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CRA EXPLORATION PTY.LIMITED.

THE LOWER FRESHWATER SEQUENCE OF THE PARMEENER SUPER GROUP - TASMANIA

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A. DEFINITION

The Lower Freshwater Sequence of the Parmeener Super Group is located between the Lower and Upper Marine Sequence, and includes the Liffey Group, Faulkner Group, Mersey Coal Measures, the Preolenna Coal Measures, and other informally named lithocorrelates.

It forms the base of the Bernacchian Stage of the Rekunian Series of Clarke and Farmer (1976), and occurs between marine macrofaunal stages 3 and 4 of Clarke and Banks (1975) in southern Tasmania.

The Mersey Coal Measures contain a microflora referrable to palynological Stage 3 (Truswell 1978), and the likely age for coal measures is early Artinskian.

B. DISTRIBUTION

The present distribution of Lower Freshwater Sequence (LFW) rocks in the state is shown on the plan accompanying this report.

In general, the most completely preserved region of LFW rocks occurs in the central, and probably southern, parts of the state, the north west and north east being characterised by outliers.

1. Lithologies

Lithologies range from micaceous quartz feldspathic sandstone interbedded with thin carbonaceous shales, to quartz sandstone and carbonaceous siltstone, to laminated sequences of interbedded fg quartz sandstone/carbonaceous siltstone/ shale.

Also present in many localities are conglomerates, worm casts, and coal/ oil

shale. Fish scales occur, and plant fossils include Glossopteris and Gangamopteris.

In some areas a crude tripartite subdivision is applicable, e.g. the upper sandstone, the coal (and shale), and lower sandstone horizons in the Mersey Coal Measure (Burns 1964); probable lithocorrelates of these at Poatina are the Creekton and Woodside Formations, the Kopanica, and the Flat Top Formations of MacKellar (1957). Elsewhere, regional mapping has not enabled this type of subdivision to be made to the unit.

2. Biostratigraphic Character of the Enclosing Marine Sequences

Clarke and Banks (1975) used marine invertebrates to define a maximum of 10 faunizones in the Lower and Upper Marine Sequences of the Parmeenar Super Group.

These faunizones occur within the Gondwana Eurydesma fauna, and allow recognition of a major depositional (and ? erosional) hiatus of variable duration during the Permian.

This hiatus is represented by the rocks of the LFW Sequence, the base of which is diachronous, with the onset of non marine conditions starting in the west, and eventually extending eastward.

The maximum extent of the hiatus (maximum time of fresh water sedimentation) is shown on the plan as represented by the faunizone 1 - 8 interval; this region is bounded by Port Sorell, Deloraine, ? Great Lake, ? Bothwell and ?Maydena on the east, but with uncertain western and southern boundaries.

Flanking this broad zone, non marine conditions were successively established eastward during the faunizone 2 - 9 interval (over the Westbury - Bracknell - Poatina - ?Lake Sorell area), during the faunizone 2 - 5 interval (over the Frankford - Exton area), and during the faunizone 2 - 6 interval (over the Beaconsfield area), as shown on the plan.

The eastern boundaries of the 2 - 9, 2 - 5 and 2 - 6 marine hiati are interpreted to lie approximately parallel to the Tamar Fracture System. In the south, the hiatus was of limited extent, such as 2 - 4 in the Hobart area and 3 - 4 on Maria Island; this latter interval is interpreted to extend NNW through the Midlands, possibly as far as Launceston.

3. Permian in North East Tasmania

Tillite is absent east of the Hobart meridian, and the Lower Marine Sequence is either absent or much condensed over most of NE Tasmania, the earliest widespread sediments being basal conglomerates of fluvial origin, overlain by litho-correlates of the LFW sequence in the west of the state.

These features may reflect the contrasting sedimentary and structural characters of the pre-Carboniferous basement rocks, resulting from the docking of an allochthanous terrane (NE Tasmania) along the Tamar Fracture System during Carboniferous (and ?later) time. Limited fossil evidence suggests a period of non deposition of marine sediments until faunizone 7.

It would therefore seem appropriate to consider the Permian palaeogeography of the region east of the Tamar Fracture System as being quite distinct from the region to the west, particularly the pre-Upper Marine Sequence of the Parmeener Super Group.

4. Thickness

Isopachs of the LFW Sequence show an average thickness to be 30 - 40m in the north and west of the state, with a maximum development in the Preolenna area (≪ 140m).

A similar 30 - 40m value is apparent in the NE of the state, but the inferred areal extent is much less than for the west of the state, (refer plan).

In the south, the LFW Sequence is characterized by ≤ 20m thickness, and shore lines have been inferred near Kingston and Bicheno (after Banks 1962).

No details exist for the unit under the cental plateau in the Lake Augusta - Lake Echo area, and the inferred thickening between Tarraleah and Mt. Field West is based on a single value at Wylds Craig.

Isopachs of contained shale/mudstone in the LFW Sequence show local thickening (≫ 2m) in the Devonport, Preolenna, Beaconsfield, Barn Bluff, Poatina and Mt. Pelion - Lake St. Clair areas, Coal is recorded in all these areas except Poatina and Beaconsfield.

Although post-Permian faulting and erosion has caused a reduction in the original extent of the Parmeener rocks, it is possible to recognize localised elongate basins characterized by the presence of:

(a) Coal and/or shale

(b) Relatively thick shale sections

(c) Local thickening of the LFW Sequence

The orientation of these basins would appear to have been controlled by regional trends in basement rocks, (e.g. Arthur Lineament, NW trending Devonian folds etc.).

C. ORGANIC MATTER IN THE LOWER FRESHWATER SEQUENCE

1. Introduction

Organic matter in the LFW Sequence has been described as boghead coal, cannel coal, torbanite, pelionite, kerosene shale, oil shale, and carbonaceous shale, which Hills et al (1922) designated under the single title of kerogenite. This material was considered to be characterized by volatile matter in excess of fixed carbon, and with a specific energy up to 37.2MJ/kg. A transitional category was termed humic kerogenite by Hills et al (1922), and was characterized by having volatile matter of 40 - 50%, and a specific energy of 27.9 - 37.2 MJ/kg.

It will be shown later in the report that the organic matter in the LFW Sequence is predominately sapropelic, with a variable, minor humic content.

The discovery of coal and oil shale in this sequence occurred about the same time as the discovery of Tasmanite oil shale in the Latrobe - Quamby Bluff and Hellyer Gorge areas.

For some time the coal and Tasmanite were considered to be facies variants of the other, but the latter contains the alga Tasmanites Punctatus, and occurs in the Lower Marine Sequence.

Black coal was first discovered in the Latrobe area in 1850, and from 1853 to

1960 total production from the Mersey Coal Measures was > 515 000 tonnes. Coal was found at Preolenna in 1901, and total production from 1918 to 1928 was approximately 20 000 tonnes.

2. Distribution

As described previously, coal is present in areas of local thickening of the host sequence and of the enclosing shales.

However, coal has not been found outside the faunizone 1 - 8 marine depositional hiatus as shown on the plan.

A similar time interval may have occurred for the 2 - 9 hiatus, but to date only oil shale (Osmaston) has been recorded in this region.

Multiple seams occur in the Preolenna CM (4), and in the western sector of the Mersey CM (3), while elsewhere (Barn Bluff, Mt. Pelion etc.) only a single coal seam is recorded.

Cumulative coal seam widths correlate best with total LFW Sequence thickness, and for the Mersey and Preolenna CM, the equivalent of 1m of coal for 50m of sequence is indicated, compared with a ratio of 1:80 for the other areas.

3. Coal/Oil Shale Seam Dimensions

(a). Devonport Area

(i) Mersey Coal Measures - generally only one seam present, which ranged from 0.08 - 0.76m, and averaged 0.46m.

A maximum of two other seams above the main seam were recorded - Dennys Colliery (0.15m), and in the Sherwood Colliery (0.27m and 0.15m). The

log of Smiths Bore records several coal bands in the shale floor to the main seam, and several shale and coal bands in the roof sandstone. However, the lack of detailed logging suggests these coal bands were probably $\leq$ 0.02m in width.

The occurrence of minor seams above the main seam coincides with near maximum widths of the main seam (0.68-0.74m in Smiths Bore and Dennys Colliery, 0.61m in Sherwood Colliery).

(ii) Don Valley Black Shale - this occurs in the Nook area, and consists of two units of oil shale, totalling $\simeq$ 2 m in width.

(b). Wynyard Area

(i) Preolenna Coal Measures - contain a minimum of four seams, of which No3 is relatively inferior, consisting of carbonaceous shale interbedded with bands of coal.

Seam No 1 (lowest) averages 0.74m, No2 averages 0.47m, No3 averages $\geq$ 1.07m, and No4 averages 0.58m.

The average width of seams 1, 2 and 4 is 0.60m, which is similar to the width of the main seam in the Mersey CM.

(c). Western Tiers

(i) Lake Holmes Coal Measures - these occur in the Barn Bluff area and consist of a single coal seam (including pelionite) $\simeq$ 0.20m thick.

(ii) Mt. Pelion - a single thin coal seam ranging from 0.08m (Hills et al 1922) to 0.43m (McLeod et al 1961), and averaging 0.27m in width.

(iii) Deloraine - oil shale is reported in a water bore near Osmaston, and which appears to be in the LFW Sequence.

(d). Lilydale Area

A single seam of oil shale (or carbonaceous shale and oil shale) up to 1m thick occurs in the Karoola and Dismal Range areas.

(e). Rossarden Area

Thin oil shales, probably aggregating $<$ 1m, occur in Castle Carey Creek at the base of the Aberfoyle Formation.

(f). Other

Sandstone containing carbonaceous and coaly debris occur in the Rossarden - Avoca, St. Marys, Seymour, Golden Valley, Poatina and Lake St. Clair areas, but no actual coal seams are recorded.

4. Coal/Oil Shale Composition

(a) Background

Hills et al (1922) described the Mersey CM as humic kerogenites, the Preolenna CM as humic kerogenite and kerogenites, and the Lake Holmes CM as humic kerogenites and "non caking humic" coals.

The Preolenna CM consists of"kerosene shale","black cannel coal", and "carbonaceous/ sapropelic shale", (Hills 1913), and were used for production of gas ($\simeq 0.33 m^3/kg$), low temperature distillation of oil ($\ll$ 450ℓ/tonne), and manufacture of coke.

The Lake Holmes CM consist of cannel coal containing lenses of "kerosene shale" termed "pelionite", the latter yielding $\ll$ 600ℓ/tonne of oil on distillation.

The Mersey CM were also considered suitable for gas generation and manufacture of coke (Hills et al 1922).

(b). Analyses

Proximate analyses are given as moisture (M), volatile matter (VM), fixed carbon(FC), ash (A) and sulphur (S).

(i) Mersey Coal Measures - The average composition of coal from the Illamatha, Spreyton, Dulverton etc. collieries was:
10.3%M, 41.1%VM, 41.4%FC, 5.3%A and ≃ 2.0%S;
The specific energy of the Illamatha and Spreyton coals was ≃ 25 MJ/kg, with a RD of ≃ 1.31.

(ii) Don Valley Black Shale

This unit has been subject to controversy concerning its stratigraphic position in view of its reported composition. It contains both algal kerogen (similar to Tasmanite oil shale), and coaly material (?vitrinite macerals), and Reid (1924) considered it to be transitional between Tasmanite and the coal of the area. An average analysis is as follows:
1.9%M, 16.3%VM, 8.5%FC, 73.3%A, 1.3%S and on distillation it yielded 90ℓ/tonne of oil.

(iii) Preolenna Coal Measures - The average composition of seams 1,2and 4 was as follows:
2.5%M, 41.7%VM, 43.4%FC, 10.4A and ≃ 2.0%S (Hills, 1913); the specific energy of "average coal" was ≃ 28MJ/kg, with a RD of 1.25 (Hills et al 1922).

The main components of the high grade coal are "kerosene shale" and "black cannel", the former averaging 1.3%M, 69.6%VM, 26.5%FC, and 2.9%A, and the latter 1.2%M, 40.5%VM, 50.8%FC, and 7.6%A.

The VM (dmmf. est.) of the kerosene shale is 72.5% and for the cannel coal 43.8%, both of which would appear to be high volatile coking and chemical coals as defined by the Joint Coal Board (categories 3 and 4).

The average analysis of seam 3 ("carbonaceous/sapropelic shale" with bands of coal), was:
2.8%M, 27.1%VM, 34.3%FC and 37.5%A; specific analysis of the "carbonaceous/ sapropelic shale" revealed: 4.5%M, 17.2%VM, 24.6% FC and 52.6%A, (Hills,1913).

(iv) Lake Holmes Coal Measures - Little work was done on this coal, and no analyses of the entire coal seam are available. The seam consists of cannel coal with lenses of pelionite (described by Nye et al (1933) as being a black kerosene shale). A single analysis of this gave: 0.2%M, 52.8%VM, 42.4%FC, 4.3%A and 0.7%S.

(v) Mt. Pelion Area - No analyses of the coal in this area were located, but it was reported to contain $\simeq$10%S, which suggests it is of sapropelic origin in common with other coals of the area.

(c). Sulphur Content

The actual sulphur content of the Mersey and Preolenna CMs appear contradictory, and to show a wide variation; Hills et al (1922) stated the PermoCarboniferous coals contained 1.5 - 6.0%S, and generally > 3.0%S. They also indicated it to occur as pyrite or marcasite in the form of nodules, lenses and veinlets, with only minor dissemination in the coal.

Detailed channel sampling of the Preolenna coal seams by Hills (1913) indicated

an erratic distribution of S, ranging up to 4% in some samples. Hills et al (1922) later quoted an average analysis of the same coal as having 5.9%S, and similarly ≃ 4%S for the MerseyCM. However, it is clear that these latter values are not statistically representative of the coals.

5. Origin of the Coal/Oil Shale

Ultimate analyses of the Mersey and Preolenna CMs enable the plotting of the data on a graph of atomic H/C vs atomic O/C; use of these atomic ratios clearly indicates a sapropelic origin of the organic matter, and conforms the cannel coal affinity of the coal measures in both areas.

An exinite maceral maturation pathway can be seen to extend from Preolenna kerosene shale to Don Valley Black Shale to pelionite to the cannel coals of the Mersey and Preolenna CMs. The VM/FC ratios of the latter cannel coals are virtually identical, apparently refuting the classification of these coals by Hills et al (1922).

The evolutionary path described above is located close to the boundary with the vitrinite maturation tract, and slightly removed from the group of boghead coals and oil shales (including Tasmanite oilshale) with higher H/C ratios.

Plotting of the atomic H/C and O/C ratios on a Van Krevelen diagram shows the coals to be transitional between herbaceous and woody kerogen (approx. equivalent to a mixed exinite and vitrinite maceral assemblage).

In conclusion, it would appear that coal (with sapropelic content in excess of humic content) accumulated contemporaneously with oil shales containing

as yet undefined exinite macerals, but which may include both alginite and the herbacous macerals.

These qualities suggest mixed continental - lacustrine (?marine) environments of formation for the coal and oil shale.

D. PALAEOGEOGRAPHY OF THE LOWER FRESHWATER SEQUENCE

Insufficient data precludes a definitive palaeogeographic reconstruction of the LFW Sequence, but certain empirical features can be recognized.

Following the late Carboniferous - early Permian glaciation (continental and wet base) as represented by the Wynyard Tillite and lithocorrelates, a period of marine sedimentation ensued in response to a glacio - eustatic rise in sea level over western and southern Tasmania. Banks (1962) considered this to be a shallow marine (platform/shelf) environment, and Clarke (1968) considered the Macrae Mudstone (in the Golden Valley area) to be a tidal flat or lagoonal deposit.

Eventually an isostatically rejuvenated (following deglaciation) highland block emerged in the west, with later marine regression in the east toward the Tamar Fracture System.

It is apparent that several different environments co existed over and peripheral to, this emerging block.

Available evidence indicates a generally non marine regime, but in which water circulation varied from free to restricted; ubiquitous sapropelic

organic matter implies many localised "basins" of deposition which in some cases appear to have formed in glacial valleys, as in the Barn Bluff area (Lake Holmes CM - Gee and Burns 1968), and in the Central Highlands (Banks 1978). The origin of the Prolenna coal "basin", now preserved as a fault bounded structure 5km wide and $\geq$ 10km long, may also have been a glacial valley.

Subsidence of these coal "basins" was generally not significant, (with the exception of the Preolenna area), and is in agreement with the shelf rather than geosynclinal conditions envisaged for the underlying marine sequence by Banks (1962).

The LFW Sequence in the west and north of the state is characterised in places by its laminated and interbedded sandstone/siltstone/shale successions, and accordingly an allochthonous origin for the coals in a high sinuosity single channel fluvial system seems unlikely.

The easterly prograding non marine sediments were apparently obstructed by the development of a syntectonic synclinal structure orientated NNW, and extending from Hobart to Port Sorell, (Banks, 1962). The axial region of this folding is approximately parallel to the Tamar Fracture System, and may reflect mild W - E compression from the NE Tasmania block during the final stages of docking in the ?Permian.

It appears that marine depositional regimes were not far removed, and once, during LFW time, a shallow gulf extended NNW across Hobart, Wylds Craig, Poatina, Port Sorell and Avoca, resulting in a marine intercalation.

The overall environment envisaged is a fluvo-deltaic system, in which fresh-water sediments were deposited in alluvial and upper delta plains, and brackish/anoxic water conditions existed in both upper and lower delta plains. Some of the wormcast sandstone/siltstone may have originated in a prodelta situation, while the more massive sandstones may represent proximal mouth bars. The elongate mature of the coal "basins" may reflect inter fluvial flood basins of the upper delta plain, or alternatively, lagoons and embayments in the lower delta plain.

Thus a tentative palaeogeography may have involved a NNW orientated highland extending from Burnie through Lake Augusta to Lake Echo which was flanked by alluvial plains; further down the palaeoslope, delta plains occurred on the west (Barn Bluff - Lake St. Clair, Preolenna and ? in the Tarraleah - Mt. Field West areas), and on the east (Devonport - Latrobe and ? Poatina areas). Further highland (alluvial plain) areas may have existed over the Badger Block near Beaconsfield, and to the west of Preolenna.

Extensive erosion in the NE of the state precludes detailed interpretation, but this highland block may have had coal measures adjacent to the oil shales shown on the plan.

The coals would therefore appear to have an allochthonous origin in water - marginal marine lagoons and embayments in and around delta plains.

Lack of development of thick seams was probably a function of;

(i) The shelf type floor to the delta complexes

(ii) The epeirogenic upwarping of the western limb of the synclinal structure

(i.e. post dating the isostatic uplift)

(iii) The climate at the time, which may not have promoted the abundance and diversity of flora required for the formation of extensive coal swamps.

There would appear to be little potential for locating large coal deposits given the size of basins, and the predicted seam widths (? 0.50m). However, several areas have not been investigated, mainly the Tarraleah - Mt. Field West area, with a lesser potential in the Beaconsfield - Frankford - Poatina region.

It is of interest however, that all the organic matter studied in the LFW Sequence represents high calibre source material for the generation of liquid hydrocarbons.

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KEYWORDS

Coal Sub-bituminous, Permian, Basin Study, Stratigraphy

LOCATION

SK55-3 Burnie
55-4 Launceston
55-5 Queenstown
55-6 Oatlands
55-8 Hobart

LIST OF PLANS

1.	Lower Freshwater Sequence Parmeener Super Group Isopachs	TASh 1762
2.	Lower Freshwater Sequence Parmeener Super Group Shale Isopachs with Coal and Oil Shale Occurrences.	TASh 1763
3.	Lower Freshwater Sequence Parmeener Super Group Marine Faunizone Indicated Extent	TASh 1764

389020

019

BURNIE

DEVONPORT

LAUNCESTON

CAMPBELL TOWN

QUEENSTOWN

HOBART

5 400 000mN

5 300 000mN

5 200 000mN

400 000mE

600 000mE

135(3)

40(4.5)

30(5.5)

40(5)

65(3)

45(1)

45(1)

45(?1)

21(3)

25approx.

30(3)

20(3)

25(25)

51

?45

5 cm

REFERENCE

OUTCROP } PARMEENER SUPER GROUP.

EDGE UNDER COVER

15 — ISOPACH IN METRES OF LOWER FRESHWATER SEQUENCE. PARMEENER SUPERGROUP.

30(3) — SAMPLE POINT & LFW WIDTH WITH SHALE WIDTH IN BRACKETS.

Compilation / Interpretation : Summons Geoservices Pty. Ltd. May 1984.

CRA EXPLORATION PTY. LIMITED

LOWER FRESHWATER SEQUENCE PARMEENER SUPER GROUP ISOPACHS

REF.	SK55 - 3,4,5,6,7,8		
SCALE	1 : 1000 000	DRAWN	R. T.
AUTHOR	T. S.	REPORT No.	12767
DATE	29 - 5 - 1984	PLAN No. TASh	1762

389021

020

Preolenna Coal Measures

0·6

2

0

BURNIE

Mersey Coal Measures

DEVONPORT

0·5

0·5

0·05

2

?

LAUNCESTON

5 400 000 mN

Lake Holmes Coal Measures

2

0·2

?

0

Coal Frags

1

?

0·4

CAMPBELL TOWN

QUEENSTOWN

?

0

1

?

5 300 000 mN

400 000 mE

HOBART

5 200 000 mN

Compilation / Interpretation : Summons Geoservices Pty. Ltd.
May 1984

5 cm

REFERENCE

OUTCROP
EDGE UNDER COVER
} PARMEENER SUPER GROUP

2 ISOPACH IN METRES OF SHALE (MAXIMUM CONTINUOUS) BEDS IN THE LOWER FRESHWATER SEQUENCE

OIL SHALE IN LOWER FRESHWATER SEQUENCE.

COAL IN LOWER FRESHWATER SEQUENCE.

● 0·5 AVERAGE COAL SEAM WIDTH.

CRA EXPLORATION PTY. LIMITED

LOWER FRESHWATER SEQUENCE PARMEENER SUPER GROUP SHALE ISOPACHS WITH COAL AND OIL SHALE OCCURRENCES

REF.	SK55 - 3,4,5,6,7,8		
SCALE	1 : 1000 000	DRAWN	R. T.
AUTHOR	T. S.	REPORT No.	12767
DATE	29 - 5 - 1984	PLAN No. TASh	1763

389022

021

BURNIE

DEVONPORT

LAUNCESTON

CAMPBELL TOWN

QUEENSTOWN

HOBART

5 400 000 mN

5 300 000 mN

5 200 000mN

400 000 mE

600 000 mE

2-6

2-5

1-8

?

?

0-7

2-9

1-8

?

?

3-4

0-7

2-4

3-4

2-4

5 cm

REFERENCE

OUTCROP

EDGE UNDER COVER

} PARMEENER SUPER GROUP

FAUNIZONE HIATUS BOUNDARY

1-8 MARINE DEPOSITIONAL HIATUS

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May 1984.

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LOWER FRESHWATER SEQUENCE
PARMEENER SUPER GROUP
MARINE FAUNIZONE INDICATED EXTENT

REF.	SK55 - 3,4,5,6,7,8		
SCALE	1 : 1 000 000	DRAWN	R. T.
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DATE	29 - 5 - 1984	PLAN No. TASh	1764