the literature that correlations of the Sydney and Bowen Basin sequences using marine faunas and palynology give different results. Palynological correlation is also discordant with correlation of the upper coal measures using the global eustacy model, and this leads to the suggestion that certain palynomorph species appeared in the Bowen Basin (Rigby and Hekel, 1977) long before they appeared in the Sydney Basin (McMinn, 1981). It is argued that this occurred because the palynology records climate-controlled vegetation zones which migrated polewards as the edges of the Permian ice cap receded.

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A RESERVOIR QUALITY ASSESSMENT OF SOME SYDNEY BASIN SANDSTONES

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Geological and engineering consultants, Davies, Almon & Associates, Inc., of Houston, Texas were commissioned by Esso in late 1980 to assess some Sydney Basin sandstones with respect to their reservoir qualities and potential response to well stimulation.

Six formations ranging in age from Early Permian to Triassic were sampled from the core of nine wells, eighteen samples being taken in all. These were assessed by three methods:

1) Petrographic analysis, using thin sections impregnated with blue epoxy resin to distinguish porosity.
2) X-Ray Diffraction analysis of the fine-grained fraction to determine the nature of the clays.
3) Scanning Electron Microscopy involving visual and chemical examination of pore geometry and pore-fill mineralogy.

Although the sandstones exhibited a wide range of grain size and sorting, all effective porosity was found to be secondary in origin, the primary pores having been blocked by ductile deformation of soft grains. The resulting pore system is made up of large, irregularly shaped pores resulting from partial or complete dissolution of unstable grains. The pores are connected by restricted pore throats, the degree of interconnection depending on the degree to which secondary porosity is developed. Pore-filling and pore-lining cements such as illite-smectite, kaolinite and illite are commonly present and cause the pore system to possess a very large surface area and abundant microporosity.

Hydraulic fracturing has been recommended for all six formations, but would result in commercial flow rates only if sufficient permeability exists to feed the induced fracture. This condition is met only in the Colo Vale Sandstone.

An optimum well stimulation fluid of water with 2.5% Potassium Chloride is recommended to suppress clay swelling problems, possibly combined with an organic-based clay stabilizer to prevent migrating fines blocking pore throats.

GEOLOGY OF THE MOUNT ARTHUR NORTH AREA AN IMPORTANT COAL RESOURCE FOR POWER GENERATION IN N.S.W.*

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The Upper Hunter Valley has become a major centre for power generation. The existing Liddell Power Station has a generating capacity of 2000 MW. The Bayswater Power Station which is now under construction is programmed to reach full capacity of 2640MW in 1987. Together these two power stations will have a potential generating capacity of approximately one-third of the projected capacity for the state's coal-fired power stations in 1987.

The two power stations will have a total annual coal requirement of approximately 11M tonnes.

Liddell Power Station has previously relied on coal supplies from opencut mines at Swamp Creek and Ravensworth, but available reserves in these areas are diminishing and the Mount Arthur North area has been chosen to complement coal supplies from the existing mines.

The Mount Arthur North area, covered by the Authorisation to Prospect No.168, is located approximately 6km south-west of Muswellbrook on the western flank of the Muswellbrook Anticline.

Coal seams of the Wittingham Coal Measures subcrop sequentially over the central and western parts of the area. These are underlain by sediments of the Maitland Group which crop over the eastern part of the area. The Greta Coal Measures occur below the Maitland Group and are at depths in excess of 200m where they are known within the authorisation.

Intensive exploration of the Wittingham Coal Measures has been carried out over many years and has proven coal reserves of opencut potential in the central part of the area where mining is planned to commence in 1984. It is proposed to reach an annual production of 11M tonnes of run of mine coal from open pit mines to be established in the area. Exploration is continuing to give a better knowledge of coal reserves beyond the proposed initial mining areas.

The multiseam nature of the deposit and seam splitting and convergence allows considerable quality variation between seams in addition to thickness and quality variations within individual seams. Many of the seams have not previously been used for power generation and have properties differing from the "traditional" feedstock of the major New South Wales power stations. Most of these seams will require treatment to produce acceptable power station feed coal.

The regional dip of strata is generally to the west with a shallow syncline plunging gently south in the western part of the area. Major faulting striking east-west traverses the area and has influenced the selection of sites for mine development.

Igneous intrusions occurring as sills are an important feature in part of the area where they have reduced reserves and affected seam quality.

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RECENT EXPLORATION IN THE GUNNEDAH BASIN BY THE DEPARTMENT OF MINERAL RESOURCES

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In September, 1981, the N.S.W. Department of Mineral Resources Coal Geology Branch commenced a regional scout coal exploration drilling programme in the Gunnedah Basin. To the end of March, 1982, 28 of the 60 planned holes were completed. The holes are up to 990m deep and in most cases have penetrated to volcanics beneath Early Permian coal measures. Drilling has so far been concentrated in the southern part of the basin to the west of the Boggabri "high", and in the north around Narrabri.

Up to 125m of Early Permian Coal Measures (Greta equivalent) is present in the southwestern part of the Basin, overlain by up to 300m of marine sediments, and then by up to 500m of Late Permian Black Jack Coal Measures. Cover rocks include the Late Permian Digby Conglomerate Triassic sediments and Jurassic volcanics.

The Early Permian coal measures are less well developed to the west of the Boggabri "high" than to the east, indicating that the "high" may have originally been a basement ridge. Pelletoidal claystone bands, similar to those found in the Skellatar and Leard Formations, are present throughout the Early Permian coal measures.

The Black Jack Coal Measures probably represent an initial lower delta plain facies which prograded perhaps from northeast to southwest, over the top of the Permian marine sediments. Several coal seams are present, including the Melvilles, Hoskissons, Caroona and Wondobah. The deposition of the Black Jack Coal Measures was terminated when a series of alluvial fans was deposited on top. These fans, consisting chiefly of conglomerate deposited by debris flow, prograded slowly across the basin from source areas in the east and/or north.

The overlying Triassic rocks, in particular a bioturbated sandstone-siltstone laminite facies tentatively called the Napperby Formation, may be at least in part near-marine.

Some of the Permian and Triassic sedimentary units persist over very large areas of the basin and into the adjacent Sydney Basin. Indeed, some units, such as the marine Porcupine Formation and the Late Permian Arkarula Sandstone and Hoskissons Seam can be correlated with units not only in the Hunter Valley, but also in the Western and Southern Coalfields.

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THE MINING HISTORY AND SEDIMENTATION OF THE TOMAGO COAL MEASURES IN THE EAST MAITLAND AREA

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While coal mining in the East Maitland area commenced at a relatively early time compared to most operating coalfields in New South Wales, at no stage did mine development reach a major level of activity comparable to that in other coal mining areas of the Newcastle - Hunter Valley region.

In this paper an outline of the history of coal mining in this area and the major impact that it has had on the coal industry of the State will be presented.

Applications of data processing and computerisation to borehole information from discontinuous drilling operations carried out in the East Maitland area since last century, have enabled an evaluation of sedimentary environments and stratigraphy of the Tomago Coal Measures, and so explain the past restricted mining operations.

PETROGRAPHY OF COAL - COKE IN THE BLAST FURNACE

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Coke for use in the ironmaking blast furnace is made from blends of suitable coal. Breakdown of coke in its passage down the blast furnace and the resultant size distribution are of great importance for gas flow and liquid drainage. Both coal type and rank contribute to the microtexture and microstructure of the feed coke and in turn to the breakdown of coke in the blast furnace.

The use of modified "geological" techniques of core drilling and microscopic examination of the core samples have revealed lump size distribution zonations around the tuyere and patterns of microtextural reactions which can be related to the coal from which the coke was made.

THERMAL ANALYSIS OF COAL, WITH PARTICULAR REFERENCE TO MINERAL CONSTITUENTS

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Differential thermal analysis (DTA) and thermogravimetric (TG) determinations of coal in inert (nitrogen) furnace atmosphere conditions have been applied to the study of minerals which commonly occur in coal. These methods provide useful sources of information concerning the detection, indentification, rates and temperatures of thermal decomposition and content evaluation of the minerals.

The order of abundance in which these minerals normally occur in coals is clays, carbonates, sulphides and silica minerals. The <u>clays</u> may be composed of illite, montmorillonite and kaolinite, the <u>carbonates</u> of siderite, calcite and members of the dolomite - ferroan dolomite - ankerite series, <u>sulphides</u> of pyrite and its polymorph marcasite, together with quartz, chalcedony and opal.

For these mineral groups thermal analysis methods are most useful for the carbonates and least applicable to the clays.

Positive identification of the individual carbonate minerals by DTA is much enhanced and the detection limits considerably improved by making the determination in flowing carbon dioxide.

Full TG curves, at preselected heating rates, provide a measure of the weight loss at various temperatures and the rate at which it occurs. From these curves, the temperatures at which specific minerals are stable, or decompose to yield gaseous products may be accurately evaluated. Isothermal determinations (heating at specific constant temperatures) provide additional information which is directly applicable in the fields of ash fusion temperatures, mineral component release and residual carbon contents in products such as power station and retort ash, together with washery residues.

Mineral contents and their decomposition products are also noteworthy in relation to catalysis, oil shale retorting practice and conditions, and perhaps liquefaction processes.

REACTIVE INERTINITE

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The paper is based on the results of NERD&D program project 78/2627.

The project's aim is the elucidation of the degree of reactivity during carbonization shown by the coal maceral group INERTINITE. The reason for the interest in these coal components is related to their abundance in some Australian coals and the alleged detrimental influence they exert on coke stability which disadvantages some Australian coking coals on the world market.

In the course of the project coking tests up to 1000 degrees Centigrade have been carried out on twenty coals of different rank in such a manner that coked portions of the samples could be correlated with their equivalent uncoked parts. A comparison of several optical properties of inertinite macerals before and after carbonization has demonstrated bireflectance to be a sensitive measure of reactivity. On this basis it has been found that a reciprocity exists between the level of precarbonization reflectance of inertinite and its bireflectance in coke. The increase in the latter is non-linear and involves a sudden jump which is taken as the boundary between reactive (high bireflectance) and non-reactive (low bireflectance) inertinite. In relation to coal rank a reactivity field for inertinite has been delineated which can be subdivided into two areas of high and low reactivity, respectively. On the whole, the proportion of reactive inertinite is higher than allowed for in petrography-based coke stability calculations. The non-reactive portion of inertinite is not all detrimental to coke making, which is shown by the beneficial influence of some inertodetrinite.

SLIM CORE TESTING FOR MAXIMUM COAL PRODUCT INFORMATION

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B.H.P. Central Research Laboratories

A method of preparing ash profiles of the coal seam intersections in bore cores by nondestructive means has been devised at BHP Central Research Laboratories. The method is based on x-radiography of the core followed by ARD testing. When combined with the macro-petrographic logging introduced by C.F.K. Diessel in the early 1960's, the geologist has as much information as he can expect from normal core testing to use for correlation purposes; and the core is still in its original position in the core box.

There is also enough information to select possible working sections although, on occasion, alternatives may be required. Products which can be expected to be quite similar to the final saleable products can then be prepared by float-sinking these sections, even from 45 to 60mm diameter cores.

The method has proved both cost-effective and time-effective. It has eliminated intensive ply-by-ply testing. The non-destructive testing can be completed within 2 to 3 days of receipt of core. It alone can provide a good appreciation of the washability and coking potential of the coal, and even of potential problems such as ash fusibility in fuel coal.

AUSTRALASIAN SEAM BULK SAMPLING DOWN A NARROW SHAFT

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One of the final stages of a coal exploration programme involves the taking of bulk samples. Such samples, whose mass may vary from half a tonne to a hundred tonnes or more, are required for such purposes as washing plant tests, coking blend trials, combustion tests and/or marketing samples.

In 1969 and 1970, Project Mining Corporation Limited carried out a coal exploration programme at Caves Beach (Mawson), just outside of Newcastle. Although a complete geological and coal quality evaluation of all seams of the Newcastle Coal Measures was carried out, the target seam for more extensive evaluation was the Australasian Seam. This seam occurs in the middle of the Measures, at the top of the Cardiff Sub-Group.

Initial attempts to sink a rectangular shaft at Swansea Heads, to gain a bulk sample of the Australasian Seam, failed because of the considerable cover of loose sand. Subsequently it was decided to sink a shaft at a site just south of the Swansea High School. The seam at this point was about 153m below the surface.

The hole was drilled between November 1969 and August 1970 using a 4 tonne hard-faced chopper bit. This bit was raised and dropped continuously, the fine rock cuttings being removed from the hole by water. The hole was lined for the first 9.2m with 915mm o.d. steel pipe. The remainder of the hole, to a total depth of 159m, was then lined with 763mm o.d. steel pipe. The annular gap between the pipe lining and the wall of the hole was pressure grouted.

After exposing the seam face by cutting out a section of the pipe and grouting, three bulk samples were extracted from the seam using a compressed air operated pick. The samples weighed a total of 8 tonnes.

During the sampling exercise, access to the seam was gained by lowering the geologist down the hole in a specially designed man cage. Ventilation air was supplied by a pump and compressor. The hole had to be bailed regularly to remove seepage water. Continual monitoring of the air for methane and oxygen levels was carried out, as were daily inspections by a retired mine deputy. Props and slabs were set for roof support.

On completion of sampling the hole was allowed to fill with water, then capped with a steel plate.

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Publication No. 195