Stratigraphic and Coal Seam Correlations of the Illawarra Coal Measures in the Ulan and Bylong Areas, Western Coalfield, Sydney Basin, New South Wales

E.K. Yoo

ABSTRACT. Stratigraphic and coal-seam correlations of the Illawarra Coal Measures between Ulan and Bylong, in the western half of the northern sector of the Sydney Basin, have been established on the basis lithofacies studies and downhole geophysical-log profiles. Eastward thickening of the stratigraphic units of the Illawarra Coal Measures occurs across hingelines at Ulan, Wollar and Bylong. The lower-section of the "Ulan seam" is a correlative with the Lidsdale Coal; the upper section of the "Ulan seam" is contemporaneous with the Long Swamp Formation and the overlying Irondale Coal. New units, the Cockabutta Creek Sandstone Member and the Bungaba Coal Member, are named in the Glen Davis Formation, and the geographic extent of the Cockabutta Creek Sandstone Member is shown. The Bungaba Coal Member of the Glen Davis Formation and the Moolarben Coal Member of the State Mine Creek Formation converge towards the western margin of the basin, and form a single coal interval west of the Ulan hingeline.

INTRODUCTION
The stratigraphy of the Illawarra Coal Measures of the Western Coalfield, documented in the Lithgow area by Bembrick (1983) (Table 1), has been widely and successfully applied in the southern part of the Western Coalfield (Standing Committee on Coalfield Geology of New South Wales 1986). However, the present study in the Ulan, Wollar and Bylong areas, in the northern part of the Western Coalfield (Figure 1) indicates that there are significant stratigraphic differences between the two areas, causing difficulties with stratigraphic and coal-seam correlations between them.

The aim of this paper is to establish the stratigraphic and coal-seam correlations between Ulan and Bylong, located in the western half of the northern sector of the Sydney Basin, on the basis of lithofacies and geophysical downhole profiles. A similar study concerning the correlative coal measures in the adjoining eastern half of the Sydney Basin is in preparation.

REGIONAL GEOLOGICAL SETTING
The Illawarra Coal Measures overlie, unconformably and nonconformably respectively, the basement rocks of the Ordovician Lue Beds and the Carboniferous Gulgong Granite near the western margin of the basin, and conformably overlie rocks of the Shoalhaven Group immediately to the east of the margin. The coal measures are overlain by the Triassic Narrabeen Group, which is overlain in turn by the Jurassic Purlawaugh Formation and Pilliga Sandstone in the northern part of the area. West of Ulan, the coal measures are absent, resulting in a nonconformable contact between the Gulgong Granite and the Narrabeen Group (Offenberg et al. 1971, Yoo in prep.).

Mesozoic phonolite intrusions are common in the area south of Wollar and Bylong. Tertiary basalt and dolerite also occur as flow-remnants on topographic highs and valley slopes, and as plugs and sills intruded within sporadic diatremes or within the coal measures.

STRUCTURE
The Illawarra Coal Measures dip gently to the east-northeast at an average of 1° from the western margin of the basin to Wollar township. East of Wollar the dip increases to an average of 2° 1/2°, a figure that is sustained to the eastern boundary of the study area. The thickness of the coal measures also significantly increases eastwards across three meridional hingelines located at Ulan, Wollar and Bylong (Figure 2), herein called respectively the Ulan, Wollar and Bylong hingelines. The coal measures are approximately 50 m thick near the western margin of the basin, but thicken to 30 m (from 50 m to 80 m), 40 m (from 80 m to 120 m) and 35 m (from 120 m to 155 m) respectively across the
Table 1
Illawarra Coal Measures - Western Coalfield
(Bembrick 1983)

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<td>Glen Davis Formation</td>
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three abovementioned hingelines. The thickness of the unit reaches 200 m east of Bylong (Figure 2).

Ulan hingeline

The most westerly thickness increase occurs east of drillhole UCLM C295, close to the western limit of the Denman Formation and the Watts Sandstone (Figure 2). From this hingeline to the western margin, the basal plies of the Lidsdale Coal (Plies E, F and G) are absent (Johnstone & Bekker 1983, Hughes 1991). Also in this drillhole, the Bungaba Coal Member (new name in the Glen Davis Formation (Figure 2) converges with the Moolarben Coal Member of the State Mine Creek Formation; and the State Mine Creek Formation converges with the Farmers Creek Formation.

Between the Ulan hingeline and the Wollar hingeline, the Lidsdale Coal (the lower section of the "Ulan seam") and the upper section of the "Ulan seam" (equivalent to the total thickness of the Long Swamp Formation) maintain generally a uniform thickness. This same area also marks the western limit of the Gap Sandstone, which thickens abruptly towards the east (figure 2), and thick, fine to medium, lithic sandstone bodies are present in the State Mine Creek Formation.

Wollar hingeline

The Wollar hingeline is a prominent structural feature (Figure 2) located east of drillhole ERC Ulan DDH 24. At this point, the upper section of the "Ulan seam" begins to split, and the beds become widely separated east of this particular hingeline. The Denman Formation and the Watts Sandstone increase substantially in thickness across this hingeline, and the Farmers Creek Formation also thickens. This hingeline trends northwest-southeast through Wollar, Barigan and Growee (Yoo in prep.).

Bylong hingeline

The easternmost hingeline is located east of drillhole AB Bylong DDH 22, where the Lithgow Coal begins to thicken eastwards. The Long Swamp Formation, Denman Formation, Watts Sandstone and Farmers Creek Formation also continue to increase substantially in thickness east of this feature. The State Mine Creek Formation becomes thinner, and the Cockabutta Creek Sandstone Member (new name) of the Glen Davis Formation wedges out west of the Bylong hingeline (Figure 2).

STRATIGRAPHY OF THE ILLAWARRA COAL MEASURES

Most units of the Illawarra Coal Measures thin towards the western margin of the basin, exceptions being the Cockabutta Creek Sandstone Member within the Glen Davis Formation, and the State Mine Creek Formation (Figure 2). The
Nile Subgroup of the Illawarra Coal Measures and the Shoalhaven Group remain undifferentiated throughout the area due to lack of sufficient information.

Figure 2 has been compiled from lithological and graphic logs and geophysical downhole (density and gamma) logs of 14 selected boreholes. Thirteen formations and four members have been identified within the coal measures; where individual units are correlated with those of the southern part of the Western Coalfield (Bembrick 1983) or with those of the Hunter Coalfield (cf. Beckett 1988), the existing stratigraphic terms for equivalent units in these areas are retained.

Marrangaroo Conglomerate

The Marrangaroo Conglomerate and the lithologically similar Blackmans Flat Conglomerate (see below) consist of quartzose, poorly consolidated, coarse to pebble-bearing sandstone. In the Bylong area, the Marrangaroo Conglomerate is quartz-lithic. Its thickness ranges from 1.5 m on the eastern side of the area to 4 m in the Wollar and Wilpinjong areas to the west. Towards the western margin of the basin, the unit tends to thicken and contains more abundant and larger clasts. The basal part is commonly stained yellow, apparently caused by ground-water movements from the underlying marine Shoalhaven Group.

Lithgow Coal

The Lithgow Coal is developed at the top of a fining-upward sequence formed by the Marrangaroo Conglomerate, and is uniformly dull with minor stonebands. Agnew and Bayly (1989) indicate that it is correlated with the Coggan Coal, a unit in the Bylong area informally named by McElroy Bryan & Associates (1983, 1985). The Lithgow Coal is up to 5 m thick east of Bylong, but thins abruptly west of the Bylong hingeline (Figure 2). It is represented by a thin carbonaceous claystone band in the Wollar area, and ranges from 0.2 m to 0.8 m thick in the Ulan area.

Blackmans Flat Conglomerate

The Blackmans Flat Conglomerate is
The "Ulan seam", informally named in the Ulan area, has been variously correlated with: 1) the Lithgow and Bayswater Coals (Holmes 1975); 2) the Irondale seam and the Newnes Formation in the Ulan-Wollar area (McMinn 1985); and 3) the upper Lidsdale seam (Agnew & Bayly 1989). Shiels and Kirby (1977) also suggested that a thin coal seam beneath the Ulan seam is correlated with the Lithgow Coal. This disparity of opinion has arisen mainly as a result of the paucity of subsurface geological and geophysical information that was available in earlier years to permit correlation of the stratigraphy in the Ulan area with that of the surrounding coalfields.

The "Ulan seam" splits east of Wollar (Shiels & Kirby 1977, Barto & Delaney 1989, Agnew & Bayly 1989). However, no attempt has ever been made to correlate the split plies of the seam with the documented Western Coalfield stratigraphy.

McMinn (1985, p. 304-305) suggested that the "Ulan seam" in the Ulan-Wollar area is slightly younger than the Irondale Coal of the Lithgow and Rylstone areas on the basis of the palynological evidence that Microreticulatisporites bi triangularis and Dulhuntyispora parvithola first appear simultaneously beneath the Ulan seam. McMinn (1985) further suggested that local erosion of the lower part of the Illawarra Coal Measures in the Ulan area allowed the development of an abnormally thick peat accumulation that subsequently gave rise to the "Ulan seam".

Outside the Ulan-Wollar area, McMinn (1985, p. 305) found that M. bi triangularis first appears immediately above the "Ulan seam" and D. parvithola first appears either within the Nile Subgroup or at the base of the coal measures. M. bi triangularis also appears immediately above the Irondale Coal at the base of the Newnes Formation and D. parvithola appears within the thin, non-marine, Gundangaroo Formation of the Nile Subgroup in the Lithgow-Rylstone area.

The results of the present study provide no evidence that significant erosion of the lower part of the coal measures took place in the Ulan-Wollar area. The "Ulan seam" continues in an easterly direction towards Bylong, overlying the characteristic quartzose Blackmans Flat Conglomerate. It is an enigma why M. bi triangularis and D. parvithola first appear simultaneously beneath the Ulan Seam in the Ulan-Wollar area.
The "Ulan seam" has been divided into seven plies for coal quality purposes (Plies A ...), ranges in thickness from 8 m to 13 m west of the Wollar hingeline but thins to 4 m at Wilpinjong, then thickens eastwards at multiple, discontinuous coal bands. At Wilpinjong, split eastwards into thin A, B and C-upper plies, totalling up of the Lidsdale Coal in the Rylstone section of the "Ulan seam" further from Bylong this interval is 20 m thick. The coal seam (the upper section of the "Ulan seam") at Ulan and Bylong (see Agnew & Bayly 1989, fig. 4).

Occurrences between the upper and lower seams of the Wollar hingeline to split the upper section of the "Ulan seam" into Lidsdale Coal, the formation is represented commonly bioturbated. West of the Wollar hingeline, the formation is represented commonly bioturbated. West of the Wollar hingeline, the formation is represented commonly bioturbated. West of the Wollar hingeline. The Lidsdale Coal ranges in thickness from 5 m to 8 m in most of the study area. The Lidsdale Coal contains the best-quality coal plies in the study area. The Lidsdale Coal consists of siltstone, lithic sandstone and claystone band occurring in the middle of the "Ulan seam" (Figure 3). The upper section of the "Ulan seam" can be grouped into two sections (upper and lower), separated by a 0.3 m interval equivalent to the C-marker at Bylong is approximately 25 m thick, and contains the top of the "Ulan seam" outside the Ulan-Wollar area can be correlated with the top of the Irondale Coal; its upper limit is split throughout the study area (Figure 4). The formation ranges in thickness from 13 m to 7 m thick between Ulan and Bylong indicates that the uppermost ply of the "Ulan seam" at Bylong is correlated with the top of the Irondale Coal at the base of the Newnes Formation and D. parvithola appears within the thin, non-marine, Gundangaroo Formation of the Nile Subgroup in the Lithgow-Rylstone area.

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The "Ulan seam" has been divided into seven plies for coal quality purposes (Plies A to G in descending order) by previous workers (Johnstone & Bekker 1983, Barto & Delaney 1989). The seam can be grouped into two sections (upper and lower), separated by a 0.3 m thick tuffaceous claystone (Ply C marker) occurring in the middle of the seam (Figure 3). The upper section contains Plies A, B and C-upper, and the lower section contains Plies C-lower, D, E, F and G.

Agnew and Bayly (1989) proposed that the "Ulan seam" could be correlated with the upper Lidsdale Coal on the basis of a thin correlatable tuffaceous claystone which has an extraordinarily high gamma response. This claystone band occurs between the upper and lower seams of the Lidsdale Coal in the Rylstone area, and comprises Ply F of the "Ulan seam" at Ulan and Bylong (see Agnew & Bayly 1989, fig. 4).

In the present study, however, it has been found that only the lower section of the "Ulan seam" can be correlated with the Lidsdale Coal. The Lidsdale Coal ranges in thickness from 5 m to 8 m in most of the study area (Figures 2, 4). It thins to 2 m at the western margin of the basin, but thickens to a 13 m interval in the Bylong area including a medium-grained sandstone and claystone band occurring above the coal seam. The Lidsdale Coal contains the best-quality coal plies in the study area.

Long Swamp Formation

The Long Swamp Formation is defined as having its basal boundary at the top of the Lidsdale Coal (Bembrick 1983) and its upper boundary at the base of the Irondale Coal. The formation consists of claystone, mudstone, siltstone, tuff bands, sandstone and thin discontinuous coals. The claystone and siltstone are commonly bioturbated. West of the Wollar hingeline, the formation is represented by a thin tuffaceous claystone band ("Ulan seam" C-marker) and an overlying coal seam (the upper section of the "Ulan seam") (Figure 2).

The upper section of the "Ulan seam" includes Plies A, B and C-upper. The A, B and C-upper plies, totalling up to 7 m thick between Ulan and Wilpinjong, split eastwards into thin multiple, discontinuous coal bands. At Bylong this interval is 20 m thick. The C-marker ply maintains a consistent thickness of 0.3 m from Ulan to Wilpinjong, then thickens eastwards at the Wollar hingeline to split the upper section of the "Ulan seam" further from the Lidsdale Coal (Figure 2). The interval equivalent to the C-marker at Bylong is approximately 25 m thick, and consists of siltstone, lithic sandstone and minor carbonaceous claystone. Density and gamma logs show the seam split throughout the study area (Figure 4).

East of the Wollar hingeline, the Long Swamp Formation contains thick, fining-upward channel sandstone lenses with green and red volcanic pebbles and granules. A similar sandstone occurs in the west Rylstone area (Bayly pers. comm. 1990). These lenses are considered to have been derived from the New England area during uplift of that particular block.

Irondale Coal

As mentioned above, the upper section of the "Ulan seam" is split east of the Wollar hingeline and interfingers there with bioturbated claystone and siltstone of the Long Swamp Formation (Figures 2, 4). The uppermost ply of this section (Ply A top) can readily be traced from Ulan to the Wollar hingeline, where eastward splitting occurs. East of the Wollar hingeline, it is possible to correlate the various split plies between boreholes with the assistance of downhole geophysical log data (Figure 4).

Re-examination of borehole graphics and downhole geophysical logs for the area from Lithgow through Rylstone to Bylong indicates that the uppermost ply of the upper section of the "Ulan seam" at Bylong is correlated with the Irondale Coal of the Lithgow-Rylstone area (Bayly and Yoo in prep.). This confirms the palynological evidence of McMinn (1985) that the top of the "Ulan seam" outside the study area can be correlated with the top of the Irondale Coal. The Irondale Coal reaches a maximum thickness of 1.5 m east of the Wollar hingeline.

Newnes Formation

The Newnes Formation in the study area, consists generally of fine to medium-grained, lithic sandstone and interbedded siltstone and claystone west of the Wollar hingeline, and an upward-fining coarse lithic sandstone east of the Wollar hingeline.

The formation conformably overlies the Irondale Coal; its upper limit is marked by the base of a thin coal/carbonaceous claystone band which is expressed by low density log values (Figure 4). The formation ranges in thickness from 8 m to 13 m west of the Wollar hingeline but thins to 4 m at
The sandstone within the formation typically has low gamma log values east of drillhole ERC Ulan 2. This characteristic profile disappears west of ERC Ulan 2, as the lithology of the formation and the lower part of the overlying Glen Davis Formation both become similarly fine to medium-grained lithic sandstone.

Glen Davis Formation

The Glen Davis Formation consists of carbonaceous claystone, claystone, siltstone and sandstone. East of the Wollar hingeline, the claystone and siltstone are commonly bioturbated. The unit is overlain by the Denman Formation east of the Ulan hingeline and by the Moolarben Coal Member west of the Ulan hingeline (Figures 2, 4). It contains two thin, uneconomic coal seams, the upper of which is referred to as the Bungaba Coal Member in this paper. The formation ranges in thickness from 17 m to 26 m throughout the study area.

A thick quartzose sandstone comprises the upper part of the Glen Davis Formation west of the Bylong hingeline. This sandstone is herein named the Cockabutta Creek Sandstone Member, and is interpreted as having been derived from the Gulgong Granite in the immediate west.

Cockabutta Creek Sandstone Member (new name)

The Cockabutta Creek Sandstone Member consists of light grey, quartzose to lithic-quartzose, very coarse-grained sandstone. It fines upward and is poorly cemented towards the base. The thickness ranges from 2.5 m to 9.8 m, and is 7.8 m at the type section. The type section is taken from JDP Ulan DDH 18, between the depths of 103.83 m and 111.63 m. This drillhole is located 8 km east of Ulan township (Wollar 1:25,000; 8833-2-N, 1427419.7 N).

Figure 4. Coal-seam coalescence of the Lidsdale Coal and the upper section of the "Ulan seam" in the lower part of the Illawarra Coal Measures between Wollar and Bylong.
drillhole AB Bylong DDH 4. The sandstone within the formation typically has low gamma log values east of drillhole ERC Ulan 2. This characteristic profile disappears west of ERC Ulan 2, as the lithology of the formation and the lower part of the overlying Glen Davis Formation both become similarly fine to medium-grained lithic sandstone.

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**Figure 5. Geographic extent of the Cockabutta Creek Sandstone Member of the Glen Davis Formation.**
The sandstone member forms an oval-shaped lobe of approximately 1000km² in the Ulan-Wollar area, bounded by Merotherie in the west, Uarbry in the north, Wollar in the east and south, and Ulan in the southwest (Figure 5). It is exposed on the bank of Cockabutta Creek (Narragamba 1:25,000; 8833-4-S, AMG Grid Reference 498 332) and in the Ulan Mine opencut. It is also well exposed in the Goulburn River diversion channel at the Ulan Mine (Conaghan pers. comm. March 1993).

The Cockabutta Creek Sandstone Member is remarkably similar to the Blackmans Flat Conglomerate in that it consists predominantly of quartz, cemented with minor kaolinitic white clay. It has a very porous texture. The member consists of very coarse sandstone with a distinct sharp base, and fines upward. It is considered to have been derived from the adjoining Gulgong Granite in the west, and is strikingly different in lithology from any other part of the formation. The Cockabutta Creek Sandstone Member is overlain by the Bungaba Coal Member developed at the top of the Glen Davis Formation (Figures 2, 6).

Bungaba Coal Member (new Name)

The Bungaba Coal Member is the topmost unit in the Glen Davis Formation. It consists of coal and carbonaceous/tuffaceous claystone. Although this member is thin and variably banded, density-log profiles show it to be continuously developed throughout the study area (Figure 2). At the type section (DM Narragamba DDH 4), it is 3.47 m thick (between 46.97 m and 50.44 m). The drillhole is located 22 km north-northeast of Gulgong (Narragamba 1:25,000; 8833-4-S, ZSG Co-ordinates 358210 E, 1438170 N). The member overlies the Cockabutta Creek Sandstone Member and is overlain by a 0.7 m-thick kaolinitic claystone west of the Ulan hingeline and by the Denman Formation east of the Ulan hingeline. West of the Ulan hingeline, this coal member (the lower coal seam in the upper part of the highwall in Figure 6) is coalesced with the Moolarben Coal Member (the middle and the upper coal seams in the highwall in Figure 6) of the State Mine Creek Formation. These coals form a banded coal seam up to 13.6 m thick northwest of Ulan (Bayly 1993). Eastward splitting of the Bungaba Coal Member away from the Moolarben Coal Member with which it is coalesced in the western margin area is illustrated in Figures 2 and 7.

Denman Formation


The Baal Bone Formation of Bembrick (1983) in the Western Coalfield, the Denman Formation of Britten (1972) in the Hunter Coalfield, and the Dempsey Formation of David (1907) in the Newcastle Coalfield represent the record of a short-lived, widespread marine incursion in those areas of the Sydney Basin (Bembrick 1983). Recent studies within the Western Coalfield (Bembrick 1983, Moloney et al. 1983, Crapp 1985, McElroy Bryan & Associates 1983) and further eastwards, between Bylong and Denman (Holmes 1975, Yoo in prep.) indicate that the genetically-related interval comprising the Denman Formation and the overlying Watts Sandstone has a distinctive and readily recognisable lithofacies in the Illawarra Coal Measures and the Singleton Coal Measures. The interval grades vertically from dark grey claystone through laminated claystone and fine sandstone with common bioturbation, into fine-grained lithic sandstone of possible delta-front environment. Therefore, the term Baal Bone Formation is here regarded as a synonym of the Denman Formation of Britten (1972). The Denman Formation (Standing Committee on Coalfield Geology of New South Wales 1974) has priority over the Baal Bone Formation (Standing Committee on Coalfield Geology of New South Wales 1986), and is proposed to be used in both the Hunter and Western Coalfields. Although the Dempsey Formation has been known to be equivalent to the Denman Formation, the correlation between the two units has not been well established due to discontinuity of the two units over the Lochinvar Anticline and scarcity of drillhole data south of the Lochinvar Anticline. Until further data are available, the term Denman Formation remains valid (Beckett pers. comm.).

The Denman Formation thickens gradually in an easterly direction, from 20 m at Bylong (in AB Bylong DDH 8) to 50 m at Denman (in DM Doyles Creek DDH 13). The western limit of the marine incursion that formed this section occurs in the study area approximately at the Ulan-Turrill-Cassilis road (Figure 1). Its northwestern limit is located approximately at Coolah (Yoo et al. 1983).

Watts Sandstone


For similar reasons to those
Figure 6. Open-cut-mine highwall at the Ulan Coal Mine showing the basal part of the Illawarra Coal Measures documented in this paper and coalesced coal-seam interval at the top of the Glen Davis Formation and the base of the State Mine Creek Formation. The highwall is 50 m high and the exposed succession is as follows: "Ulan seam" (in floor of pit and at base of distant endwall) (us); lithic sandstones of the Newnes Formation and the Glen Davis Formation (light-coloured interval) (ng); Cockabutta Creek Sandstone Member (grey-coloured interval) (kb); Bungaba Coal Member of the Glen Davis Formation (bg); kaolinitic claystone band, representing the base of the State Mine Creek Formation; Moolarben Coal Member of the State Mine Creek Formation (ml); and overlying clastic sediments of the State Mine Creek Formation (sm). The Gap Sandstone and the Farmers Creek Formation are not present here.

applied to the Denman Formation, the Angus Place Sandstone of Bembrick (1983) is regarded herein as a synonym of the Watts Sandstone of Britten (1972). The Watts Sandstone (Standing Committee on Coalfield Geology of New South Wales 1974) has priority over the Angus Place Sandstone (Standing Committee on Coalfield Geology of New South Wales 1986, p. 156), hence, the term Watts Sandstone is used in the present paper.

The Watts Sandstone is 15 m in thickness east of Bylong (in AB Bylong DDH 8) and 28 m at Denman (in DM Doyle Creek DDH 15). It is overlain by the Moolarben Coal Member of the State Mine Creek Formation.

State Mine Creek Formation

The State Mine Creek Formation overlies the Watts Sandstone and is overlain by the Gap Sandstone. It generally contains three coal units, claystone, sandstone and tuff interbeds.

The basal seam is the Moolarben Coal Member (Bembrick 1983), and the topmost seam has been informally called the "Lennox seam" (borelogs of JDP Ulan DDH 1 & 2, by Kirby 1975) and the "Goulburn seam" (Hughes 1991). North of the Ulan Coal Mine opencut, this seam and the Middle River Coal Member of the Farmers Creek Formation form one seam approximately 10 m in thickness (Hughes 1991) (Figure 7). The thickness of the formation varies from 20 m to 33 m.

Moolarben Coal Member

The Moolarben Coal Member was defined by Bembrick (1983) as a coal seam developed at the base of the State Mine Creek Formation. The "Goulburn seam" in the Bylong area is correlative with the Moolarben Coal Member (McElroy Bryan & Associates 1983, McElroy and Rose 1990). The Moolarben Coal Member overlies the Watts Sandstone east of the Ulan hingeline, and coalesces with the Bungaba Coal Member where the Watts
Figure 7. Coal-seam coalescence of the Glen Davis, State Mine Creek and Farmers Creek Formations of the Illawarra Coal Measures in the area immediately north of Ulan.
Sandstone and the Denman Formation have wedged out (Figure 2). The lower limit of the Moolarben Coal Member near the western margin is the top of the kaolinitic claystone band (0.7 m thick in DM Narragamba DDH 4) that occurs towards the middle of the coalesced coal-seam interval. This kaolinitic claystone band can be correlated with the Denman Formation and Watts Sandstone to the east (Figure 2).

The member consists of coal and a number of thin claystone bands. The coals split in an easterly direction as the interbedded claystone bands thicken, and the upper sections of the coal member thin out east of UCML C234 (Figure 2). The member varies in thickness from 1 m to 4.2 m.

The "Lennox seam" (in borelogs of JDP Ulan DDH 1 & 2, Kirby 1975) is the topmost seam of the State Mine Creek Formation, developed locally in the Ulan area. It consists of carbonaceous claystone and thin coal seam. The maximum thickness is 2.23 m at JDP Ulan DDH 1, and it thins out east of UCML C234. The term "Goulburn seam" was used for this interval north of the Ulan Mine opencut (Hughes 1991).

Gap Sandstone

The Gap Sandstone is a persistent off-white to light grey upward-fining, lithic, coarse to very coarse sandstone, commonly with pebbles at the base, and is readily identifiable over most of the study area. It is considered to be a sheet-sand, deposited in a fluvial environment. The Gap Sandstone is generally 4 m to 5 m thick over most of the area, increasing to 10 m in some places. The sandstone thins out towards the western margin of the basin (Figure 2).

Farmers Creek Formation

The Farmers Creek Formation, the uppermost unit of the Illawarra Coal Measures in the Western Coalfield, consists of coal, carbonaceous claystone, tuff, siltstone, claystone and minor lithic sandstone. The formation thins towards the west, being 30 m thick at Bylong, 10 m thick at Wollar and represented by 3 m of coal and tuffaceous claystone at Ulan.

Density-log profiles from the various boreholes indicate that the Farmers Creek Formation thickens eastwards due to the progressive addition of units at the top. The coal/carbonaceous claystone unit at Ulan and the lower part of the Farmers Creek Formation at Bylong appear to correlate with the Middle River Coal Member.

Middle River Coal Member

The Middle River Coal Member is the basal coal seam of the Farmers Creek Formation (Bembrick 1983). The interval was named the "Goulburn seam" in the Ulan area (borelogs of JDP Ulan DDH 1 & 2, by Kirby 1975). It consists mainly of carbonaceous and tuffaceous claystones and tills. The thickness of the coal in this area is approximately 3 m in the western margin area, but thickens to 10 m at Bylong.

CONCLUSIONS

Eastward thickening of the stratigraphic units of the Illawarra Coal Measures occurs across hingelines at Ulan, Wollar and Bylong. The Narrangaroo and Blackmans Flat Conglomerates maintain their thicknesses and lithologies throughout the study area. The Lithgow Coal, which is poorly developed in the Wollar area, thickens east of the Bylong hingeline. Only the lower section of the "Ulan seam" is a correlative with the Lidsdale Coal; this interval maintains its thickness throughout the study area. The upper section of the "Ulan seam" maintains its thickness eastwards to the Wollar hingeline, then thicken abruptly to become the Long Swamp Formation. The uppermost ply of the upper section of the "Ulan seam" can be correlated with the Irondale Coal. The Newnes and Glen Davis Formations occur throughout the study area and maintain generally uniform thicknesses. The quartzose Cockabutta Creek Sandstone Member comprises the upper part of the Glen Davis Formation west of the Bylong hingeline. It appears to have been derived from the Gulgong Granite in the immediate west. The Baal Bone Formation and the Angus Place Sandstone are correlatives of the Denman Formation and the Watts Sandstone respectively. Both units wedge out west of the Ulan hingeline where the equivalent interval is represented by a thin kaolinitic claystone band. The Bungaba Coal Member of the Glen Davis Formation and the Moolarben Coal Member of the State Mine Creek Formation coalesce west of the Ulan hingeline. The "Lennox seam" at the top of the State Mine Creek Formation and the Farmers Creek Formation coalesce west of the Ulan hingeline, where the intervening Gap Sandstone wedges out.
ILLAWARRA COAL MEASURES IN THE ULAN-BYLONG AREA

ACKNOWLEDGEMENTS

Thanks are expressed to Mr W. Hughes of Ulan Coal Mines Ltd for supplying graphics and geophysical logs of four boreholes used in this study and the two photographs published herein; Mr K. Bayly of the N.S.W. Department of Mineral Resources for his continuous cooperation; Ms N. Clark of the same department for the preparation of the borehole data; Mr W. Hughes and Mr F. Morris of Coalex Pty Ltd for advice and comments; the Electricity Commission of N.S.W. (now Pacific Power) and Mr A. Butta for permitting inspection of borecore; and Dr P. Conaghan of Macquarie University and Mr M. Armstrong of the N.S.W. Department of Mineral Resources for reviews of the manuscript. This paper is published with the permission of the Director-General, N.S.W. Department of Mineral Resources.

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Communicator: Dr. John William Picket

(Manuscript received 29-4-1993)

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