THE UNIVERSITY OF NEWCASTLE

Department of Geology

ADVANCES IN THE STUDY OF THE SYDNEY BASIN

EXCURSION GUIDE FOR THE 23rd NEWCASTLE SYMPOSIUM

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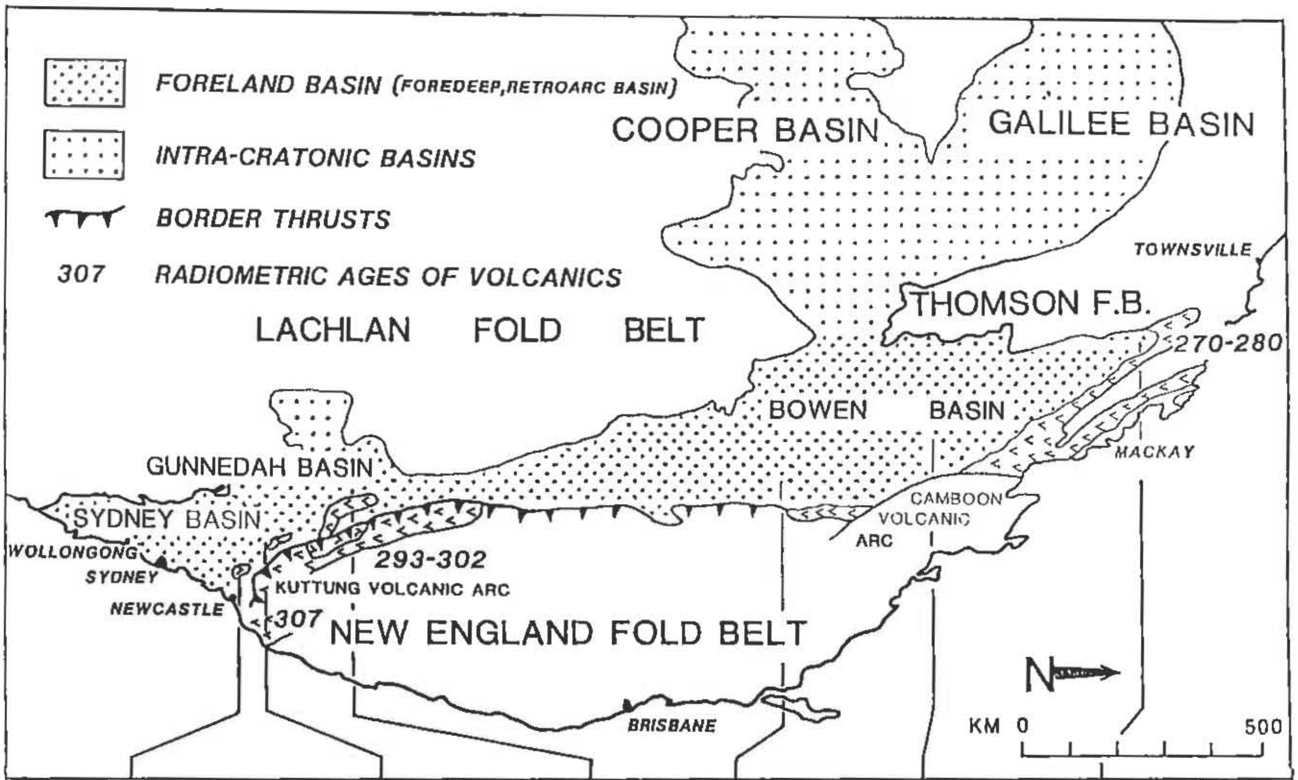
Geological Setting

The Hunter Valley in New South Wales is situated adjacent and parallel to the orogenic margin of the Sydney Basin which, together with the contiguous Gunnedah and Bowen Basins, constitutes a 2000 Km long foreland basin (Jones et al., 1984) between the New England Fold Belt to the east and the craton to the west.

From the Permian to the Triassic Period the area of the present Hunter Valley accommodated large quantities of clastic debris from the nascent New England Fold Belt (e. g. David, 1907, Branagan and Johnson, 1970, Branagan et al., 1976, Herbert, 1980) for which reason it has been variously referred to as an "exogeosyncline" (Voisey, 1959) or "molasse foredeep" (Diessel, 1970, 1980a). Sediment isopach patterns (e. g. Branagan and Johnson, 1970, Mayne et.al., 1974, Warbrooke, 1981), as well as palaeocurrent directions in epi- and pyroclastic coal measure rocks (e. g. Diessel, 1966, 1980b, 1985, Conaghan et al., 1982) led to the postulation of an off-shore continuation of the New England Fold Belt thereby placing the Newcastle Coalfield into an orogenic recess, called the Newcastle Recess by Jones et al. (1987).

In the Lower Hunter Valley, the upper portion of the Permian System is formed by some 1,200 m of predominantly terrestrial sediments which have been subdivided into two groups, the Newcastle and Tomago Coal Measures. The stratigraphic position of the coal measures and their possible correlation with other Permian sequences in the foreland basins is illustrated in Figure 1. This division has both economic and geological reasons, and it is highlighted by the occurrence of a very prominent marker bed in the form of 10-30 m thick Waratah Sandstone separates an upper highly productive sequence, the Newcastle Coal Measures, from a lower group of coal bearing sediments containing fewer economic coal seams (Tomago Coal Measures). The reason for this contrast is related to the palaeo-environmental setting of the two groups which ranges from lower to upper delta plain for the Tomago Coal Measures and from upper delta to alluvial braidplain for the Newcastle Coal Measures. The Waratah Sandstone separating the two groups, represents a prograding barrier beach environment Diessel et al. (1989) and marks the last substantial marine transgression before the end of the Permian Period.



NARRABEEN GROUP	NARRABEEN GROUP	DIGBY	REWAN GROUP	REWAN GROUP	REWAN GROUP	TRIAS
NEWCASTLE COAL M.: Moon Island Beach S.-Gr. Boolaroo S.-Gr. Adamstown S.-Gr. Lambton S.-Gr. Waratah Sandstone	WOLLOMBI COAL M.: Glen Gallic S.-Gr. Doyles Creek S.-Gr. Horseshoe Cr. S.-Gr. Apple Tree Flat S.-Gr. Walls Sandstone	Black Jack Formation	BARALABA S.-Gr.: Rangal Coal Measures Kaloola F.	Rangal Coal Measures Burngrove F.	BLACKWATER GROUP: Rangal Coal Measures Fort Cooper	LATE PERMIAN
TOMAGO C.M.: Hexham S.-Gr. Four Mile Creek S.-Gr. Wallis Creek S.-Gr.	WITTINGHAM C.M.: Jerrys Plains S.-Gr. Archerfield-Bulga F. Foybrook F. Saltwater Creek F.	Black Jack Formation	Gyranda F.	Fair Hill F. MacMillan F.	Coal Measures Moranbah Coal Measures	LATE PERMIAN
MAITLAND GROUP: Mulbring Siltstone Muree Sandstone Branxton Formation	Mulbring Siltstone Muree Sandstone Branxton Formation	Watermark F. Porcupine F.	Flat Top F. Barfield F. Oxtrack F. Brae F. Pinari F.	German Creek Coal Measures Blenheim Formation	Exmore F. Blenheim Formation	LATE PERMIAN
GRETA COAL M.: Paxton F. Kitchener F. Kurri Kurri Cgl. Neath Sandst.	Rowan F. Skeletar F.	Maules Creek F. Leard F.	Bulfel F.	undifferentiated	BACK CREEK GROUP: Collinsville Coal M. Gebbie F. Tiverton F.	EARLY PERMIAN
DALWOOD GROUP: Farley F. Rutherford F. Allandale F. Lochinvar F	Gyarran Volcanics	Boggabri Volcanics	Camboon Volcanics	Lizzie Creek Volcanics	Lizzie Creek Volcanics	EARLY PERMIAN
Seaham Formation Paterson Volcanics Mt.Johnston Formation	Seaham Formation Paterson Volcanics Martindale Formation	Curra-bubula F.	undifferentiated	undifferentiated	undifferentiated	LATE CARB

Figure 1. Correlation of the Permian stratigraphy across the foreland basins to the New England Fold Belt.

The Newcastle Coal Measures

A stratigraphic section of the Newcastle Coal Measures is illustrated in Figure 2. The coal measures outcrop in the coastal portion of the Hunter Valley. The largest continuous area of exposure occurs around the northern closure of the Lake Macquarie Syncline (Figure 3). As the axis of this structure plunges to the south, younger sediments of the Mesozoic Narrabeen Group tend to conceal the coal measures in this direction, while to the north of Newcastle up to 100 m thick alluvial and aeolean Holocene deposits do the same. To the east the outcrop is restricted by the sea whereas the western boundary is erosive against the Lochinvar Anticline which is one of several large synsedimentary structures that developed in the Hunter Valley during the Permian Period. West of the Lochinvar Anticline time-equivalent coal measures of similar combined thickness occur throughout the Hunter Valley.

The age of the coal measures is Kazanian and possibly Tartarian for the upper portion. Apart from some worm burrows and insect remains. the Newcastle Coal Measures contain abundant representatives of the Gondwana flora. No detailed systematic inventory has as yet been mode but common genera are *Annularia, Phyllotheca, Glossopteris, Gangamopteris, Vertebraria, Cordaites, Noeggeratiopsis* and the fossil wood *Dadoxylon*.

The Hunter Valley which forms the north-eastern margin of the Sydney Basin was the depositional centre of Permian Sedimentation. It thus acted as a foreland basin (retroarc basin) to the New England Fold Belt from which it received a large proportion of clastic wedge deposits that occasionally overlapped onto the older and then largely peneplained Southern and Central Fold Belt to the south-west. Palaeocurrent directions derived from cross-bedding measurements in the Upper Permian coal measures of the Hunter Valley show, therefore, a strong centripetal tendency while in other parts of the Sydney Basin palaeocurrents have often a tangential or parallel arrangement with respect to the basin margin (Herbert and Helby, 1980).

Throughout the Tomago Coal Measures marine, or at least brackish.

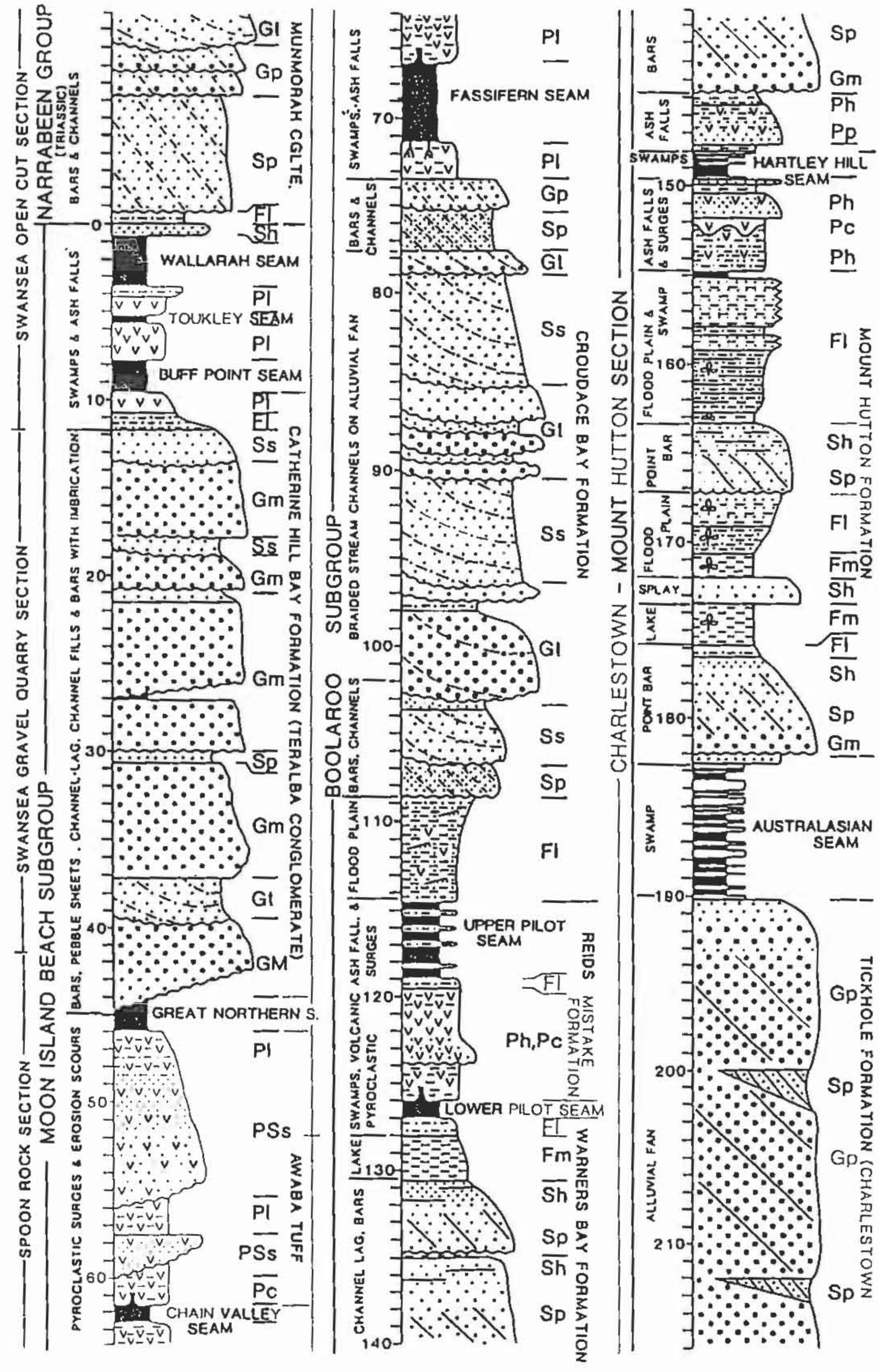


Figure 2a Columnar section through the upper Newcastle Coal Measures, based mainly on the measurement of outcrop sections. Their position is indicated next to the columns.

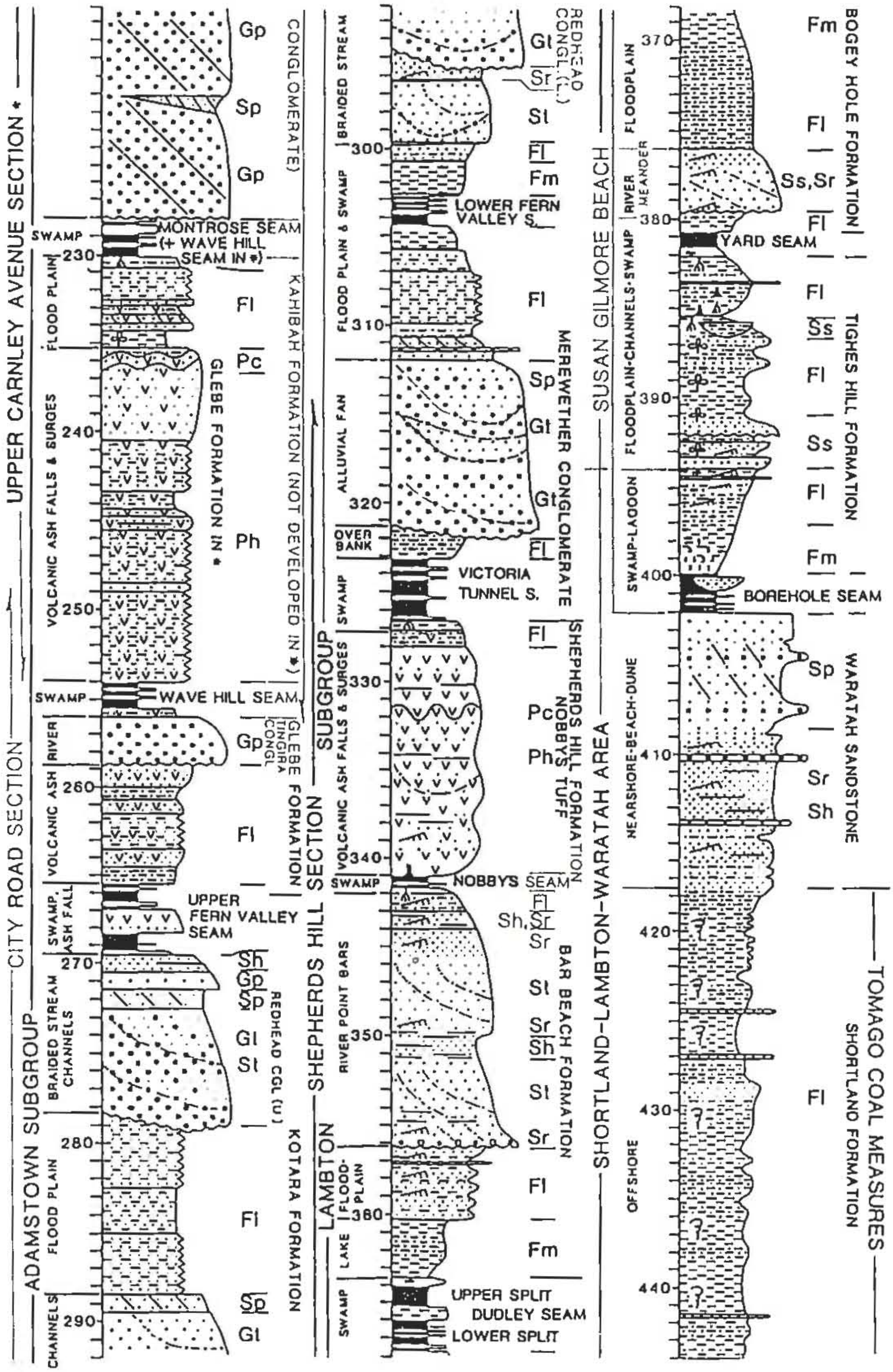


Figure 2b.Columnar section through the lower Newcastle Coal Measures, based mainly on the measurement of outcrop sections. Their position is indicated next to the columns.

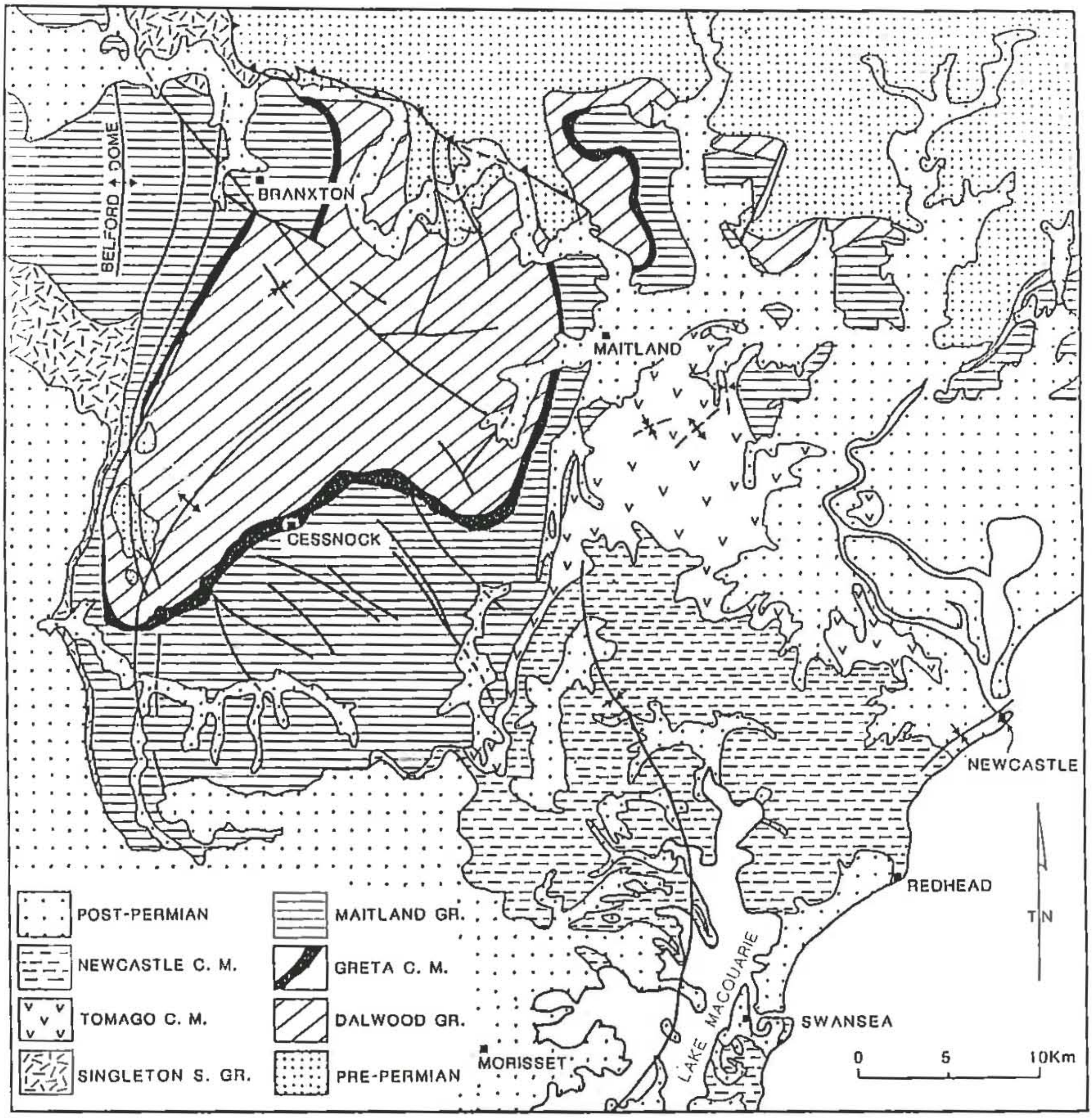


Figure 3. Geological map of the Lower Hunter Valley showing the Lochinvar Anticline and Lake Macquarie Syncline.

influence is apparent and is exemplified by many intercalations of shale, siltstone and fine sandstone, all containing worm burrows and other forms of bioturbation.The frequently laminated structure of the sediments, the occurrence of mud drapes and flaser bedding, starved ripples and frequent micro-cross-lamination suggest tidal influence. In contrast to this marine transitional environment the overlying Newcastle Coal Measures contain worm burrows in their lower portion only. They were formed in a more terrestrial setting characterised by high energy release. The result is a substantial increase in the proportion of coarse sediments as shown by the following lithologic comparison between the Newcastle and Tomago Coal Measures (after Diessel, 1980):

	Tomago C. M.	Newcastle C. M.
Conglomerate	1 %	29 %
Sandstone	58 %	23 %
Shale	34 %	17 %
Tuff and claystone	1 %	19 %
Coal	6 %	12 %
	(15 seams)	(21 seams)

The high proportion of conglomerate and pyroclastic material in the Newcastle Coal Measures seems to indicate an acceleration of tectonic activity in the adjacent orogen to the north and east.

The coarsest conglomerates interbedded with coal seams occur in the upper portion of the Newcastle Coal Measures a stratigraphic section of which is illustrated in Figure 1. The conglomerates are composed of large trough cross- beds (Gt facies) and remnants of channel bars that form compound lithosomes up to ten metres thick (Gm facies). Internally the latter are crudely divided into sheets which vary in particle size. Isolated thin lenses of flat bedded or massive sandstone (Sh facies) are present but overbank deposits (Fl and Fm facies) are rare. Allochthonous coal lenses, probably incorporated as eroded peat, are present in the Teralba testifying to the rapid rate of transportation and deposition. Isolated layers of bright coal (vitrain) have been derived from the wood and bark tissues of uprooted and transported trees. Contacts between lithosomes are abrupt and commonly erosive.

Some trough cross-beds exceed twenty metres in width and five metres in height with foreset angles up to 30°. Coalified tree trunks are often oriented normal to the trough axes, indicating rolling down the slip faces of the gravel masses (Gt facies) choking the channels. The latter are confined to relatively narrow zones within the 10 to 15 Km wide braid plain and they are separated by the quantitatively more important composite gravel sheets of the Gm and Gp facies. In terms of Miall's (1977) braided stream models, some of the conglomerates (e. g. Karignan Cgl.) closely resemble the Scott type whereas others (e. g. Teralba and Bolton Point Cgl.) are transitional to the Donjek type.

The middle portion of the Newcastle Coal Measures, contains several examples of interbedded conglomerates and sandstones of which the Croudace Bay Formation is a good example. Its conglomerates and sandstones form the top of an upward coarsening sequence which begins with coal (Upper Pilot Seam), followed by several metres of redistributed tuffite. With increasing sand content, the latter grade first into medium, then coarse braid plain sandstones and conglomerates of Miall's (1977) Donjek type.

Trough cross-bedded pebbly sandstones and (St facies) and solitary pebble conglomerate channel bars (Gm facies) are the main lithosomes. The trough cross-beds may be up to six metres wide and two metres in height. They occur either as solitary sets (theta type of Allen, 1963), or as cosets, like Allen's pi type. Both have upward concave foresets. In addition to the large sets, small to medium scale cross-beds are common in small cut-and-fill channels (Ss facies).

In cross-bedded conglomerates the foresets are commonly steep and have discordant basal contacts, whereas in the sandstones the foreset angles are more variable but are usually shallow and may be tangentially aligned with the lower bounding surface. Heterogeneous cross-beds are quite common and show a steepening of the foreset angles with increasing grain size. Coalified tree trunks are frequent and are often oriented normal to the trough axes.

The conglomerates have been formed on fan-shaped braidplains and down palaeoslope they grade into finer grained clastics of reduced thickness.

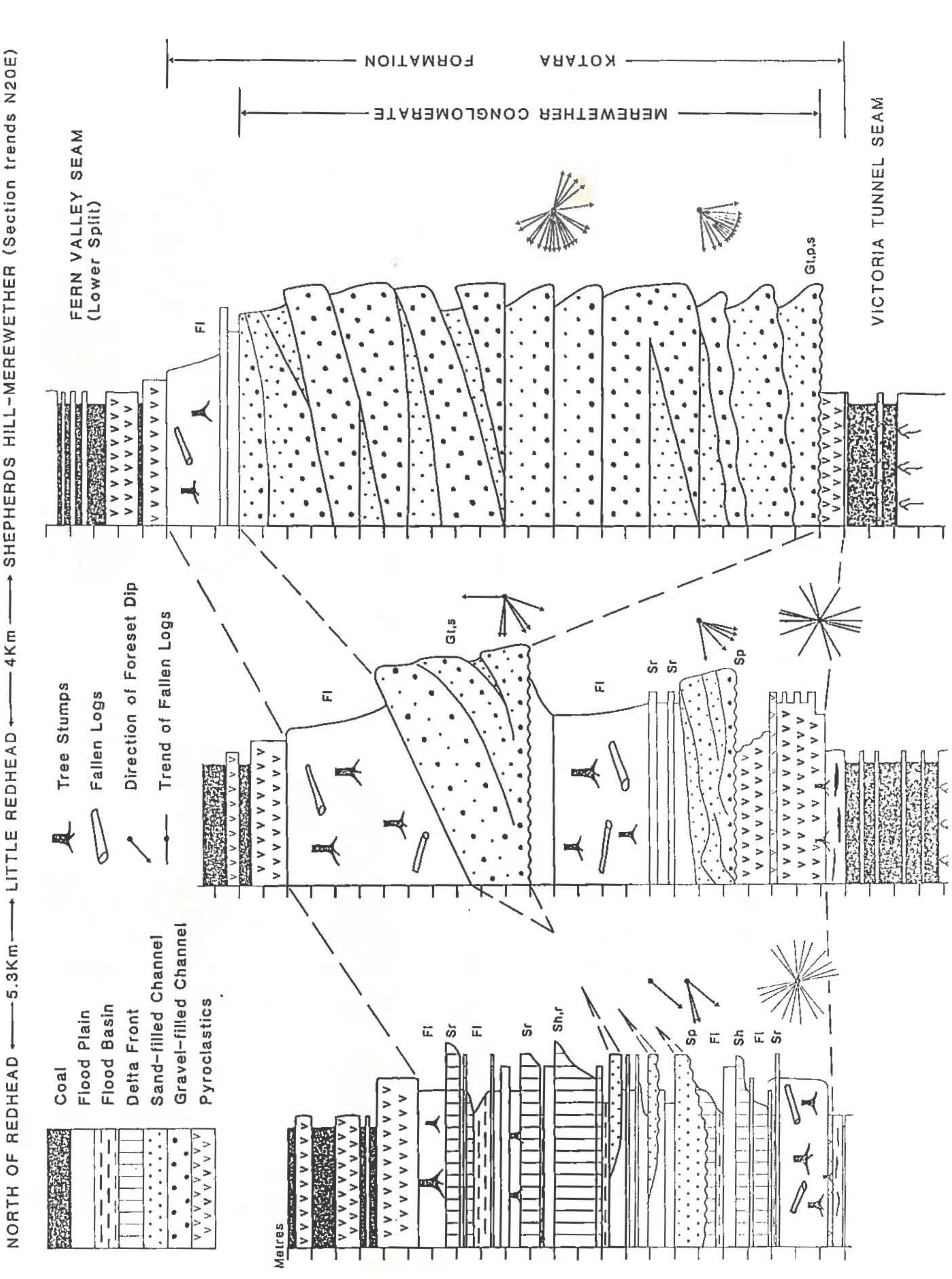


Figure 4. Three columnar sections through the Kotara Formation showing the thinning of the Merewether Conglomerate towards the south-eastern margin of its braidplain.

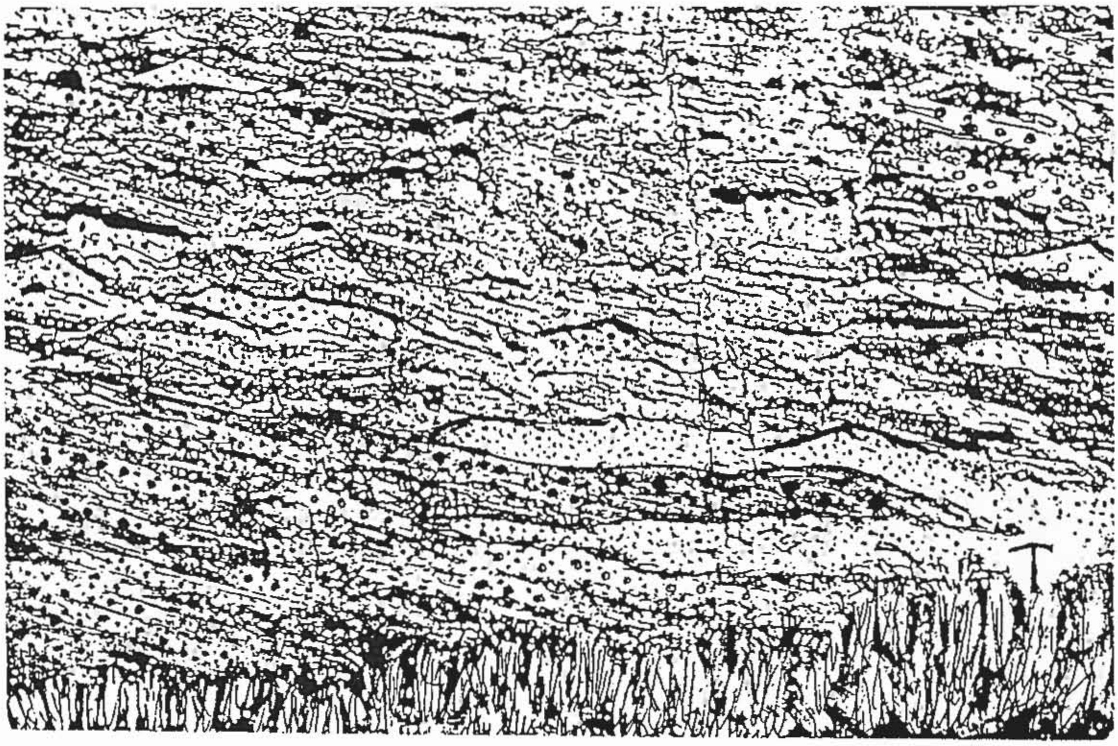


Figure 5a Geological sketch based on a photograph by Warbrooke (1981) of the Merewether Conglomerate at the Memorial Drive, Shepherds Hill.

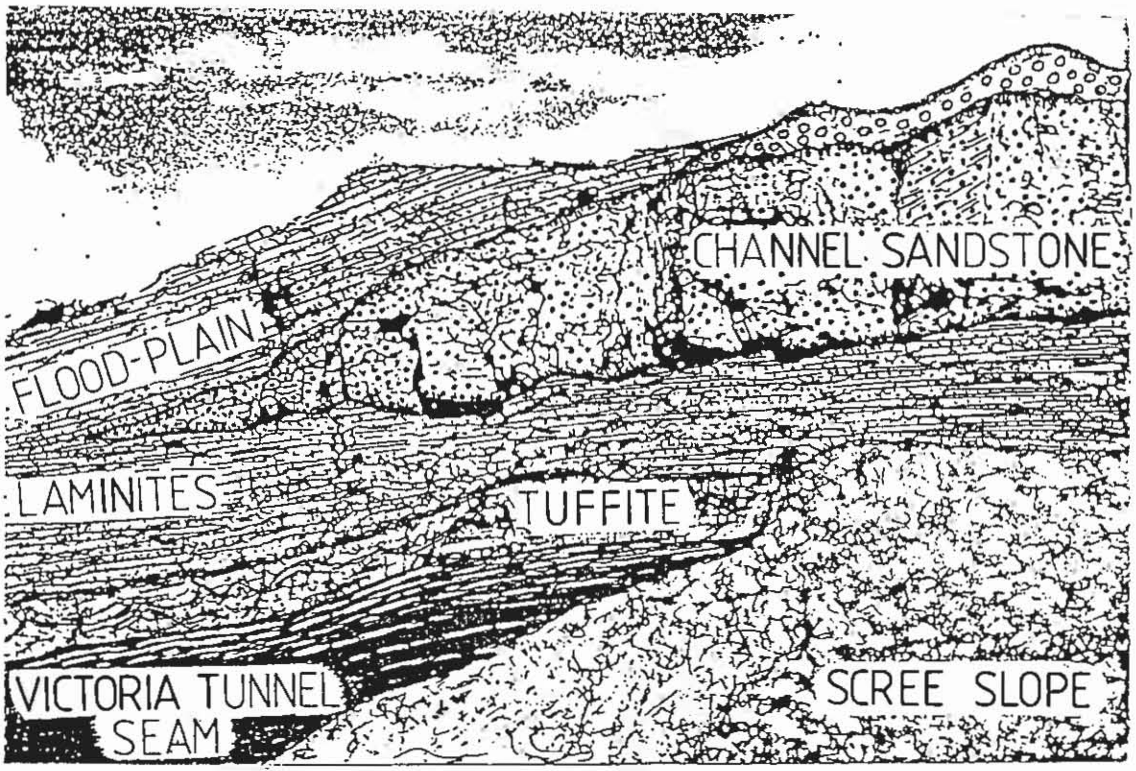


Figure 5b Geological sketch of the south-eastern edge of the Merewether Conglomerate (reduced in thickness and particle size) at Little Rehead Point, north of Dudley Beach.

The Merewether Conglomerate

During the excursion the Merewether conglomerate will be studied at two localities. One is at Shepherds Hill (first stop), where the conglomerate is 25 m thick, and the other is at Little Redhead (third stop), where its sandy south-eastern margin is exposed (Figure 4). As illustrated in the stratigraphic section of Figure 2b, its stratigraphic position is within the Kotara Formation of the Lambton Subgroup.

At Shepherds Hill the outcrop of the Merewether Conglomerate extends for some 300 m south from the northern end of Memorial Drive. Its top is not well exposed but its base is clearly defined as a sharp erosional contact with the underlying tuffaceous roof of the Victoria Tunnel Seam. The main body of the Merewether Conglomerate displays considerable particle size variation ranging from pebbly gravel to silt. As illustrated in Figure 5a, the various particle sizes are concentrated in lenticular beds which are rarely continuous but alternate with each other in a rather abrupt

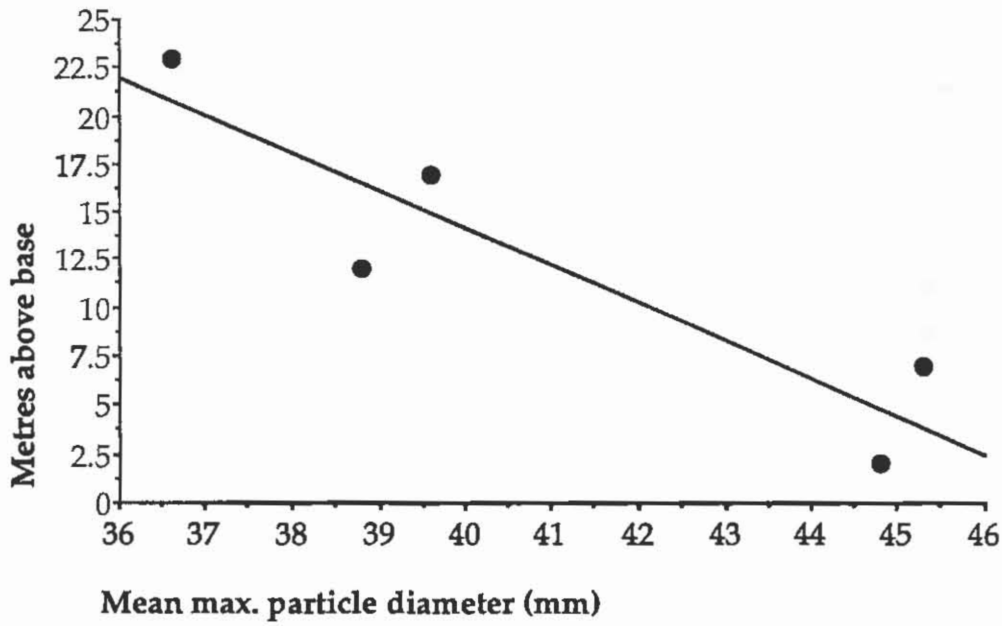


Figure 6. Distribution of mean maximum particle size measured at 5 m intervals through the Merewether Conglomerate at Shepherds Hill. After measurements by Andrew Kohlrusch, The University of Newcastle.

manner. Erosional contacts between beds are common resulting in the destruction of the otherwise ubiquitous graded bedding but some bedforms, such as megaripples are still visible. Although the frequent erosional contacts make a positive identification difficult, it seems that the sandy fraction has been formed in channels while the gravel fraction consists largely of remnants of channel bars.

Some of the gravel-dominated lithosomes are matrix-supported whereas others are clast-supported. The latter are between 10 and 20 cm in thickness and may exhibit weak pebble imbrication. This is lacking in the matrix-supported beds which are also considerably thicker (up to 2-3m). These also contain the largest pebbles (up to 60 mm in diameter) in spite of the sandy matrix, whereas the clast-supported thinner beds commonly consist of a more evenly grained finer pebble fraction. The distribution of mean maximum particle size (mean of longest diameters of the ten largest clasts) measured at five metre intervals is illustrated in Figure 6 which shows some upward fining for the whole conglomerate.

Most clasts are composed of Carboniferous volcanic rocks, followed by Carboniferous lutites and arenites, Devonian chert and some quartz of unknown origin. The sandstones are polymict and contain abundant feldspar the partial kaolinitisation of which gives them a whitish appearance. They have been derived from the New England Fold Belt and its offshore extensions to the north and east which is supported by the cross-bedding direction indicated in Figure 4. Their mean azimuth is directed towards 230°.

The lenses and beds consisting of sand- and siltstone frequently carry a lag of coarser grains on their upper bounding surfaces which are the result of scouring and winnowing by a strong current. Also two cross-bedded units in superposition are sometimes separated by a coarse lag layer.

An interesting phenomenon in the Merewether conglomerate at this locality is the dip of beds and lenses plus some slumping in the lower to middle portion of between 12 and 18 degrees to the south. This is not due to tectonic tilt as the outcrop is situated in the core of the Shepherds Hill Anticline and and tectonic tilt is almost zero, as is demonstrated by the flat basal contact of the conglomerate with the Victoria Tunnel Seam and its tuffaceous roof sediments.

Although it may be tempting to regard the tilted beds as large foresets, or as the lip faces of a prograding delta, the tilt is probably better explained as the result of unequal loading on relatively uncompacted substrata. Differential compaction due to unequal loading is commonly found in peatlands subjected to the encroachment of bedload channels. The high with/depth ratio of coarse bedload streams prevents accommodation of large volumes of clastic debris within the shallow channels which leads to rapid lateral fanning of the depositional environment if down-slope transportation cannot remove the incoming clastics. In a coal forming environment braid plain deposits will then spread laterally across peat which, depending on its state of pre-compaction, will respond in a variety of ways to the loading.

The Newcastle Coal Measures contain a large number of conglomerates which overly coal seams showing a variety of angular relationships with the coal underneath. In some cases, the principal bedding planes of both lithosomes have similar attitudes irrespective of the occurrence of irregular erosional scours at the conglomerate base. In other couples, a marked angular discordance exists between the bedding planes (Sp) of the two units, and there are many transitions between the two types. It must be assumed that conglomerates and other sediments whose principal bedding planes do not display a steep angular discordance but are concordant with the underlying coal have been deposited on an already partly compacted peat, probably because of loading from a previous sediment which was subsequently removed preceding the emplacement of the conglomerate. A particularly spectacular example of a strong angular discordance between a coal seam (Lower Fern Valley Seam) and the internal bedding of an overlying conglomerate (Redhead Conglomerate) occurs at Redhead which was visited by last year's Symposium's excursion. The tilt of bedding in the Merewether Conglomerate

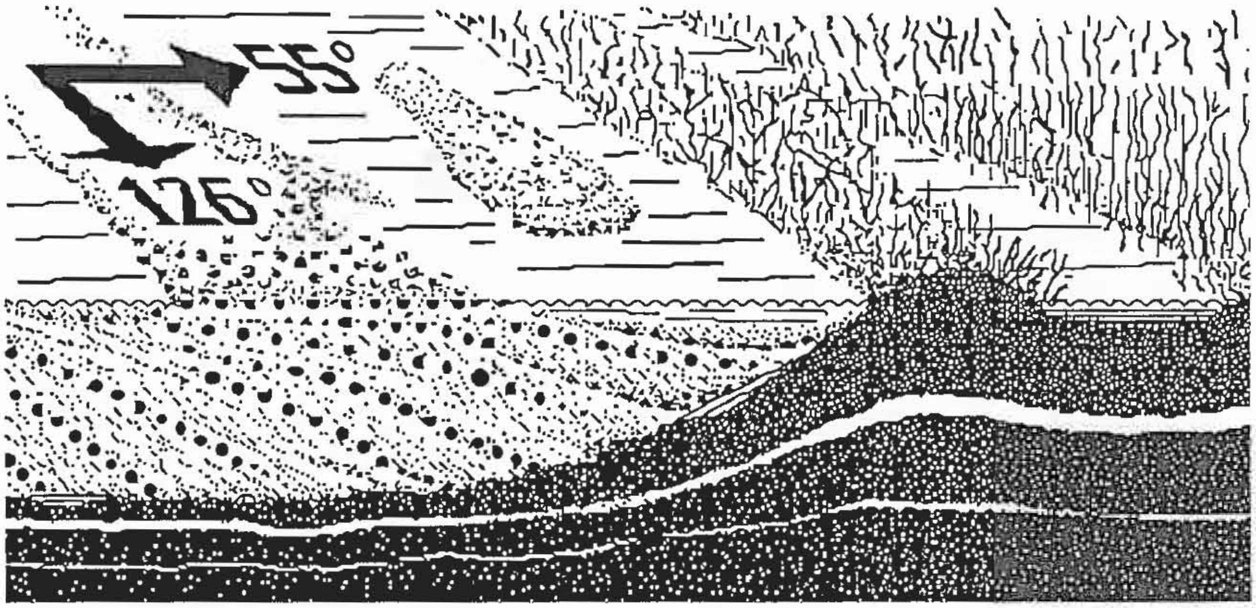


Figure 7. Cartoon illustrating the formation of the tilted beds within the Redhead Conglomerate by loading and compaction. From 22nd Newcastle Symposium, Excursion Guide.

is not as strong as in the Redhead Conglomerate illustrated in Figure 7 which suggests that the degree of compaction was lower.

At the second stop of the excursion (Burwood Beach) only a small portion of the Merewether Conglomerate will be visible in outcrop but it will be picked-up again at the third stop, at Little Red Head, where the edge of the braidplain on which the Merewether Conglomerate has been formed can be seen high in the cliff section. A geological sketch of the outcrop is provided in Figure 5b. Much of the Kotara Formation which at Shepherds Hill consists almost exclusively of the Merewether Conglomerate, is made up of overbank shales, silts and fine sands which contain many plant fossils and both transported tree trunks and stumps in growth position. A conspicuous 1 m thick band of contorted sandstone (catastrophic sheet flow?) can be followed across the outcrop.

The Nobbys Tuff at Burwood Beach

The Newcastle Coal Measures contain a large number of tuffaceous sediments which range in particle size from coarse crystal-vitric tuff with occasional lapilli to dense ashstones, the latter now appearing mostly as bentonitic claystone. Quartz, biotite, plagioclase, orthoclase, volcanic rock fragments and unwelded glass shards occur in varying proportions in the tuff layers which often display normal grading from coarse crystal tuff at the base through vitric tuff to fine ashstone within a thickness of only a few centimetres.

As discussed by Diessel (1985), a rhyolitic to rhyodacitic source is suggested for most tuffs of the Newcastle Coal Measures but post-depositional alterations have often obliterated their genetic association. The fine grained intra-seam tuffs are generally more altered to chalcedony, analcime and montmorillonite/illite than the coarser and thicker inter-seam tuffs which results from a combination of both the general instability of small particles and the high concentration of volcanic glass in them. In the coarse grained verities quartz is often the dominant pyroclast, followed by plagioclase and biotite. The latter is usually affected by baueritisation.

A common characteristic of all pyroclastic deposits in the Newcastle Coal Measures is their considerable lateral persistence, although significant thickness variations occur mainly in the interseam tuffs. Some of these appear to represent distal pyroclastic flows and surges (Diessel, 1985) whereas the thin intra-seam tuffs have been formed as ash falls.

An example of a possible flow or surge deposit which has been emplaced under a regime of strong NE-SW movement is Nobbys Tuff which will be studied together with the underlying Nobbys Seam at the second stop of the excursion, at Burwood Beach. The outcrop is one of several examples in the Newcastle Coal Measures of coal seams carrying a pyroclastic roof. The special significance of such occurrences is that peat accumulation in these coal seams was violently interrupted by a volcanic event unrelated to the development of the mires affected in this way, and it is interesting to note that in each case tree stumps in growth position mark the coal/tuff interface. Like the Fassifern, the Lower Pilot, the Upper Fern Valley and some other coal seams in the Newcastle Coal Measures, the

Nobbys Seam contains tree stumps which are rooted in the coal and protrude up to a metre into the overlying vitric and crystal tuff over much of the Newcastle Coalfield. In its western portion, where Nobbys Seam is combined with the Dudley Seam to form the Young Wallsend Seam, the tree stumps can be readily seen in the underground workings. There appears to be a difference in the maturity of the fossil forest between the eastern and western portion of the coalfield. Along the western margin, for example at Stockton Borehole Colliery, many tree trunks are more than 20 cm in diameter, whereas near the coast the size of the trees is commonly less than that ranging between 15 and 20 cm in diameter, with a mean spacing of 1. 4 m (mean of 50 readings). Since much thicker tree trunks with diameters up to 1 m are known from the Newcastle Coal Measures it can be concluded that firstly, the majority of the the coal seams were formed from arborescent vegetation, and secondly, that the peat from which Nobbys Seam derived was covered by a young and dense forest before it was killed by the volcanic event. A peculiar splitting of Nobbys Seam which might be related to the violent emplacement of volcanic ash should give rise to much discussion.

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