Disk 22

NERDDC PROJECT

Rept. Bk. No. 83/34

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES - A PRELIMINARY EVALUATION OF THE GEOLOGICAL STRUCTURE OF TELFORD BASIN

C.V. MURRAY-WALLACE[1]

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

ENERGY DIVISION

AND

ELECTRICITY TRUST OF SOUTH AUSTRALIA

COAL RESOURCES BRANCH

MARCH, 1983

---

[1] Current address: Department of Geology and Mineralogy University of Adelaide, S.A., 5001.

CONTENTS

FIGURES

PLATES

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES - A PRELIMINARY EVALUATION OF THE GEOLOGICAL STRUCTURE OF TELFORD BASIN

ABSTRACT

Telford Basin is an asymmetrically shaped synclinal basin containing sediments of upper Triass-Jurassic age, and covers an area of 25 km^2. Sub-bituminous coal occurs in three major series named the Lower, Main and Upper Series. These were deposited in an intramontane fluvio-lacustrine environment. The Lower and Main Series are pervasively faulted whilst the Upper Series appears unfaulted.

Four areas of the Telford Basin were initially considered potential targets for underground coal gasification (UCG) including the northwestern, eastern, southern areas and the Upper Series. This investigation, however, indicates that the potential in the southern area is very low.

The geological parameters facilitating UCG include coal seam continuity (determined by facies changes, faulting and folding), coal seam thickness, depth of coal and attitude, competence and permeability of surrounding strata and presence of meteoric and ground waters.

It is concluded that UCG may be feasible. Future studies, however, will have to quantify coal resources available for UCG. This will involve an extensive drilling programme including geophysically logged with fully and partially cored holes and several seismic traverses of the potential areas. Site characterization would also require hydrogeological studies and analysis of the strength of roof materials.

1. STUDY OBJECTIVES

The aims of this study are to identify potential target areas for underground gasification of inaccessible Leigh Creek coal measures. The gases produced would be suitable for use in a gas turbine electricity generation plant. The coal measures considered occur at depths below 200 m and would remain economically unexploitable by conventional open cut mining techniques.

In this study four portions of the Telford Basin (Figure 1) are identified as possible target areas for underground coal gasification. These areas include northwestern, eastern, southern and the Upper Series in the southwestern part of the Basin (Figure 2).

Besides many geological parameters, the study areas have in part been delineated by the maximum envisaged limit of mining outlined in the ETSA Forty Year Mine Plan, in association with available borehole data. At the time of writing, the Forty Year Mine Plan is considered a relatively accurate representation of the proposed areas of mining in the Telford Basin to 2021 (M. O'Brien, *pers. comm.*, 1982).

The study also highlights some of the problems in underground coal gasification presented by the local geology of the Telford Basin.

It must be stressed that this study is a preliminary investigation and involved only three months of study with one week devoted to fieldwork. It is hoped, however, that the conclusions obtained will form the basis for a more detailed feasibility study, involving additional drilling and geophysical surveys of the potential areas.

2. GEOLOGICAL PARAMETERS FACILITATING UNDERGROUND COAL GASIFICATION

2.1 Geological Parameters

Underground coal gasification (UCG) refers to the controlled burning of coal *in situ* producing a mixture of hydrogen, carbon monoxide and various other hydrocarbons with the calorific value dependent on the precise nature of the reaction (i.e., oxygen or air controlled combustion). (Nadkarni *et al.*, 1975; Zvyaghintsev 1977).

Two major factors influence the success of underground gasification of coal: 1) the quality of the coal, and 2) the geologic setting in which the coal occurs, (Bartel *et al.*, 1980). The latter forms the basis of this discussion.

The geological parameters influencing the feasibility of UCG for a given area include:

(1) Coal seam thickness should be in excess of 1.5 metres. This is because heat loss to adjacent strata reduces the thermal energy available to drive the endothermic gasification reaction, and thus lowers the heating value of the gas. (Bartel *et al.*, 1980).

Soviet experience suggests that such heat loss becomes unacceptable when coal seams are less than 1.2 metres thick (Bartel *et al.*, 1980).

(2) Depth to coal should be at least 90 metres, and preferably no more than 300 metres (Bartel *et al.* 1980, Westmoreland *et al.* 1978, Thompson *et al.* 1976, Zvyaghintsev 1977). At such depths adequate containment is provided for the UCG process. Moreover competition for coal resources that are recoverable by conventional surface mining techniques will not occur.

It should be pointed out, however, that studies such as Bartel *et al.* (1980), base the maximum feasible depth of UCG on economic as well as geological criteria. Thus the maximum depth to which UCG is viable will vary according to site characteristics and economic circumstances.

(3) The geological structure should be relatively simple. Optimum results are obtained in seams where major faults and folds are absent. Thus seam continuity represents an extremely important geological parameter.

(4) "A demonstrated resource should be available for a commercial operation" (Bartel *et al.* 1980, p. 1316), particularly when considering long term power generation. In estimating a reasonable minimum size for a deposit Clayton (1980) examines the requirement for a 300 MW power station operating for 20 years. If an overall energy conversion efficiency of 25% is assumed, the following minimum sizes of deposits are obtained:

Coal Type	Calorific Value MJ/kg	Coal Required 10^6t/a	Coal Required 10^6/20y
Lignite	10.0	3.8	76
Sub-bituminous	14.0	2.7	54
Bituminous	18.0	2.1	42

This is supported by Bartel *et al.* (1980).

Bartel *et al.* (1980) suggest that a period of 30-35 years of electrical power generation would require a demonstrated resource of 50-60 million tons of sub-bituminous coal. Alternatively, if bituminous coal is involved, an estimated 40-50 million tons would be required.

The need for large blocks of coal highlights the necessity that essentially undeformed coal resources be used (see 3 above).

Sub-bituminous coal resources have traditionally been preferred as such coal shrinks upon heating, this being considered a desirable characteristic. This feature however, is even more pronounced in lignites. Such coals shrink on drying and develop a strongly jointed, highly permeable zone behind the heated face, offering a very large surface of highly reactive char for the reduction reactions. Moreover they are easier to ignite and do not form a hard coke residue. Thus as Leigh Creek coal is of sub-bituminous/lignite rank, it is suitable for UCG.

(5) The coal seam(s) should be overlain and underlain by thick (ca. 2-3 times seam thickness), relatively competent and impermeable strata. Seams directly overlain by an aquifer should be avoided and thus coals directly overlain by sandstones should not be used.

Coal seams should have a moderate permeability (in the order of several hundred millidarcies), thus minimizing the influx of meteoric and ground water to the gasification zone and hence improving the burn.

Another noteworthy point is the ratio of vertical to horizontal permeability, as it ensures confinement of linking and gasification to the bottom of the coal seam, thus preventing only the top of the seam from burning.

2.2 Parameters examined in this study

Most of the above criteria (2.1) can be determined, although at varying levels of confidence. This is largely a reflection of the variable quality of the existing data, and is elaborated upon in Section 3.

An understanding of the three-dimensional geometry of the Telford Basin is obtained by construction of geological cross-sections, supplemented by several seismic traverses, and field studies.

(1) Where data are available coal seam thickness is easily determined on cross-sections, and is quantified by simple measurement. Rapid lensing of the major coal seams does not appear to occur and hence may not significantly influence this parameter.

(2) Depth of the coal is also determined by simple measurement. The maximum depth to which UCG is feasible, however, being strongly based on economic criteria, is beyond the scope of this discussion.

(3) The geological structure of the basin can be determined at varying confidence levels. Some areas are demonstrably

faulted, whereas others may appear so but only because of poor quality logging, or unrecorded deviation in boreholes. In this context, caution must be exercised when invoking faults to explain 'apparent' dislocations. Moreover, the exact nature of the faults remains problematic. Rapid lensing of seams and rapid seam splitting does not appear to be a characteristic feature of the basin, although the Upper Series consists of numerous thin seams of coal.

(4) Coal resources can be determined with reasonable confidence. When calculating the tonnage of coal required, one 500 x 500 x 15 metre block will provide 4.5×10^6 tonnes of coal (G. Kwitko, *pers. comm.*, 1982). This represents a conservative estimate. For the purposes of the NERDDC study, calculations of coal resources required for UCG will be based on a requirement for a 3 x 35 MW power generation option. This paper, however, does not attempt to quantify suitable coal resources.

(5) Only cursory consideration of the lithological characteristics of overburden immediately above and below the coal seams (permeability and competence) can be given. This is due to the limitations imposed by existing data and lack of time.

2.3 Reliability levels for the data used in this study

In an attempt to show data reliability, a reliability index (R1 to R4) is given for each drill hole. Although it may be argued that data confidence levels are too subjective to be of any practical use (i.e., one person's high confidence level is likely to be another's low confidence level), such a scheme is nevertheless required to distinguish good and poor quality data.

With this in mind a reliability index is arrived at by simply ranking the quality of data (Category one being most reliable). The scale is listed below.

R1 - geophysically logged with deviation (tropari) readings. Detailed lithological analysis based on a totally cored hole.

R2 - geophysically logged, but no deviation (tropari) readings available. Detailed lithological analysis, based on geophysical log interpretation.

R3 - no geophysical analysis, or deviation (tropari) readings taken. Reasonably detailed lithological analysis based on cuttings and core samples.

R4 - no geophysical analysis, or deviation (tropari) readings taken. Poor quality lithological log, with coal seam data aggregated. Coal seam omission, significant core loss with little chemical analyses of coal.

3. METHODOLOGY

3.1 Data Availability

Available data include borehole logs obtained during the 1950's, 1960's and early 1970's. This is supplemented by more accurate, geophysically logged boreholes with deviation surveys (tropari readings) made in 1978. Drilling at various locations around the Telford Basin conducted in 1981, has only been geophysically logged. The complete record of drilling is available at the Coal Resources Branch of the Electricity Trust of South Australia. The Department of Mines and Energy also has records of the drilling at Leigh Creek since the mine's inception. The latter records are stored on microfilm, but terminate at approximately mid-1978.

The more recent drilling (1979 and 1981) has not yet had the geophysical data interpreted. Currently, regression analysis is being used to formulate a computer model to predict the spatial distribution of coal seams within the Telford Basin (D. Swift, *pers. comm.*, 1982). However, this is only being done for the coal logged on the 1981 data, and thus detailed lithological logs for this drilling remain incomplete. Several seismic traverses of the basin conducted in 1978 are also available.

For the purposes of this study, time permitted only interpretation of coal from the 1981 geophysically logged boreholes. Borehole distribution plans are currently stored at ETSA and the S.A. Department of Mines and Energy.

Fault plans for the Leigh Creek coal basins are also available from ETSA and the S.A. Department of Mines and Energy. Caution must be exercised when using the fault plans, because the delineation of faults has largely been based on geological cross-sections, several of which have arrived at erroneous interpretations owing to the nature of the available data.

Proximate analyses of coal appear on many of the borehole logs, and are often used to distinguish coal from carbonaceous shale.

At the time of writing, no data were available regarding relative aquifer pressures throughout the sediments. Likewise very little detailed hydrogeological investigations have been conducted. Thus, data concerning aquifer recharge capacities are currently not available.

References concerning the geology of Leigh Creek are cited in this paper, whereas strength tests on core or joints are documented in several geotechnical investigations (Coffey *et al.* 1975, 1977a, b, c, d, e. 1978a, b. 1979a, b).

3.2 Necessary Assumptions

When constructing cross-sections caution must be exercised owing to the limitations imposed by the variability of available data. Besides the various limitations inherent in the data several tacit assumptions are necessary. These are:

- Boreholes without deviation surveys have to be assumed vertical. This is a safe assumption for holes drilled to moderate depths, in the order of 50 metres, but is not so for deeper holes.

- When constructing cross-sections, borehole data have to be regarded as accurate. Only upon the final production of a given cross-section can the validity of particular data be questioned. This facilitates greater consistency, and accuracy.

- Boreholes that do not precisely fall on the section line (i.e. positioned slightly along strike from the section line), have to be considered representative. In this study, care was exercised not to select boreholes too far away from the section lines.

3.3 Limitations of available data

The limitations inherent in the available data include:

- The aggregation of data on the earlier drill logs, making many of the coal seams appear thicker than they actually are. For example, a thick seam of coal may in fact comprise a sequence of shale, carbonaceous shale and coal.

- No deviation (Tropari) readings. This is extremely important because if a borehole is taken as being vertical, when in fact considerable deviation occurred during drilling, a fault may be invoked to explain the anomalous change in seam depth within a short distance.

- Problems also arise when attempting to correlate some of the very early drilling records (e.g., 1954), with more recent data. This is due to the comparative lack of detail of the earlier logs.

- Often the nature of the drilling results in the delineation of incorrect seam thicknesses. That is, on several occasions slightly thinner seams were intercepted than predicted. This may reflect whether rotary or percussion drilling was used, or whether core-loss occurred.

- A dearth of drillhole data in the areas primarily considered for UCG; these being outside the areas occupied by the ETSA Forty Year Mine Plan. Thus where coal measures occur at depths greater than 200 m, considerably less data are available. This is because conventional mining techniques have traditionally dictated where drilling is carried out.

  This necessitates the assumption that similar geological characteristics can be extrapolated from moderate depths to greater depths. This paper thus draws the inference that if a section at moderate depth is pervasively faulted it is likely to be faulted at greater depths.

It should be stressed that these observations do not represent a critique of the earlier drilling, or their subsequent interpretation. The earlier drilling was largely for the purpose of shallow open cut mining around the margin of the basin. In this context sophisticated drilling technology was not required. Moreover, geophysical analyses were not available until the late 1970s.

4. GENERAL GEOLOGICAL SETTING FOR THE TELFORD BASIN

4.1 Geological Setting

Accumulation of the Leigh Creek coal measures occurred within a relatively shallow intramontane basin during the Upper Triassic* (Parkin 1953, Johns 1973, Townsend 1975). According to Johns (1973) the separate lobes may represent remnants of a more ubiquitous sedimentary sequence deposited in a freshwater fluvio-lacustrine environment.

Evidence for a freshwater depositional environment is supported by the presence of Unio eyrensis, a freshwater mussel occurring in some of the more lithified, ferruginous-rich sandy-shale beds within the Lower Series overburden. Leighiscus hillsi, a comparatively rare species of fish, is also documented to occur within these sediments (Coats, 1973). Preliminary analysis of plant spores (Playford and Dettmann, 1965) has delimited an Upper Triassic age (Rhaetic) for the basin sediments, although later work (Hos, 1977, 1978) showed that the uppermost part may be Jurassic.

The Triass-Jurassic sequence is preserved within folded Adelaidean rocks resulting from a predominantly brittle deformational event. This comparatively localized example of brittle with associated ductile deformation is likely to have occurred during Early Jurassic times. This is elaborated upon in 4.4.

Adelaidean sediments locally representing basement to the unconformably overlying Triassic sequence were deposited within the Adelaide 'Geosyncline'.

4.2 Sedimentology

Deposition of the Triass-Jurassic sequence in Telford Basin occurred under freshwater conditions within an intramontane basin. The presence of the coal seams and Unio eyrensis indicates that the region was non-marine.

---

* see appendix for geological time scale.

During Upper Triassic times the basin was a fluvio-lacustrine environment (Parkin, 1953; Johns, 1972, 1973; Johns and Townsend, 1975; Townsend, 1978). In this environment meandering streams flowed across broad swampy floodplains which from time to time were the sites of temporary shallow lakes. The shifting of the stream (and hence deposition and erosion by the stream) across the floodplain, adds to the complexity of lithofacies distribution. Thus a clear understanding of the sedimentary features that characterize this type of complex environment is invaluable in establishing the feasibility for UCG.

One approach to developing an understanding of the sedimentary environment is to consider it in the context of a geological model. Geological models are "idealized simplifications set up to aid our understanding of complex natural phenomena and processes" (Reading (ed.). 1978 p. 9). A model describing a fluvio-lacustrine environment should be able to account for its variability, and to be equally well applied to a similar depositional environment elsewhere.

In connection with lacustrine environments, however, it should be stressed that such descriptions at best are generalizations. This is due to the highly variable character of the resultant deposits and because contemporary research on ancient lake sediments is in its infancy.

In fluvio-lacustrine environments coal forms in the poorly drained swamps and shallow lakes occurring on the floodplains bordering the river (Figure 3). Proximal sands occur within the meander belt preserved as overbank deposits and crevasse splays and above the basal conglomerate of the point bar deposits. Crevasse splays develop when coarser channel sediment is introduced to the floodplain by rupture (crevassing) of a levee during flood. These deposits form fans or tongues of sand elongated away from a crevasse cut in the river levee. The sands thin distally from the crevasse and have cross-lamination directions divergent from the adjacent channel sands. All the coarser sediments can later give rise to aquifers. In contrast, silts and clays deposited beyond the crevasse splays may eventually transgress the swamps producing confining materials to the underlying coals. The meander belt shifts its position on the flood plain through time, thus eventually leading to a complex suite of sediments that are highly variable both laterally and vertically. In humid settings the floodplain may never fully dry out and remain a backswamp or even a lake. Under these conditions vegetation dominates the flood plain and leads to the development of peats.

Given time, heat and pressure, the peats will be transformed to coal. This change is not sudden and involves some tens of millions of years. Coal, an organic substance primarily containing carbon and varying proportions of hydrogen, oxygen, nitrogen and sulphur, represents the fossilized remains of land vegetation.

The first stage of coalification is the formation of peat. This forms as a result of the compression and gradual decomposition of vegetative material, under additional layers of plant life. This change is represented by;

$$\underset{\text{(cellulose)}}{6C_6H_{10}O_5} = 7CO_2 + \underset{\text{(methane)}}{3CH_4} + 14H_2O + \underset{\text{(peat)}}{C_{26}H_{20}O_2}$$

Peat, the most primitive form of coal, contains approximately 90 percent water and decayed plant material.

The quality and usefulness of coal is largely determined by the pressure and heat exerted upon it. Thus neither the age nor the depth of a coal necessarily indicates its rank in terms of utility. As the higher the proportion of carbon to moisture in coal determines its heat value, a coal that has experienced greatest compression and condensation is ranked the highest. The various grades of coal listed in order of increasing rank include lignite, sub-bituminous, bituminous and anthracite.

The implications to UCG of such a model include:

- in any one stratum, permeability is highest near the palaeochannel (point bar and levee bank) deposits and decreases away from these;

- thinnest coal is found in the palaeochannel area and separated from permeable aquifers by strata having poor confinement. Water ingress in this zone has a high probability of being detrimental to successful UCG; and

- further away from the palaeochannels, the coal thickens and the confining sediments exhibit progressively lower permeability. Here water influx problems are minimized due to more effective confinement and isolation of coal seams and thus the surrounding materials are less capable of transmitting significant quantities of water or product gas. This is the most favourable site for UCG.

The majority of sediments in Telford Basin are finely laminated but appear massive (non-bedded) in outcrop. The relatively undisturbed nature of these sediments and the presence of clam shells and fish skeletons, indicates they were deposited below wave base, in shallow lakes, on floodplains that were regularly inundated with water. The relatively thick bedded and laterally persistent coal measures lend support to this contention. Occasional thin lenses of symmetrically ripple marked medium-fine grained sandstones occurring in the Main Series overburden, however, and polygonal mudcracks and gypsum in hardbars indicates shallowing in water depth with episodic exposure to subaerial conditions. Since the majority of the sediments are massive and laterally persistent, the problems resulting from rapid lensing or facies changes would not arise during UCG.

Occurring above the Upper Series coal measures, however, is a sequence of permeable sandstones. These would present problems for UCG (Section 5.2).

Although the origin of the sediments is not entirely clear, Townsend (1978, *pers. comm.*, 1983) suggests that a likely provenance for the sequence in Telford Basin is from the southwest, where Adelaidean sediments formerly provided the higher relief. This contention is based on the thinning of sandstones distally from the suggested source area. Proximal sands are suggested to be represented by thicker units.

It should be pointed out, however, that during Upper Triassic times, higher relief also occurred to the northwest and this could equally represent a source area. This would be expected as the Telford Basin is suggested to represent an intramontane basin. Moreover thinning of sands distally does not provide compelling evidence for a source area. Furthermore, the argument is circular as Cainozoic denudation has removed most of the sedimentary evidence upon which confident understanding of provenance may be based.

'Hardbars' : Epidiagenetic structures (?)

'Hardbar' is a generic term used locally to describe any lithology intercepted during drilling or in mine faces significantly harder than adjacent strata. The hardbars observed in the Telford Basin assume a variety of habits (Plates 1, 2 and 3) and their formation remains problematic.

Within the Lower Series overburden hardbars crop out as concretionary nodules, and continue along strike over considerable distances (> 1 km). Marked variability in the size of concretions is apparent with the largest observed attaining the dimensions of 1400 x 700 x 350 mm. The majority of the concretions however, are smaller with long axes in the order of 150 - 250 mm. The hardbars predominantly occur in discrete layers regularly intercalated with shales and occasional sands within the Lower and Main series overburden.

In the southern portion of the Telford Basin the concretionary nodules crop out at regular intervals (every 2-4 m). Their resistance to denudation has resulted in the higher relief in parts of the basin, as evidenced by the hogbacks and cuestas they form.

Exposed at depth within the mining pits of the Main Series overburden, the hardbars are massive. Here they assume a characteristic rectangular shape and contain fine grained pyrite and siderite within a silty matrix.

Coffey *et al.* (1978) suggest that the hardbars represent palaeosols, but a two-stage mechanism involving the interaction of primary sedimentary features with epidiagenetic activity is preferred. In this context subsurface initiation of weathering within a vadose zone can account for the concretionary features. The concretions are likely to form by similar processes responsible for spheroidally weathered granite tors.

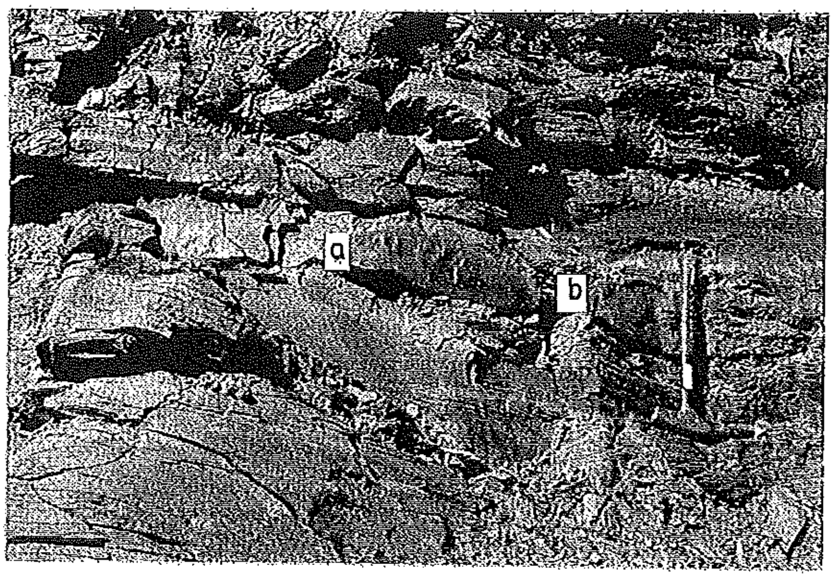


PLATE 1

Hardbars exposed in open pit within Main Series overburden (a,b). Note their resemblance to boudinage structures Hammer provides scale.

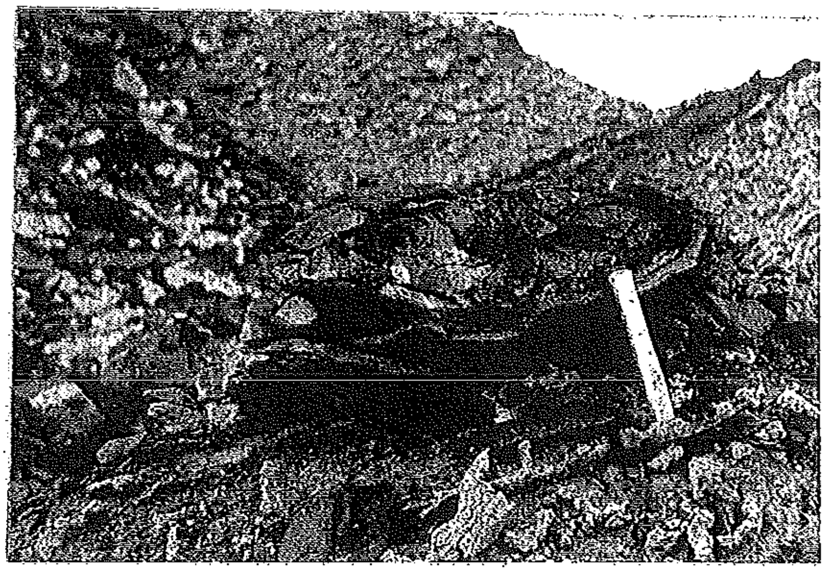
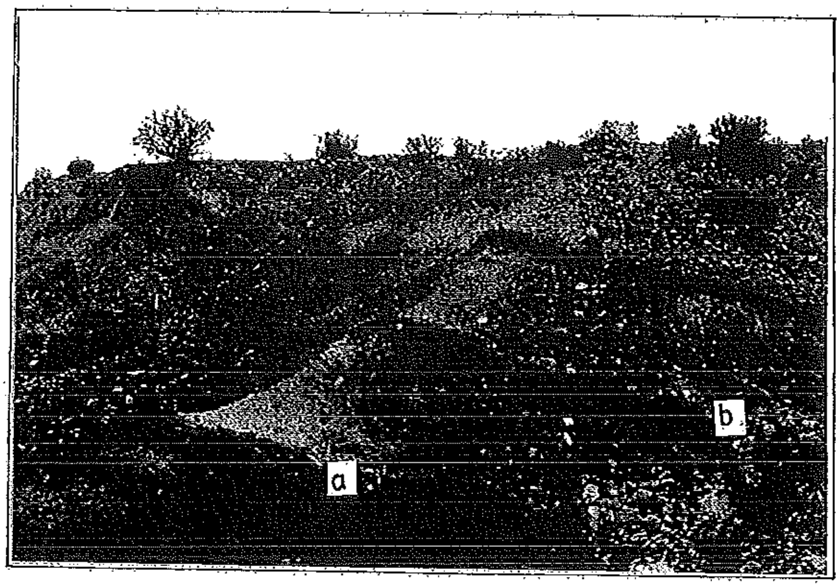


PLATE 2

Concretionary nodule ("hardbar"), in Main Series overburden. Hammer provides scale.



2m

PLATE 3

Hardbars in outcrop (a,b). Differential weathering gives rise to the linear outcrop pattern observed.

The first stage in their formation involves the initiation of weathering along joints, resulting in the transition from an essentially rectangular to a spheroidal shape. The second stage involves their exposure to subaerial conditions by denudation. Although this is termed a two stage process, in reality the processes occur concurrently.

Although concern is later expressed regarding the competence of the overburden lithologies, the 'hardbars' may counteract this problem. This will be largely dependent however, on the lateral persistence of hardbars.

4.3 Stratigraphy

The general stratigraphy of the Telford Basin is outlined by Parkin (1953), Playford and Dettmann (1965), Johns (1972, 1973), Johns and Townsend (1975), Townsend (1978), and Coffey *et al.* (1978).

The nomenclature invoked to describe the sequence of lithologies is after Coffey *et al.* (1978) (Figure 4).

The Triassic sequence unconformably overlies Precambrian siltstones and limestones. These were deposited during Adelaidean times within the Adelaide Geosyncline, and represent the Umberatana Group (Figure 5). This represents basement to the Triassic sequence and is usually encountered in the deeper boreholes.

The upper part of the folded basement siltstones and limestones are strongly weathered. The depth to the weathering front ranges between 10 and 30 metres below the unconformity surface (Coffey *et al.* 1978). The siltstones display a pronounced fissility and have a characteristic pale grey-green colour, and consist predominantly of silt-sized particles. However, numerous sand-sized particles with occasional well lithified nodules of silica or dolomite occur within the sequence.

The limestones are generally grey, laminated and contain silt-sized impurities. Below the weathering front the samples tested by Coffey have high strength ranges.

Resting directly above the unconformity is a succession of shales and mudstones followed by the Lower Series Coal (LC).

Lower Series Coal (LC)

This unit comprises a succession of thin coal seams (up to 5 m) intercalated with carbonaceous shales, and separated by beds and mudstone. Siltstone as well as occasional lenses of sandstone frequently interdigitate. Numerous 'hardbars' occur within this unit.

Lower Series Overburden (LO)

Overlying the Lower Series is a succession of dark grey to black mudstones and siltstones, containing a persistent sequence of 'hardbars'. They are considered in more detail in section 4.2.

These shales and siltstones are slightly more fissile than those in the Main and Upper Series overburden. This enables the rock to cleave, revealing a variety of flora and fauna viz., broad leaf plants including *Classopteris* sp., *Dicroidium* sp. and freshwater mussels *Unio eyrenis*. Rare fish *Leighiscus hillsi* has also been identified in LO (Playford and Dettmann, 1965).

Main Series Coal (MC)

The Main Series generally consist of a thick seam of coal and carbonaceous shale with minor shale partings. Coal seam thickness varies from 6 to 18 m. No hardbars are identified in this unit.

Seams may not be laterally persistent due to minor faulting post dating deposition, growth faulting and occasional facies changes. Moreover, as demonstrated by the 1978 drilling, the Main Seam frequently splits into two or more beds separated by mudstone, siltstone and carbonaceous shale partings.

Main Series Overburden (MO)

Resting above the Main Series Coal is a succession of dark grey mudstones and siltstones, characterized by lenses of rectangular shaped massive hardbars containing finely disseminated pyrite and its weathering products haematite and limonite as well as siderite. They are ubiquitous and frequently lens out. Sometimes they resemble boudinage structures. Their average thickness is in the order of 150 - 200 mm.

Thin (200 x 2000 mm) lenses of symmetrically ripple marked fine-medium grained sandstones are identified in the Main Series overburden. This, in association with polygonally mudcracked 'hardbars' (G. Kwitko *pers. comm.*, 1983), suggests subaqueous - subaerial deposition, and lends support to the notion of a fluvio-lacustrine environment. Gypsum within some of the hardbars indicates episodic exposure to subaerial conditions.

In the northern half of the basin the Main Series overburden attains a thickness of approximately 600 metres. Progressive thinning however, occurs and overburden thickness of only 120 m is observed on the southern limb of the basin. This characterises the asymmetry of the basin.

Upper Series Coals (UC)

Next in the succession are the Upper Series Coals with basal clays.

The Upper Series coal measures consist of 25 m of coal in approximately 10 seams in 80 m of carbonaceous mudstones and siltstones which are essentially free of hardbars. Although these coals were considered unfaulted, recent work (K. Slee *pers. comm.*, 1983) suggests that low angle thrust faults parallel to bedding may be present.

According to Coffey *et al.* (1978) defect spacing is wide to extremely wide. The most common defects are bedding plane joints.

Upper Series Overburden (UO)

Resting directly above the Upper Series coals is a sequence of poorly lithified sandstones interbedded with siltstones. The sandstones are sufficiently charged with groundwater to present a problem in UCG of part of the Upper Series. Few hardbars occur in this sequence. Coffey *et al.* (1978) term this sand unit Upper Series Overburden 1 (UO1).

Directly above the sands is a sequence of siltstones and mudstones with occasional sandstones. This sub-unit is described as Upper Series Overburden 2 (UO2).

Quaternary Surface Cover (QSC)

The Mesozoic sequence is unconformably overlain by a thin mantle of Cainozoic sediments. This surface cover includes:

(a) unconsolidated aeolian surface silts and fine, well sorted sands

(b) alluvial sands and gravel

(c) an occasionally well lithified poorly sorted conglomerate, locally termed Telford Gravel

(d) extremely weathered rocks including shale and coal derived from the underlying Triassic sequence

(e) and a resistant gypsum at some localities. The gypsum predominantly occurs directly beneath the conglomerate, although a genetic relationship is not inferred.

According to Coffey *et al.* (1978) in view of the generally shallow depth of Quaternary cover (i.e., generally less than 10 m) in relation to proposed depths of mining, no systematic study has been conducted to ascertain its spatial distribution, nature, or precise depth throughout the basin. However an inferred distribution of the Telford Gravels is described by Johns and Townsend (1975), and numerous unpublished ETSA studies.

The surface soils are characterised by their high permeability and often contain groundwater.

The Triassic age for the series of coals and associated overburden is also based on the occurrence of a Jurassic outlier preserved in the form of two isolated mesas near Copley (Plates 4 and 5). Here, Triassic strata are unconformably overlain by an outlier of essentially flatlying Upper Jurassic tabular cross-stratified sandstones (Parkin 1953, Johns 1973, 1978).

4.4 Structure

The Telford Basin is an asymmetrically shaped synclinal basin of Upper Triass-Jurassic age. It is an example of a large scale gentle fold, as the interlimb angle falls between 120° and 180°, (Figure 6). The basin covers an area of approximately 25 km^2. The asymmetry of the basin is likely to be controlled by a major fault which strikes along the southern perimeter (Figure 5).

Deformation appears to have been predominantly brittle (Plates 6, 7, and 8) with minor ductile deformation being observed at only one locality in the mine. For convenience two successive deformations are recognized: D_1 and D_2. The first post-dates deposition of Lower (LC) and Main (MC) Series coals and associated overburden (Townsend, 1978). During this event a series of normal faults, now commonly arranged in an *en echelon* pattern, were formed although a variety of other orientations are also found. Many of the fault planes are sub-parallel to bedding, whilst others truncate bedding at angles greater than 80°. This series of faults have the greatest displacement.

Associated with the series of normal faults are smaller scale, randomly oriented, parasitic faults. The parasitic faults also vary greatly in style, and reverse, low angle thrust, conjugate and occasional pivotal faults are recognised. The faults often given rise to mesocopic graben and horst structures, with displacement equal to or greater than seam thickness. In these localities the lateral continuity of the coal seams is greatly reduced and thus would present a problem for UCG. It is possible, however, that these fault bounded blocks occur on a

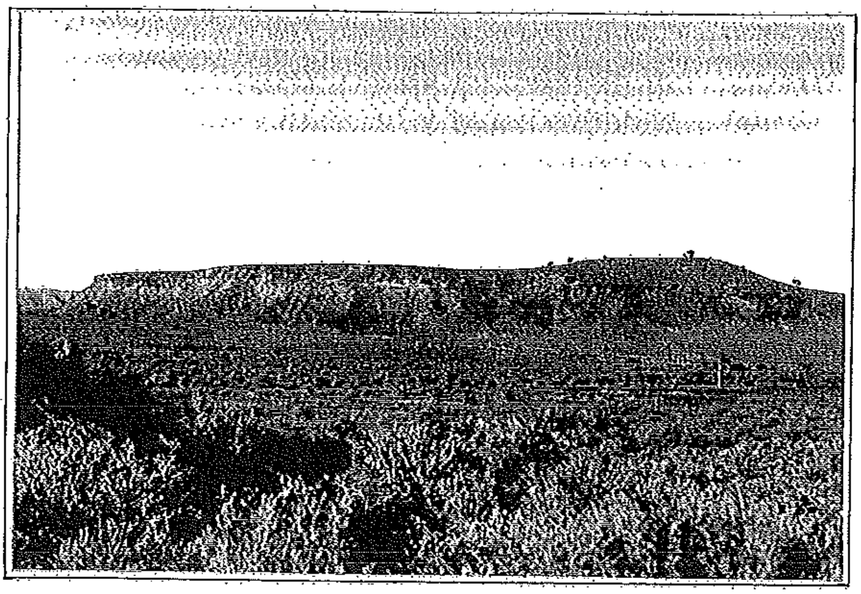


PLATE 4

Isolated mesa at Copley (looking south)

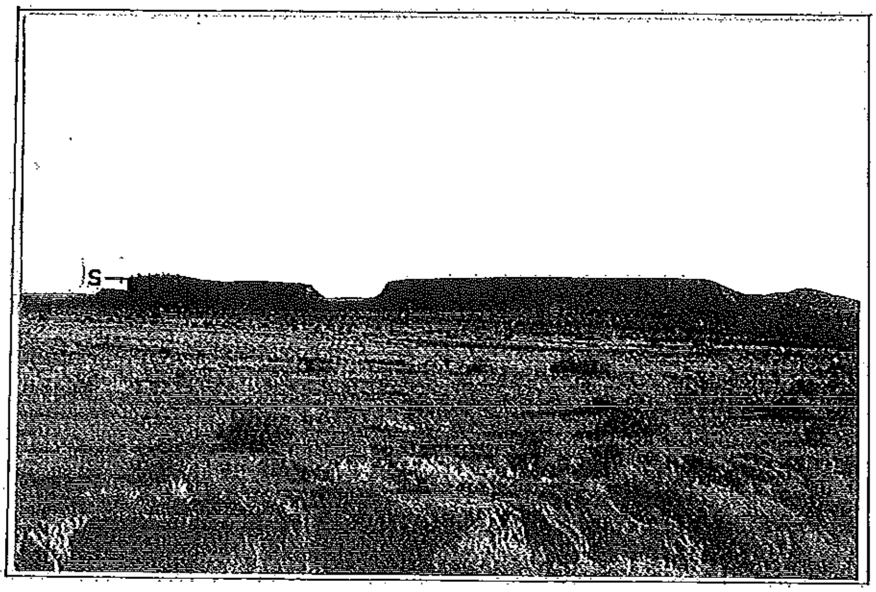


PLATE 5

Mesas at Copley comprising Jurassic tabular cross-stratified sandstone.
S. Silcrete capping (looking northeast).

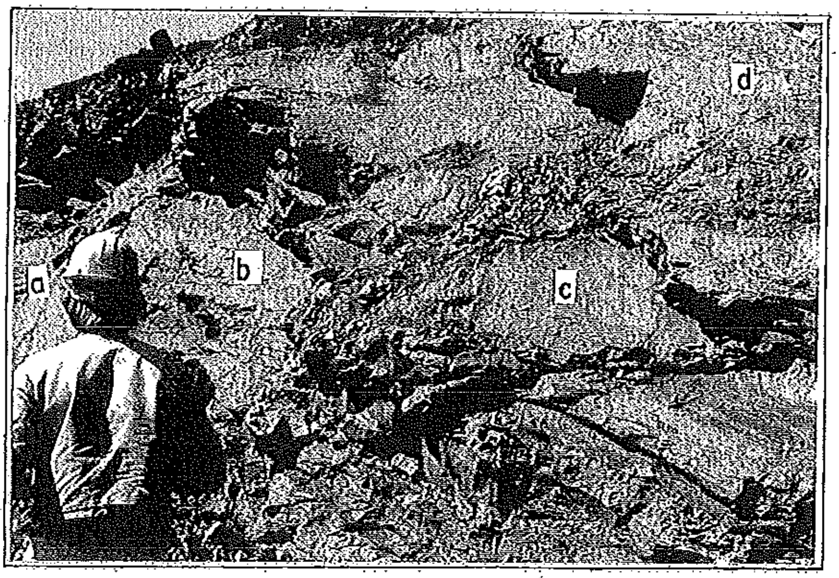


PLATE 6

Series of *en echelon* Faults sub-parallel to bedding in Main Series overburden. a,b,c,d - exposed fault planes.

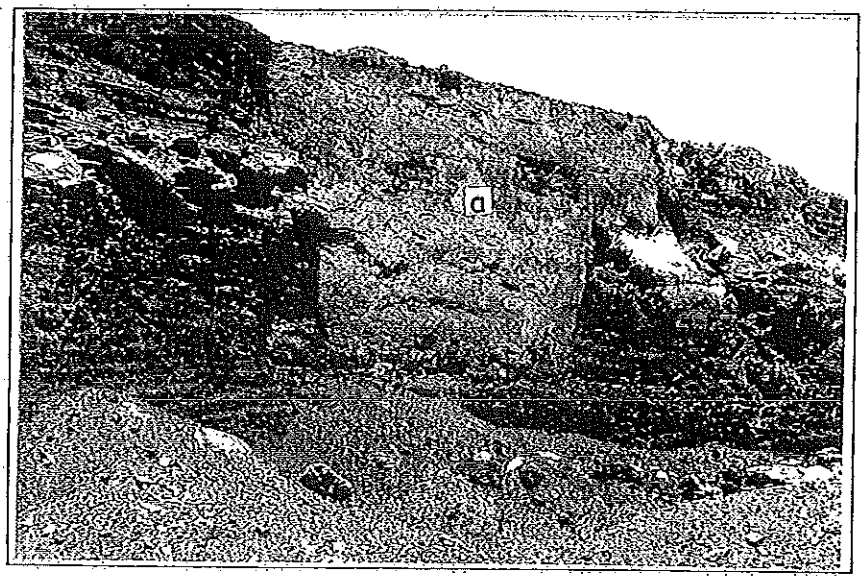


PLATE 7

Exposed Fault plane in Lower Series overburden.

2m

larger scale at greater depths and thus blocks of coal suitable for UCG may yet be delineated by future studies, when more accurate data are available.

An example of localised ductile deformation was identified along one fault during field studies. This was a normal drag flexure (sinistral displacement) and represents one of the few examples of ductile deformation observed in Telford Basin (Plate 9). The drag is likely to be an expression of an early history of limited ductile deformation followed by brittle fracture.

The first deformation D_1, involving heterogeneous simple shear is most probably a response to localised downwarping of the underlying Precambrian strata.

A second deformation D_2, involved the downwarping of the Upper Series (UC) coals and overburden (UO). Whether D_2 is a syn-sedimentary feature or post-dates deposition of (UC) remains unknown. The Upper Series is free of faults, although recent work (K. Slee *pers. comm.*, 1983) indicates that low angle thrusts which are essentially parallel to bedding may be present.

As stated earlier the nature of existing data presents problems in interpreting the details of structure of coal seam continuity at depths below 200 - 300 m. This is due to previous drilling activity being restricted to the margin of the basin where more accessible coals occur. Previous investigations, however, suggested that the margin of the basin is more faulted than the deeper parts (Johns, 1972; Johns and Townsend, 1975; Townsend, 1978). Although this would be expected as a natural response of strain distribution within folded strata (compression in the troughs of synclines and tension at the crests anticlines), caution must be exercised in stating that the trough of Telford Basin is relatively free of faults.

This is especially so in view of the problems encountered with data collection. The 1978 seismic traverses are a case in point (Figures 7 and 8). Problems in transmission of shock waves through the mantle of Cainozoic sediments and regolith of Triassic strata resulted in reduced resolution at depth. Thus fault delineation became difficult at depths below 800 m.

Slickensided surfaces on the footwall of fault planes are well preserved in the open pits. Few joints have been identified with confidence that result from unloading of overburden in physically homogeneous rocks.

The presence of faults and joints has several implications for UCG viz.,

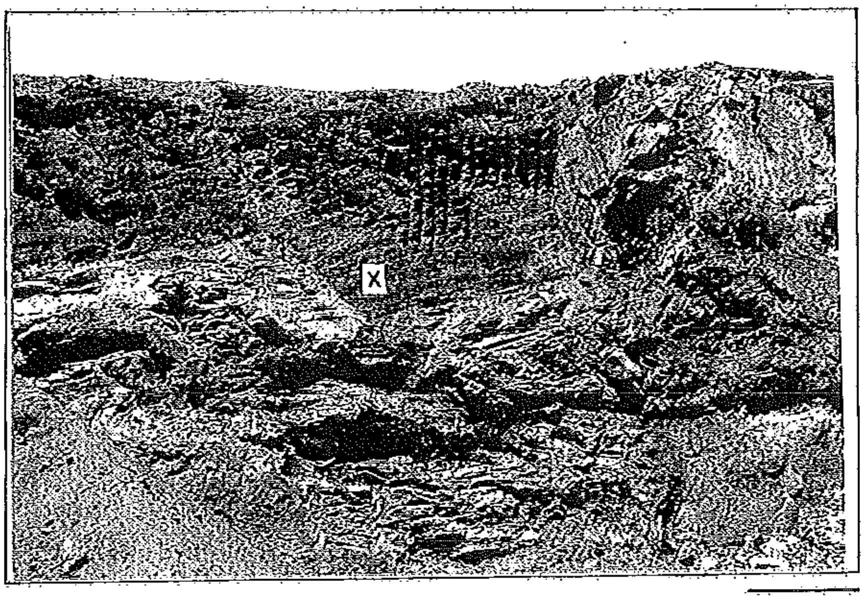
- preventing continuation of burn if faults have throws greater than half seam thickness

- collapse of roof materials owing to renewed movement along fault planes during burn

- escape of gases along faults and joints, and the possibility of contamination of groundwaters

- the translocation of meteoric and ground waters along fractures, extinguishing the flame front.

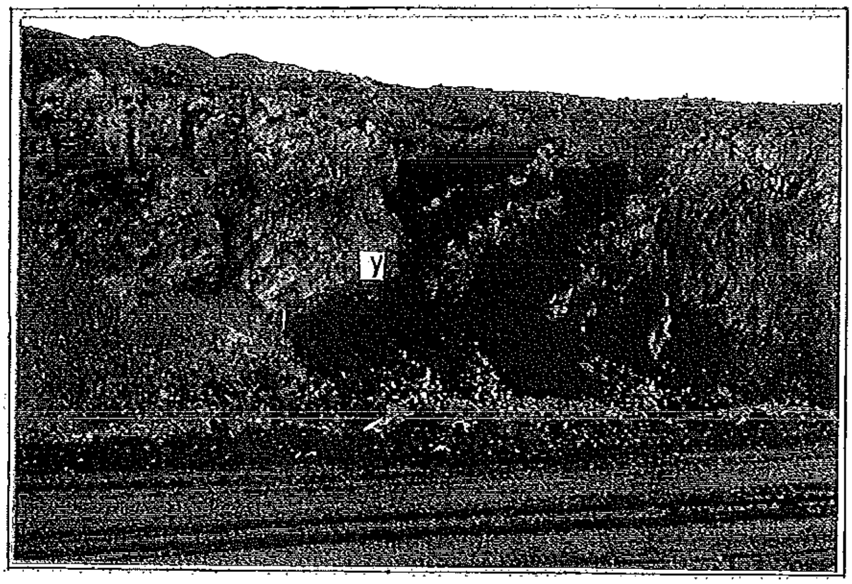
Further studies of the above in connection with Telford Basin are necessary (see Section 7).



1m

PLATE 8

Mesoscopic graben structure in Lower Series Coal Measures, Telford Basin.



2m

PLATE 9

High angle reverse fault with associated drag flexure in Main Series Coal.

5. TELFORD BASIN, LOBE B : INTERPRETATION

5.1 Main and Lower Series Coal Measures

5.1.1 Southern Area

The structure and stratigraphy of the southern portion of the Telford Basin is arrived at using cross-sections along dip (sections H1500, H2300, H2600). These sections represent a distance along strike of just over 1 km.

Analysis of borehole data collected in 1954 in association with that of the early 1970s and those geophysically logged in 1978 is made. The problems and limitations of available data encountered are outlined in Section 3.

Structure

The limitations imposed by the data necessitate a moderate confidence level regarding the three-dimensional geometry of the southern area of the Telford Basin. From the data available, however, it is apparent that the study area is characterised by a succesion of moderately to steeply dipping Main and Lower Series coal seams, with average dips in the order of 35-40° NNE. Maximum dips in the order of 60° NNE are also recognised, however these are generally obtained towards the western portion of the area. This variation is attributed to a general shallowing of dip progressively along the margin of the basin in an easterly direction.

The area is extensively faulted. Brittle deformation is likely to have occurred penecontemporaneously with down folding during Early Jurassic times, post-dating depositional phase 1. Faults strike in a predominantly northwest-southeasterly direction (Parkin, 1953). This contention is supported by sections constructed for the southern portion of the basin.

Displacement along faults varies from a micro- to a mesoscopic scale, with maximum displacement in the order of several tens of metres. Variation in fault geometry is apparent with the presence of normal and reverse faults, occurring in association with conjugate, and low angle thrust faults. Occasional pivotal faults also occur within the anastomosing framework of faults.

Regrettably, the nature of borehole data prevents accurate delineation of fracture style. Thus, whether displacement occurs along discrete faults, or within minor shear zones remains problematic. Field studies suggest the presence of both.

Field work has identified considerable variability in fault style and geometry. Several growth faults displace Main and Lower Series coal respectively. Evidence supporting their presence is seen in the Main Series overburden. Here, faults with displacements greater than one metre die out very quickly several metres below the coal seam (K. Slee *pers. comm.*, 1983).

Minor graben and horst structures within the Main and Lower series coal are identified. A series of normal and conjugate sets of faults has produced these features. Individual graben and horst structures frequently occur within short distances (ca. 10 m) and displacements along their bounding faults is often in the order of 2-3 m. The frequency of faults and the magnitude of their displacement suggests that this area may have a very low potential for UCG.

Within the open pits slickensided fault planes are remarkably well preserved. Frequently, movement along these surfaces is reinitiated by off-loading of the overburden. The ease with which movement occurs along these surfaces indicates that the sediments may form poor roof materials.

Stratigraphy

The Lower Series Coal Seams appear to lens out, leaving only the Main Series to the west in the area considered. This feature is likely to be associated with the major lineament striking essentially east-west, along the southern perimeter of the basin. The lineament representing a major fault can be identified on conventional aerial photographs. This feature is represented on Figure 5 and is observed to displace even the underlying Precambrian sequence.

The sequence developed in the southern portion of the Telford Basin, as throughout the rest of the basin, rests unconformably on Precambrian siltstones and limestones. This represents basement to the Triassic sequence and is usually intercepted in the deeper boreholes. The exception to this is along the margin of the basin where it is intercepted at shallow depths.

The Triassic sequence developed in this study area includes the Lower and Main series coals and their respective overburden as well as Quaternary cover. Detailed descriptions of these lithologies is provided in section 4.3. Figure 9 summarises this sequence.

Tentative Conclusion : Southern Area

The potential for underground gasification of coal measures within the southen area is currently regarded as very low. This conclusion is primarily based on the pervasive nature of faulting within the area, a characteristic which prevented continuation of mining operations within this region. Here, displacement in the order of and greater than seam thickness considerably reduce seam continuity.

5.1.2 Northwestern Area

Structure

Understanding of the structure and stratigraphy of the northwestern portion of the basin is derived from several sections constructed essentially along dip (sections 1100, 1300, 1600 and 1700) and subsequent field work. Although the sections constructed are not exactly perpendicular to strike, the deviation is not great enough to result in erroneous interpretations.

True dips in the order of 17-22° SSE-S are recognised. Dip angles however increase as the strike approaches a southerly direction; this occurring out of the area considered. Here, dips in the order of 30-60° E are obtained.

The area is characterised by a series of faults often arranged in an *en echelon* pattern, giving rise to large faulted blocks of Main and Lower series coal. Conjugate faults producing small-scale graben and horst structures are also identified. They may be suitable targets for UCG if equivalent structures occur at greater depths and larger scales. The sequence of faults is suggested to have formed penecontemporaneously with the first deformational event D_1, post-dating depositional phase 1.

The cross-sections indicate that, within the limitations afforded by available data, the area is less faulted than previously considered. Although the area is less fractured than the southern margin of the basin, the frequency of fractures is likely to present a major problem for UCG, especially as many of the faults have displacements greater than half seam thickness.

Regrettably the quality of the data prevents accurate delineation of the style of faulting. Thus, whether displacement occurs along discrete faults or within minor shear zones is unknown, whereas the possible presence of monoclinal flexures adds to the complexity. Field studies however, show that displacement occurs predominantly along discrete faults.

Displacement along faults varies from a micro- to a mesoscopic scale. Displacements in the order of 20-30 m are recognised along some faults. A significant proportion of the faults observed have displacements in the order of half seam thickness or more, and it is likely that this feature continues at depth.

Fault drag is identified along one of the faults in this part of the basin, and represents one of the very few documented examples of ductile deformation observed within the basin. The style of flexure would present problems for UCG. Fortunately however, this does not appear to be a common feature of the basin.

The majority of faults are normal in style, truncating the coal seams in a sub-parallel orientation. The associated parasitic faults however, assume a variety of orientations and styles, and generally show smaller displacements.

Stratigraphy

As the area considered involves the margin of the basin and that immediately adjacent , the stratigraphy is essentially a repetition of the southern area. For this reason and the sake of brevity it will not be repeated here.

5.1.3 Eastern Area

Understanding of the structure and stratigraphy of the Eastern Area is derived from sections 1700a, b and 2000a, b.

Lower and Main Series coal measures occur in this area and have average dips in the order of 15-20° SSE. The Lower and Main Series coal measures are faulted towards the margin of the basin. This feature, however, appears to die out at depth, and thus presents a suitable target for UCG.

The Main Series Overburden includes shales with numerous hardbars. The hardbars are likely to provide strength for the roof materials during the burn. The stratigraphy of the area is the same as the southern study area and thus is not repeated here.

5.2 Upper Series Coal Measures

Regrettably, time did not enable detailed examination of the Upper Series. The Upper Series coal measures consist of 25 m of coal within an 80 m unit of sandy mudstone. The coal occurs in approximately 10 seams (Figure 10). The seams are laterally persistent, appear unfaulted and are thus suitable targets for UCG.

Occurring within the Upper Series overburden is a sequence containing poorly lithified sandstones interbedded with siltstones. This sequence is termed UO1 by Coffey *et al.* (1978). The coals in UO1 can not be gasified as they are directly overlain by fine, medium and coarse grained sandstones. In contrast the Upper Series coals occurring at greater depths can be gasified.

The sands in UO1 are permeable and often contain ground water. This presents a problem for UCG as groundwater could migrate along joints to the coal seams and extinguish the burn. Moreover, escape of product gas is likely owing to the permeability of the sands. The deeper coal measures within the Upper Series have high potential for UCG and require further investigation.

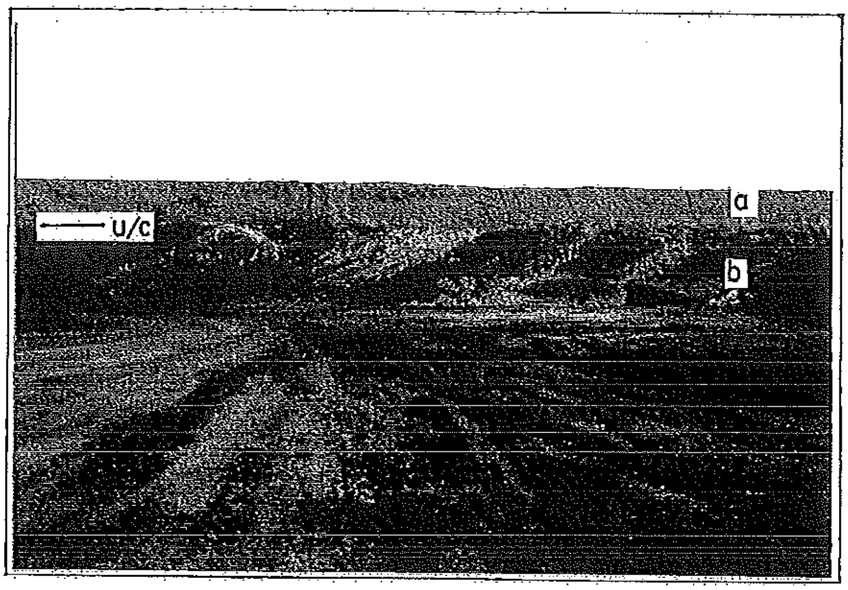


PLATE 10 Cainozoic sediments unconformably overlying Upper Series Coal Measures of late Triassic age.

a - Cainozoic sediments

u/c - unconformity

b - Upper Series Coal Measures and associated overburden.

6. CONCLUSIONS

6.1 Geological Conclusions

From the foregoing discussion the following geological conclusions are made;

(1) The sediments in Telford Basin are of Upper Triass-Jurassic age and were deposited in shallow water conditions within an intramontane basin. Sedimentation occurred within a fluvio-lacustrine environment.

(2) The provenance of the sediments can not be stated with confidence.

(3) Two deformational events are recognised. The first (D_1), post dates depositional phase 1 and involves brittle fracture of the Lower and Main Series coal measures, a response to tectonic downwarping of the underlying basement. The second deformation (D_2) involved the downwarping of the Upper Series coal measures and associated overburden, and is an example of ductile deformation.

(4) Coal seam discontinuity is mainly attributed to faulting. Considerable variation in fault geometry and style is evident.

(5) The Main and Lower Series coal measures are pervasively faulted, although the Upper Series appear unfaulted. Fault displacement in the former is commonly equal to or greater than half seam thickness.

(6) Whether the magnitude of faulting at the margin of the basin is higher than at the centre can not be determined with confidence.

6.2 General Conclusions Concerning UCG

In connection with UCG of inaccessible coal measures within the Telford Basin the following conclusions are made:

(1) The variability and often poor quality of data presents problems when considering UCG. As the data are not entirely suited to such a study, new data are required.

(2) Underground gasification may be feasible for the Main and Lower Series in the northwestern and eastern areas and the Upper Series. The potential, however, in the southern area is very low. The eastern area and the Upper Series appear most suited to UCG, followed by the northwestern area. It should also be pointed out that an area between the northwestern and eastern areas (not considered here), may be suited to UCG.

(3) The structure of the Telford Basin is more complex than previously considered and presents several implications to UCG:

- disruption of seam continuity by faulting (often greater than half seam thickness), preventing continuation of the burn;

- competence of roof materials is questionable and collapse may occur during burn; the presence of faults and joints may contribute to collapse;

- translocation of groundwaters along faults and joints to the coal seams may extinguish the burn; and

- possibility of escape of product gases through permeable roof materials or along joints and faults.

(4) If UCG takes place concurrently with open cut mining, shockwaves derived from explosions (for open cut mining), may damage boreholes required for UCG.

7. RECOMMENDATIONS

From the conclusions obtained several recommendations are made:

(1) An extensive drilling programme be made in the areas considered potential for UCG, involving:

- geophysically logged holes with deviation surveys
- fully and partially cored holes
- seismic surveys; and
- more detailed analysis of fault geometry and style.

(2) Geotechnical investigations to determine the strength of roof materials.

Although beyond the scope of this discussion, the following must be considered:

(3) Hydrogeological studies should be carried out to ascertain

- the water resources available for a commercial UCG operation
- the possibility of ground water extinguishing the flame front
- aquifer recharge capacity, and
- contamination of groundwaters

(4) Investigations must be carried out to establish the possibility of

- environmental pollution, and
- and problems in industrial relations

(5) Detailed cost benefit analyses must be made in order to establish the economic feasibility of a commercial UCG operation at Leigh Creek.

Finally, such studies must observe that not every site is amenable to underground coal gasification. Indeed, it is pointless to perform detailed site characterization if there is a commitment to gasification regardless of the results. Thus, if site characterization is performed, the investigators must be prepared to abandon that site for another if the results are unfavourable.

8 ACKNOWLEDGEMENTS

This research was supported by the Electricity Trust of South Australia and the South Australian Department of Mines and Energy. The author is indebted to Dr. N.F. Alley (Energy Division) and Mr. G. Kwitko and Mr. K. Wigglesworth (Oil and Gas) at the South Australian Department of Mines and Energy. The assistance and constructive criticism provided by Mr. M. O'Brien (ETSA, Coal Resources Branch) is also appreciated. The paper was reviewed by Dr. N.F. Alley, Mr. G. Kwitko, and Mr. M. O'Brien. The manuscript was typed by Miss Narelle Knight and Anna Fallarino.

C.V. MURRAY-WALLACE

9. REFERENCES

GEOLOGICAL

Beaumont, E.A. (1979): "Depositional Environment of Fort Union Sediments (Tertiary, Northwest Colorado) and their Relation to Coal". American Assoc. Pet. Geol. Bull. 63(2); 194-217.

Brown, D.A., Campbell, K.S.W., and Crook, K.A.W. (1969): The Geological Evolution of Australia and New Zealand. Pergamon Press, Oxford.

Coats, R.P. and Forbes, B.G. (1976): "Precambrian Geology of the Adelaide Geosyncline" in, LATE PRECAMBRIAN AND CAMBRIAN GEOLOGY OF THE ADELAIDE 'GEOSYNCLINE' AND STUART SHELF, SOUTH AUSTRALIA. 25th International Geological Congress Excursion Guide No. 33A p. 11-15.

Daily, B., Coats, R.P., and Forbes, B.G. (1976): "LATE PRECAMBRIAN AND CAMBRIAN GEOLOGY OF THE ADELAIDE 'GEOSYNCLINE' AND STUART SHELF, SOUTH AUSTRALIA". 25th International Geological Congress Excursion Guide No. 33A.

Daily, B., Firman, J.B., Forbes, B.G., Lindsay, J.M. (1976): "Geology" in, Twidale, C.R., Tyler, M.J., Webb, B.P. (Eds.). Natural History of the Adelaide Region Roy. Soc. of South Australia.

Hansen, E. (1971): "Strain Facies" in, Minerals, Rocks and Inorganic Materials Monograph Series of Theoretical and Experimental Studies. 2; 208 pp.

Harland, W.B., Smith, A.G., and Wilkock, B. (1964): "The Phanerozoic Time Scale". Geol. Soc. Lon. London. 458 pp.

Johns, R.K. (1972): "The Leigh Creek Coal Measures" Mineral Resour. Rev., S. Aust. 132; 145-154.

__________ (1973): "A Summary of South Australian Coal Deposits" S.A. Department of Mines and Energy Rept. Bk. No. 73/249; pp. 23-33.

__________ and Townsend, I.J. (1975): "Geology of the Leigh Creek Coalfield". Paper presented to, Aust. I.M.M. Conf. South Australia, June.

Mawson, D. and Sprigg, R.C. (1950): "Subdivision of the Adelaide System". Aust. J. Sci. 13: 69-72.

Murray-Wallace, C.V. (1982): "The Adelaide Geosyncline: Stratigraphy and General Geology: (unpubl.).

Parkin, L.W. (1953): "The Leigh Creek Coalfield" Geol. Surv. of S. Aust. Department of Mines. Bull. 31; pp. 74.

__________ (Ed.) (1969): Handbook of South Australian Geology. Geol. Surv. of S. Aust.

Phillips, F.C. (1979): The use of Stereographic Projection in Structural Geology. (Third Edition). Edward Arnold, London.

Playford, G. and Dettmann, M.E. (1965): "Rhaeto-Liassic plant micro-fossils from the Leigh Creek Coal Measures, South Australia" Senkenberg, leth. 46 (2/3); 127-181.

Ramsay, J.G. (1967): Folding and Fracturing of rocks. McGraw-Hill Book Company, New York.

Reading, H.G. (1978): Sedimentary Environments and Facies. Blackwell Scientific Publications, Oxford.

Townsend, I.J. (1978): "The Correlation and Depositional History of the Leigh Creek Coal Measures". S.A. Department of Mines and Energy. Rept. Bk. No. 78/140; pp. 10.

Wilson, R.G. (1976): "Estimating the Potential of a Coal Basin" in, Muir, W.L.G. (Ed.) Coal Exploration: Proc. of the first International Coal Exploration Symposium; London, England. May 18-21, 1976.

UNDERGROUND COAL GASIFICATION TECHNOLOGY

Bartel, L.C., Dobecki, T.L. and Stone, R. (1980): "Characterization of a Potential Underground Coal Gasification Site in the State of Washington:. Proceedings of the 15th Intersociety Energy Conversion Engineering Conference, Seattle, Washington pp. 1315-1320.

Clayton, J.M. (1980): "IN-SITU COAL GASIFICATION (REVISED)". AMDEL REPORT NO. 1328. Adelaide.

Edgar, T.F., Humenick, M.J., Kaiser, W.E., Carbeneau, R.J. (1981): "Environmental Effect of In-Situ Gasification of Texas Lignite". E.P.A., May.

Grupping, A.W. and Pieterson, R. (1970): "Underground Gasification of Coal: The Filling of Dipping Underground Cavities". (Source unknown).

Humenick, M.J., Edgar, T.F., and Charbeneau, R.J., (1982): "Environmental Effects of In-Situ Coal Gasification" pp. 38. (Source unknown).

Krantz, W.B., and Gunn, R.D. (1981): "An Overview of Underground Coal Gasification - A Comparison of Modelling Studies with Field Test Data". (Source unknown).

Ledent, P. (1981): "From Classical Mining to the Underground Gasification of Coal". Instelling Voor de Ontwikkeling Van de Ondergrondse Vergassing.

__________ and Beckervordersandforth Chr. P., (1979): "Joint Belgium-German U.C.G. - Field Test in Deep-lying Coal Deposits. 5th Underground Coal Gasification Symposium Alexandria, Virginia, pp. 119-126.

__________ and ____________________ and Chandelle, V. (1980): "Linking Study at Great Depth". 6th Underground Coal Gasification Symposium. Afton, Oklahoma, pp. 10.

Levie, B.E., Krantz, W.B., Camp, D.W., Gunn, R.D. and Youngberg, A.D., (1981): "Application of the Spalling - Enhanced Drying Model in Predicting Cavity Geometry and Operating Strategy for the Hanna 2, Phase 2 U.C.G. Field Test". 7th Underground Coal Gasification Symposium. Fallen Leaf Lake, California pp. 236-245.

McKee, C.R., Way, S.C. and Gunn, R. (1980): "Hydrologic Site Characterization for In-Situ Coal Gasification:. 6th Underground Coal Conversion Symposium. July 13-17, 1980 Afton, Oklahoma.

Nadkarni, R.M., Bliss, C., Watson, W.I. and Little, A.D., (1975): "Underground Gasification of Coal". Clean Fuels from Coal. Symposium II, Chicago, Illinois, pp. 611-637.

Schmidt, R.A. (1979): Coal in America. - An Encyclopedia of Reserves, Production and Use. McGraw-Hill Productions Co.

Schrider, L.A., and Wasson, J.A. (1981): "Eastern In-Situ Coal Gasification Field Trial". A.I.A.A. Vol. 5., No. 4.

Simeons, C. (1978): Coal - Its Role in Tomorrow's Technology Pergamon Press.

Stephens, D.R., Brandenburg, C.F. and Burwell, E.L. (1980): "Underground Coal Gasification". C.E.P., April.

Thomspon, P.N., Mann, J.R., and Williams, F., (1976): Underground gasification of coal. - A National Board reappraisal N.C.B. Harrow.

Westmoreland, P.R., Forrester, R.C., and Sikri, A.P. (1978): "In-Situ Gasification: Recovery of Inaccessible Coal Reserves". Alternative Energy Soruces. Vol. 7 Hydrocarbon Conversion Technology. (Ed.) Verziroglu. McGraw-Hill pp. 3113-3132.

Zvyaghintsev, K.N. (1977): "Underground Gasification of Coal in the U.S.S.R." in, M. Grenon (Ed.): Future Coal Supply for the World Energy Balance. Third 11ASA Conference on Energy Resources November 28-December 2, 1977. pp. 239-244.

GEOTECHNICAL REPORTS : TELFORD BASIN, LOBE B, LEIGH CREEK

Reports by Coffey and Partners Pty. Ltd. to ETSA on the Leigh Creek coalfields, with particular reference to Lobe B, pertinent to this and subsequent studies include;

Coffey et al. (1975): "South-eastern marign - Report on Geotechnical Studies for Slope Design". Report No. A183/1-1; 31 October, 1975.

____________ (1977a): "Report on Geotechnical Studies, Phase 3 - Field and Laboratory Studies". Report No. A183/2-1, 4 April, 1977.

____________ (1977b): "Report on Geotechnical Studies - Proposed Diversion of Leigh Creek". Report NO. A183/2-2, 18 May, 1977.

____________ (1977c): "Report on Geotechnical Studies Phase 3 Stability Analyses". Report No. A183/2-3, 27 July, 1977.

____________ (1977d): "Report on Geotechnical Studies - Mine Dewatering Studies". Report No. A183/2-4. 11 October, 1977.

________________ (1977e): "Report on Geotechnical Studies - Phase 3 Additional Stability Studies". Report No. A183/2-5. 30 November, 1977.

________________ (1978a): "Drainage Planning Study". Report No. A183/4A, 20 June, 1978.

________________ (1978b): "Spoil Dump Stability Studies". Report No. 183/4C, 18 July, 1978.

________________ (1979a): "Electricity Trust of South Australia". Leigh Creek Coalfield, Lobe B - Results of Geotechnical Investigation (1978)". Report No. A183/4E, 30 March, 1979.

________________ (1979b): "Stability Studies based on 1978 Geotechnical Investigation". (Report released during 1979).

APPENDICES

10. ABBREVIATIONS

D_1	-	First deformation
D_2	-	Second deformation
u/c	-	unconformity
Ma	-	1×10^6 years
MW	-	mega-watts
m	-	metres
mm	-	millimetres
UCG	-	Underground Coal Gasification
ETSA	-	Electricity Trust of South Australia
SADME	-	South Australian Department of Mines and Energy

GEOLOGICAL TIME SCALE WITH REFERENCE TO THE 'ADELAIDE FOLDBELT'

(Period designation after Harland et al., 1964)

(A)pproximate (a)ge in Ma.	Period / Division	Subdivision	Events
0	QUATERNARY	Holocene	
			10,000 y.
1.8		Pleistocene	
	TERTIARY		Episodic uplift during the Tertiary
65	CRETACEOUS		
136	JURASSIC		
193	TRIASSIC		Leigh Creek coal: Fluvio-lacustrine sedimentation in intramontane basins.
225	PERMIAN		
280	CARBONIFEROUS		
345	DEVONIAN		Prolonged cycle of denudation
395	SILURIAN		
440	ORDOVICIAN		Encounter Bay Granites 506 Ma.
500	CAMBRIAN		Cambro-Ordovician Delamerian orogeny. Folding, faulting and geosynclinal uplift.
			Archaeocyathids, trilobites, gastropods, brachiopods attain diversity.
570	PRECAMBRIAN – ADELAIDEAN	UPPER PROTEROZOIC	Ediacara fauna - world's first recorded Metazoa
			Wooltana and Depot Creek Volcanics ca. 1390 Ma.
1400?	PRECAMBRIAN – CARPENTARIAN	MIDDLE PROTEROZOIC	Initiation of sedimentation in 'Adelaide Geosyncline'. (?)
1600			Formation of crystalline basement ca. 1600-1800 Ma.
(Age) of Earth 4600 Ma.			

C.M-W.

11. GLOSSARY OF TERMS

AEOLIAN	Pertaining to or caused by wind. Dune fields for example, result from aeolian activity.
AQUIFER	Permeable rocks or other subsurface materials capable of producing water (as from a well).
BITUMINOUS COAL	Coal high in carbonaceous matter and gaseous constituents, having 20-40% volatile matter, and 80-90% fixed carbon and 5-10% moisture.
BRITTLE DEFORMATION	In this type of deformation rocks deform by developing marked discontinuities across which there is often a break in cohesion (e.g., faults).
BOREHOLE DEVIATION	A measure of eccentricity (deviation) of the bore from the vertical.
BOUDINAGE	(Fr. boundin, 'sausage'). A minor structure resulting from tensional forces. It develops by the stretching of a competent bed along bedding planes, giving rise to pull-apart structures, tension cracks or necks, which may become filled with incompetent material from either side. The usual appearance in cross-section is that of a string of sausages.
CAINOZOIC	The division of geological time which succeeds the Mesozoic and ends at the Quaternary. The duration is approximately 63 Ma extending from 65 Ma ago to 2 Ma. ago.

COMPETENCE	Referring to rocks that during folding, flex without appreciable flow or internal shear. Competency of rocks is a relative term, depending to some extent on the surrounding rocks, i.e. a rock in one situation may act as a competent horizon while in other circumstances an identical rock may act incompetently.
CUESTA	(Sp. 'Flank, slope'). A ridge formed of a gently inclined surface parallel to the dip of the bedding planes, and an escarpment or scarp face which is steeply inclined in the opposite direction to the dip slope and cutting across the bedding planes.
DENUDATION	The sum total of the processes resulting in the general lowering of the landscape. Weathering, transportation and erosion are involved in this process.
DIP	The maximum angle of inclination of a given stratum from the horizontal.
DUCTILE DEFORMATION	When rocks deform by distributing the strain in a smoothly varying manner throughout the deforming mass, it is said to have undergone ductile deformation. (e.g. as in a fold).
EN ECHELON	Attributed to geological structures having a parallel orientation.
EPIDIAGENETIC	Alternation of consolidated strata within a vadose zone (i.e., above the water table).

FACIES	The sum total of features such as sedimentary rock type, mineral content, sedimentary structures, bedding characteristics, fossil content etc., which characterise a sediment as having been deposited in a given environment.
FAULT	A fracture or fracture zone in rocks along which there has been displacement of rocks on one side relative to the other.
FLUVIAL	Of, or pertaining to, rivers; growing or living in streams or ponds; produced by river action, as a fluvial plain.
GEOPHYSICAL	In this context, means information obtained through exploration methods such as seismic, electrical, gravity, magnetic, thermal, gamma ray and other tests.
GEOSYNCLINE	An large actively subsiding trough in which sediments accumulate.
GRABEN	A downthrown block between two parallel faults.
HOGBACK	A linear, ridge formed on resistant, steeply dipping sediments producing opposing slopes of roughly the same inclination by the erosion of upfolded layers of rock.
HORST	An upthrown area between two parallel faults. Horst and graben structures commonly occur together.
IN SITU	(L. 'in place') Referring to rocks found in place as opposed to material derived from another locality.

INTRAMONTANE BASIN	A sedimentary basin located within a series of mountains.
JOINT	A fracture in rock along which no appreciable movement has occurred.
LACUSTRINE	A lake environment.
LIGNITE	Lowest rank coal, with low fixed carbon (60-75%) and high volatile matter (45-55%) and moisture (50-70%).
LITHOFACIES	The rock record of any sedimentary environment, including both physical and organic characters.
LITHOLOGY	The description and study of rocks, especially those of sedimentary origin, as seen in a hand specimen or as exposed on the earth's surface.
MESOZOIC	The era of geological time from the end of the Palaeozoic, (225 Ma ago) to the beginning of the Cainozoic (65 Ma ago). The Mesozoic encompasses the Triassic, Jurassic and Cretaceous Periods.
METEORIC WATER	A term applied to water which penetrates the rocks from above, derived from precipitation.
PALAEO-	A combining form meaning old or ancient, used to denote remote in the past; palaeochannel is where a river channel once flowed and is now represented in the strata as a lens of sand and gravel.
PALAEOSOL	An ancient soil.
PENECONTEMPORANEOUS	Occurring almost at the same time.

PERMEABILITY	Measurement of the ability of rock to transmit fluid.
SHEAR ZONE	A zone across which blocks of rock have been displaced in a fault-like manner, but without prominent development of visible faults.
SLICKENSIDES	These are a common and diagnostic feature of fault planes often displaying a prominent parallel ribbing striation. The striations are believed to be parallel to the direction of relative movement during their formation.
STRATA	(plural of stratum) referring to layers in sedimentary rocks, each layer consisting of approximately the same kind of rock material.
STRIKE	A direction in which a horizontal line can be drawn on a plane perpendicular to true dip.
STRUCTURE	A significant geological feature such as bedding plane, joint, fault, fold and so on.
SUB-BITUMINOUS COAL	Coal rank between lignite and bituminous coal with fixed carbon of 75-80%, volatile matter 40-45%, and moisture 25-30%.
SYNCLINE	A geological structure consisting of a fold in rocks characterized by strata dipping inward from both sides toward the axis.

UNCONFORMITY — A buried surface (often an erosion surface) separating younger strata from older rocks that were exposed to prolonged erosion or non deposition before the deposition of the younger.

VADOSE WATER — Suspended water. A term proposed by Franz Posephy to designate subsurface water above the zone of saturation in the zone of aeration.

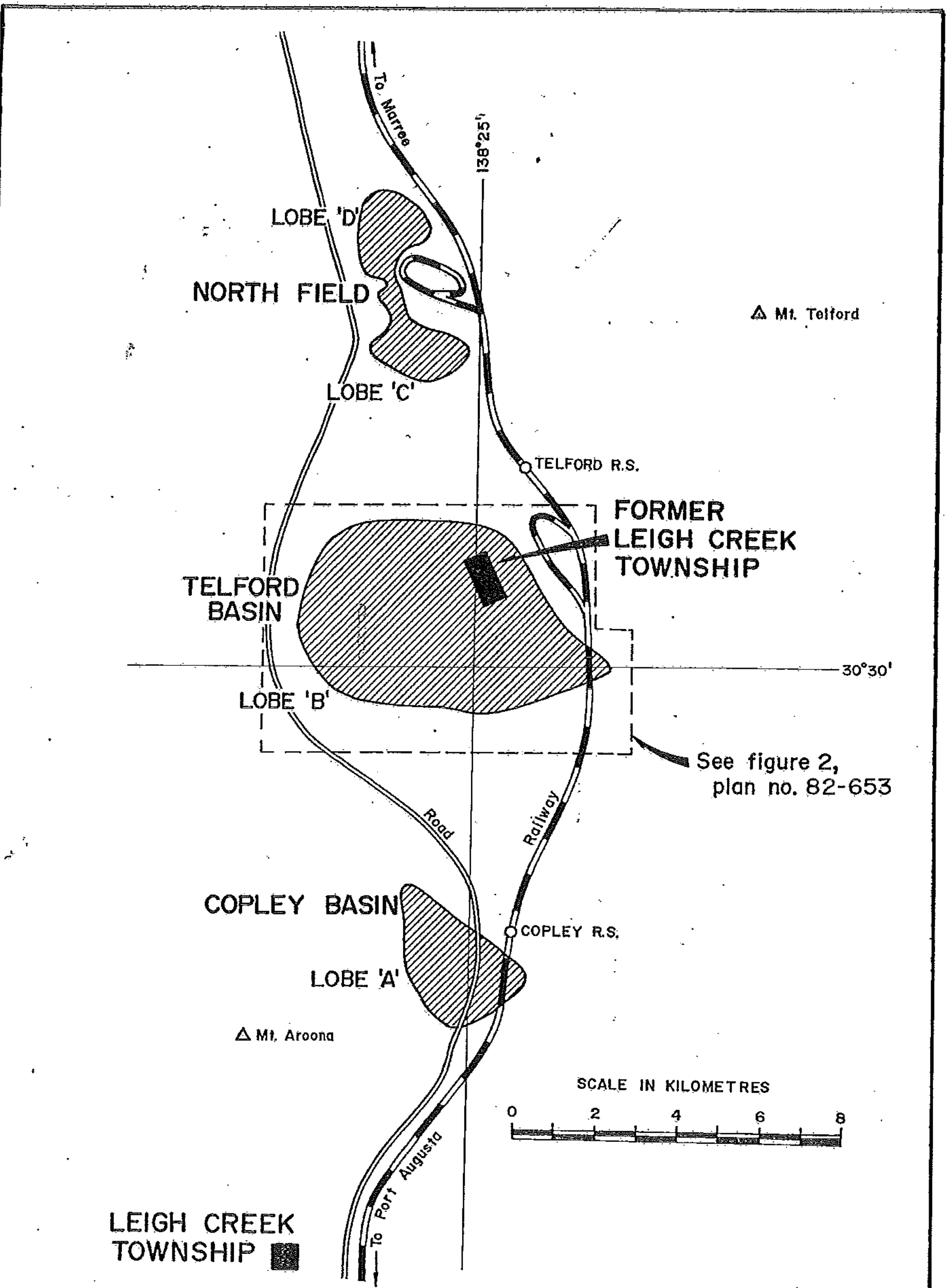


FIG. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

LEIGH CREEK COALFIELD

UNDERGROUND GASIFICATION OF INACCESSIBLE COAL MEASURES

LOCALITY PLAN

COMPILED C. M. W.	C.D.O 9-2-83	DATE
DRAWN E. CALABIO	SCALE AS SHOWN	
DATE DEC. 1982	PLAN NUMBER S16504	
CHECKED		

3051

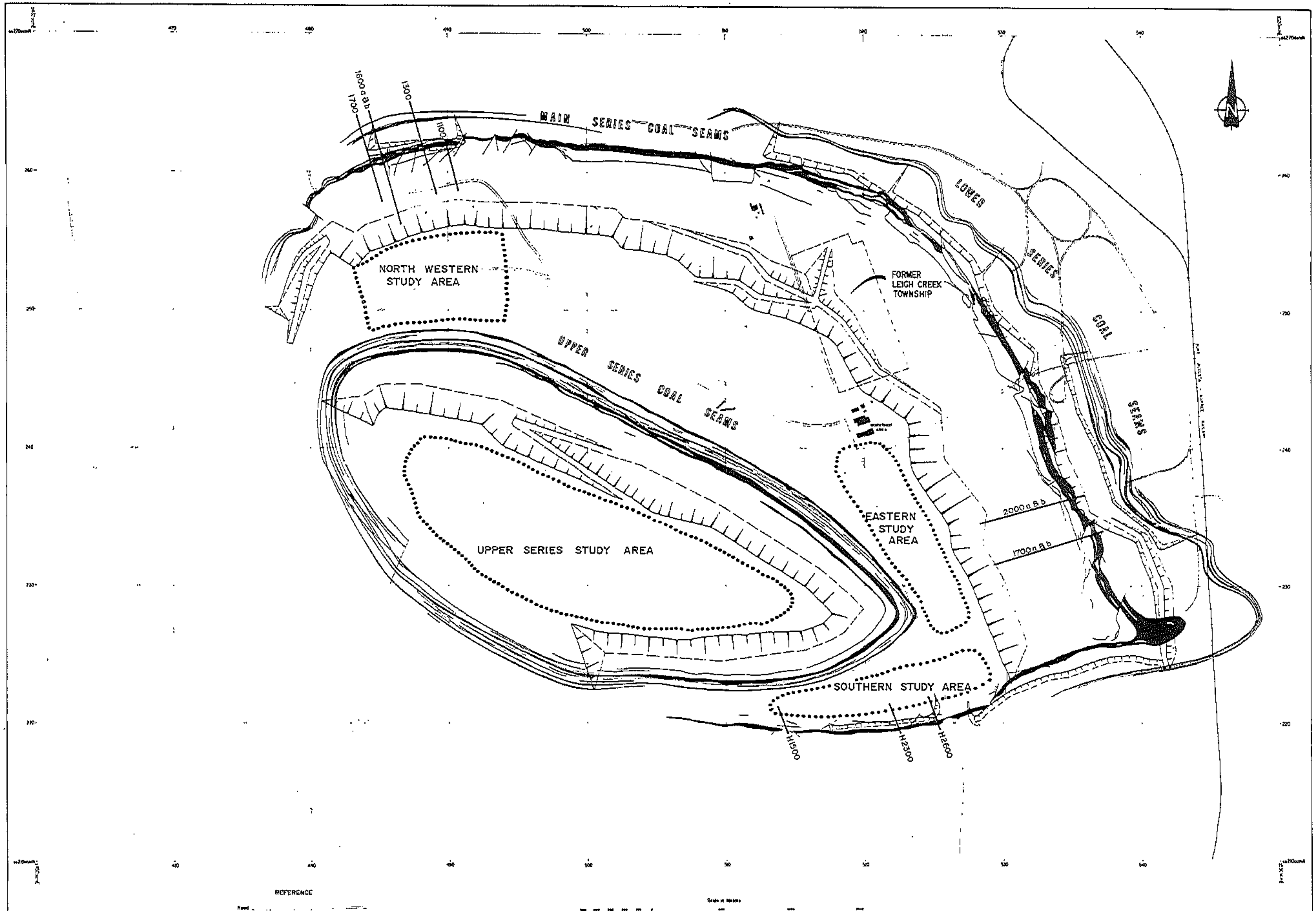


FIG. 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

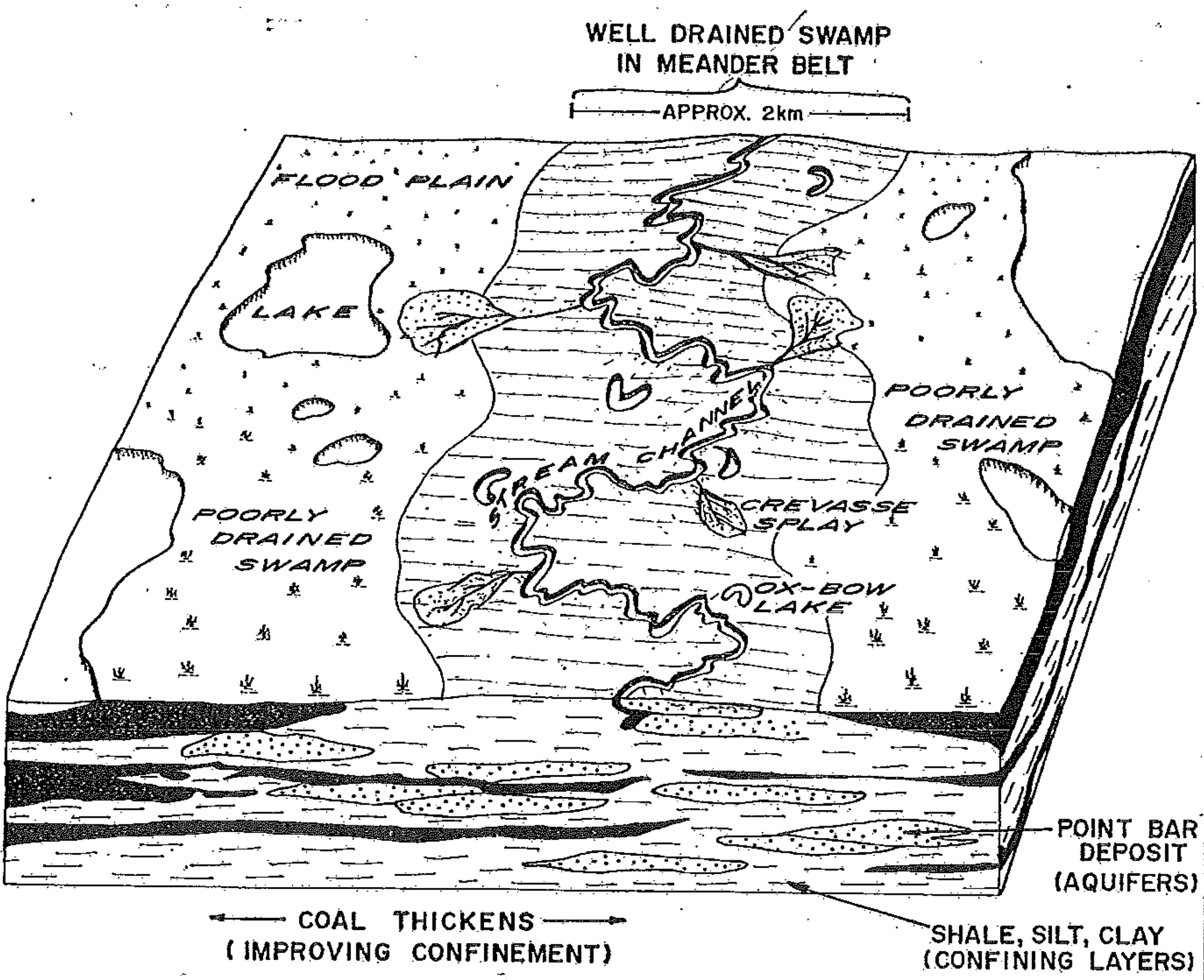
LEIGH CREEK COALFIELD

UNDERGROUND GASIFICATION OF INACCESSIBLE COAL MEASURES

DETAILED LOCATION PLAN

AS SHOWN

82-653



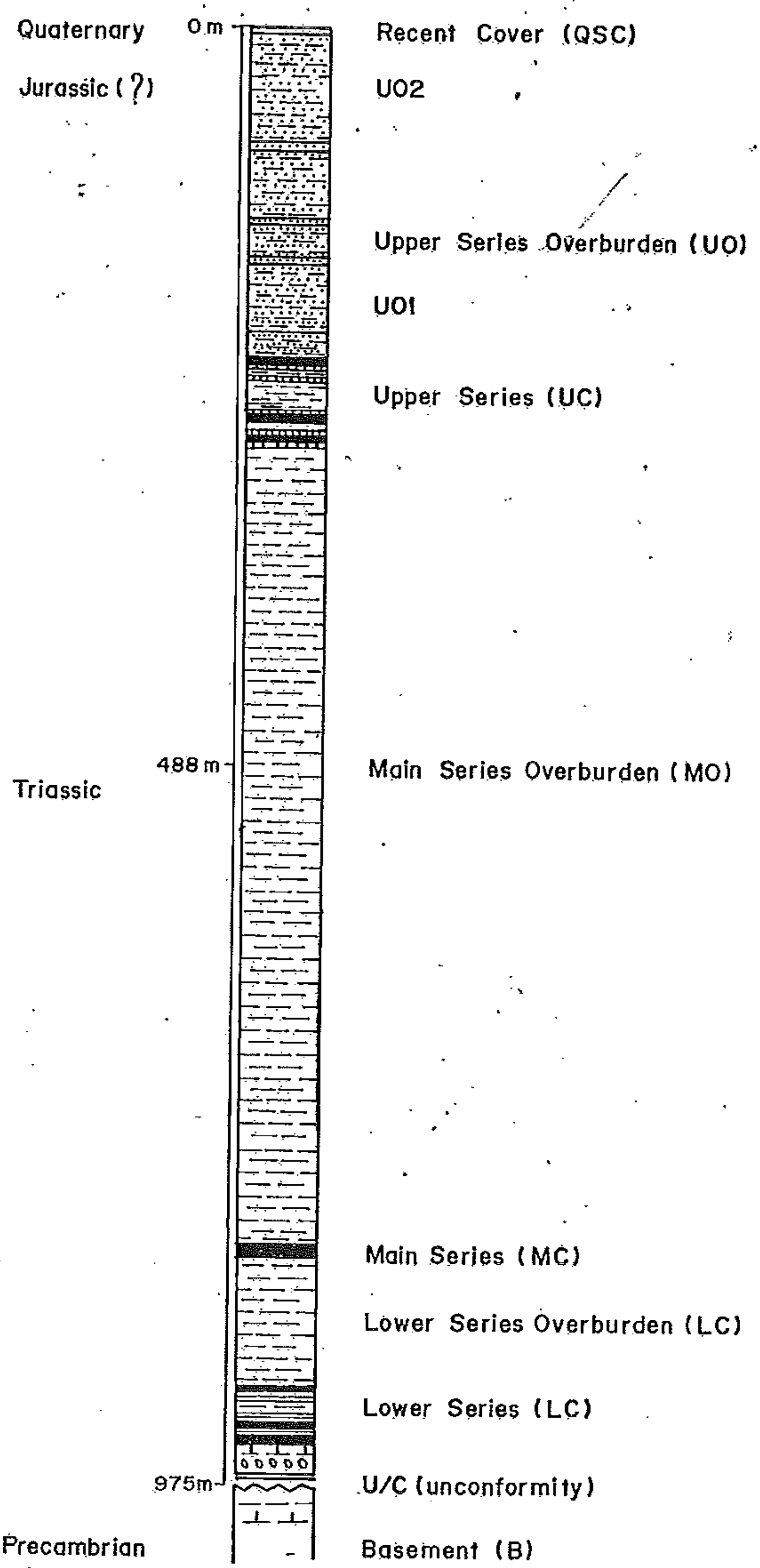
Note: In general thicker coal and better confining conditions for UCG are found away from the channel.

(Modified after Beaumont, 1979)

FIG. 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C. M. Wallace	18-5-83 CDO DATE
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE not to scale
TYPICAL PALAEO-CHANNEL ILLUSTRATING PATTERNS OF SEDIMENTATION AND COAL FORMATION	DATE April, 1983 CHECKED	PLAN NUMBER S 16651

3051



(Nomenclature after Coffey et al. 1978)

FIG. 4

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

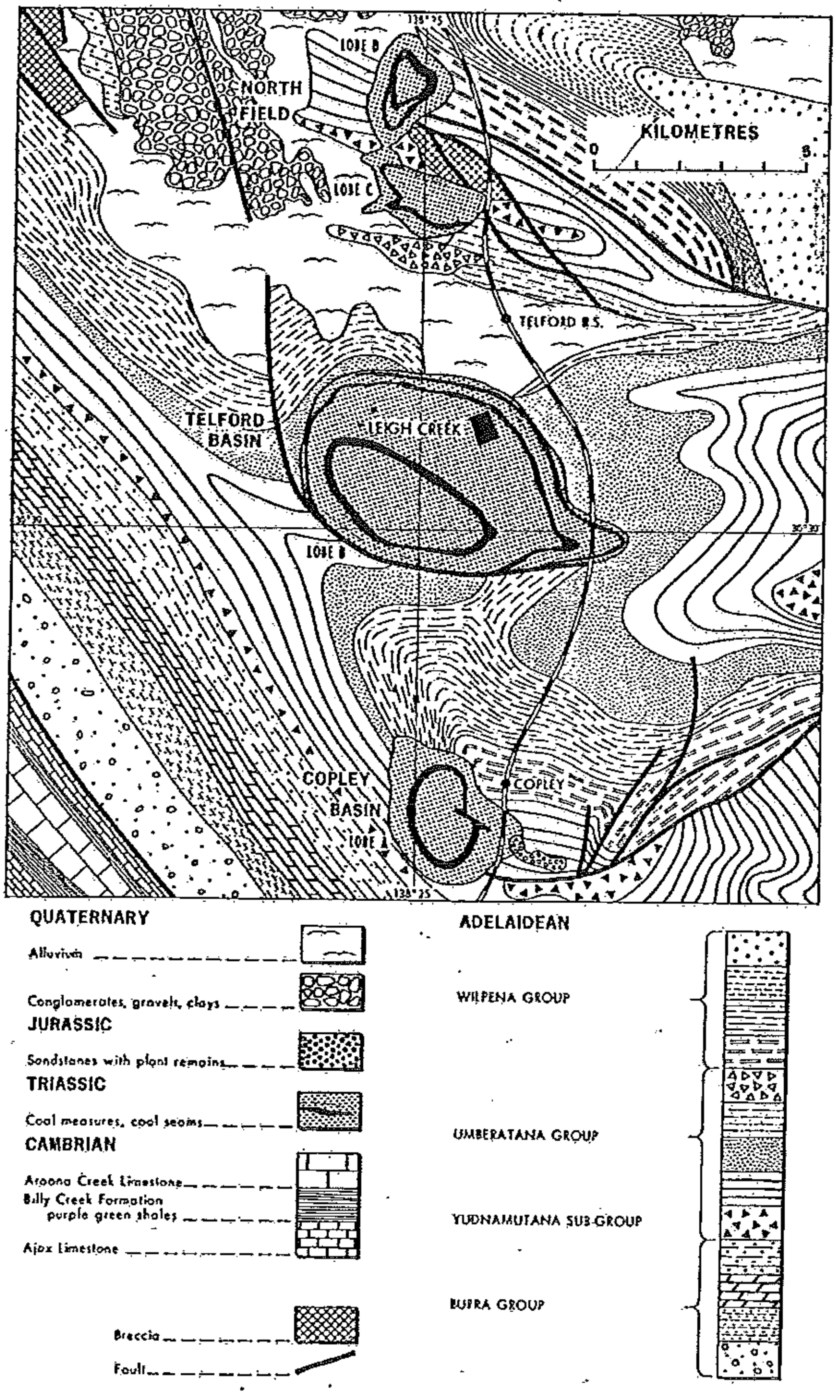
UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES

TELFORD BASIN

COMPOSITE STRATIGRAPHIC COLUMN

COMPILED C.M.Wallace	CDO	DATE 10.5.83
DRAWN E. Calabio	SCALE as shown	
DATE April, 1983	PLAN NUMBER	
CHECKED	S 16652	

3051

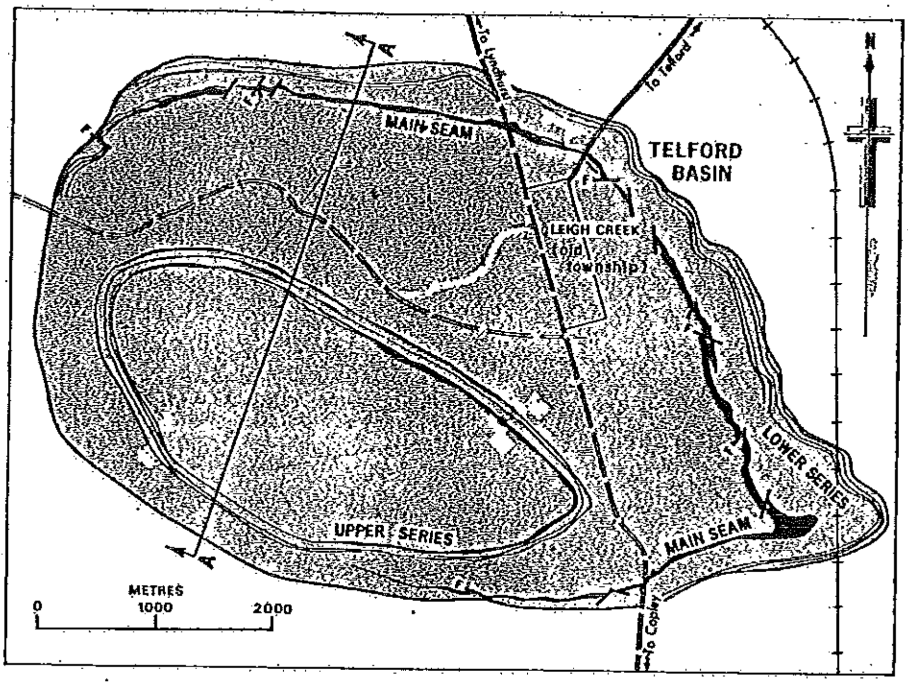


(After Townsend, 1978, Plan no. 79-214)

FIG. 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C.M. Wallace	C.D.O. 18-5-83 DATE
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE as shown
LEIGH CREEK REGIONAL GEOLOGY	DATE April, 1983 CHECKED	PLAN NUMBER S 16653

3051



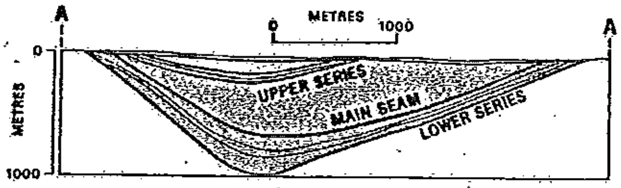


FIG. 6

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C.M.Wallace	C.D.O. DATE 10.5.83
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE as shown
TELFORD BASIN DIAGRAMMATIC CROSS SECTION	DATE April, 1983	PLAN NUMBER
	CHECKED	S 16654

3051

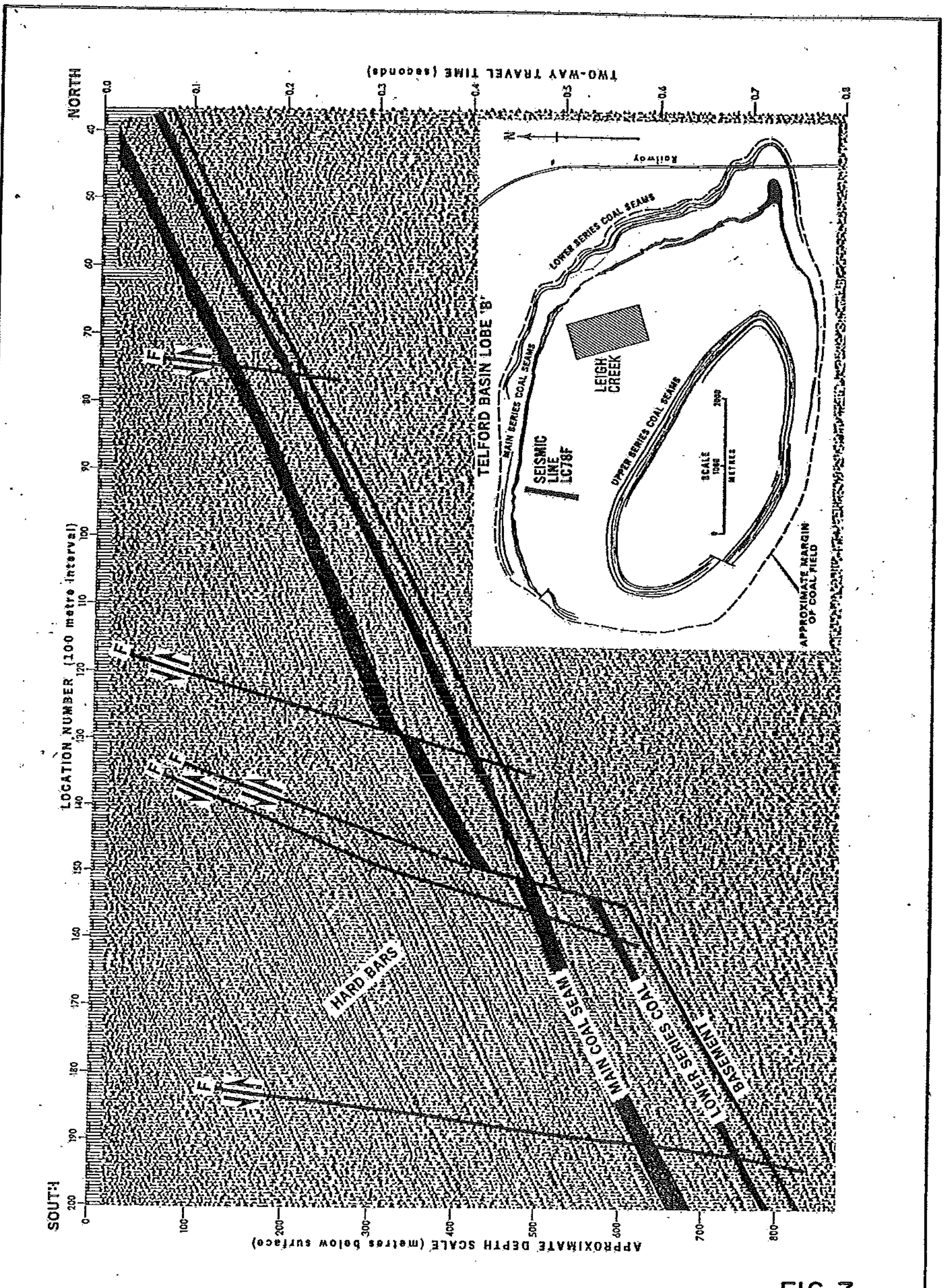


FIG. 7

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C.M.Wallace	C.D.O.	18.5.83 DATE
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE as shown	
TELFORD BASIN HIGH RESOLUTION SEISMIC LINE LC78F	DATE April, 1983 CHECKED	PLAN NUMBER S 16655	

3051

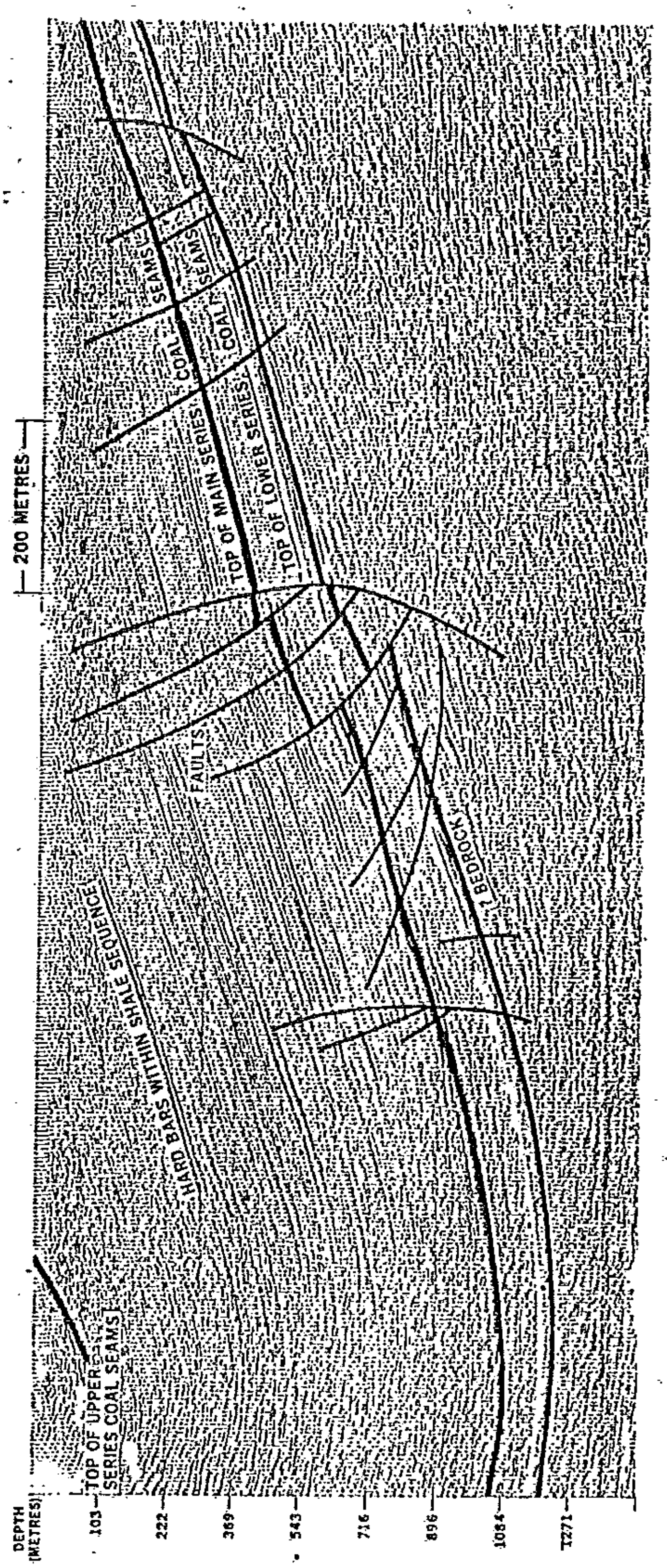
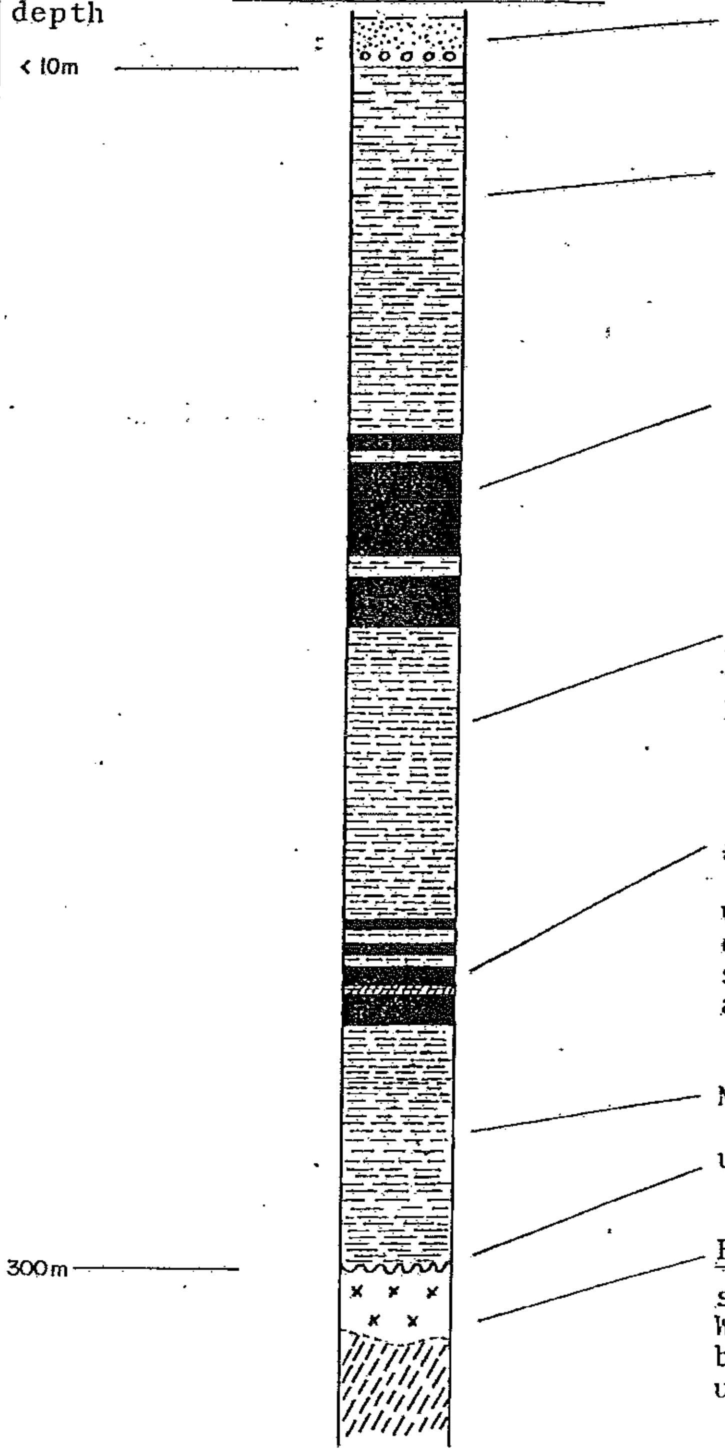


FIG. 8

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C.M.Wallace	C.D.O. DATE 18.5.83
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE as shown
LINE LC-78-F	DATE April, 1983	PLAN NUMBER
MIGRATED SECTION	CHECKED	S 16656

3051

Stratigraphic column



Quaternary Surface Cover (QSC)

- silts, sands, conglomerates

Main Series Overburden (MO) - Triassic

Mudstones with interdigitated 'hardbars', and shales containing pyrite.

Main Series Coal (MC) - Triassic

Coal and carbonaceous shale with minor partings of shale; no 'hardbars'. Generally >12m.

Lower Series Overburden (LO) - Triassic

Mudstone with some sandy "mudstone" and hardbars.

Lower Series Coal (LC) - Triassic

with intercalated partings of mudstone, carbonaceous shale and occasional sandstones and hardbars.

Mudstone.

unconformity (u/c)

Basement (B) - Precambrian

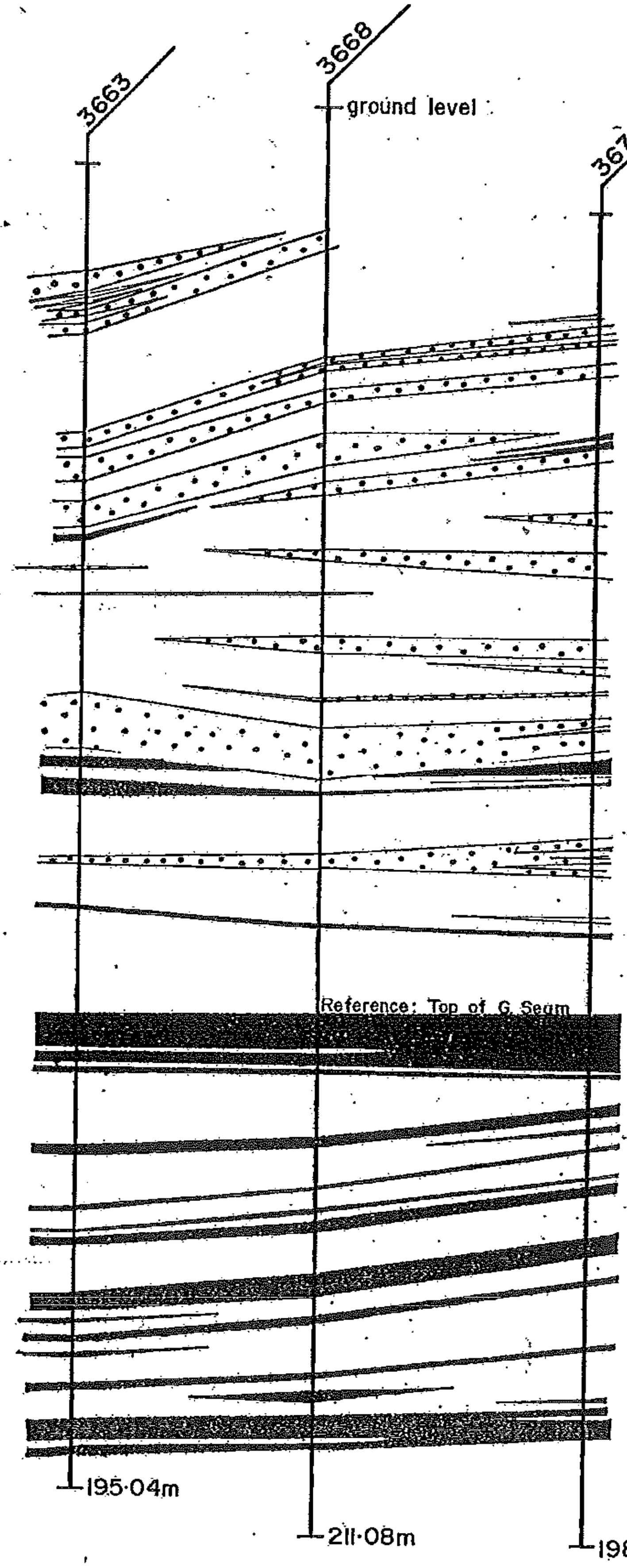
siltstones and limestones. Weathering front occurs between 10-30 m below unconformity.

(Nomenclature after Coffey et. al. 1978)

FIG. 9

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED C.M.Wallace	C.D.O. DATE 18·5·83
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES **TELFORD BASIN** SOUTHERN, NORTH WESTERN AND EASTERN STRATIGRAPHIC SUCCESSION	DRAWN E. Calabio	SCALE
	DATE April, 1983	PLAN NUMBER S 16657
	CHECKED	

3051



REFERENCE

Well number 3671
(Prefix with 6537 to obtain unit no.)

Total depth. . . . . 198·3m

Coal seam . . . .

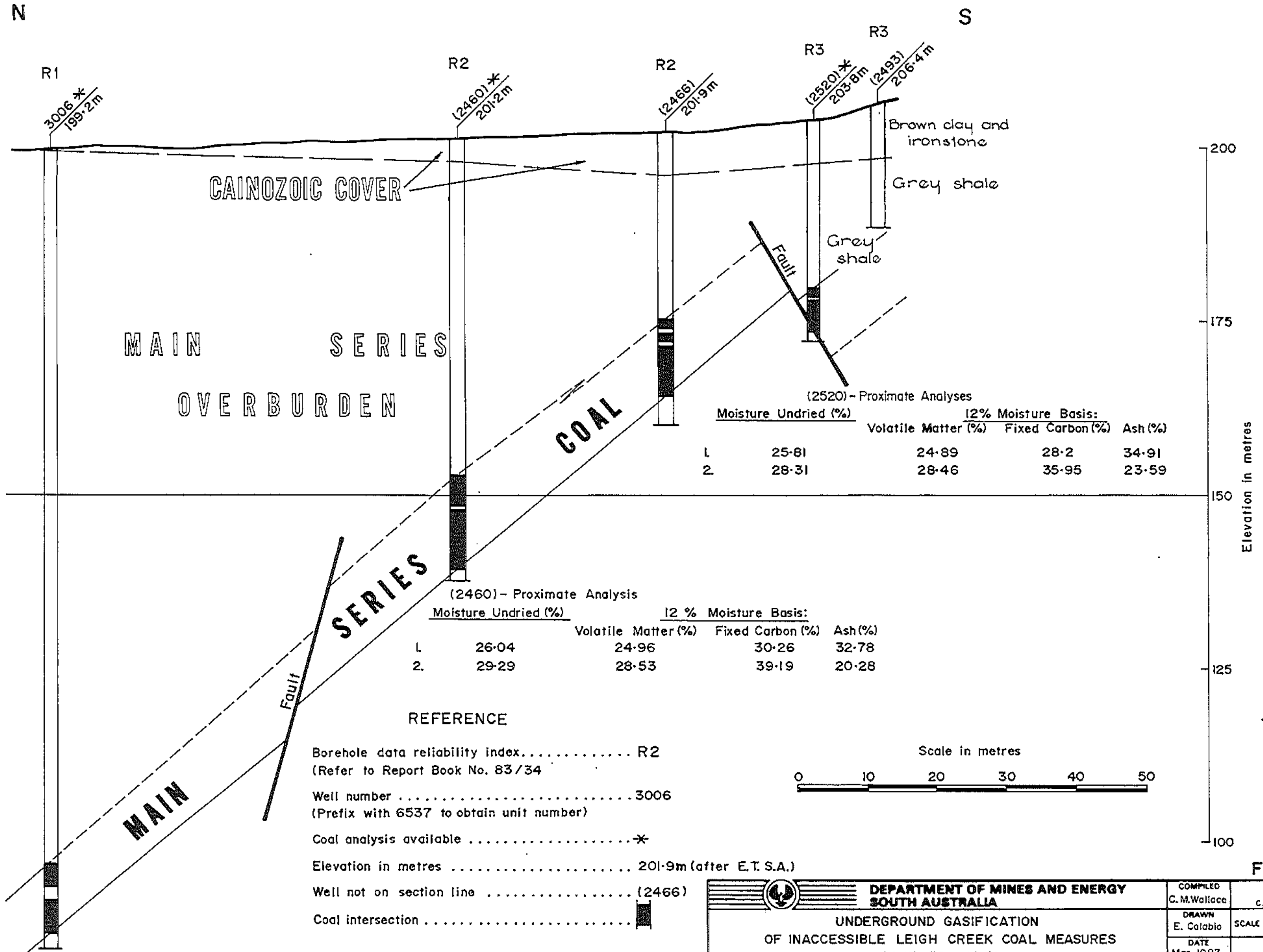
Sandstone (med. – coarse grained). .

Mudstone, siltstone, minor sandstone. (very fine to fine grained)

FIG. 10

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED G. Kwitko	C.D.O. 18·5·83 DATE
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES	DRAWN E. Calabio	SCALE as shown
TELFORD BASIN SECTION THROUGH THE UPPER SERIES	DATE April, 1983 / CHECKED	PLAN NUMBER S 16658

3051



(2520) – Proximate Analyses

	Moisture Undried (%)	12% Moisture Basis: Volatile Matter (%)	Fixed Carbon (%)	Ash (%)
1.	25·81	24·89	28·2	34·91
2.	28·31	28·46	35·95	23·59

(2460) – Proximate Analysis

	Moisture Undried (%)	12 % Moisture Basis: Volatile Matter (%)	Fixed Carbon (%)	Ash (%)
1.	26·04	24·96	30·26	32·78
2.	29·29	28·53	39·19	20·28

REFERENCE

Borehole data reliability index R2
(Refer to Report Book No. 83/34

Well number 3006
(Prefix with 6537 to obtain unit number)

Coal analysis available .... *

Elevation in metres .... 201·9m (after E.T.S.A.)

Well not on section line .... (2466)

Coal intersection .... ▮

For location of section see plan 82-653, figure 2.

FIG. 11

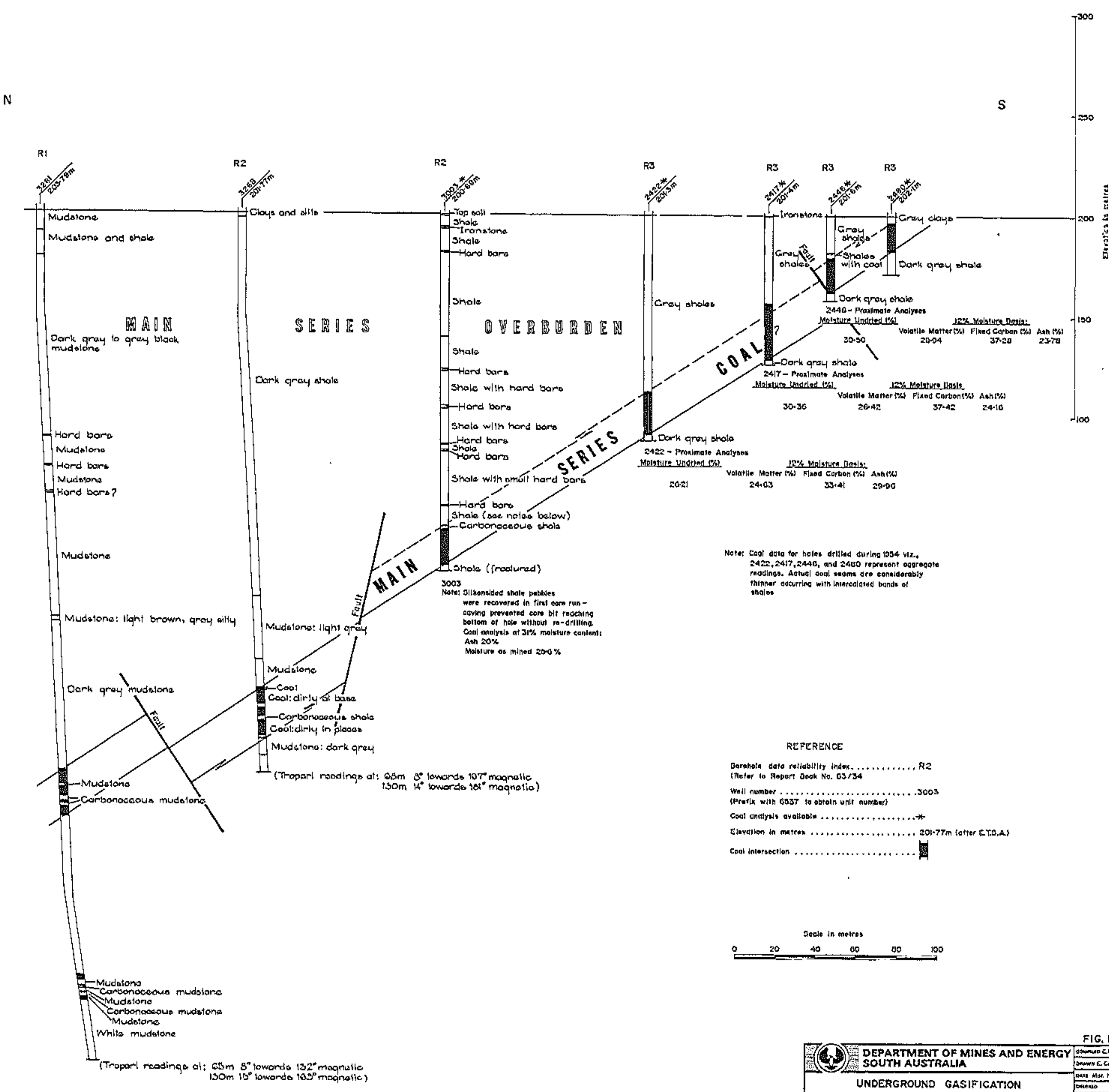
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES
SOUTHERN AREA

SECTION H1500 – MAIN SERIES

COMPILED C.M.Wallace	C.D.O.	DATE
DRAWN E. Calabio	SCALE 1:500	
DATE Mar. 1983	PLAN NUMBER	
CHECKED	83-149	

3051



For location of section see plan 82-653, figure 2.

FIG. 12

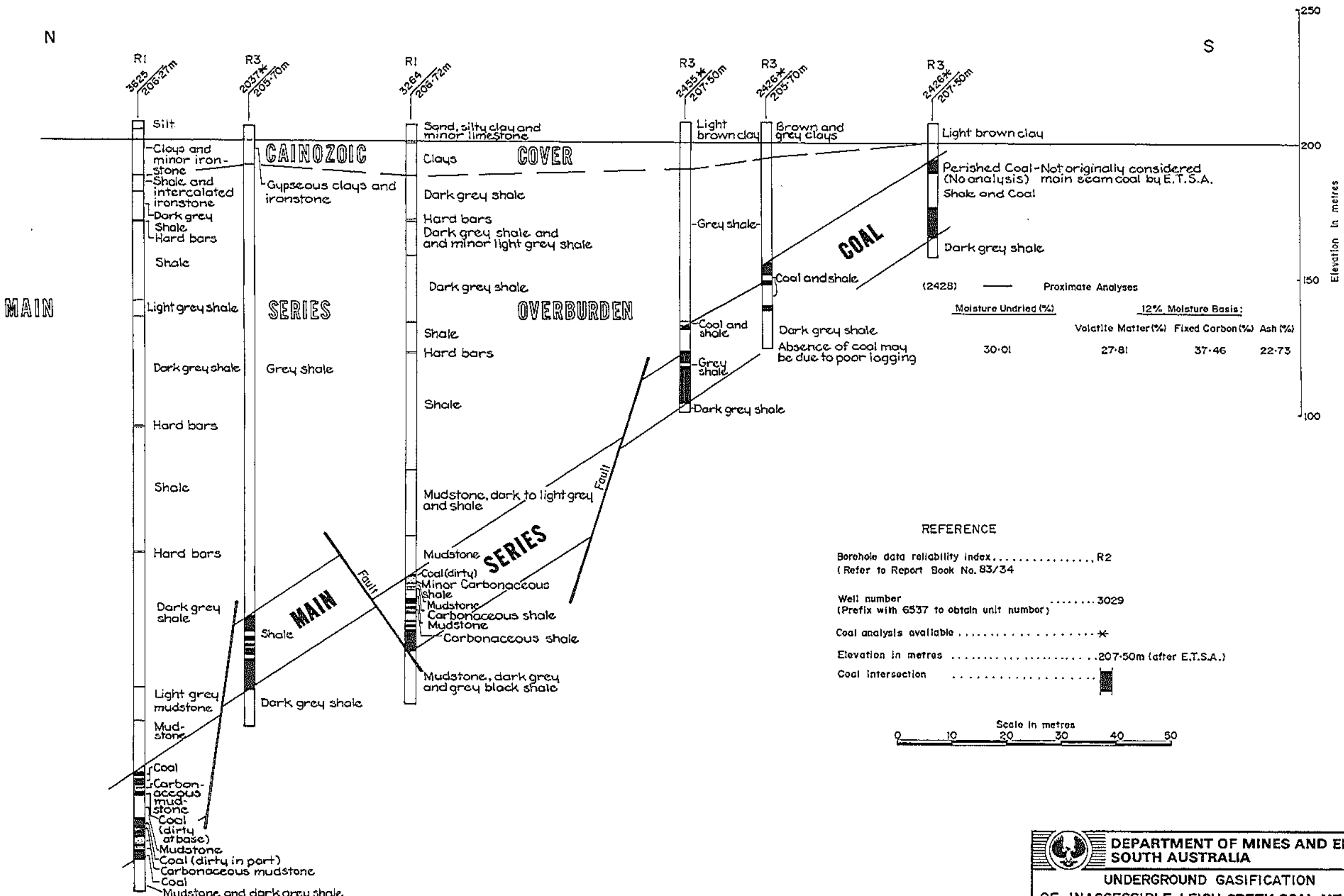
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES

SOUTHERN AREA

SECTION H2300 - MAIN SERIES

Compiled	C.M. Wallace
Drawn	E. Catalano
Date	Mar. 1983
Checked	
Scale	1:4,000
Plan number	83-150



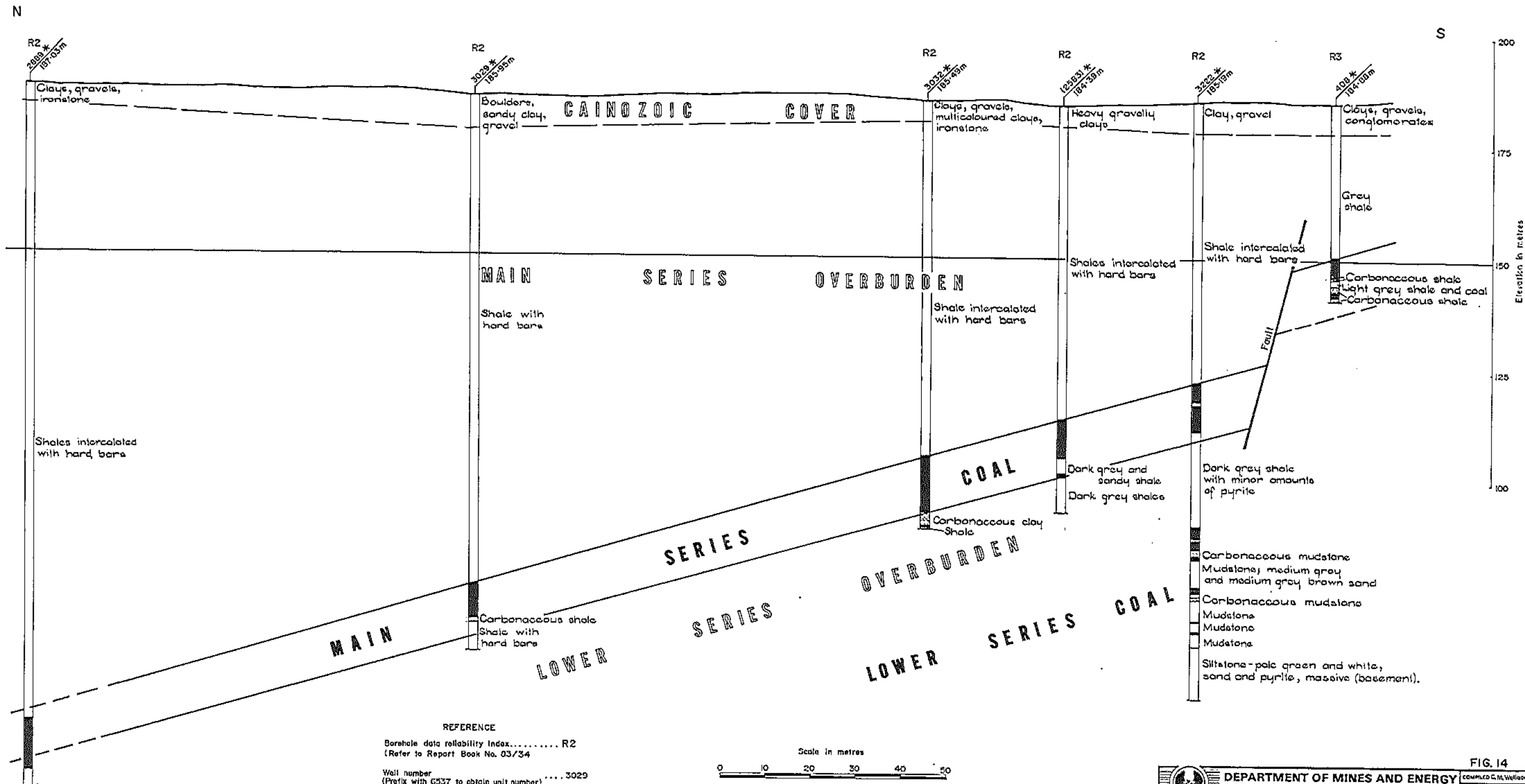
For location of section see plan 82 - 653, figure 2.

FIG. 13

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES
SOUTHERN AREA
SECTION H2600 - MAIN SERIES

COMPILED	C.M. Wallace
DRAWN	A. Dawe
DATE	March '83
CHECKED	C.D.O. 18·3·85
SCALE	1:1000
PLAN NUMBER	83-151



REFERENCE

Borehole data reliability index.......... R2
(Refer to Report Book No. 83/34

Well number
(Prefix with 6537 to obtain unit number) 3029

Coal analysis available .... *

Elevation in metres .... 185·95m (after E.T.S.A.)

Well not on section line .... (2583)

Coal intersection ....

For location of section see plan 82-653, figure 2.

FIG. 14

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES
NORTH WESTERN AREA

SECTION 1100 — MAIN SERIES

COMPILED	C.M. Wallace
DRAWN	C. Calabio
DATE	Feb. 1983
CHECKED	
C.G.O. DATE	
SCALE	1:500
PLAN NUMBER	83-152

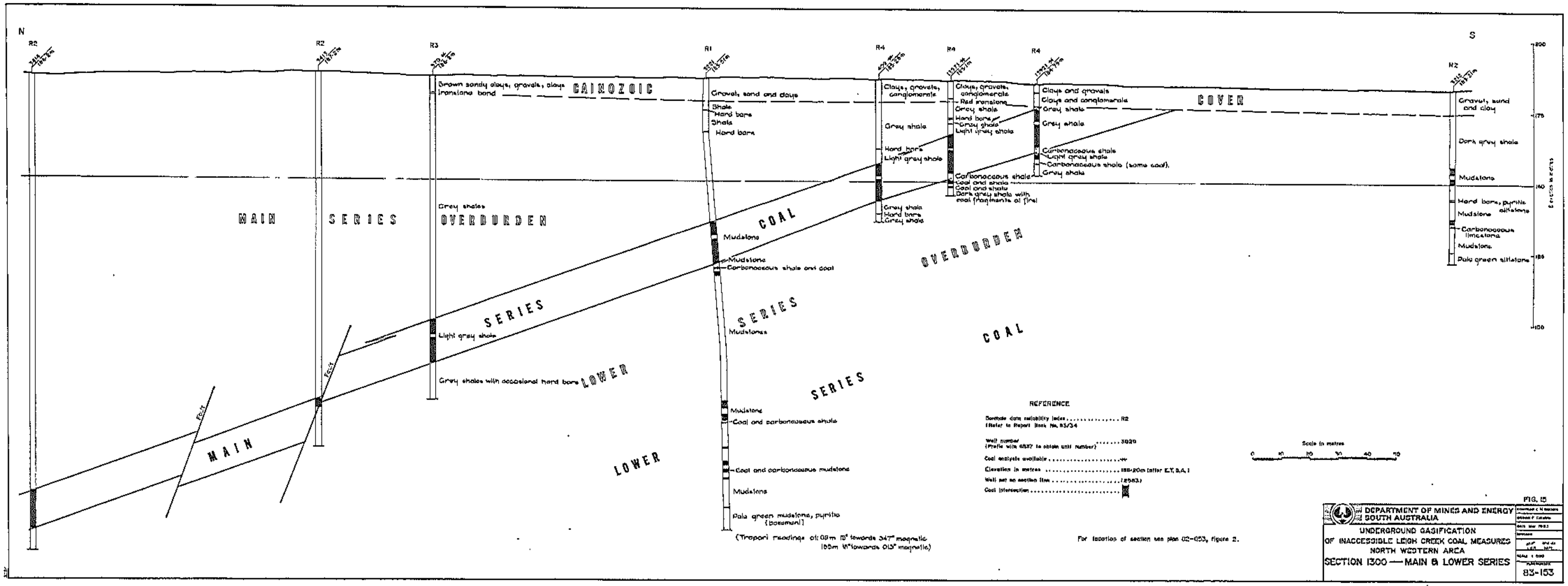


FIG. 15

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES NORTH WESTERN AREA

SECTION 1300 — MAIN & LOWER SERIES

83-153

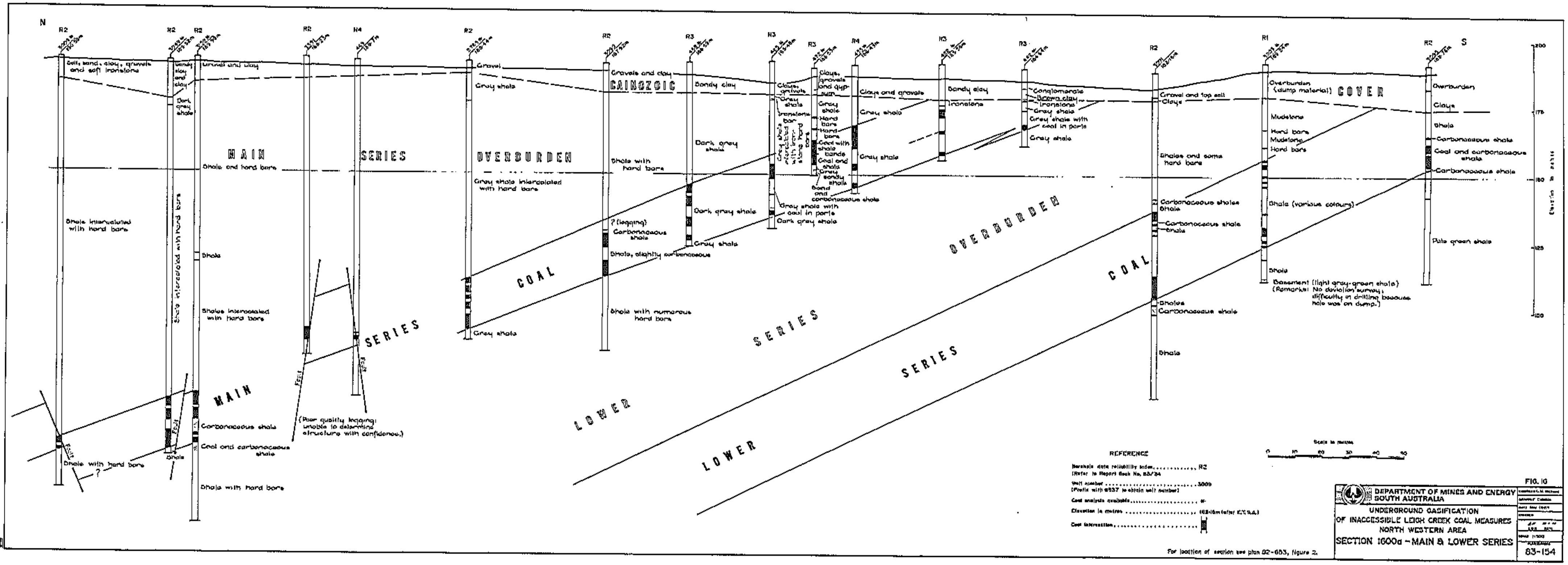


FIG. 10

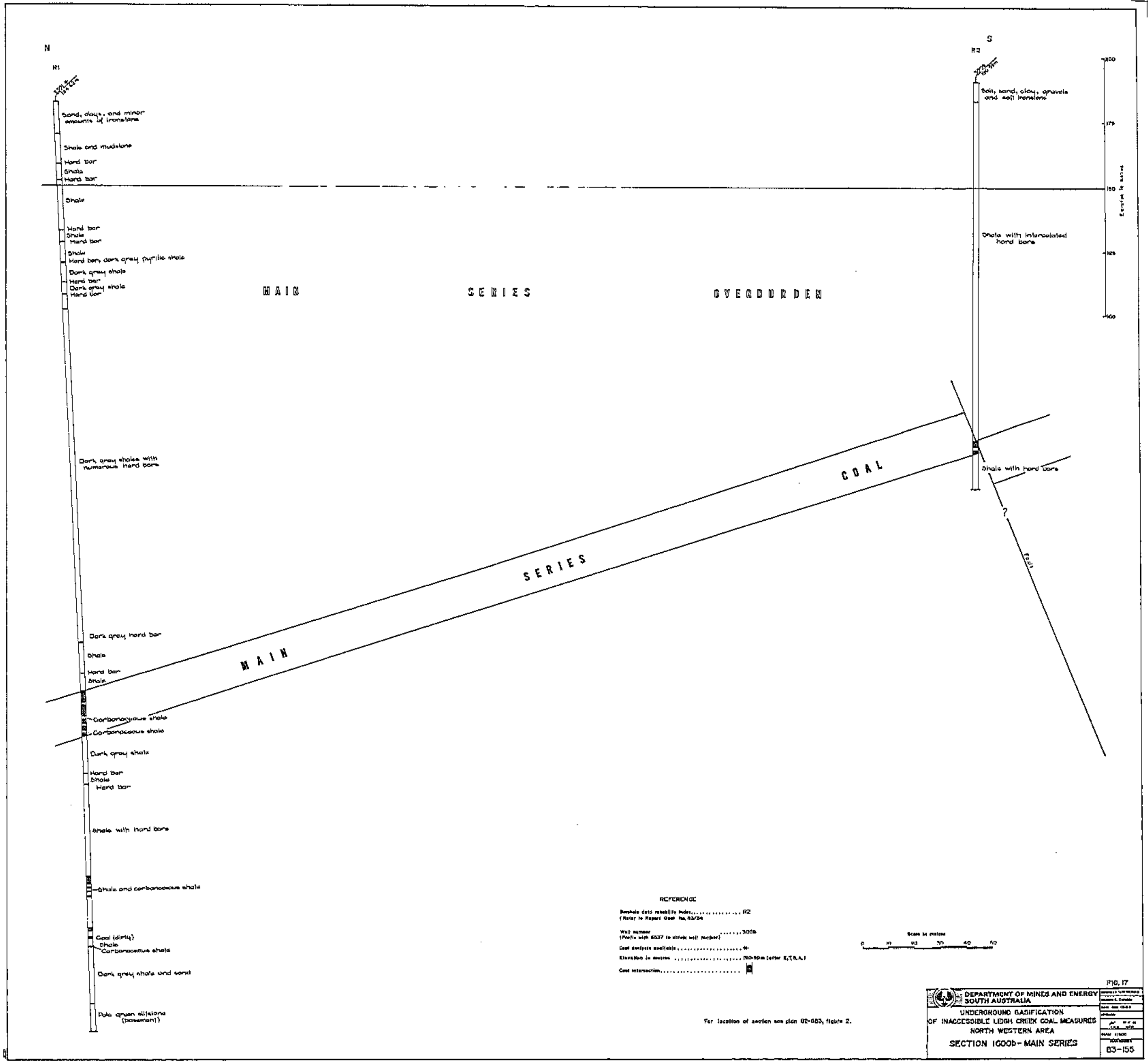
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES NORTH WESTERN AREA

SECTION 1600a - MAIN & LOWER SERIES

83-154

For location of section see plan 82-653, figure 2.


N
R1
Sand, clays, and minor amounts of ironstone
Shale and mudstone
Hard bar
Shale
Hard bar
Shale
Hard bar
Shale
Hard bar
Shale
Hard bar, dark grey pyritic shale
Dark grey shale
Hard bar
Dark grey shale
Hard bar
Dark grey shales with numerous hard bars
Dark grey hard bar
Shale
Hard bar
Shale
Carbonaceous shale
Carbonaceous shale
Dark grey shale
Hard bar
Shale
Hard bar
Shale with hard bars
Shale and carbonaceous shale
Coal (dirty)
Shale
Carbonaceous shale
Dark grey shale and sand
Pale green siltstone (basement)
S
R2
Soil, sand, clay, gravels and soft ironstone
Shale with intercalated hard bars
Shale with hard bars
Fault
?
MAIN SERIES OVERBURDEN
MAIN SERIES COAL
200
175
150
125
100
REFERENCE
Scale in metres
0 10 20 30 40 50
For location of section see plan 82-653, figure 2.
FIG. 17
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES
NORTH WESTERN AREA
SECTION 1600b - MAIN SERIES
83-155

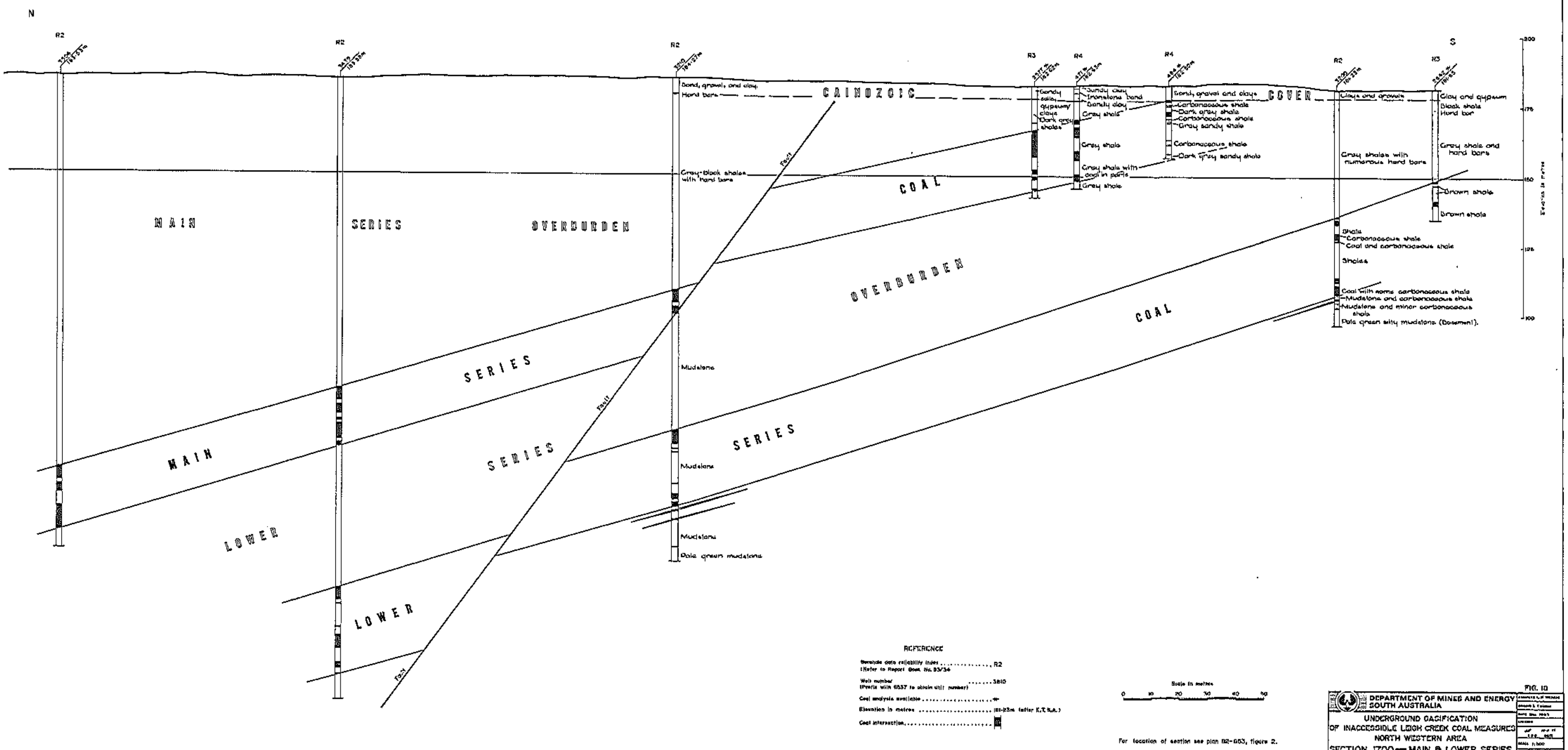


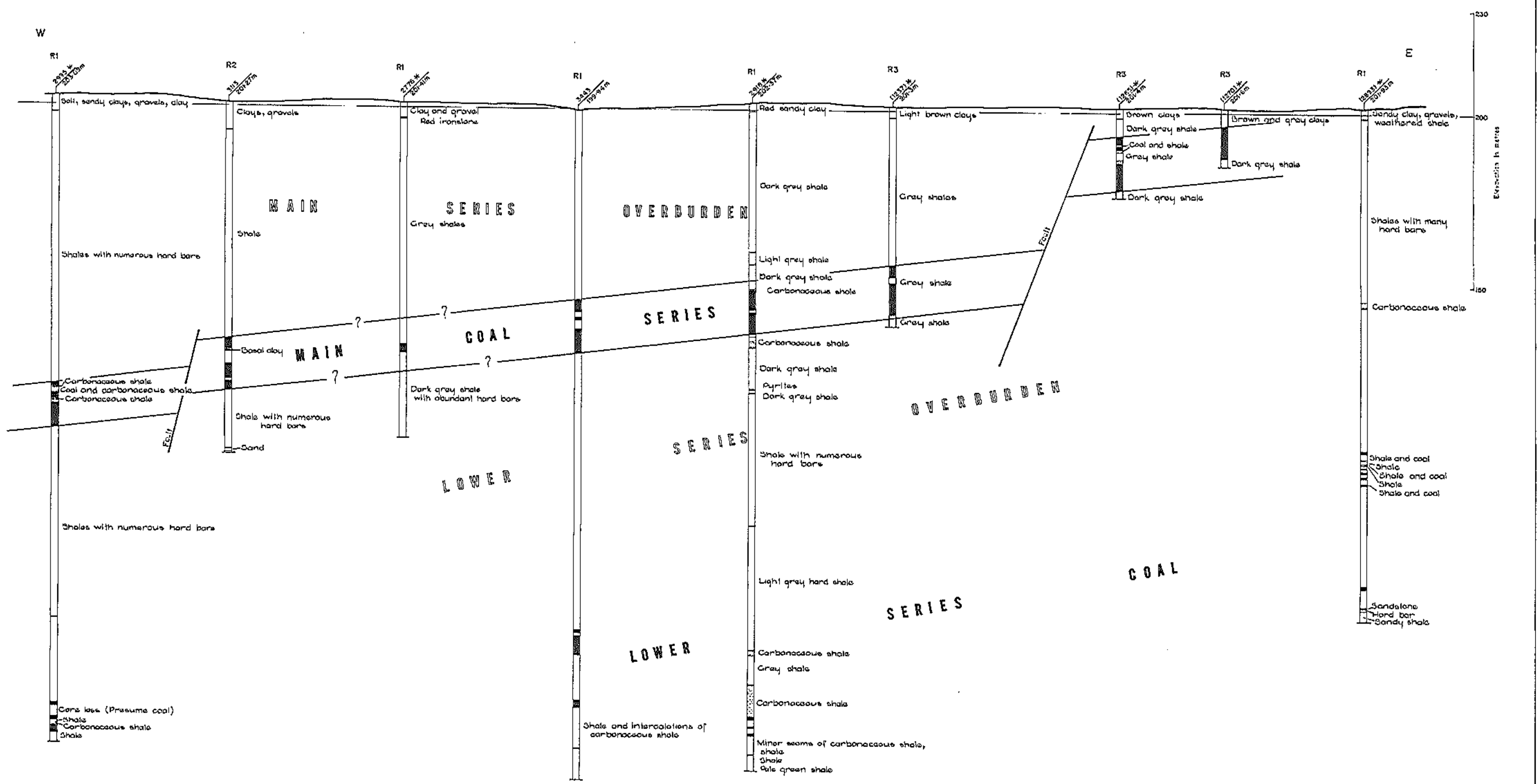
FIG. 10

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES NORTH WESTERN AREA

SECTION 1700 — MAIN & LOWER SERIES

83-156



REFERENCE

Borehole data reliability index.............R2
(Refer to Report Book No. 83/34

Well number..............................2018
(Prefix with 6537 to obtain unit number)

Coal analysis available..................*

Elevation in metres......................201·3m (after E.T.S.A)

Well not on section line.................(1237)

Coal intersection........................

For location of section see plan 82-653, figure 2.

Scale in metres

0 10 20 30 40 50

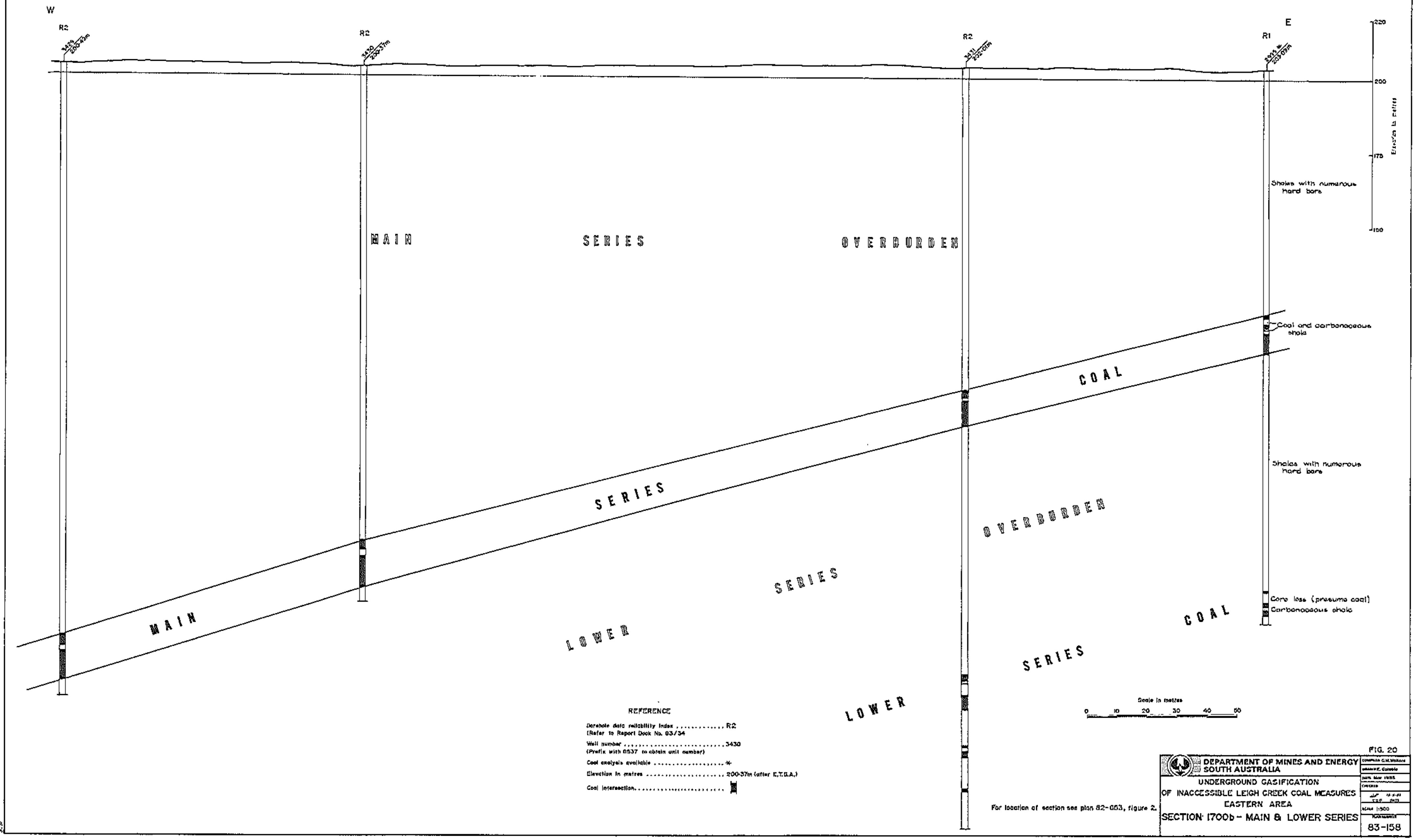
FIG. 19

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES
EASTERN AREA

SECTION 1700a-MAIN AND LOWER SERIES

83-157



REFERENCE

Borehole data reliability index R2
(Refer to Report Book No. 83/34)
Well number 3430
(Prefix with 6537 to obtain unit number)
Coal analysis available .... *
Elevation in metres .... 200·37m (after E.T.S.A.)
Coal intersection.........................

For location of section see plan 82-653, figure 2.

FIG. 20

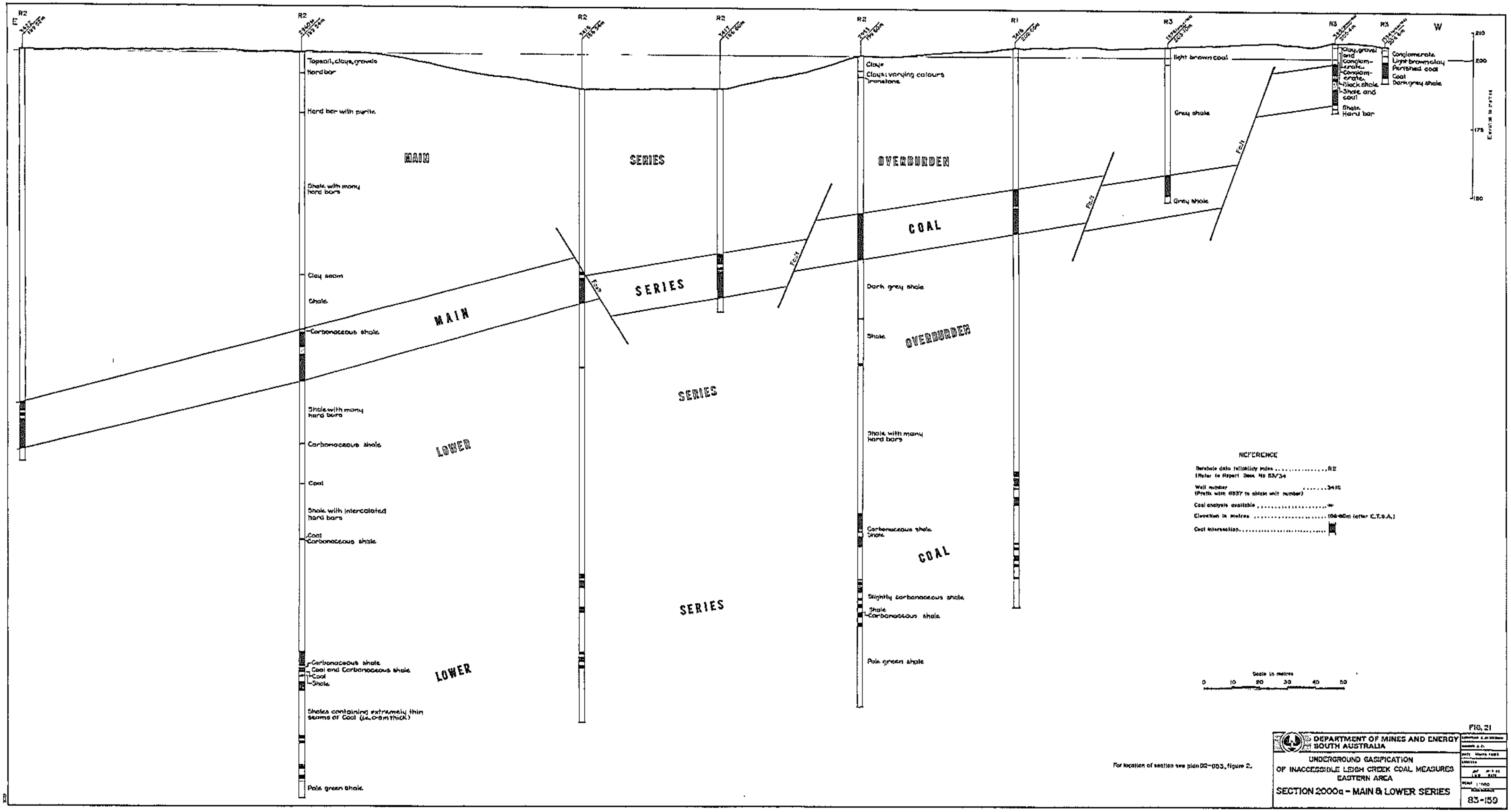
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

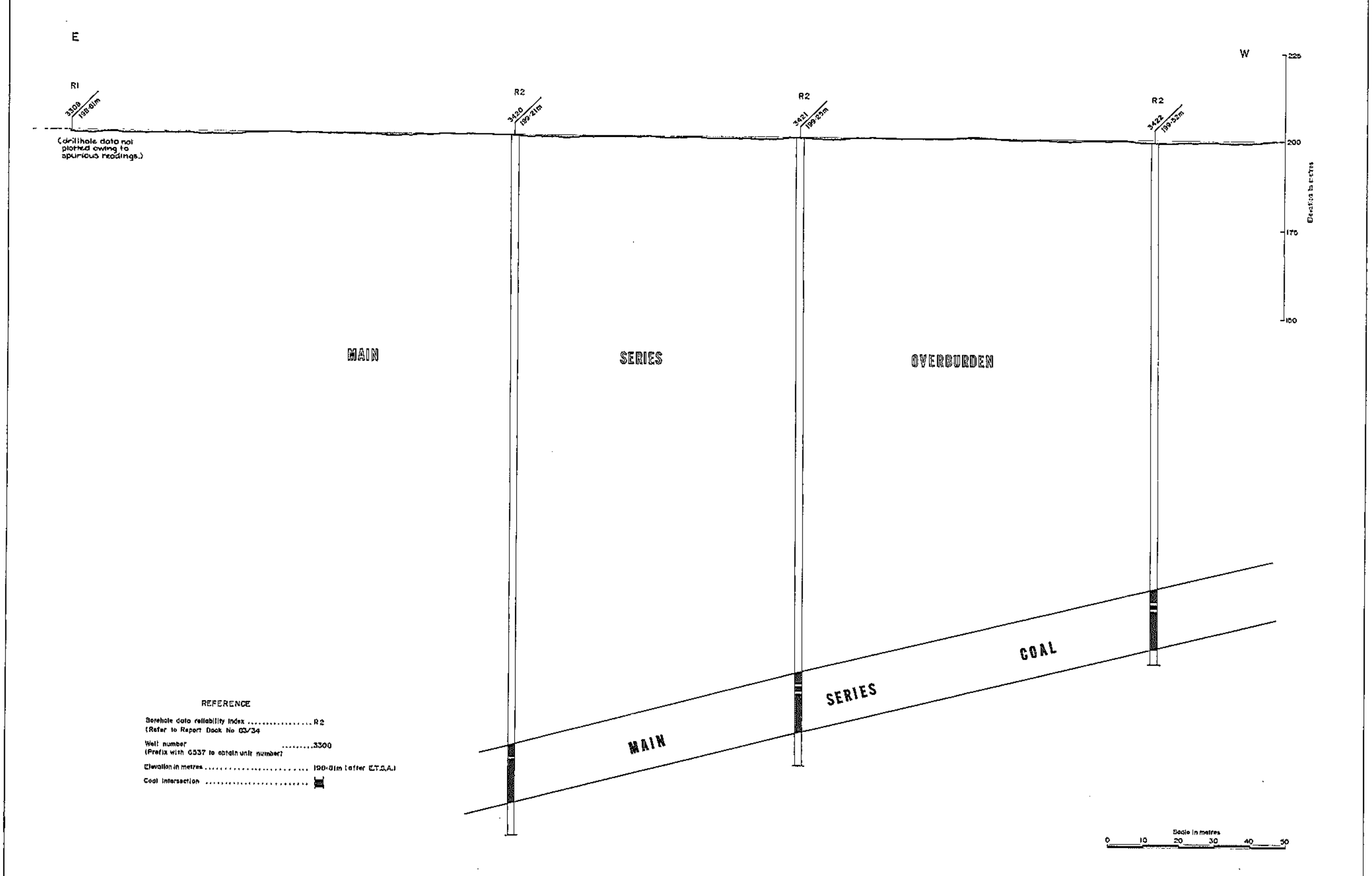
UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES EASTERN AREA

SECTION 1700b – MAIN & LOWER SERIES

Scale 1:1500

83-158


E
W
R2
R1
R3
MAIN
SERIES
OVERBURDEN
COAL
LOWER
Fault
Topsoil, clays, gravels
Hard bar
Hard bar with pyrite
Shale with many hard bars
Clay seam
Shale
Carbonaceous shale
Coal
Shale with intercalated hard bars
Pale green shale
Shales containing extremely thin seams of Coal
Clays
Clays; varying colours
Ironstone
Dark grey shale
Slightly carbonaceous shale
light brown coal
Grey shale
Conglomerate
Light brown clay
Perished coal
Dark grey shale
Black shale
Shale and coal
REFERENCE
Borehole data reliability index R2
(Refer to Report Book No 83/34
Well number 3410
(Prefix with 6537 to obtain unit number)
Coal analysis available ....*
Elevation in metres ....(06-80m) (after C.T.S.A.)
Coal intersection..................
Scale in metres
0 10 20 30 40 50
For location of section see plan 82-653, figure 2.
FIG. 21
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA
UNDERGROUND GASIFICATION
OF INACCESSIBLE LEIGH CREEK COAL MEASURES
EASTERN AREA
SECTION 2000a - MAIN & LOWER SERIES
83-159



For location of section see plan 82-653, figure 2.

FIG. 22

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

UNDERGROUND GASIFICATION OF INACCESSIBLE LEIGH CREEK COAL MEASURES EASTERN AREA

SECTION 2000b MAIN SERIES

Compiled C.M.Wallace
Drawn AD
Date March 1983
Scale 1:1500
Plan number 83-160

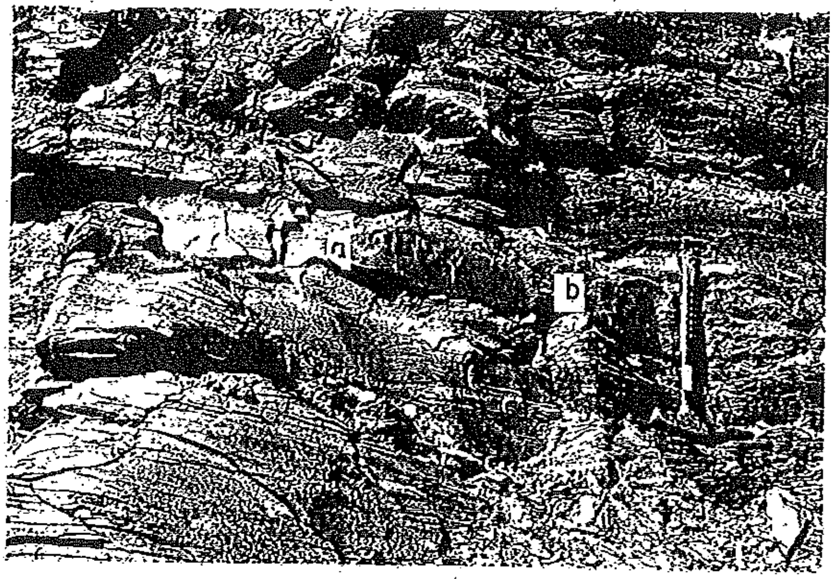


PLATE 1

Hardbars exposed in open pit within Main Series overburden (a,b). Note their resemblance to boudinage structures Hammer provides scale.

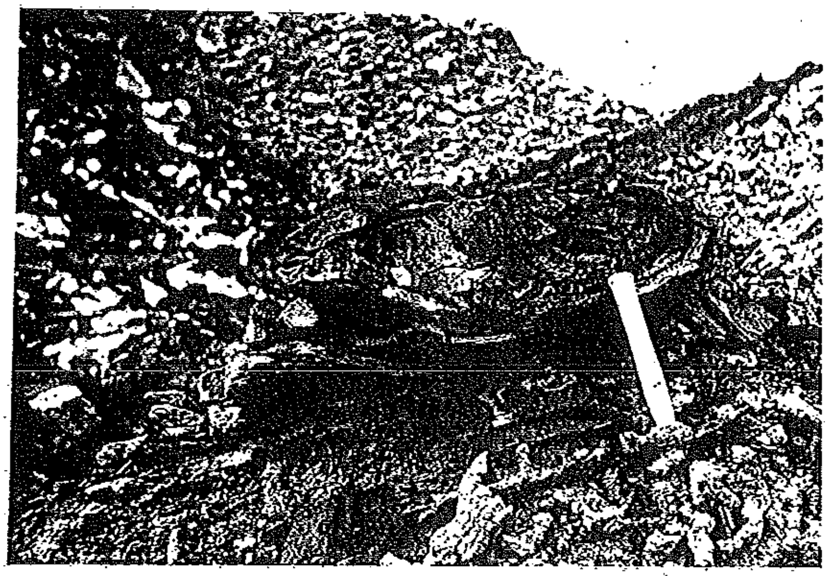


PLATE 2

Concretionary nodule ("hardbar"), in Main Series overburden. Hammer provides scale.

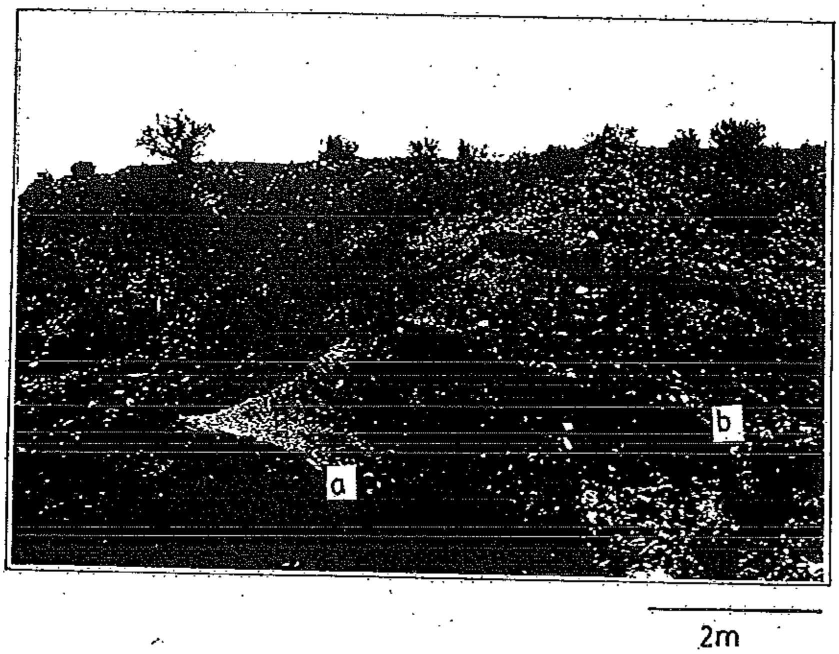


PLATE 3

Hardbars in outcrop (a,b). Differential weathering gives rise to the linear outcrop pattern observed.

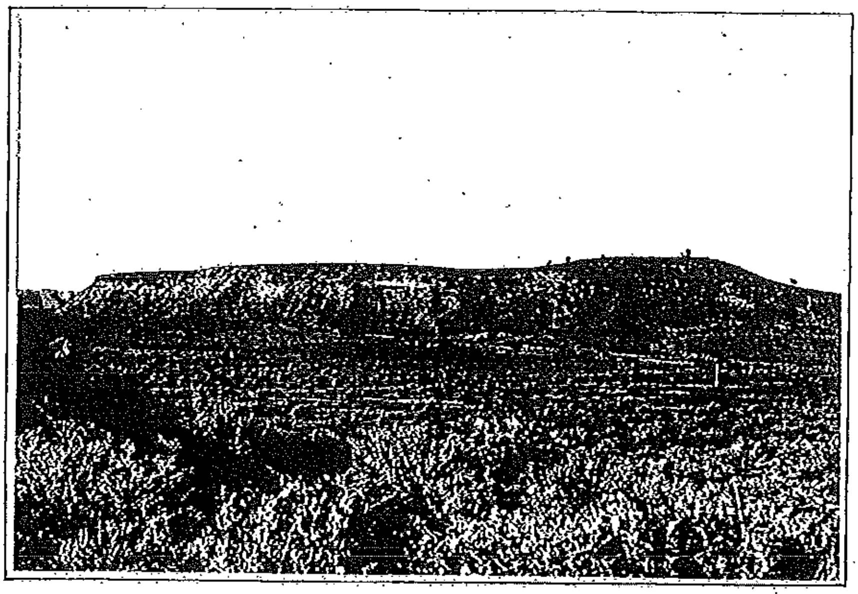


PLATE 4

Isolated mesa at Copley (looking south)

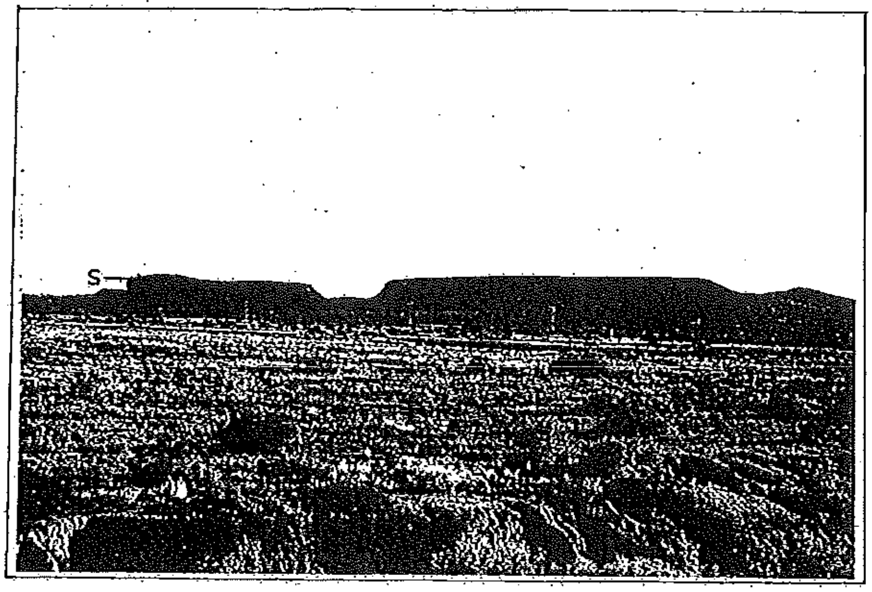


PLATE 5

Mesas at Copley comprising Jurassic tabular cross-stratified sandstone.
S. Silcrete capping (looking northeast).

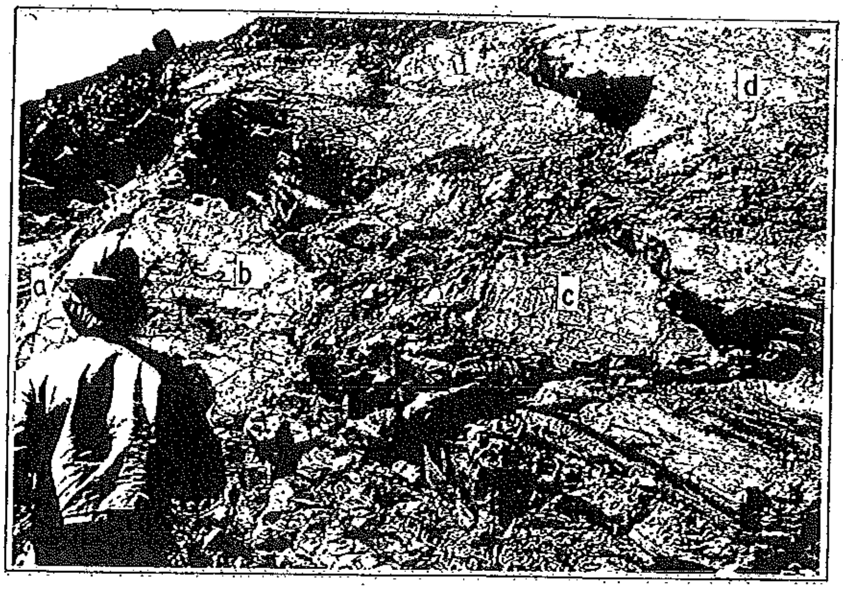


PLATE 6

Series of *en echelon* Faults sub-parallel to bedding in Main Series overburden. a,b,c,d - exposed fault planes.

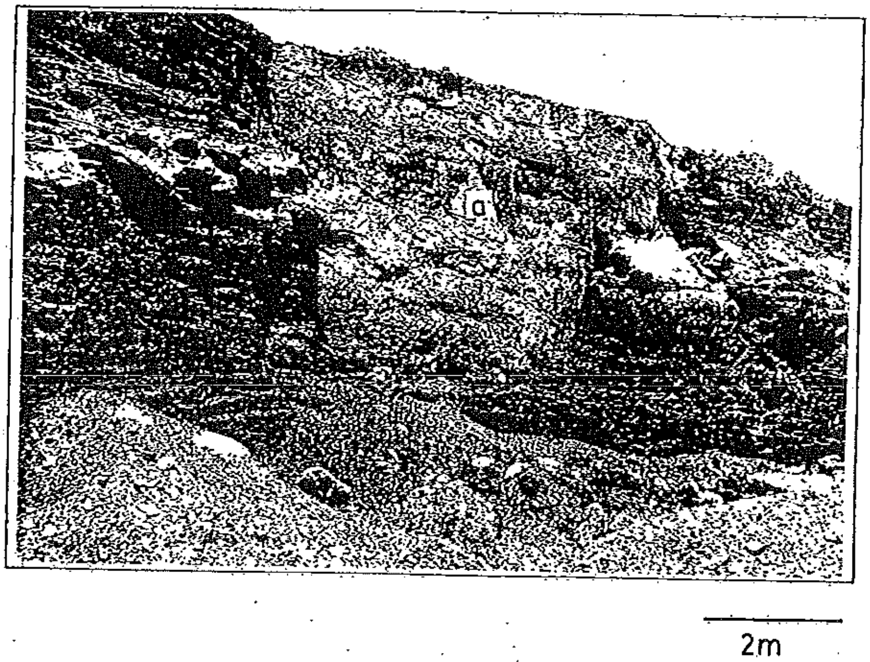


PLATE 7

Exposed Fault plane in Lower Series overburden.

PLATE 8

Mesoscopic graben structure in Lower Series Coal Measures, Telford Basin.

PLATE 9

High angle reverse fault with associated drag flexure in Main Series Coal.

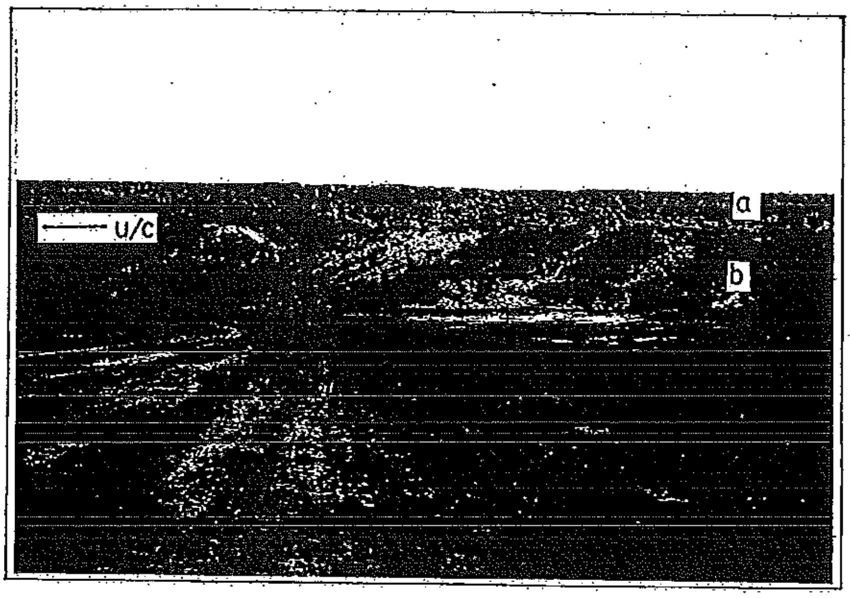


PLATE 10 Cainozoic sediments unconformably overlying Upper Series Coal Measures of late Triassic age.

a - Cainozoic sediments

u/c - unconformity

b - Upper Series Coal Measures and associated overburden.