THE UNIVERSITY OF NEWCASTLE

Department of Geology

ADVANCES IN THE STUDY OF THE SYDNEY BASIN

EXCURSION GUIDE FOR THE 22 nd NEWCASTLE SYMPOSIUM

Friday, 15 th April, 1988.

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Stop 1 - Redhead Beach : The Redhead Conglomerate

Compiled by C. F. K. Diessel with contributions from B. Lay.

Introduction

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, e. g. Teralba Conglomerate / Great Northern Seam, the principal bedding planes of both lithosomes have similar attitudes irrespective of the occurence of irregular erosional scours at the conglomerate base. In other couples, e. g. the Charlestown Conlomerate / Montrose Seam a marked angular discordance exists between the bedding planes (s_p) of the two units. The Redhead Conglomerate / Lower Fern Valley Seam couple belongs to the second type, and it is the purpose of the excursion stop to demonstrate the geometric relationship between its members and to present a model of its formation.

Weather permitting, the excursion will leave the coach at Ocean Street. After a short walk to the top of the northern end of the cliff section the party will descend along a foot track, first through the (largely obscured) Redhead Conglomerate, then through the Lower Fern Valley Seam, Kotara Formation (note the absence of the Merewether Conlomerate), and Victoria Tunnel Seam to beach level. At the bottom of the track, the wave-cut platform is formed by the upper portion of Nobby's Tuff. At this point the base of the Redhead Conglomerate is located approximately 15 m above sea level but as the party moves south to Redhead Beach, the Lower Fern Valley Seam and the overlying Redhead Conglomerate will come within physical reach because of the southwestely dip of the strata.

> **Warning!** Although the walk is easy to moderately difficult it involves some climbing over fallen blocks and should not be undertaken by persons suffering from severe acrophobia or not wearing suitable footwear. Persons not wishing to walk, remain on the coach and go straight to Redhead Beach where refreshments and most of the Redhead Conglomerate (except the contact with the Lower Fern Valley Seam) are quite accessible.

Stratigraphic Position and Distribution

The Redhead Conglomerate has been named by David (1907) after the prominent outcrop it forms at the headland at Redhead on the coast, south of the Newcastle suburb of Dudley. As shown in the stratigraphic column of Figure 1, it occurs between two splits of the Fern Valley Seam in the

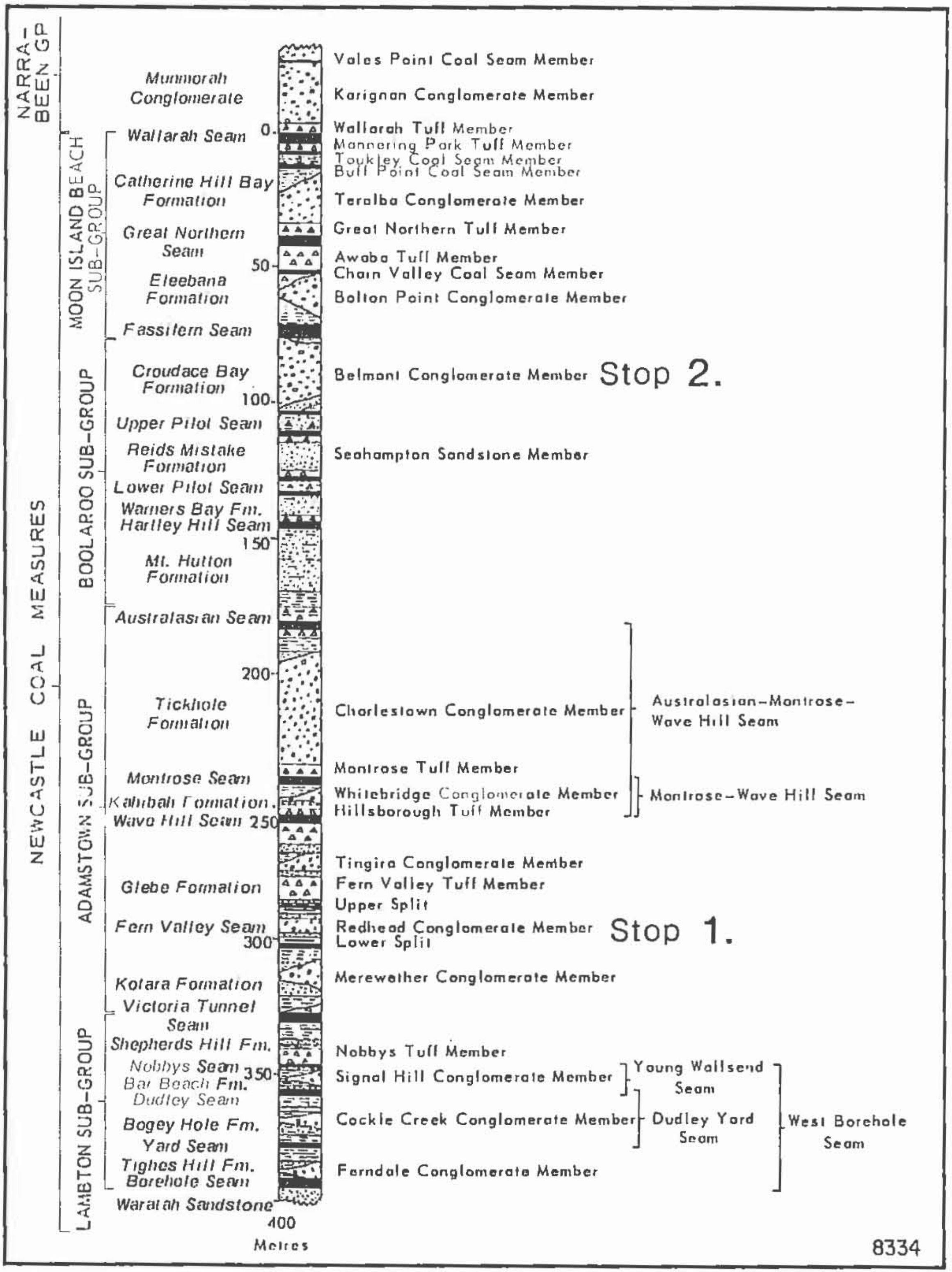

Figure 1. Columnar section through the Newcastle Coal Measures From Diessel (1980), redrawn and amended after Mckenzie (1962) The two conglomerates studied during the excursion are indicated stop 1. and stop 2.

Adamstown Subgroup of the Upper Permian Newcastle Coal Measures.

The Redhead Conglomerate forms a belt of interbedded conglomerate and sandstone lenses stretching inland from the coast between Redhead and Merewether to the area between Edgeworth and Toronto. Its continuation further west is uncertain because of poor outcrop and lack of bore coverage. In spite of the relatively narrow areal extent of the sequence the conglomerate reaches a thickness of almost 40 m at Readhead.

Physiographic Expression

Good inland exposures of the Redhead Conglomerate are rare being restricted to a few road cuttings in the Newcastle area. It is best exposed along a 50 m high cliff north of Redhead Beach where it forms a continuous outcrop for approximately 700 m. Subvertical penetrative joints pass through the conglomerate and have an average spacing of 5 to 6 m. These joints form the surfaces of the of the SW and SE facing parts of the cliff and are coated with crusts of limonite up to 2 cm thick. Where the cliff face corresponds to a joint surface the coatings obscure the conglomerate. The penetrative nature of the joints has caused large blocks of conglomerate to fall. Some of the blocks are in excess of 15 m long and 10 m wide.

Lithologic Description

The Redhead Conglomerate consists of mostly 10 to 30 cm thick layers of granule to pebble conglomerate alternating with up to 2 m thick beds of coarse to pebbly sandstone. The average phenoclast diameter of the conglomerate is 3 to 5 cm but in most cases, grain sizes decrease in an upward direction. The beds are laterally persistent and often massive, although crossbedding is not rare. In the 10 to 30 cm thick layers the majority of the foresets is straight and planar with relatively steep angles of repose. Markedly curved (upward concave) and tangentially aligned trough crossbeds are more common in thicker scour fills. Because of the paucity of flat particles in the conglomerate pebble imbrication is not widespread but some excellent examples do occur. Mean maximum particle size (based on 10 largest clasts) was found to be 74 mm for the longest and 39 mm for the shortest diameter.

The three most common clast species are (in order of frequency, based on a count of 200 species): chert, sandstone, and acid volcanics.

The cherts make up slightly over 40% of the phenoclasts. They are mainly grey and black in colour with with some addition of green chert. Red jasper is present in the conglomerates as an accessory. The proportion of the chert varieties varies considerably within different parts of the conglomerate. In some portions black cherts dominate whereas in others grey and green chert are more abundant.

The sandstone clasts of which there are several kinds, constitute about 30% of the phenoclasts. Although they rank second in overall frequency, in some horizons they are dominant. The clasts consist mainly of greywacke and friable, white, kaolinitic, lithic sandstone which seem to be more common near the top of the outcrop.

The acid volcanics contribute approximately 25% to the phenoclasts. They all are partially weathered and display either white (kaolinite) or green (celadonite) colours. Most of them are fine grained and display small quartz and feldspar phenocrysts in an aphanitic groundmass.

The remaining 5% of the detritus is composed of a variety of rock types and a conspicuous quantity of coalified plant material. Much of the latter consists of flat lenses of bright coal (vitrain) and has, probably been derived from wood and bark. Most clasts are subrounded to rounded and of medium high (0.40 to 0.55) sphericity. The coarser portions of the Redhead Conglomerate are all clast- or framework-supported but with decreasing particle size and in conglomerate/sandstone transitions the fabric becomes more matrix-supported.

In contrast to the often sheet-like conglomerates, the sandy intercalations are laterally more confined to cut-and-fill structures. Several large sand filled channels, approximately 40 m wide and, at the centre 2 m deep, are exposed in the cliff section, one at Redhead Beach. This channel contains abundant, large scale, heterogeneous cross-bedding and many current scours carrying pebble lag at their bases. Elsewhere, erosion contacts are quite frequent and trough cross-bedding is ubiquitous. Most sets are 20 to 40 cm high.

The often heterogeneous foresets alternate between medium sand and granule conglomerate. Commonly, the latter occurs near the base of the sets which usually display an upward decrease in particle size to coarse or even medium sand. However, some pebbly sandstone beds have been found in which the depositional fabric has been totally destroyed by fluidisation.

Fine grained sand is rare, but occurs as silt-laminated sand in some thin lenses, several metres in diameter. Some of them show ripple drift lamination and contain clay ironstone nodules.

Palaeocurrent Analysis

The most conspicuous feature of the Redhead Conglomerate is the strong angular discordance of the principal bedding planes of the conglomerate with bedding in the underlying coal seam. The latter follows

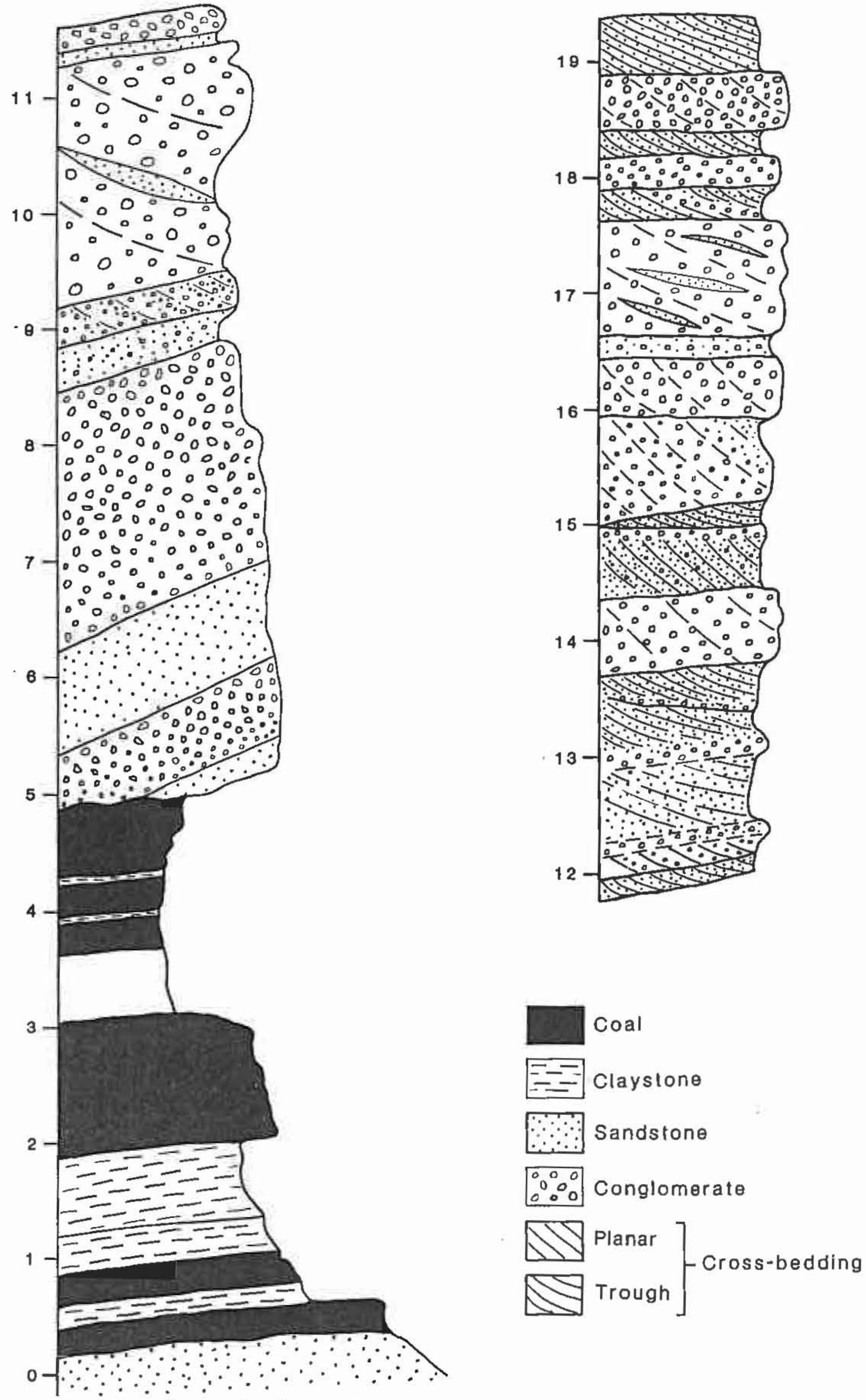

Figure 2. The spatial relationship between the lower split of the Fern Valley Seam and the basal portion of the Redhead Conglomerate at Redhead. Modified after Lay (1987).

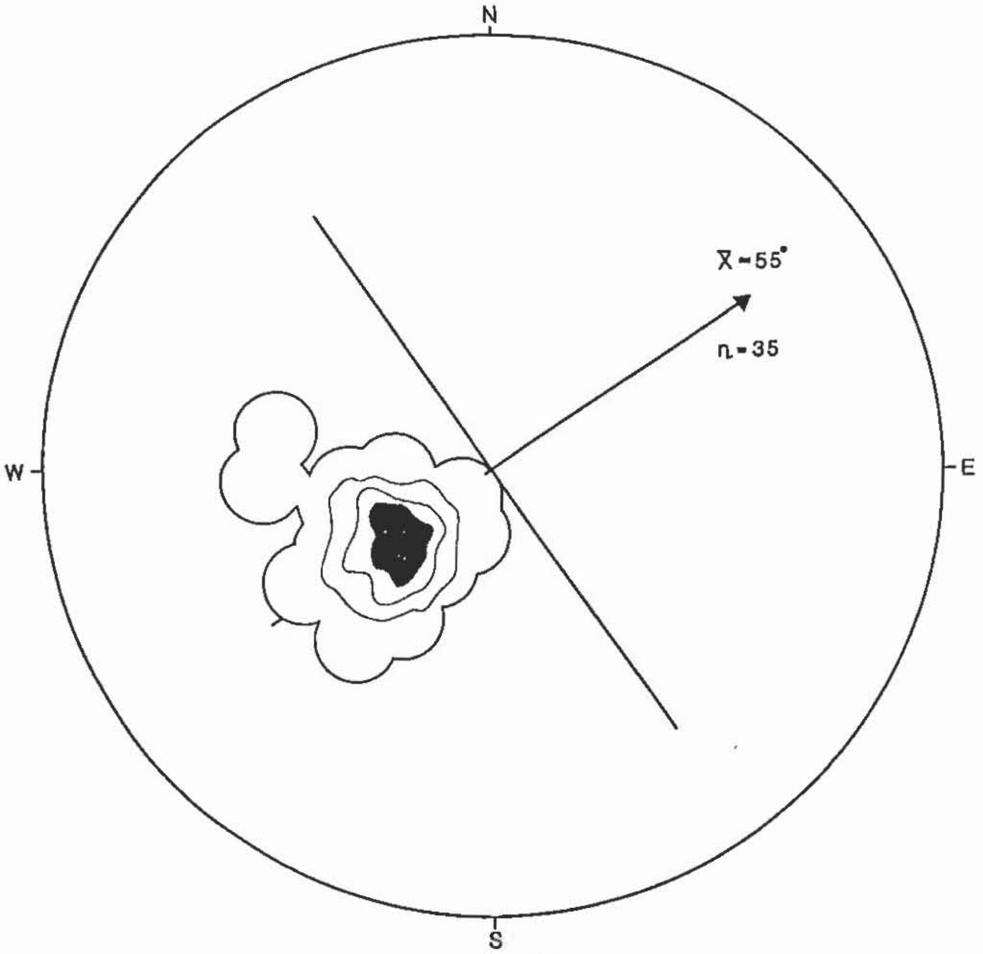

Figure 3. Polar stereogram of Sp-planes.
Concentration intervals = 5 readings.

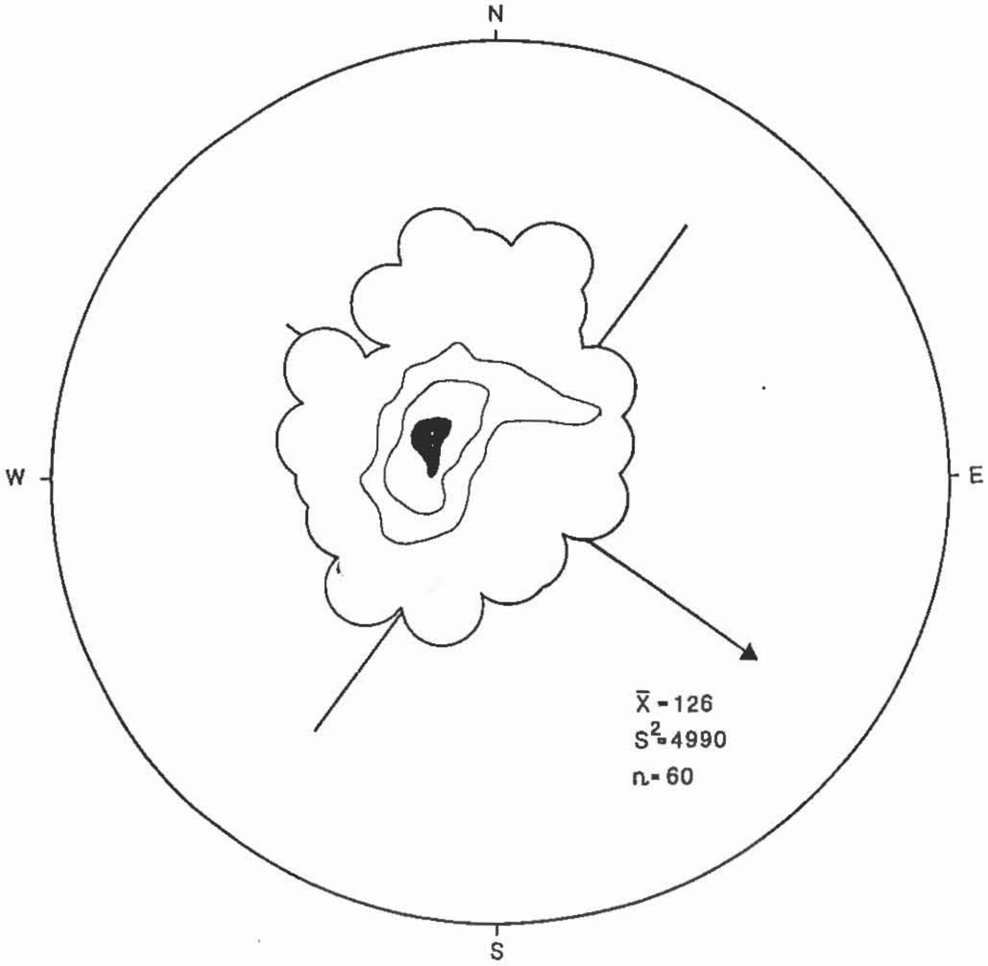

Figure 4. Polar stereogram of tilt-corrected Sf-planes.
Concentration intervals = 5 readings.

the regional dip of 6 degrees to the southwest (230º), whereas the lowermost conglomerate layers and lenses rest on the coal with northeasterly dips up to 45º. In several localities, the clastics protrude into the coal as load casts. Figure 2 is a sketch of the conglomerate/coal contact south of Redhead Beach and shows how in an upward direction the dip of the conglomerate bedding planes decreases so that from approximately 10 m above its base the principal surfaces of deposition flatten and approach regional dip. Figure 3 is a polar stereogram of 35 principal bedding planes measured mostly in the lower half of the Redhead Conglomerate.

Without having a close look the inclined bedding planes appear like very large scale foreset beds or like rather steep slipfaces of a prograding alluvial cone or fan delta. However, a close inspection reveals abundant internal cross-bedding with foresets dips of up to 60º. There is no doubt that at the time of deposition the both S_p and S_f planes must have been considerable flatter than they are now. A polar stereogram (extended after Lay, 1987) constructed from 60 tilt-corrected foresets is illustrated in Figure 4. The calculated vector mean is 126º with a moderately low variance of almost 5000.

Depositional Environment

It appears that most of the conglomerates have been deposited as gravel sheets, banks and bars in a braided river system, although the occurence of some trough cross-bedding suggests that some channels were filled by conglomerate, as well. However, sandstone channels are more common. Some of the silt-laminated fine sandstone lenses have probably been formed

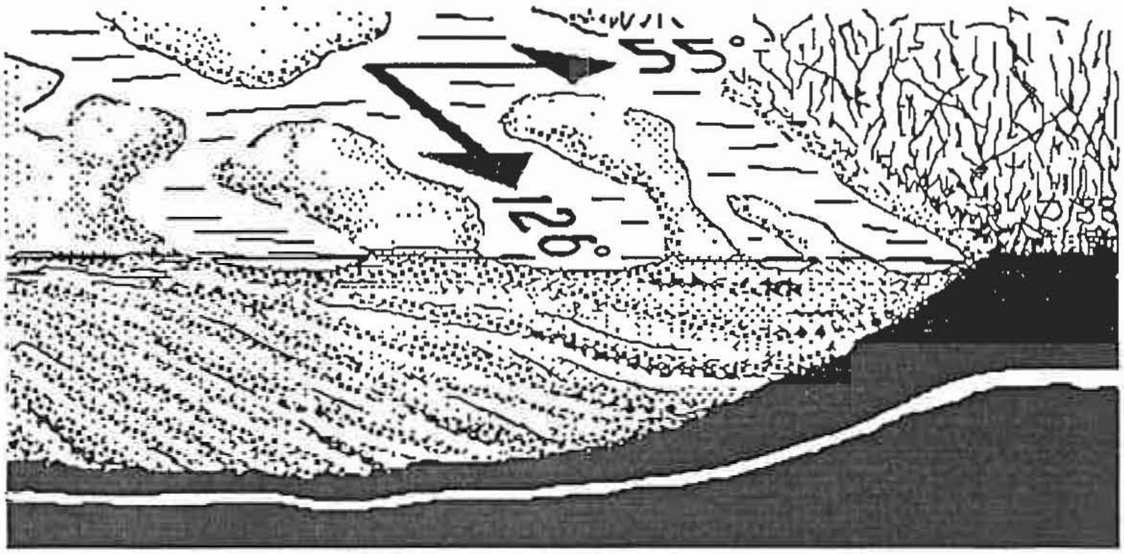

Figure 5. A graphic model showing the emplacement of the first 12 metres of the Redhead Conglomerate by south-east flowing rivers. Rapid north-easterly migration of the braidplain causes a 3 : 1 compaction of the underlying lower split of the Fern Valley Seam which results in tilting of bedding in lower portion of the Redhead Conglomerate.

in ephemeral ponds betweeen active channels. The southeasterly flow direction is almost at right angles to the northeasterly dip of the main bedding planes. As illustrated in cartoon form in Figure 5 this is interpreted as a compaction feature resulting from the weight of the sand and gravel loaded on the water-logged peat as the braid plain extends laterally in a northeasterly direction across the Fern Valley swamp. As the peat responds to the loading by progressive dehydration and compaction the concomitant subsidence creates more space near the surface which attracts more sediments in a similar way as has been suggested by Mallet (1986) for the tilted fluvial channels in the German Creek and Rangal Coal Measures of the Bowen Basin.

The sediments deposited at the peat margin on the right hand side of Figure 5 will show the steepest inclination because they will follow the full 3 : 1 to 4 : 1 compaction the peat will suffer under a 12 m overburden which is the height of the sediment column above the seam at which bedding planes begin to flatten. Sediments deposited to the left of the peat margin will become progressively less inclined because of the increasing compaction of the underlying peat at the time of sediment deposition.

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. Examples of this type will be studied at the next stop.

Stop 2 - Council Quarry at Floraville Road : The Belmont Conglomerate.

Sedimentology

Compiled by C. F. K. Diessel, with contributions from T. R. Wiggins

Introduction

The upper portion of the Newcastle Coal Measures contains several prominent conglomerate horizons which outcrop to the north of Belmont and have been responsible for the strong physiographic relief in that area. Some of the conglomerates are quarried for road metal, and one of the quarries will be visited on the excursion. It is located off Floraville Road and displays an extensive exposure of the Belmont Conglomerate and overlying strata.

Stratigraphic Position and Distribution

The Belmont Conglomerate has first been named by Jones (1929). It is situated within the Croudace Bay Formation near the top of the Boolaroo Subgroup, between the Upper Pilot and Fassifern Seams. It reaches its maximum thickness of 41 m in the central Lake Macquarie region. At the Floraville Road quarry a true thickness of 11.5 m is represented. The exposure in this quarry implies that the sequence is part of the eastern flank of the southward plunging Lake Macquarie Syncline.

Lithologic Description

The Belmont Conglomerate consists of clast supported beds of granule to pebble conglomerate intercalated with lenses of coarse and often pebbly sandstone. Sandstones comprise approximately one third of the unit. Individual conglomerate beds range in thickness from 5 to 47 cm with a mean of 13.9 cm (n = 24). Most of these beds possess planar upper and lower bounding surfaces and display a conspicuous upward gradation from coarse to fine particle sizes.

Wiggins (1987) made a detailed study of phenoclast types and their abundance in three parts of the quarry at different stratigraphic levels. The results of his observations are listed in Table 1 which suggest that several sources contributed to the clastic detritus of the conglomerate. The various cherts which comprise the largest proportion of the phenoclasts, have been derived from Devonian deep water sediments of the New England Fold Belt or its (now obscured) southeastward extension. The acid volcanics and porphyries are probably of Carboniferous age having been derived from the destruction of remnants of the volcanic arc not far from the basin margin.

Table 1. The composition of phenoclasts in the Belmont Conglomerate. After Wiggins (1987)

Lithology	Lowermost Conglomerate units 1m height	Units of 6m height	Units of 9.5m height
Red, brown, green banded and black cherts	A	A	A
Chalcedonic quartz	V C	C	C
Acid volcanics (e.g. rhyolitic)	A	A	V C
Porphyry	C	C	C
Intermediate volcanics	C	C	N C
Basic volcanics	U C	C	N C
Tuffaceous material (lithic and cherty)	V C	V C	N C
Wacke and greywackes	C	C	N C
Other sedimentary fragments	V C	C	N C
Coaly material	N C	C	C
Logs and branches	U C	C	V C

Key to abundance are as follows

A	Abundant
V C	Very Common
C	Common
N C	Not Common
U C	Uncommon

Determinations were made using sample square metres of the quarry face.

Table 2: Ten maximum diameters within the Belmont Conglomerate. After Wiggins (1987)

NO.	SIZE (cm)	NO.	SIZE (cm)
1.	8.30	6.	6.44
2.	10.29	7.	6.81
3.	7.69	8.	9.41
4.	7.32	9.	9.52
5.	9.43	10.	8.63

Mean = 8.38cm

Range = 3.85cm

Various sedimentary sources also contributed to the detritus, including pre-Permian wackes, greywackes, tuffs, and cherty tuffs. Coal inclusions have been incorporated in the clastic sediments as vegetable matter at the time of deposition rather than as coal clasts eroded from older seams. Large silicified wood debris increases in proportion near the top of the conglomerate. Likewise, the phenoclasts become depleted in pyro- and epiclastic debris, and conversely richer in chert and acid volcanics. This may reflect a gradual change in the source area with time or an increased compositional maturity within the sediments with a proportional increase in the intensity of transportation conditions. The conglomerate clasts possess moderate to low levels of roundness but variations occur between different clast species.

Mean maximum clast size was determined by Wiggins (1987) using the longest diameters of the largest clast found at ten different locations in the quarry. The results of the measurements are shown in Table 2.

The composition of the sandstone lenses in the quarry appears to be similar that of the conglomerate, although quartz and, to a lesser extent feldspar grains are more common in the sandstone, at the expense of coarse rock fragments. In the lower portion of the Belmont Conglomerate sandstone intercalations contain an iron oxide cement with addition of calcite. Approximately 4 m above the quarry floor a distinctive white sandstone unit with inclusions of coalified plant fragments possess a white kaolinitic cement. Above this layer carbonate cements appear to become more common. Within some of the stratigraphically higher sandstones dark chert fragments are concentrated in distinct bands.

Palaeoenvironmental Interpretation

The Belmont conglomerate can de interpreted as a sequence of overlapping bars and channels formed in a gravelly braided stream system. Within the conglomerate facies bars are the domianant morphogenetic feature with an exposed width of many metres and an average height of 10 to 14 cm (Wiggins [1987] gives a mean bar height of 10.5 cm based on 20 readings, Diessel [see above] obtained a mean of 13.9 cm from 24 readins). Within a single bar upward gradation from coarse to fine is most evident. Planar cross-bedding consisting of Allen's (1963) beta and gamma types is common in the conglomeratic bar sets whereas alpha and beta types are frequent in the sandy bars. Both facies contain numerous erosional contacts and re-activation surfaces within and between bars which suggest that much of the originally deposited material has been subsequently reworked and dispersed further downstream.

Channel deposits are also present in the Belmont Conglomerate but their proportion is smaller than that of the bars. They are widely spaced and filled with fining upward conglomerate and pebbly sandstone. Most channels are relatively small, rarely exceeding 2 m in width. They reach between 20 and 40 cm in height (Wiggins' [1987] mean of 20 readings is 24 cm) and usually display internal trough cross-bedding or Allen's (1983) theta type. All channels possess erosional lower bounding surfaces covered by gravel lag.

Compared with the Redhead Conglomerate, the Belmont Conglomerate is coarser and possesses a higher bar/channel ratio. This indicates a more proximal setting where sheet flow conditions were more common than channelised flow. The distinct graded bedding in channel and bar sets is a function of decreasing flow velocities reflecting the waning stages of periodic floods at the height of which gravel bar migration occurred.

Palaeocurrent Analysis

In order to elucidate flow directions at the time of deposition, direction of dip and dip were measured on 81 foreset beds in both conglomerate and sandstone. Their poles have been plotted and contoured in Figure 6 A giving a calculated vector mean of 210° and a variance of 3713. Both flow direction and variance differ considerably from the results of the respective measurements and calculations in the Redhead Conglomerate. If the mean foreset azimuth obtained at the Floraville Road quarry is representative of other localities the Belmont Conglomerate would have had a much more easterly source than the Redhead Conglomerate. The higher variance of the latter is related to the fact that most foreset directions were obtained from the more common high variance in-channel trough cross-beds, whereas in the Belmont Conglomerate more measurements could be made in the low variance bar sets. As mentioned above, within a bar/channel environment the bars only migrate downstream during periods of peak flood conditions and are thus likely to indicate the direction of axial flow more precisely than is possible by current indicators within channels which weave between stationary bars during low water conditions.

Figure 6 B gives the orientation of 110 long pebble axes. The rose diagram indicates a preferred orientation normal to the current flow as suggested by the foreset azimuths in Figure 6 A. This is a common relationship during the actual transportation by traction of elongated clasts along the channel floor where they roll downstream with their long axes oriented normal to the current. However, as the flow velocity drops below the transportation threshold there is a transient stage in which the current is not anymore strong enough to push the particles along but still capable to rotate them into a hydrodynamically stable position with their long axes parallel to current flow. It is this spatial relationship between flow direction and the orientation of prolate particles that is most commonly preserved in fluvial deposits. An orientation of long pebble axes normal to palaeocurrent direction as displayed in Figure 6 B suggests an abrupt cessation of high velocity flow conditions.

The orientation of 13 large plant fragments (branches and logs) is illustrated in Figure 6 C. The low number of readings gives an inconclusive result but suggests a preference towards a parallel orientation with respect to the current direction.

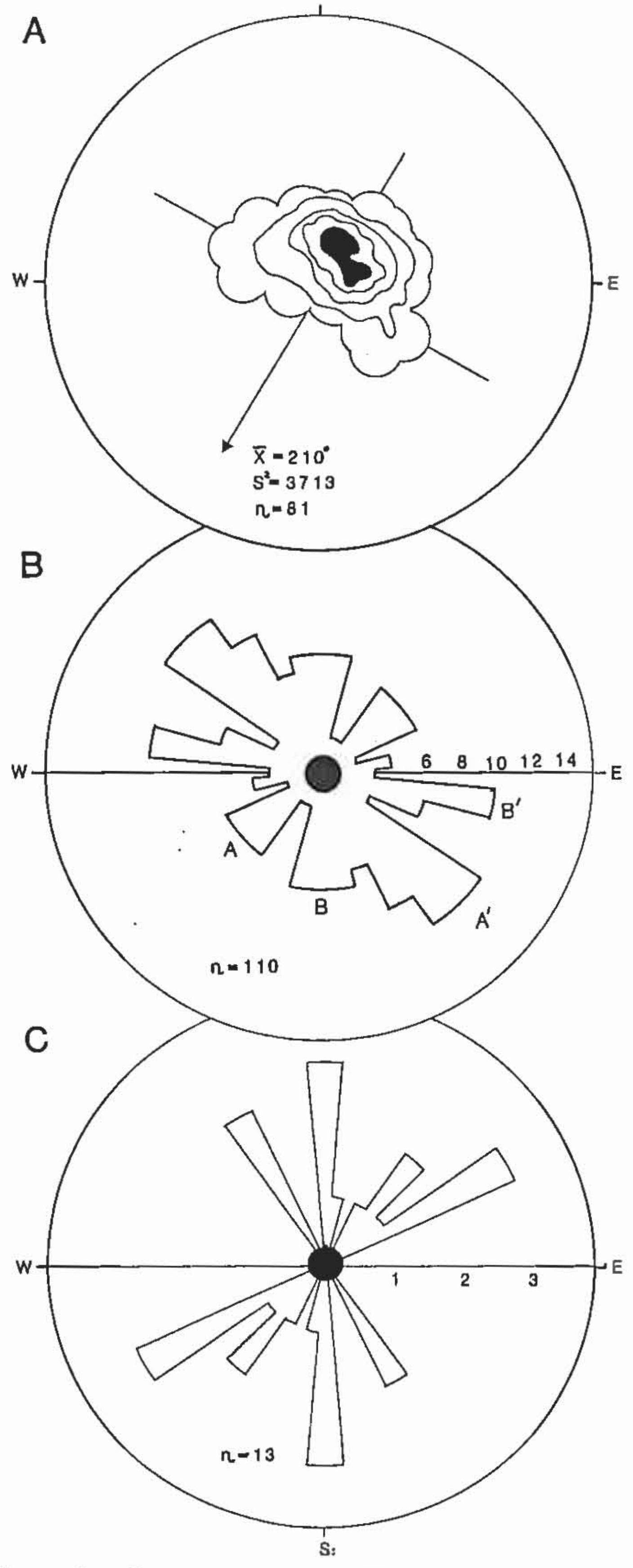

Figure 6. Three diagrams illustrating the results of palaeo-current measurements in the Belmont Conglomerate at the Floraville Road quarry. A = stereogram of poles to foreset-beds; B = Rose diagram of long pebble axes; C = Rose diagram of coalified tree trunks and branches. Modified and amended after Higgins (1987).

Engineering - Geological Aspects

Compiled by K. H. R. Moelle, with contributions from J. H. Gibson

The engineering-geological part of the excursion is concerned with a failure pattern in the Teralba Conglomerate at the top of the sequence north of Belmont and with the absence of any mechanical deterioration in two quarries previously operated in the underlying Belmont Conglomerate.

The two now disused quarries were operated by the Lake Macquarie City Council to obtain gravel by shotfiring and bench formation. The shotholes and detonation zone cracks can be seen in various parts of the quarries.

The first stop will be in the northern quarry (see sketch map in Figure 7), which has a generally NW trending face. The Belmont Conglomerate contains several sandstone lenses and also shows minor faulting (NNE trend) in places. The depositional direction has been determined as 210°. The spatial attitude of the conglomerate is N55°W - 04°SW. An unusual joint system has been measured in the Belmont Conglomerate (Figure 8):

N86°W - 74°NE   N25°W - 84°NE
N03°E - 75°SE   N23°E - 82°SE

Several shear zones have been identified with a general strike of N25°W and dipping approximately 70° to 80° to the NE. Preferential weathering occurs along these shear zones, but does not create significant zones of weakness. The quarry high wall is remarkably stable and does not show any evidence of mechanical weakness.

A relatively narrow ridge of Belmont Conglomerate separates this quarry from a smaller one adjacent to the southwest. No sign of instability has been detected in the smaller quarry.

The second stop is planned to be at a H.D.W.B. reservoir founded on the Belmont Conglomerate. The reservoir is situated on a narrow ledge formed by the two quarries. The reservoir shows no sign of distress.

The sedimentary sequence with the Fassifern Coal seam overlying the Belmont Conglomerate will be inspected. Several palaeochannels can be seen just above the Fassifern Seam. Channel trends have been measured ranging between 78° and 85°, as well as 110° and 150°. Differential compaction structures can be observed in the cliff to the west behind the reservoir.

The excursion party will then move on foot from the reservoir to the top of the adjacent ridge southwest of the quarries.

The morphology of the area reflects the outcropping lithology. The tuffaceous members of the Eleebana Formation, and in particular the Awaba Tuff Member, have preferentially weathered and consequently the support for the overlying jointed Teralba Conglomerate has been progressively removed.

Such processes are still active despite fairly dense vegetation on the slope, consisting of shrubs, small undergrowth and large trees. There is no evidence of creep movement along the easterly facing hillslopes.

The ridge is capped by approximately 3 metres of Teralba Conglomerate. Large cracks (>30 centimetres) have developed in the conglomeratic rocks. The development of these cracks causes some concern and their propagation should be controlled by minor engineering works in order to maintain the integrity of the underlying lutateous rock units and to preserve the present hill slope physiography. The attitudes of the wide cracks have been measured; their general trends are:

N16°W	N55°E
N34°W	N45°E

There are much more spectacular engineering-geological problems in several areas of the Newcastle and Lake Macquarie Districts, although most natural instabilities appear to be initiated and sustained by the great diversity of rock types occurring in close vertical succession.

The type of "failure" now developing, on a small scale, at this ridge at North Belmont can be observed in many instances involving, invariably, conglomerates underlain by fine-grained and argillaceous strata with coal seams (see stratigraphic section in Figure 9).

The purpose of the excursion's visit to this site has been to show that no deep-seated failure plane is required to create considerable lateral rock movement at the present surface.

Very similar instability patterns have been investigated at other sites in the Greater Newcastle District on a variety of scales. Such works have resulted in a number of explanations, including suggestions of deep-seated circular failure surfaces being involved.

This site at North Belmont is probably a good example for the study of failure initiation by surface-near erosional processes and subsequent failure due to gravity and disintegration of certain rock types.

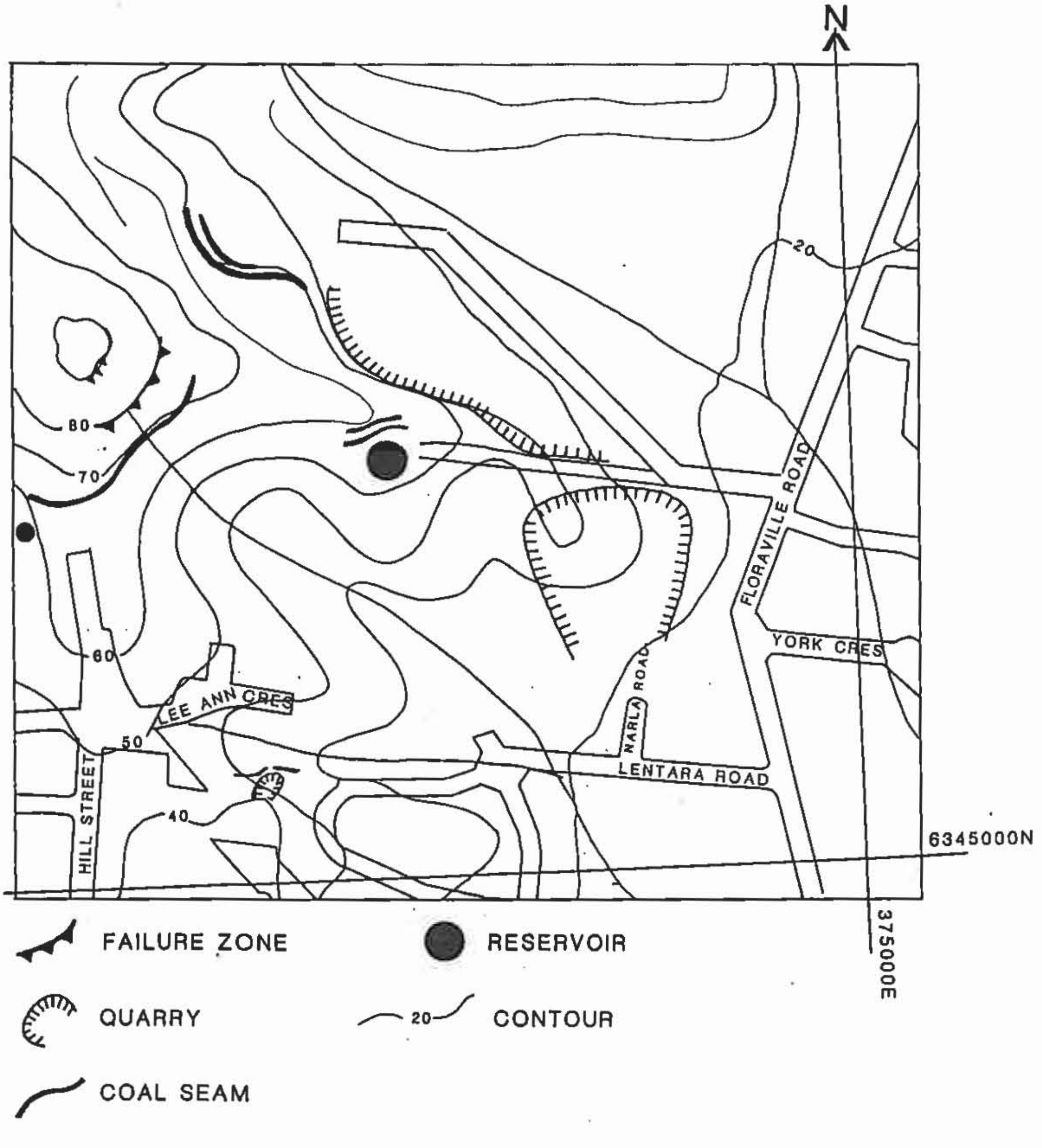

Fig. 7 Sketch map North Belmont Quarry area

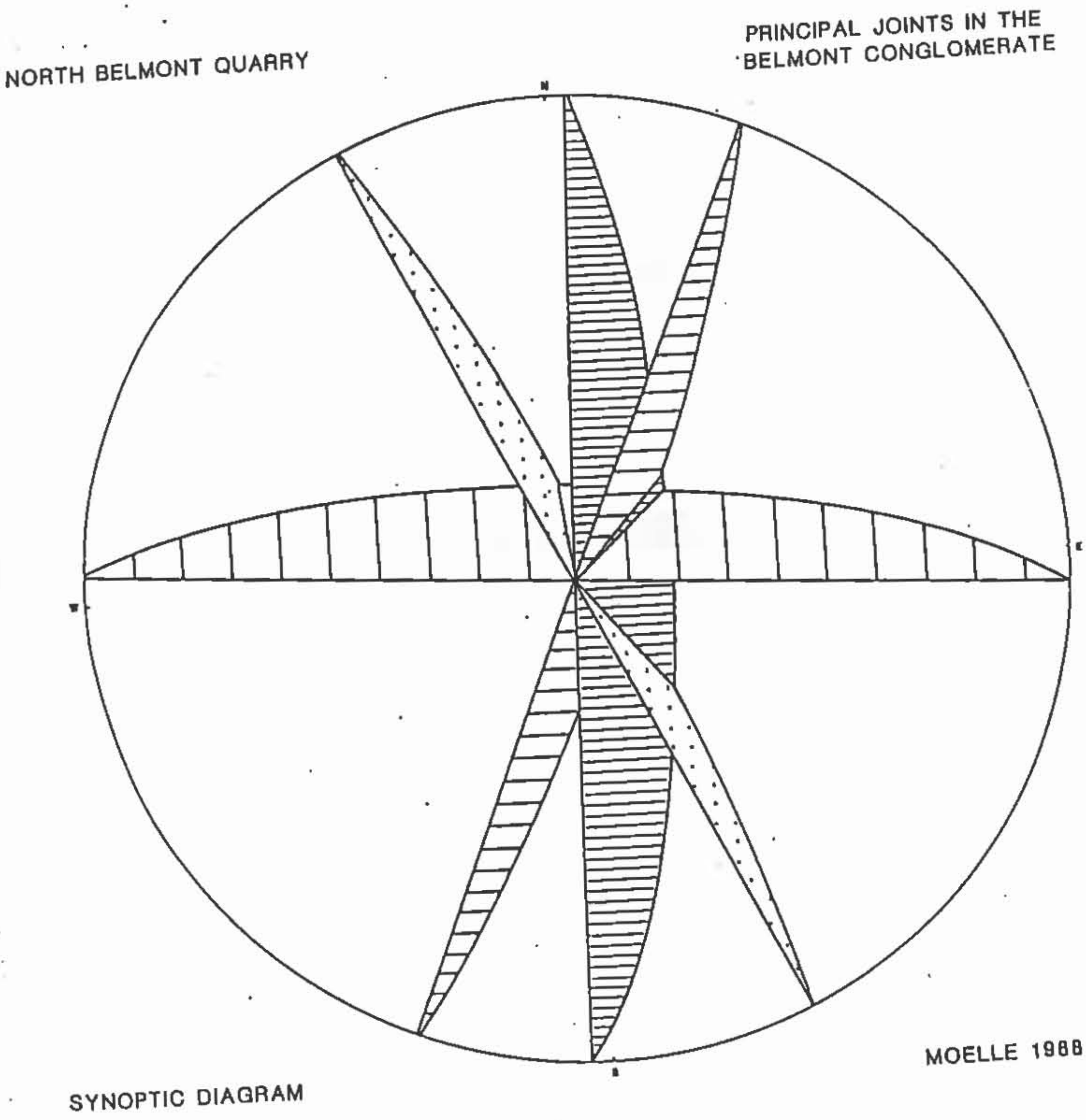

Fig. 8 Stereographic projection of joints in the North Belmont Quarry

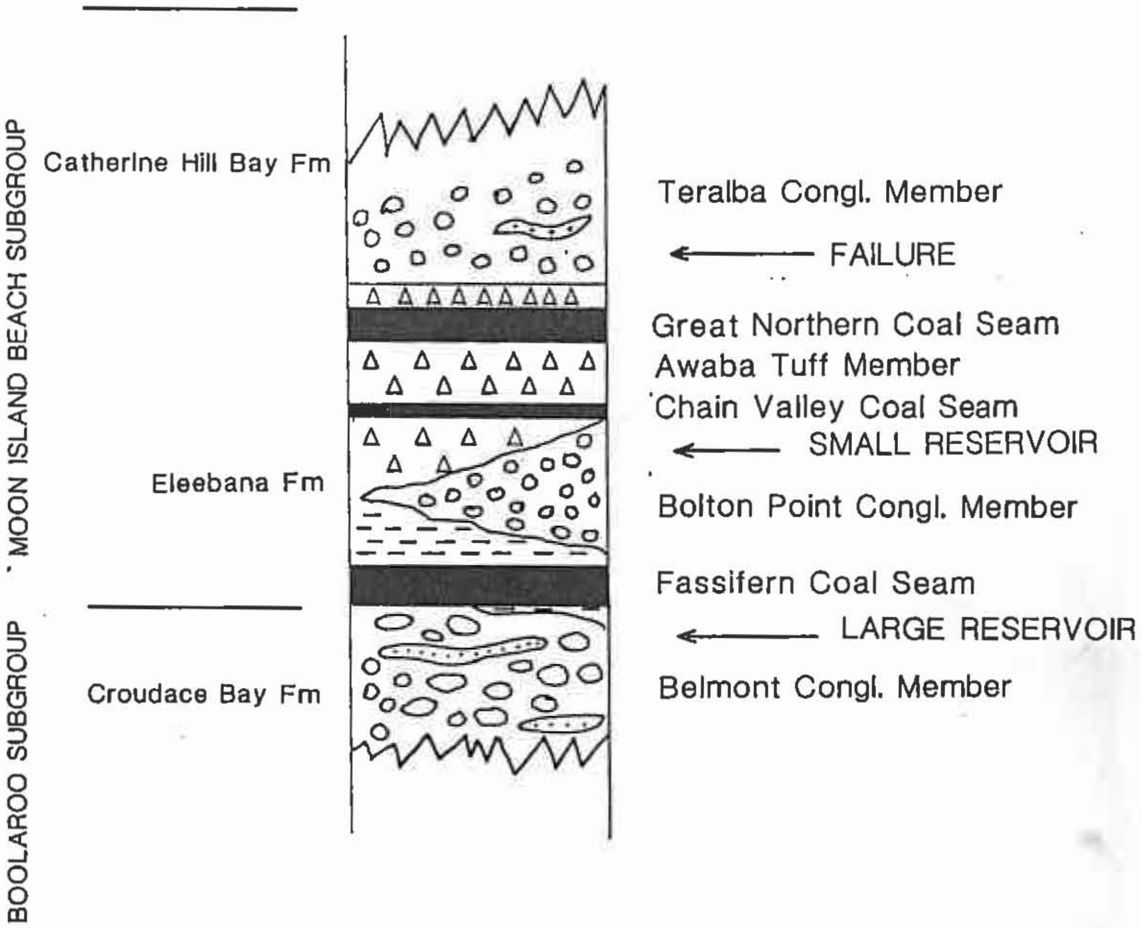

Fig. 9. Stratigraphic section at the North Belmont Quarry area

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