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BROWSE BASIN MODULE

VOLUME 1

BY

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PREFACE

In preparation of the Browse Basin Module Report, significant time and effort were contributed by members of the Australian Petroleum Systems Group. Without the dedication of those involved, the project study would have been less extensive and correspondingly certain products would not have been produced. Areas of responsibility were assigned to each member of the group, as listed below.

John Wilmot and Steve Winn, senior authors of the Module Report, were mainly responsible for the geophysical and geological interpretation, respectively. In conjunction with other members of the Group, Steve and John were involved in most aspects of the Project study, ranging from data organisation of STRATDAT and PROSPECTIVITY databases, in-depth basin analysis to product generation.

John Bradshaw, manager/co-ordinator of the Australian Petroleum Systems Group, was largely involved with the organisation of geological and geophysical information for the project study, as well as, producing various data outputs from STRATDAT and ORGCHEM database for analysis. Based on his experience in the previous Projects, John has provided valuable technical information and assistance to the Stage III Project.

Marita Bradshaw, synthesized the results of the detailed basin analysis into a petroleum system framework and provided valuable technical information and assistance, based on her experience in the previous Palaeogeographic Map Projects.

Clinton Foster, was mainly involved with the organisation of the STRATDAT database and contributed towards the analysis of the biostratigraphic data that were upgraded by Robin Helby and Alan Partridge.
Chris Boreham, contributed towards the analysis and interpretation of geochemistry data.
Technical support were provided by John Vizy, Scott Edgecome and Guiliana Zuccaro, and ranged from data collation, writing software programs to generating the various products.
Acknowledgments are also forwarded to Andrew Murray for his contribution to the geochemistry interpretation.

INTRODUCTION

PURPOSE

The aim of the project was to analyse the palaeogeographic controls on source, seal, reservoir distribution, and the structural and maturation history of the Browse Basin. This study builds upon previous work and concepts developed in the AGSO-APIRA Palaeogeographic Maps and Phanerozoic History of Australia Projects. Analyses are based on information from 29 wells and up to 3000 km of seismic line data. Results are presented as time slice data and interpretation maps, regional well log cross sections and seismic data, summary tabulations.

DIGITAL DATA

A series of digital databases containing prospectivity data (porosity, permeability, shows, etc) and biostratigraphic data (STRATDAT) have also been prepared. Below is a file listing example of the data from the Prospectivity database. This data was originally compiled from Excel (Windows) format, and hand copies are included in Appendices 5 to 9 in spreadsheet and map format.

WELL NAME	Depth m RT	Depth to m RT	Porosity Average	Porosity Minimum	Porosity Maximum	Source	Who
ASHMORE REEF #1	298.1	321.0		31	32	LOG	BOCAL
ASHMORE REEF #1	321.0	421.2		22	33	LOG	BOCAL

The STRATDAT database is in an ORACLE relational format and a hard copy of the data is shown in Appendix 3 with plots of the data in Appendix 4. STRATDAT links to AGSO's Petroleum Exploration Database (PEDIN) by the use of the Unique Number (UNO).

TIME SLICE DEFINITION AND BOUNDARIES

The following section on time slice definition and boundaries is summarised from the "1992 BMR Palaeogeographic Atlas of Australia, Volume 8 - Jurassic by Bradshaw,M.T. & Yeung,M., 1993 and Volume 9 - Cretaceous by Bradshaw, M.T., Yeung, M., Beynon,R.M., & Burger,D. (in prep.)"

Biostratigraphic schemes used in the study are:

(1) Integrated dinoflagellate and spore-pollen zonation of the Australian Mesozoic developed by Helby et al (1987)

(2) Foraminiferal zonation for the North West Shelf (Wright, 1977; Heath & Apthorpe, 1981, & 1984; Apthorpe, 1988)

(3) Foraminiferal zonation for the Cainozoic (Blow, 1969, & 1979; Berggren, 1969; Kennett & Srinivasan, 1983)

(4) Australian Phanerozoic Timescales Volume 1 - 10 (Shergold, 1989; Webby & Nicoll, 1989; Strusz, 1989; Young, 1989; Jones, 1989; Archibold & Dickens, 1989; Balme, 1989; Burger, 1989a; Burger, 1989b; Truswell et al, 1989).

These schemes are referenced to the Harland 1982 Time Scale (Harland et al, 1982).

The time slice boundaries occur at natural breaks in sedimentation or changes in facies that are common to several basins. Some time slices are representative of geological events that have continent wide effects.

There are difficulties in selecting time slices that are applicable across Australia due to contrasting depositional and tectonic regimes and correlation difficulties of the biostratigraphy such as relating the spore-pollen zonations in Eastern Australia with the main and dinoflagellate zones of Western Australia.

The precise correlation, duration and absolute ages of the time slices were derived in previous projects after lengthy consultation with many biostratigraphers, industry sponsors and the State Geological Surveys. The time slices were the basis of the products in both the Palaeogeographic Maps Project and the Phanerozoic History of Australia project. Thus the details presented in this study can immediately be related to more regional concepts and maps already produced.

Key time slices interpreted in the Browse Basin Study are predominantly within the Jurassic and Cretaceous periods. A total of ten time slices for the Jurassic and eleven for the Cretaceous have been recognised from the previous projects. The selection criteria for these time slices are provided in the following sections, illustrated in Figures 1 and 2 and shown in Enclosure 3.

JURASSIC TIME SLICE 1: HETTANGIAN TO SINEMURIAN (213 - 200 Ma)

The Jurassic/Triassic boundary is not marked biostratigraphically. It occurs within the *A.reducta* and *P.crenulatus* spore-pollen zones, and the *D.priscum* dinoflagellate zone.

JURASSIC TIME SLICE 2: PLIENSBACHIAN TO EARLY TOARCIAN (200 - 191 Ma)

Time Slice J2 corresponds to the *N.vallatus* datum. It is marked by facies change in many basins and the commencement of deposition in others, eg on the northwest margin there was a facies change from marginal marine clastic sediments to shallow water limestone.

JURASSIC TIME SLICE 3: EARLY TO MIDDLE TOARCIAN (191 - 189 Ma)

Time Slice J3 is marked by a distinct change in lithology and depositional environment in the Surat and other eastern Basins. It corresponds to *Applanopsis spp*, and is marked by the development of ironstone oolite beds within the Evergreen Formation and its equivalents, and corresponds to high sea level episode.

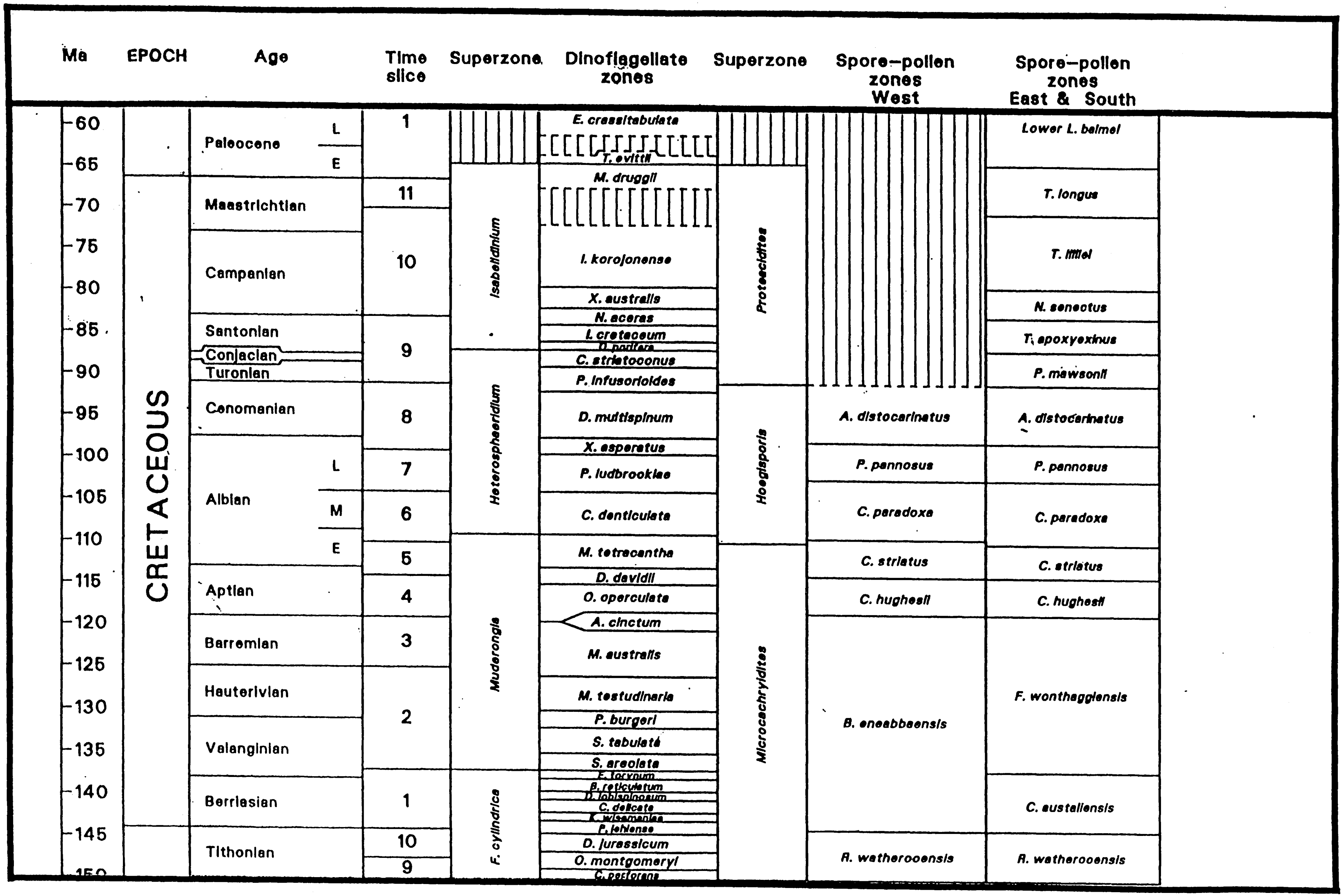


Figure 1 Cretaceous time slices versus fossil zonations

Ma	EPOCH	Age	Time slice	Superzone	Dinoflagellate zones	Superzone	Spore–pollen zones West	Spore–pollen zones East & South
140		Berriasian	1	F. cylindrica	E. torynum B. reticulatum D. lobispinosum C. delicata K. wisemaniae P. iehiense			C. australiensis
145	JURASSIC	Tithonian	10 9	F. cylindrica	D. jurassicum O. montgomeryi C. perforans		R. watherooensis	R. watherooensis
150–155	JURASSIC	Kimmeridgian	8	Pyxidiella	D. swanense W. clathrata	C. dampieri	M. florida	M. florida
160	JURASSIC	Oxfordian	8	Pyxidiella	W. spectabilis R. aemula	C. dampieri	M. florida	M. florida
165	JURASSIC	Callovian	7	P. ceratophora	W. digitata	C. dampieri	M. florida	M. florida
170	JURASSIC	Bathonian	6	P. ceratophora	W. indotata C. halosa	C. dampieri	C. cooksoniae	C. cooksoniae
175–180	JURASSIC	Bajocian	5	P. ceratophora	D. caddaense	C. dampieri	Upper / Lower D. complex	D. complex
185	JURASSIC	Aalenian	4			C. dampieri	C. turbatus	C. turbatus
190	JURASSIC	Toarcian	3 2			C. dampieri	C. turbatus	C. turbatus
195	JURASSIC	Pliensbachian	2	Shublikodinium	D. priscum	C. dampieri	C. torosa	C. torosa
200–205	JURASSIC	Sinemurian	1	Shublikodinium	D. priscum	C. dampieri	C. torosa	C. torosa
210	JURASSIC	Hettangian	1	Shublikodinium	D. priscum	C. dampieri	C. torosa	C. torosa
215	C	Rhaetian	6	Shublikodinium	R. rhaetica		A. reducta	P. crenulatus
220–225	C	Norian		Shublikodinium	H. balmei S. listeri		M. crenulatus	P. crenulatus

Figure 2 Jurassic time slices versus fossil zonations

JURASSIC TIME SLICE 4: LATE TOARCIAN TO EARLY BAJOCIAN (189 - 180 Ma)

Time Slice J4 corresponds to the commencement of deposition of the Hutton sandstone in the Eromanga and Surat Basins, the Algebuckina sandstone in the Poolowanna Trough, the Cattamarra Coal Measures in the Perth Basin, and the expansion of deposition in the Papuan Basin. Biostratigraphically it is loosely defined as occurring within the lower part of the *C.turbatus* zone.

JURASSIC TIME SLICE 5: EARLY TO MIDDLE BAJOCIAN (180 - 177 Ma)

Time Slice J5 is marked by a marine transgression in the Perth Basin. It is biostratigraphically defined by the *D.caddaense* dinoflagellate zone. Ammonites contained within sediments of Time Slice J5 in the Perth Basin allow direct correlation with the European stages.

JURASSIC TIME SLICE 6: LATE BAJOCIAN TO EARLY CALLOVIAN (177 - 167 Ma)

The base of Time Slice J6 equates with the top of the *D.caddaense* dinoflagellate zone. Stratigraphically, the base of the time slice coincides with the end of the Cadda transgression in the Perth Basin and the top of the time slice equates to the regional "Callovian Unconformity" seen in several basins on the North West Shelf.

JURASSIC TIME SLICE 7: MID CALLOVIAN TO EARLY OXFORDIAN (167 - 162 Ma)

The base of Time Slice J7 equates with the bases of the *M.florida* and *W.digitata* zones and the top is defined by the base of the dinoflagellate zone *W.spectabilis.* It also represents an episode of uplift and erosion, prior to the commencement of sea floor spreading, on the North West Shelf. It also coincides with the transition of the Hutton Sandstone deposition to a lower energy shale prone Birkhead fluvio-lacustrine regime.

JURASSIC TIME SLICE 8: EARLY OXFORDIAN TO KIMMERIDGIAN (162 - 150 Ma)

Time Slice J8 encompasses the time of maximum transgression in the Jurassic. The top boundary coincides with an unconformity on the North West Shelf, the Papuan and Laura

Basins. It also coincides with a facies change in many other basins. Biostratigraphically, the base of the time slice equates to the base of the *W.spectabilis* dinoflagellate zone and the top corresponds to major zonation boundaries in both dinoflagellate and spore-pollen schemes.

JURASSIC TIME SLICE 9: EARLY TITHONIAN (150 - 147.5 Ma)

The base of Time Slice J9 is marked by a regional unconformity observed in the Papuan and Bonaparte Basins. It is defined biostratigraphically by the *C.perforans* and *O.montgomeryi* dinoflagellate zones and is within the lower part of the *R.watherooensis* spore pollen zone. Time Slice J9 represents a phase of relative regression on the North West Shelf that corresponded to a shift in the Eromanga Basin from low energy Birkhead deposition to higher energy sand sheet regime of the Adori Sandstone.

JURASSIC TIME SLICE 10: LATE TITHONIAN (147.5 - 144 Ma)

The base of Time Slice J10 corresponds to the base of *D.jurassicum* dinoflagellate zone. The top of the time slice represents the Jurassic/Cretaceous boundary which lies within the *P.iehiense* dinoflagellate zone. The first appearance of *C.australiensis* pollen is used as the biostratigraphic definition of the base Cretaceous in Australia. Time Slice J10 also represents a transgressive phase following the regression of Time Slice J9.

CRETACEOUS TIME SLICE 1: BERRIASIAN TO EARLY VALANGINIAN (144 - 137 Ma)

The base of Time Slice K1 is defined by the Jurassic/Cretaceous boundary, which is within the *P.iehiense* dinoflagellate zone and equates with the base of the *C.australianensis* spore-pollen zone.

CRETACEOUS TIME SLICE 2: VALANGINIAN TO HAUTERIVIAN (137 - 125 Ma)

The base of Time Slice K2 represents a major unconformity in many basins, particularly on the western margin of the Australian continent. It also corresponds to a major sea level fall on the Haq et al (1987) chart. Biostratigraphically the base is defined by the *E.torynum* /

S.areolata dinoflagellate zone and the *C.australianensis / F.wonthaggiensis* spore-pollen boundary. It equates to the M10 magnetic anomaly and to the start of a major phase of sea floor spreading along the western margin in the Perth, Cuvier and Gascoyne Abyssal Plains.

CRETACEOUS TIME SLICE 3: BARREMIAN (125 - 119 Ma)

This time slice is characterised by transgression of the sea into central and western Australia. There is no direct biostratigraphic correlation to the Barremian stage, but a working definition equivalent to the *M.australis* dinoflagellate zone.

CRETACEOUS TIME SLICE 4: APTIAN (119 - 114 Ma)

Time Slice K4 records the peak marine transgression across the Australian continent. It is biostratigraphically defined by the dinoflagellate zones *A.cinctum*, *O.operculata* and *D.davidii*; and the *C.hughesii* spore-pollen zone. Time Slice K4 corresponds to changes in stratigraphy in many basins with the deposition of marine shales over sandstones in offshore locations. Time Slice K4 may be absent and represented by a condensed sequence.

CRETACEOUS TIME SLICE 5: EARLY ALBIAN (114 - 110 Ma)

Time Slice K5 encompass a period of sea level retreat. It equates to the *C.striatus* spore-pollen zone and approximates the *M.tetracantha* dinoflagellate zone.

CRETACEOUS TIME SLICE 6: MIDDLE ALBIAN (110 -104 Ma)

Continued regression occurred during Time Slice K6. The base of the time slice equates to the base of *C.paradoxa* spore-pollen zone and the top equates to the top of *C.denticulata* dinoflagellate zone.

CRETACEOUS TIME SLICE 7: LATE ALBIAN (104 - 99 Ma)

Time Slice K7 represents a transgressive episode and corresponds to a global oceanic anoxic event. Biostratigraphically it approximates the *P.ludbrookiae* dinoflagellate zone.

CRETACEOUS TIME SLICE 8: LATE ALBIAN TO CENOMANIAN (99 - 91 Ma)

During this time slice the sea retreated from the centre of the continent, but there is a rise in relative sea level on the western margin. It is biostratigraphically defined by the C2, C3a and C3b foram zones, approximates the *X.asperatus* and *D.multispinum* dinoflagellate zones and *A.distocarinatus* spore-pollen zone.

CRETACEOUS TIME SLICE 9: TURONIAN TO SANTONIAN (91 - 83 Ma)

Carbonate sedimentation became dominate on the western margin during this time slice. It is biostratigraphically defined by the C4 to C8 foram zones, the *C.triplex* and *T.pachyexinus* spore-pollen zones, and approximates the *P.infusorioides* to *I.cretaceum* dinoflagellate zones.

CRETACEOUS TIME SLICE 10: CAMPANIAN TO EARLY MAASTRICHTIAN (83 - 70 Ma)

Time Slice K10 corresponds to the commencement of sea floor spreading in the Tasman Sea. It is biostratigraphically defined by the C4 to C8 foram zones, the *N.senectus* and *T.lilliei* spore-pollen zones, and approximates the *N.aceras* to *I.korojonense* dinoflagellate zones.

CRETACEOUS TIME SLICE 11: MIDDLE TO LATE MAASTRICHTIAN (70 - 65 Ma)

Time Slice K11 is biostratigraphically defined by the C12 and C13 foram zones, the *M.druggii* dinoflagellate zone and the *T.longus* spore-pollen zone. Its top boundary represents the Mesozoic / Cainozoic boundary.

METHODOLOGY

Biostratigraphic data from Well Completion Reports and published information were reviewed by consultant biostratigraphers Alan Partridge and Dr Robin Helby. The reinterpreted palynological and palaeontological assemblages were further reviewed and documented into the STRATDAT database by Dr Clinton Foster (see Appendix 3).

Age/depth plots were constructed to provide quick-look interpretations of apparent changes in the rate of sedimentation, presence of condensed sections and unconformities, fault intersections at well locations and to assess the nature of the biostratigraphic control. An example of an interpreted age/depth plot is shown in Figure 3 and a chart of age/depth plot interpretations in Figure 4. Age/depth plots for all wells studied are in Appendix 4. Depths of time slice boundaries are derived from age/depth plots and correlated with wireline logs as shown in Figure 5. Interpretational picks of time slice boundaries from age/depth plots often coincide with key sequence boundaries and marine flooding surfaces with reasonable consistency, thus providing easier correlation of the chronostratigraphic surfaces identified from logs.

Lithological descriptions from ditch cuttings, sidewall cores and conventional cores were used together with gamma ray and sonic log signatures to determine facies type and depositional environments for each time slice. Biostratigraphic data were also used to provide additional information on the environment of deposition from fossil content such as diversity, abundance and the ratio of spore-pollen to marine microfossils.

Digital well log data, provided by Woodside, BHPP, NORCEN, Santos and Shell, were utilised to construct four well log correlations (Enclosures 4 to 7) displaying codes representing the various depositional environments and landform elements as provided in Figure 6 and Table 1.

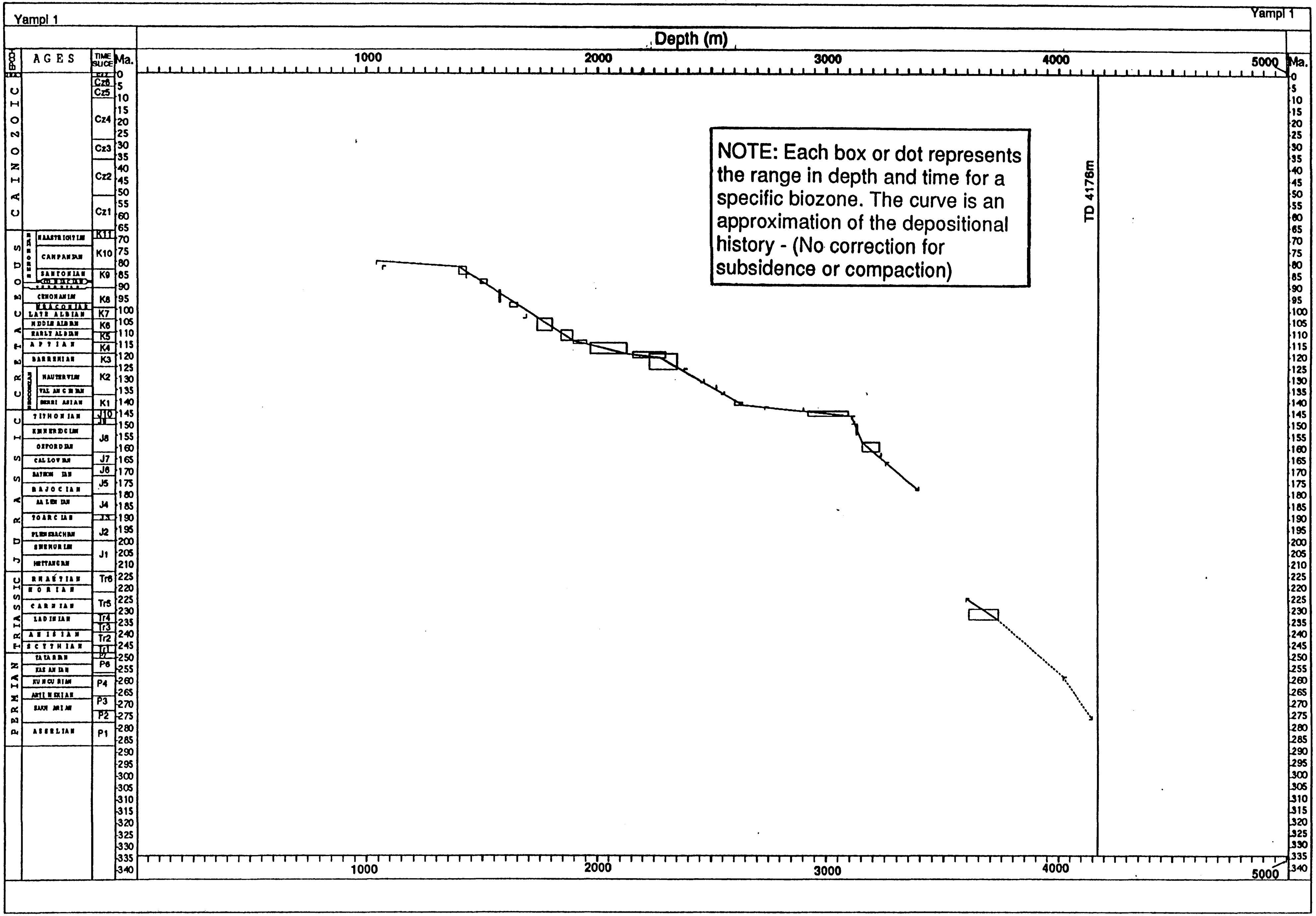


Figure 3 Example of an interpreted age/depth plot

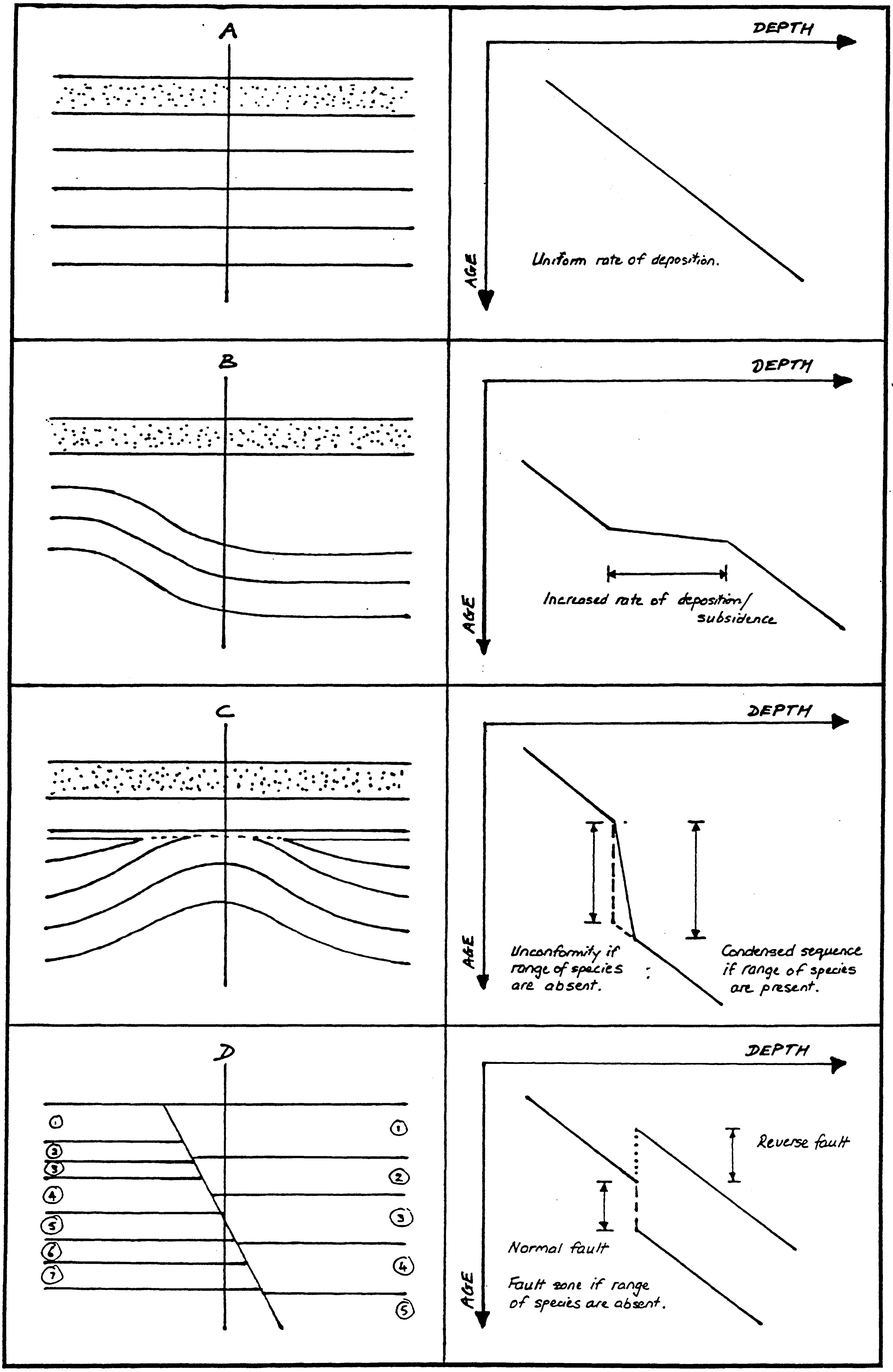
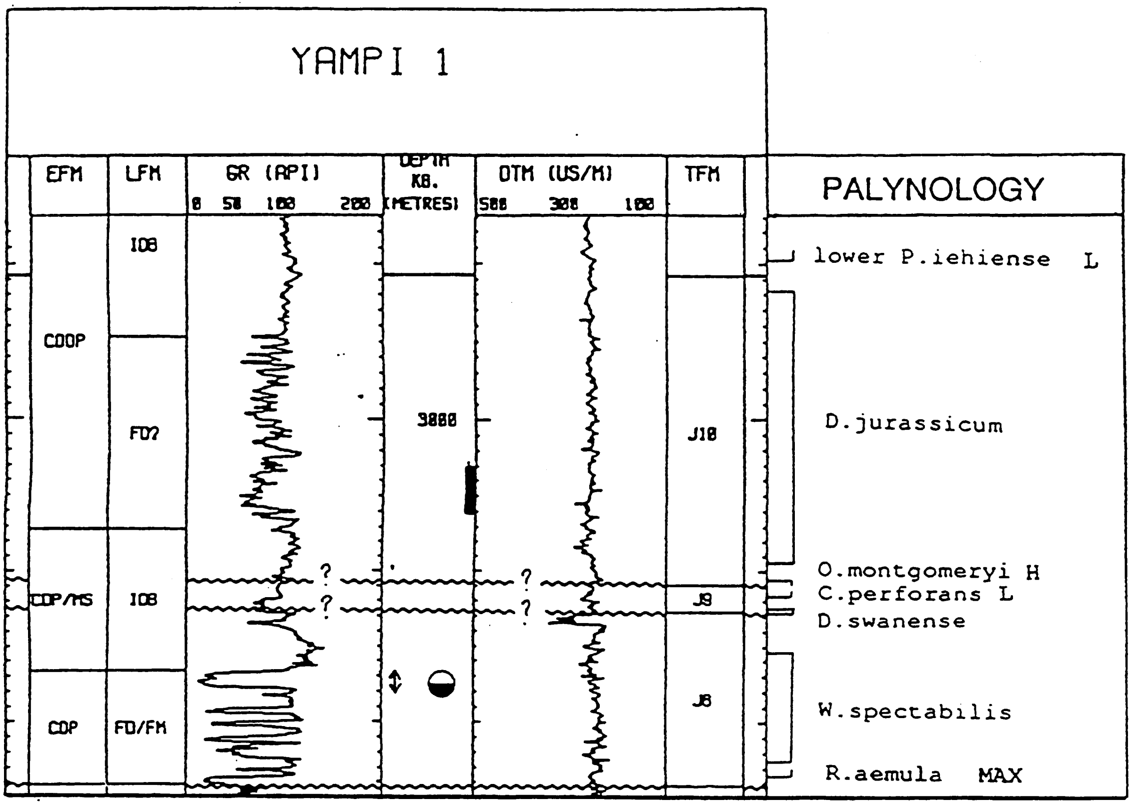


Figure 4 Schematic diagram of age/depth plot interpretations

LEGEND



EFM CODES FOR DEPOSITIONAL ENVIRONMENTS-SEE TABLE 1

LFM CODES FOR LANDFORM ELEMENTS-SEE TABLE 1

TFM CODES FOR TIME SLICES

PALYNOLOGY SEE APPENDIX 3 & ENCLOSURE 3

CORE

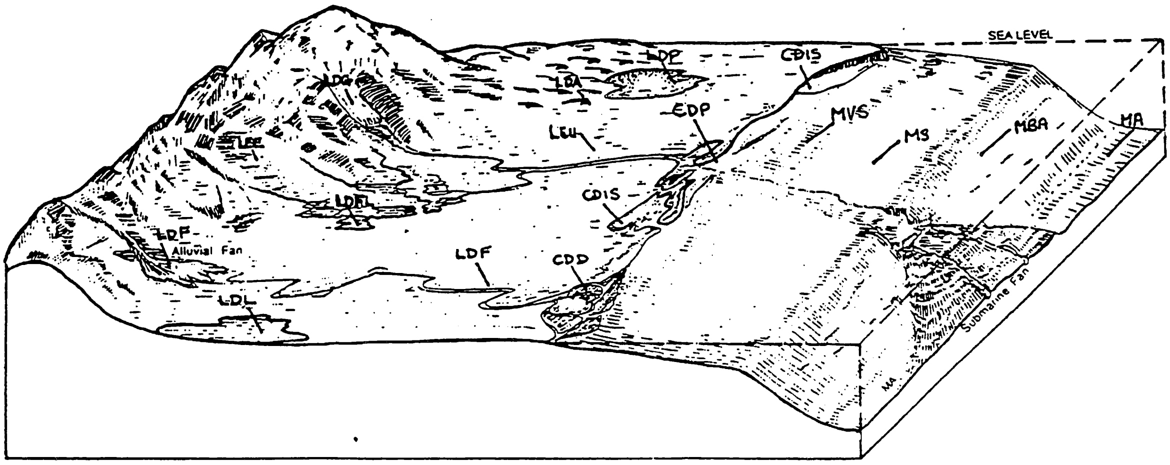
Unconformity

Possible Unconformity or Condensed Sequence

VERTICAL SCALE 1:5000

Figure 5 Legend for Enclosures 4 - 7 displaying time slices boundaries (TFM), environment codes (EFM) and landform element codes (LFM)

CODE	ENVIRONMENT	WORKING DEFINITION
Land & land depositional environments		
LEU	Unclassified	Areas with no preserved sediments of time-slice age, interpreted as land, for example the Ashmore Platform. Also areas that are largely unknown that may have Jurassic sediments, such as the Queensland Plateau.
LEE	Erosional	Highland areas of sediment erosion, indicated by palaeocurrents, provenance studies, tectonic setting and the presence of igneous intrusions, for example the Arburn Arch.
LDF	Depositional, Fluvial	River deposits such as alluvial fans, braided and meandering channel deposits and coarser overbank sediments, and sand-dominated continental sequences with no evidence of aeolian or lacustrine deposition.
LDFL	Depositional, Fluvio-Lacustrine	Sediments deposited in low-energy river environments such as channels, overbanks, backswamps and shallow lakes on low-gradient floodplains; typically sequences dominated by fine-grained sediments and coal, with sheet geometry.
LDL	Depositional, Lacustrine	Deposits of deep, persistent lakes, usually in tectonically controlled basins. Distinguished from LDFL by thicker shales and more restricted distribution.
Coastal depositional environments		
CDP	Paralic	Deposits of coastal or marginal marine environments. Includes the range of environments situated at the land/sea boundary such as lagoonal, beach, intertidal, deltaic, etc., and is recognised by a variety of depositional facies ranging from coarse cross-bedded beach sand, to sand deposited in tidal deltas, to finely laminated organic sediment deposited in lagoons and estuaries (includes deltaic and intertidal-supratidal environments).
CDIS	Intertidal-Supratidal	Sediments deposited in the tidal zone, indicated by the presence of finely interlaminated fine and coarse detritus, herringbone cross-bedding, flaser bedding, evidence of periodic exposure, etc.
CDD	Deltaic	Deltaic deposits indicated by isopach patterns, upward-coarsening sequences and the map pattern of adjacent environments. Cuspate or lobate form of deltas on maps in some cases follows isopach pattern.
Marine environments		
MVS	Very Shallow (0-20 m water depth)	Marine sediments with evidence of deposition above wave base and/or occasional emergence, e.g. oolites, cross-bedding.
MS	Shallow (0-200 m water depth)	Marine sediments deposited on the continental shelf or on flanks of volcanic islands, e.g. sand, mud and limestone containing fossils that typically lived in shallow water; also includes areas along young, active spreading ridges (includes MVS).
MBA	Bathyal to Abyssal (> 200 m water depth)	Marine sediments with indicators of deep-water deposition, e.g. condensed sequences, turbidites, monotonous shale, and the presence of deeper-water organisms (includes abyssal environments).



Schematic Diagram Showing
Classifications of Depositional Environments

Figure 6 Schematic diagram showing classifications of depositional environments (Cook, 1990)

Table 1 Environment and Landform Element Codes

ENVIRONMENT CODES

LAND	LEU	Unclassified		
	LEE	Erosional		
	LUD	Unclassified Depositional		
	LDF	Fluvial	LDFB	Braided
			LDFM	Meandering
	LDL	Lacustrine		
	LDFL	Fluvial-Lacustrine		
	LDP	Playa		
	LDA	Aeolian		
	LDG	Glacial		
COASTAL	CDP	Paralic		
	CDIS	Intertidal / Supratidal		
	CDD	Deltaic	CDDU	Upper Delta Plain
			CDDL	Lower Delta Plain
			CDDP	Pro Delta
	CDE	Estuarine		
MARINE	MU	Unclassified		
	MSS	Starved Shelf		
	MS	Shallow (0 - 200m)		
			MVS	Marine Very Shallow (0 - 20m)
	MBA	Bathyal to Abyssal (>200m)		
			MA	Abyssal

LANDFORM ELEMENT CODES

V	Volcano		
LF	Lava Field		
VM	Volcanics Mixed		
C	Channel		
AF	Alluvial Fan	AFT	Fan Toe
		AFD	Debris Flow
		AFS	Sheet Flow
PB	Point Bar		
AC	Abandoned Channel		
LE	Levee		
CS	Crevasse Splay		
BS	Backswamp		
LD	Lacustrine Delta		
SF	Salt Flat		
MF	Mud Flat		
P	Pond		
D	Dune		
S	Swale		
B	Beach		
BR	Beach Ridge		
SMB	Stream Mouth Bar		
IDB	Interdistributary Bay		
SML	Submarine Levee		
CE	Chenier		
M	Marsh		
LA	Lagoon		
OB	Offshore Bar		
BI	Barrier Island		
F	Fan	FP	Fan Proximal
		FM	Fan Mid
		FD	Fan Distal
R	Reef	RT	Reef Toe
		RF	Reef Front
		RB	Reef Back
CSH	Continental Shelf		
CSL	Continental Slope		
TF	Turbidite Fan	TFP	Turbidite Fan Proximal
		TFM	Turbidite Fan Mid
		TFD	Turbidite Fan Distal
AP	Abyssal Plain		

Palaeogeographic maps summarising the interpreted depositional environments and landform elements are presented for selected time slices.

EXPLORATION HISTORY AND HYDROCARBON OCCURRENCES

A detailed review of the History of Exploration is presented by Willis (1988) and briefly summarised in the following paragraphs.

Exploration began in 1964 with a 1500 kilometre seismic survey. The first well was drilled in 1967 at Ashmore Reef 1 and confirmed the presence of a thick sedimentary sequence dating back at least to the Triassic, but encountered no indications of hydrocarbons. The pace of exploration accelerated in the 1970s and by 1975 some 22,000 kilometres of seismic had been shot and ten wells drilled, including the gas condensate discovery well at Scott Reef 1. As a consequence of water depth placing a constraint on the location of these early wells and in order to meet work obligations, some ill defined traps in shallow water had to be drilled. Nevertheless, these wells proved that generation and migration of hydrocarbons had taken place within the basin and gave stratigraphic control for seismic interpretation. To date, a total of 33 wells have been drilled in and adjacent to the Browse Basin, of which 29 wells have been incorporated into the Module Study, see Table 2.

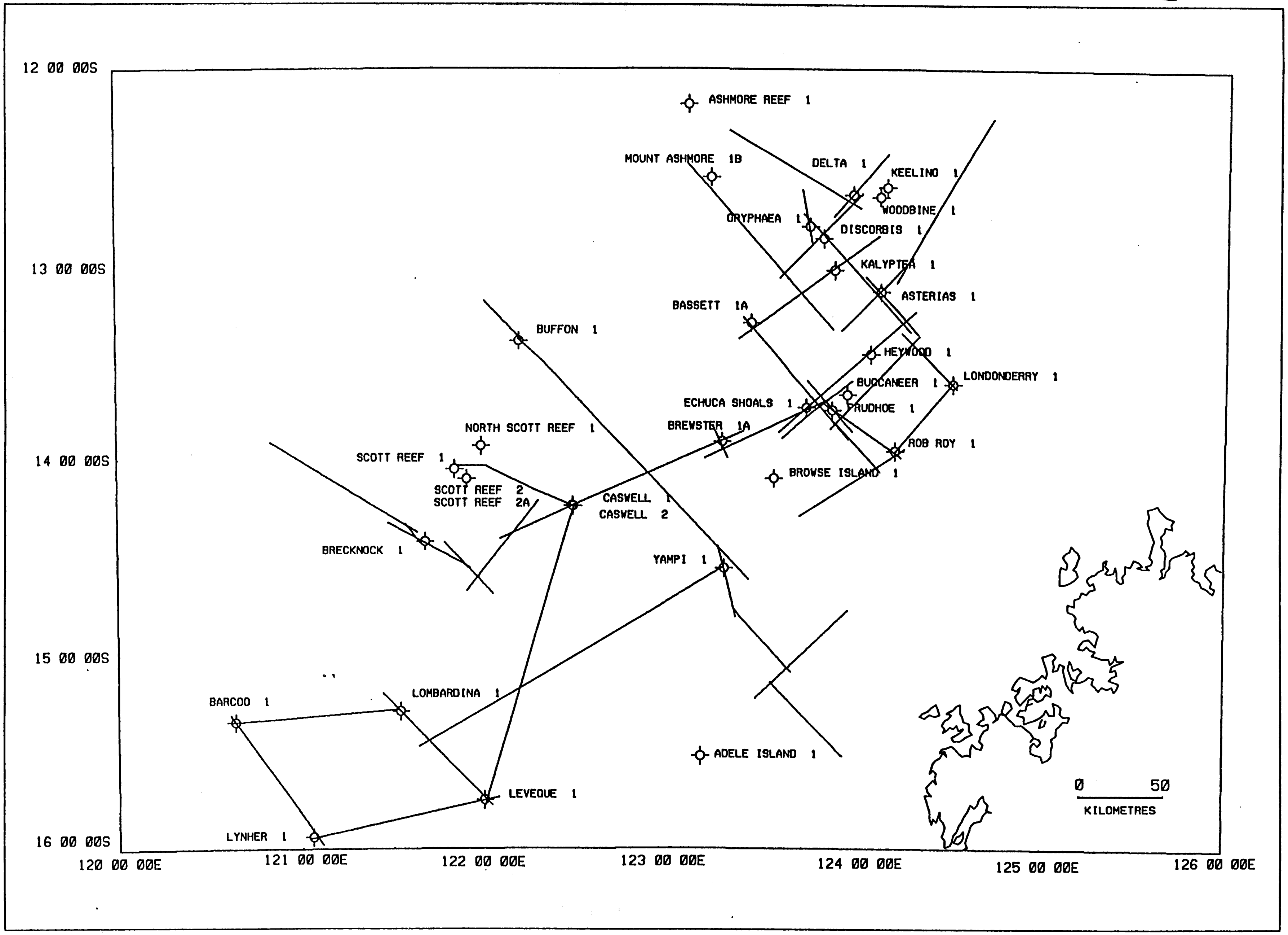
The major discoveries to date are gas and condensate in Scott Reef 1 and 2 and North Scott Reef 1, and gas in Brewster 1 and Echuca Shoals 1. The most significant oil shows, although relatively minor when compared to the gas discoveries, occur in Caswell 1 and 2, Asterias 1, Buccaneer 1 and Yampi 1. Significant hydrocarbon shows are summarised in Figures 8 to 16 and presented fully in Appendix 7. Very recent work not included in this study (Haston & Farelly, 1993) has shown that potentially a large oil accumulation exists in the southwest of the basin in Arquebus 1.

Figure 7 shows well and seismic line locations used in the module. A tabulation of seismic lines incorporated in the study is shown in Table 3 in the Geophysical Interpretation section.

WELLNAME	OPERATOR	SPUD DATE	COMPLETION DATE
ASHMORE REEF 1	BOCAL	16/10/67	2/04/68
ASTERIAS 1	BHPP	14/06/87	15/09/87
BARCOO 1	WOODSIDE	14/12/79	12/07/80
BASSETT 1	WOODSIDE	26/05/78	28/07/78
BRECKNOCK 1	WOODSIDE	31/07/79	12/12/79
BREWSTER 1A	WOODSIDE	23/05/80	19/12/80
BUCCANEER 1	SHELL	26/02/90	12/04/90
BUFFON 1	WOODSIDE	4/01/80	3/08/80
CASWELL 1	WOODSIDE	16/08/77	13/01/78
CASWELL 2	WOODSIDE	1/04/83	6/11/83
DELTA 1	ELF AQUIT	26/02/88	16/04/88
DISCORBIS 1	BHPP	8/08/89	21/11/89
ECHUCA SHOALS 1	WOODSIDE	8/11/83	29/02/84
GRYPHAEA 1	BHPP	17/09/87	24/11/87
HEYWOOD 1	BOCAL	7/04/74	14/07/74
KALYPTEA 1	BHPP	17/09/88	26/03/89
KEELING 1	NORCEN	16/12/89	18/01/90
LEVEQUE 1	BOCAL	22/08/70	6/09/70
LOMBARDINA 1	BOCAL	15/05/74	21/07/74
LONDONDERRY 1	BOCAL	28/09/73	8/10/73
LYNHER 1	BOCAL	24/12/70	16/02/71
MT ASHMORE 1	WOODSIDE	26/07/80	26/10/80
NTH SCOTT REEF 1	WOODSIDE	6/02/82	18/06/82
PRUDHOE 1	BOCAL	13/09/74	12/11/74
ROB ROY	BOCAL	27/01/72	28/02/72
SCOTT REEF 1	BOCAL	18/02/71	9/06/71
SCOTT REEF 2	WOODSIDE	27/04/77	9/08/77
WOODBINE 1	WOODSIDE	6/03/79	22/05/79
YAMPI 1	BOCAL	3/06/73	27/09/73

Table 2 Wells used in study

Figure 7 Well and seismic line locations



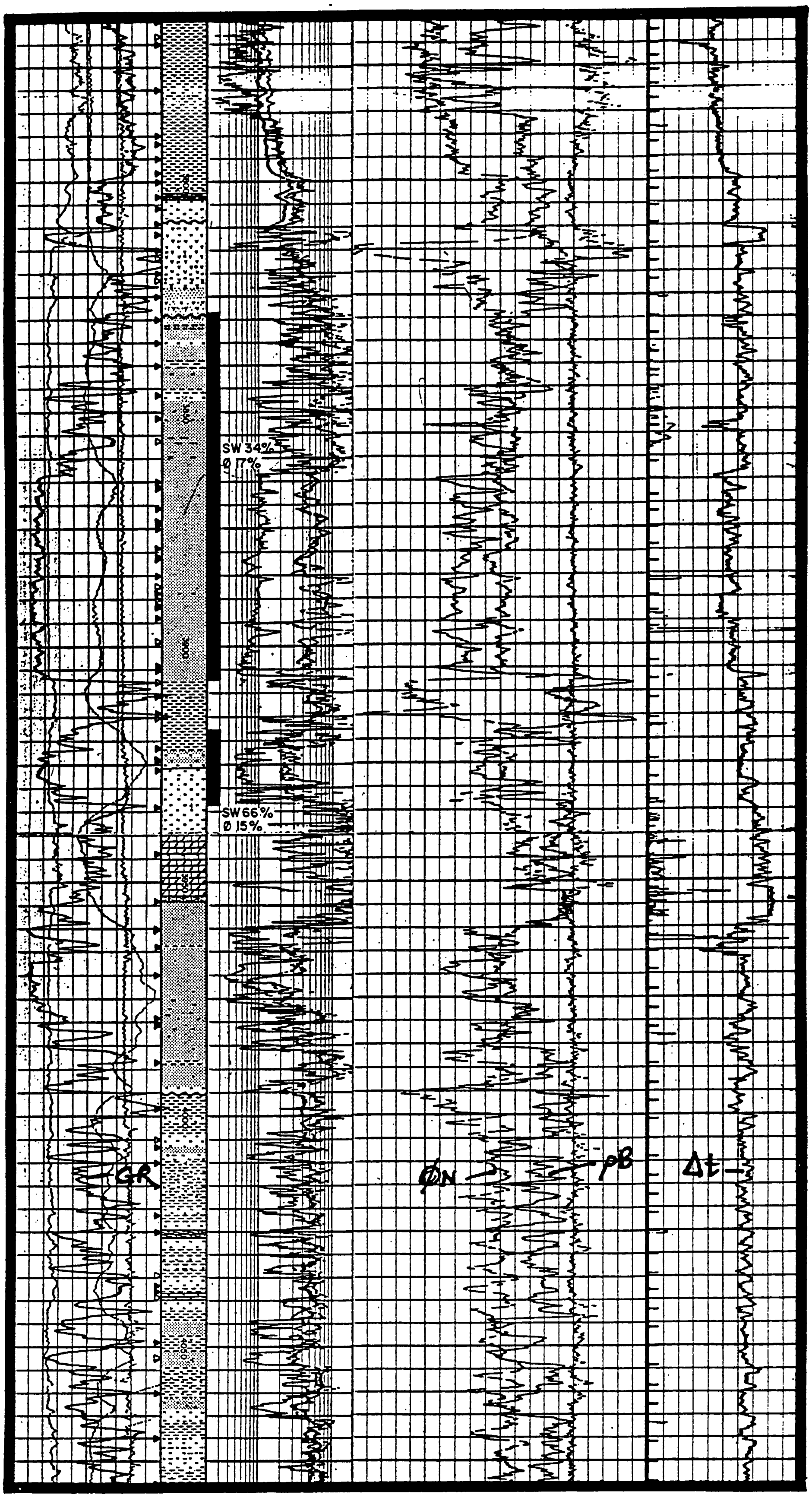


Figure 8 **Brecknock 1** - Gas condensate recoveries from RFTs between 3847m-3890m.

RFT 3847m rec. 100cc cond, 2.55 to 3.68 m^3 of gas.
RFT 3866.5m rec. 500cc cond, 3.03 m^3 of gas.
RFT 3878m rec. 200cc cond, 4.25 m^3 of gas.
RFT 3890m rec. 250cc cond, 2.35 to 3.03 m^3 of gas.

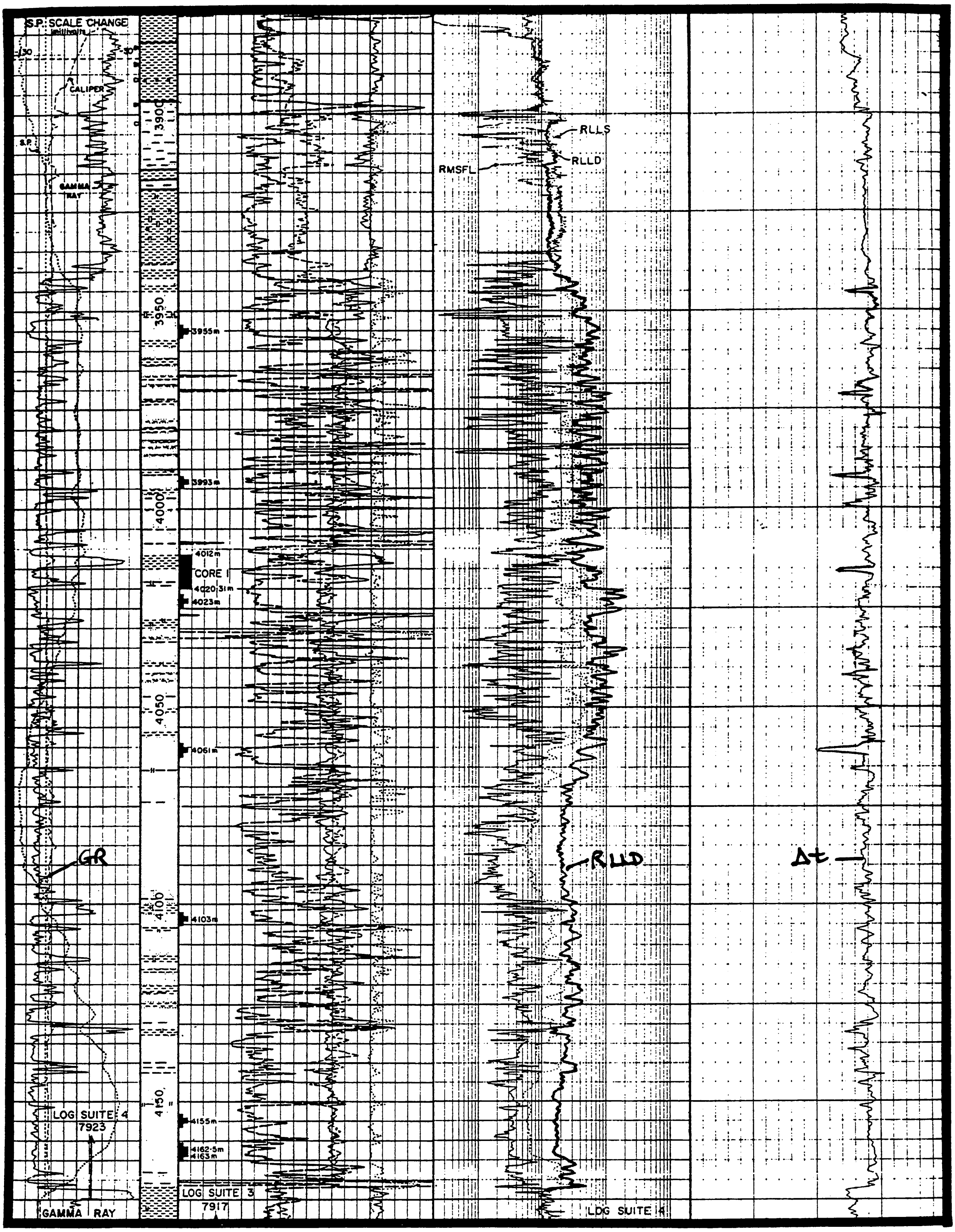


Figure 9 **Brewster 1** - Untested, electric logs indicate gas zone between 3942m-4173m.

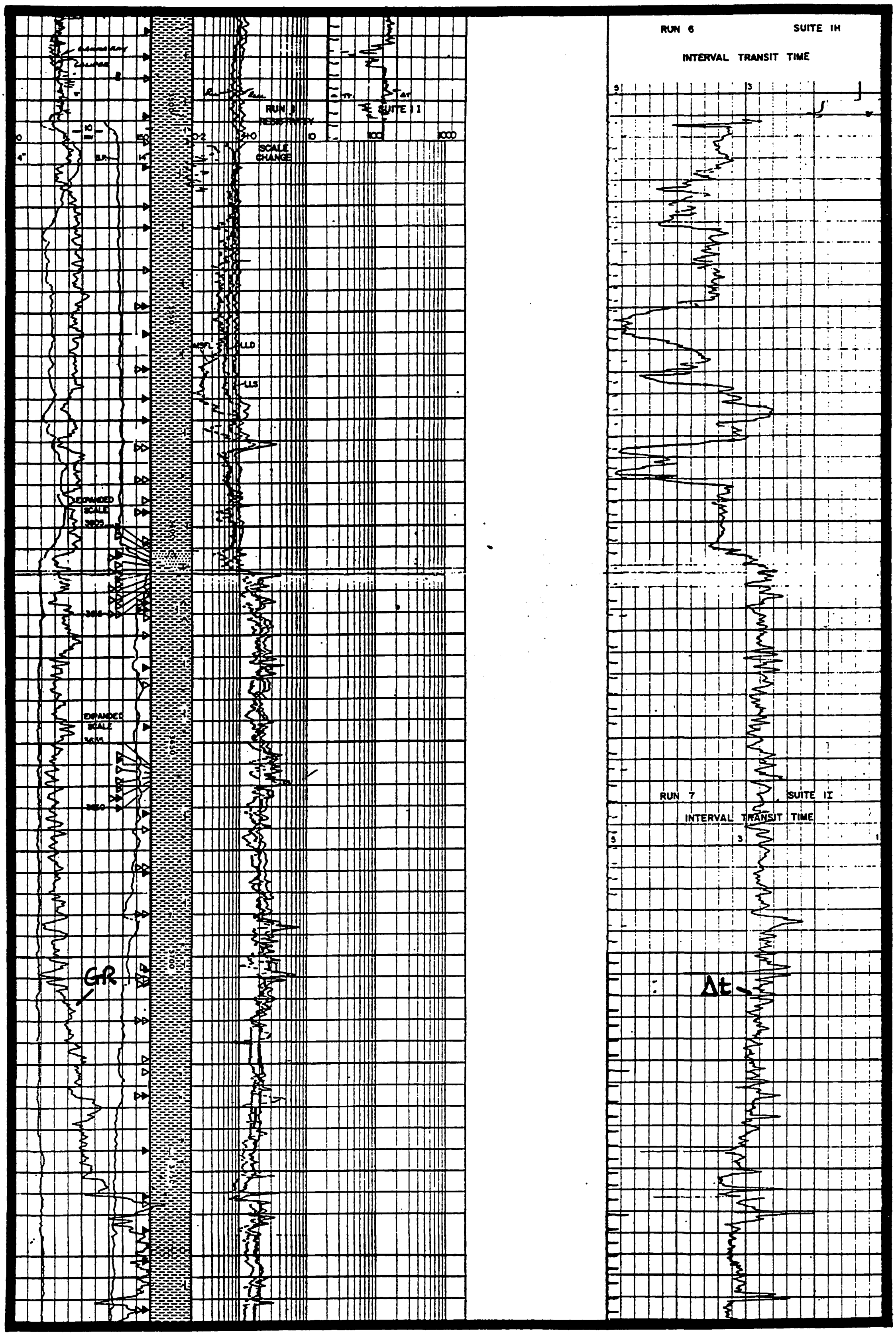


Figure 10 **Caswell 1** - Live oil in mud, interpreted to be from 3606m-3611m.

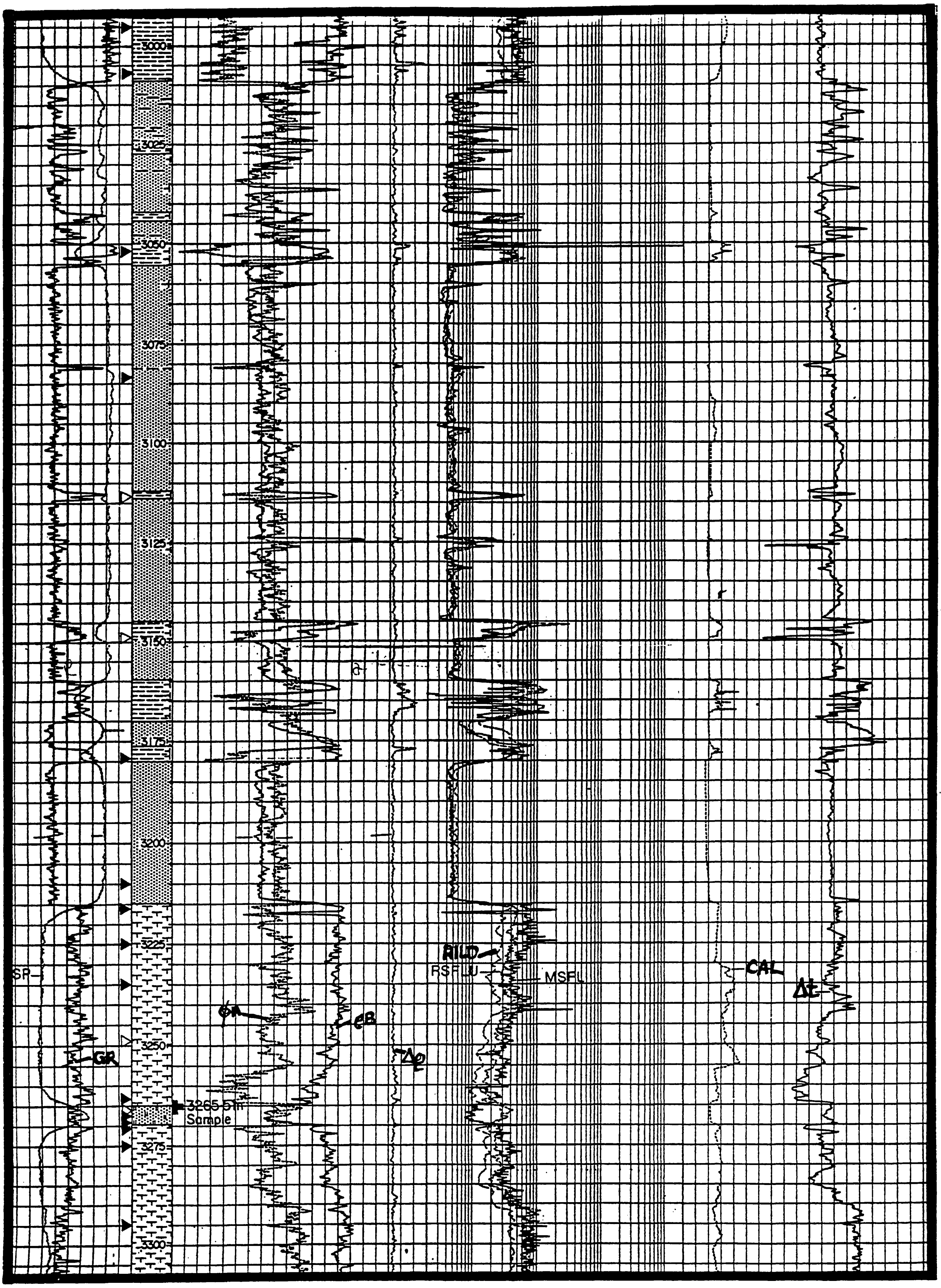


Figure 11 **Caswell 2** - Oil recovery from RFT 3265.5m rec. 800cc of 47 deg API oil, 0.6 m^3 of gas.

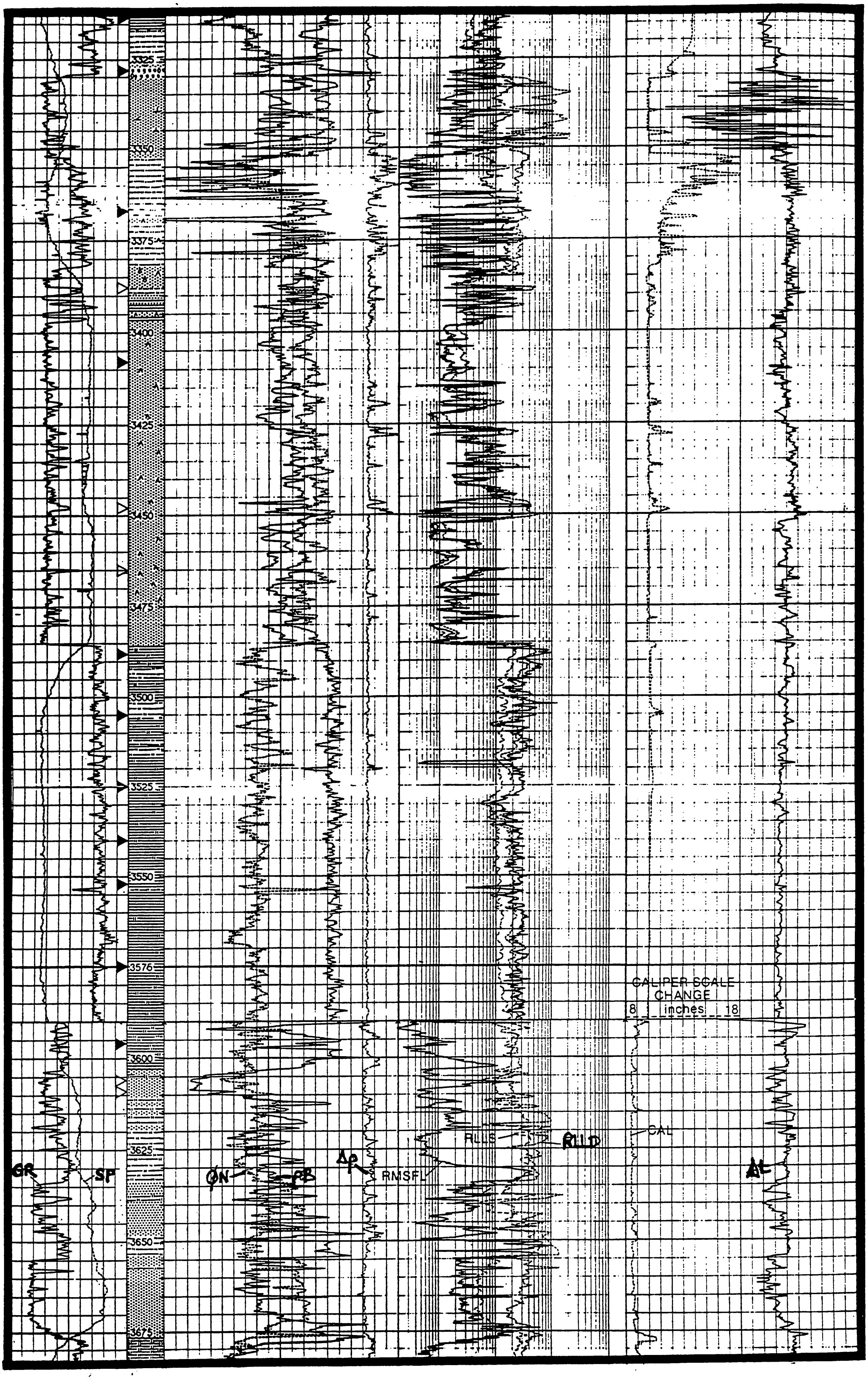


Figure 12 **Echuca Shoals 1** - RFT pressure data and logs indicate gas zone from 3331m-3656m. No samples were taken from RFTs.

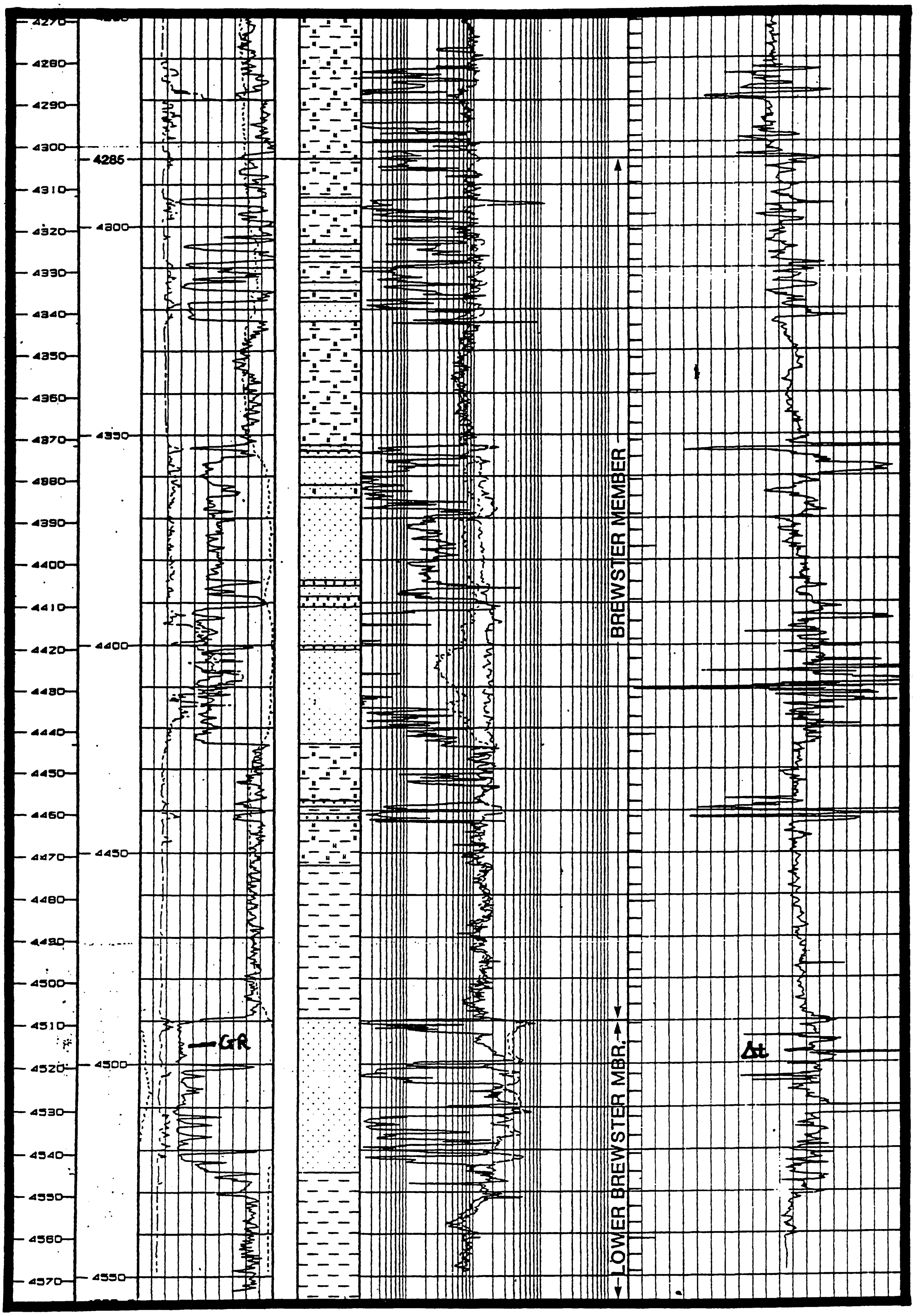


Figure 13 **Kalyptea 1 (st)** - Gas condensate recovery from RFT 4541m rec. 95cc cond, 1.86 m^3 of gas, 12.3 litres water.

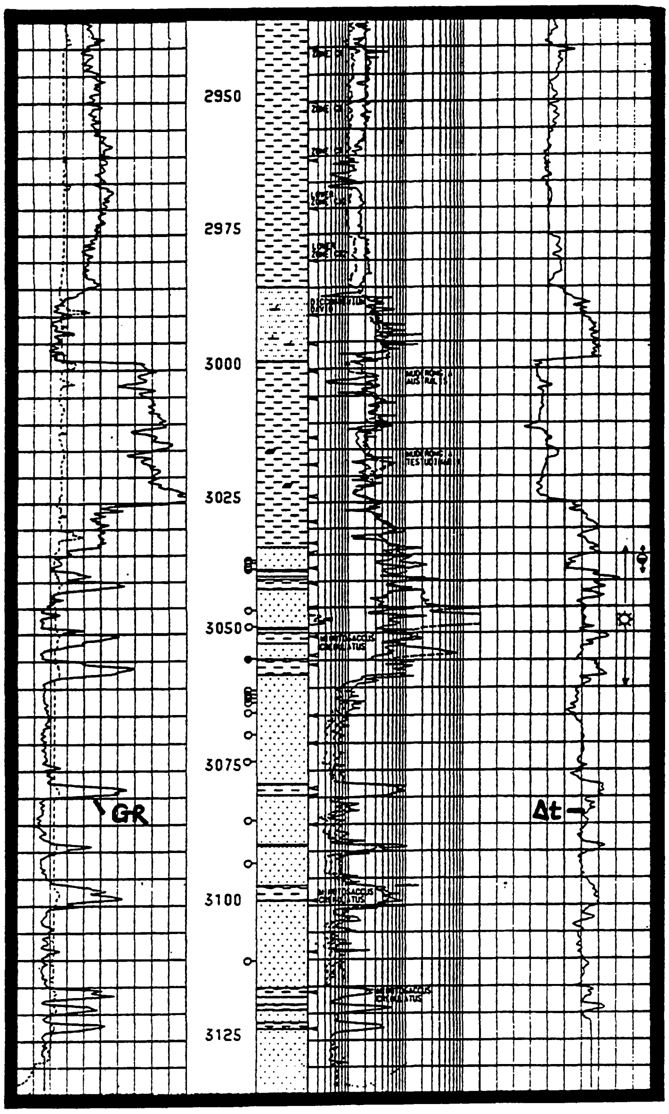


Figure 14 **Keeling 1** - RFT pressure data and logs indicate gas zone between 3025m-3059m. No samples were taken from RFTs.

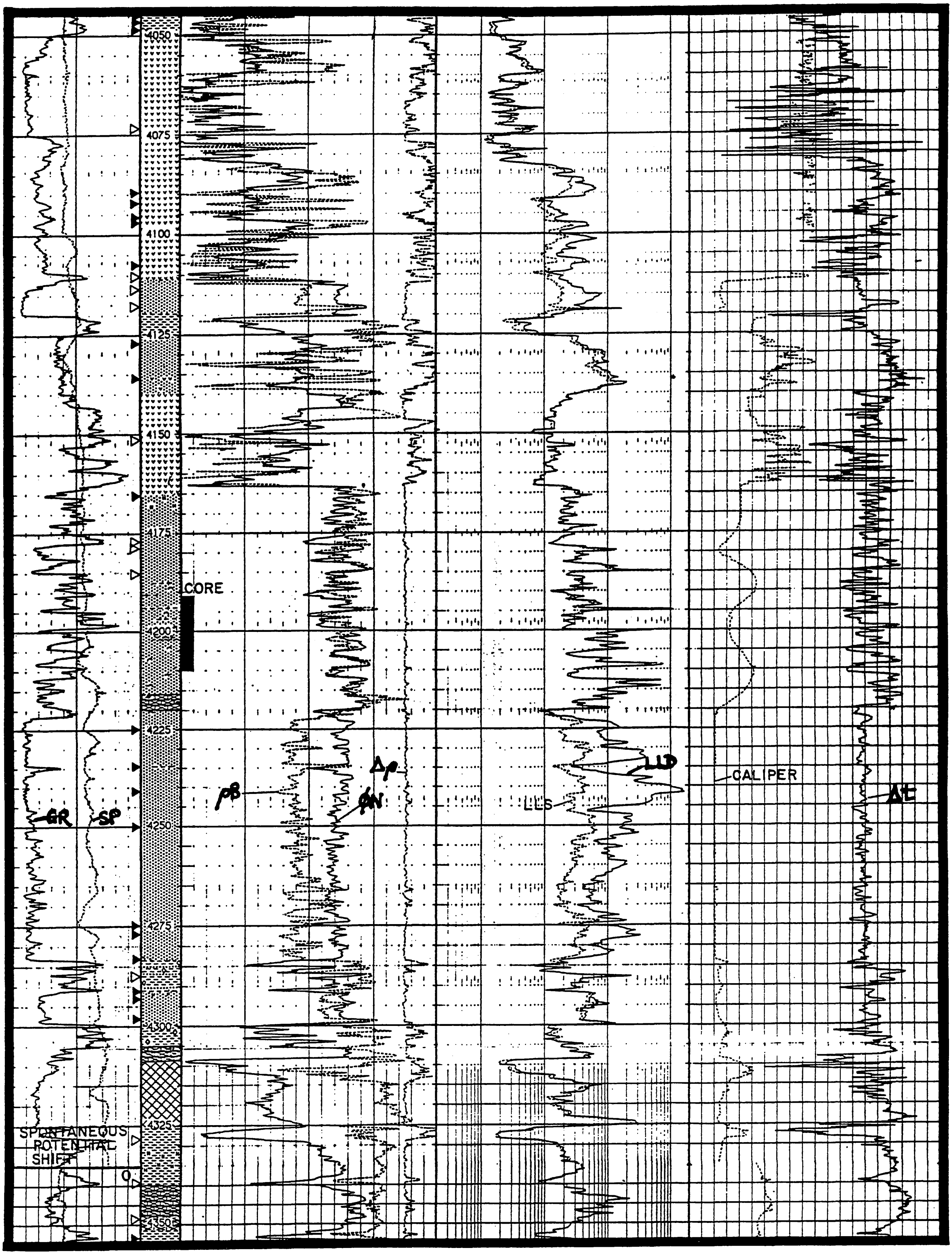


Figure 15 **North Scott Reef 1** - Gas condensate recoveries from RFTs. Production tests between 4223m-4283m flow range 293-484 BCPD, gas 0.745 - 1.275 MMm^{3}D.

RFT 4225.5m rec. 0.034 m^3 of gas, 9500cc water/filtrate - tool failure
RFT 4241.2m rec. 250cc cond, 1.61 m^3 of gas, 2000cc water

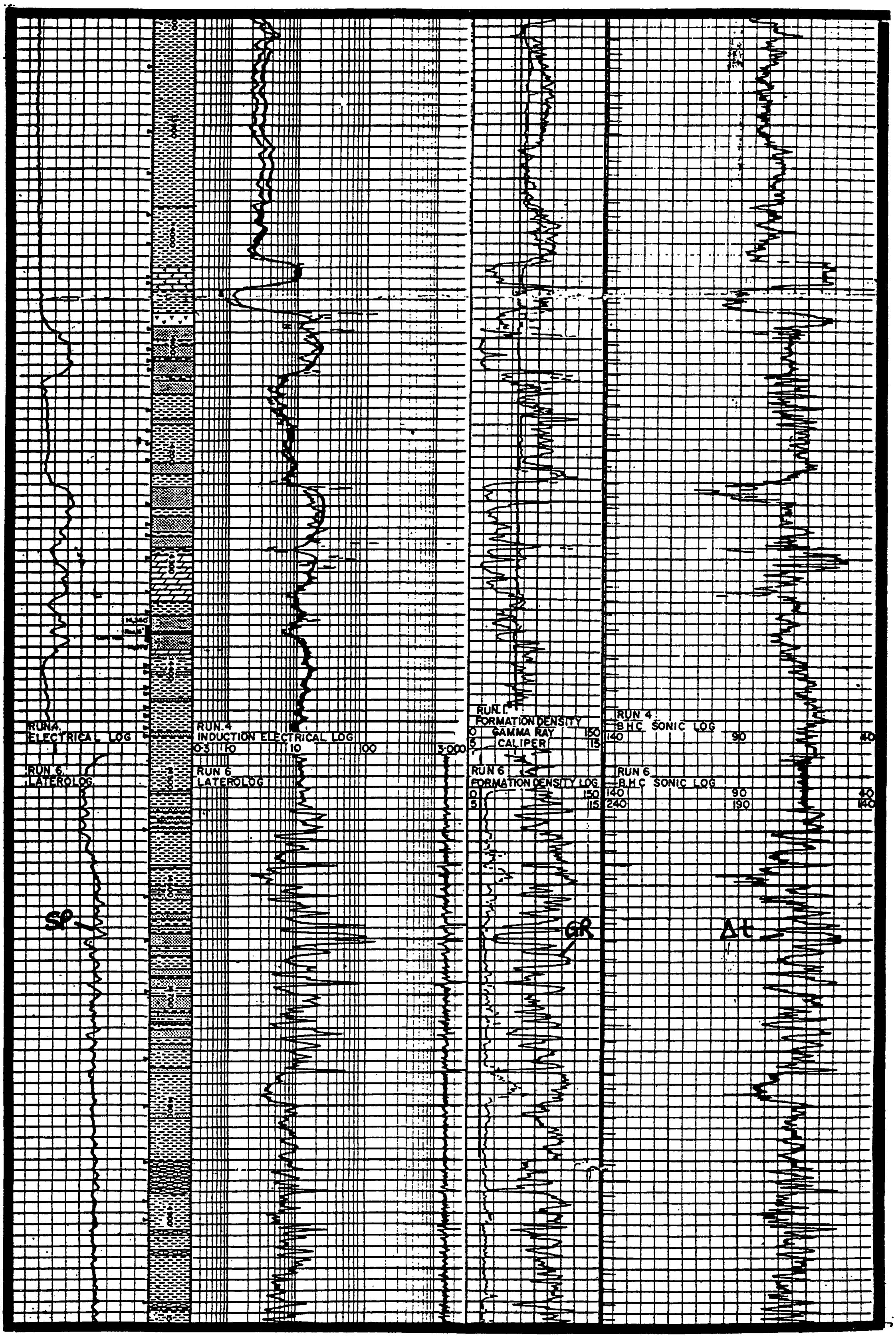


Figure 16 **Scott Reef 1** - Gas condensate recoveries from DSTs between 4299.2m-4386.07m

DST(4) 4299.2m-4305.3m gas flow 0.515 MMm3D of gas.
FIT(2) 4299.81m rec. 40cc cond, 0.2265 MMm3D of gas.
DST(1) 4340.35m-4346.45m gas flow 0.2265 MMm3D (Perf interval)
DST(1) 4351.32m-4354.07m gas flow 0.2265 MMm3D (Perf interval)
DST(1) 4361.69m-4367.78m gas flow 0.2265 MMm3D (Perf interval)
DST(2) 4379.98m-4383.02m gas flow 0.4728 MMm3D (incl DST1)
DST(3) 4379.98m-4386.07m gas flow 0.2775 MMm3D.

REGIONAL GEOLOGY

BASIN DEFINITION

The Browse Basin is one of a series of northeast trending sub-basins located offshore from the Kimberley Block. The basin is bounded to the west by the Scott Reef Trend, beyond which lies the Argo Abyssal Plain comprising oceanic basaltic crust, and a thin veneer of Mesozoic and Cainozoic sediments. The Ashmore Platform and the structural extensions of the Londonderry High form the northern boundary, separating the Browse Basin from the Vulcan Sub-basin. The southern margin is defined by the Leveque Shelf and its extensions, dividing the Rowley Sub-basin from the Browse Basin. The Yampi Shelf and Prudhoe Terrace areas broadly form the eastern margin of the basin.

Figure 17a shows the various tectonic elements of the Browse Basin. The same map is also provided at 1:1000000 scale in Enclosure 1.

TECTONIC EVENTS AND REGIONAL STRATIGRAPHY

Figure 17b is a Summary Stratigraphic Column for Browse Basin. A Time Space Correlation shown as Fig 18 outlines the various regional unconformities/disconformities and 'condensed' sections. A large scale version of the Time Space correlation is provided in Enclosure 2. A series of schematic diagrams Figures 19 to 23 show the key evolutionary stages of the Browse Basin. Additional detail on the interpretation are provided in the Geophysical Analysis section.

Rob Roy 1 intersected sediments of Namurian to Westphalian age (Time Slice C5) overlying a section of low grade metamorphosed rocks, which are interpreted to be part of the Kimberley Block Complex. This mid Carboniferous sequence consist of carbonate sediments and thin interbedded sandstones deposited in a relatively shallow marine

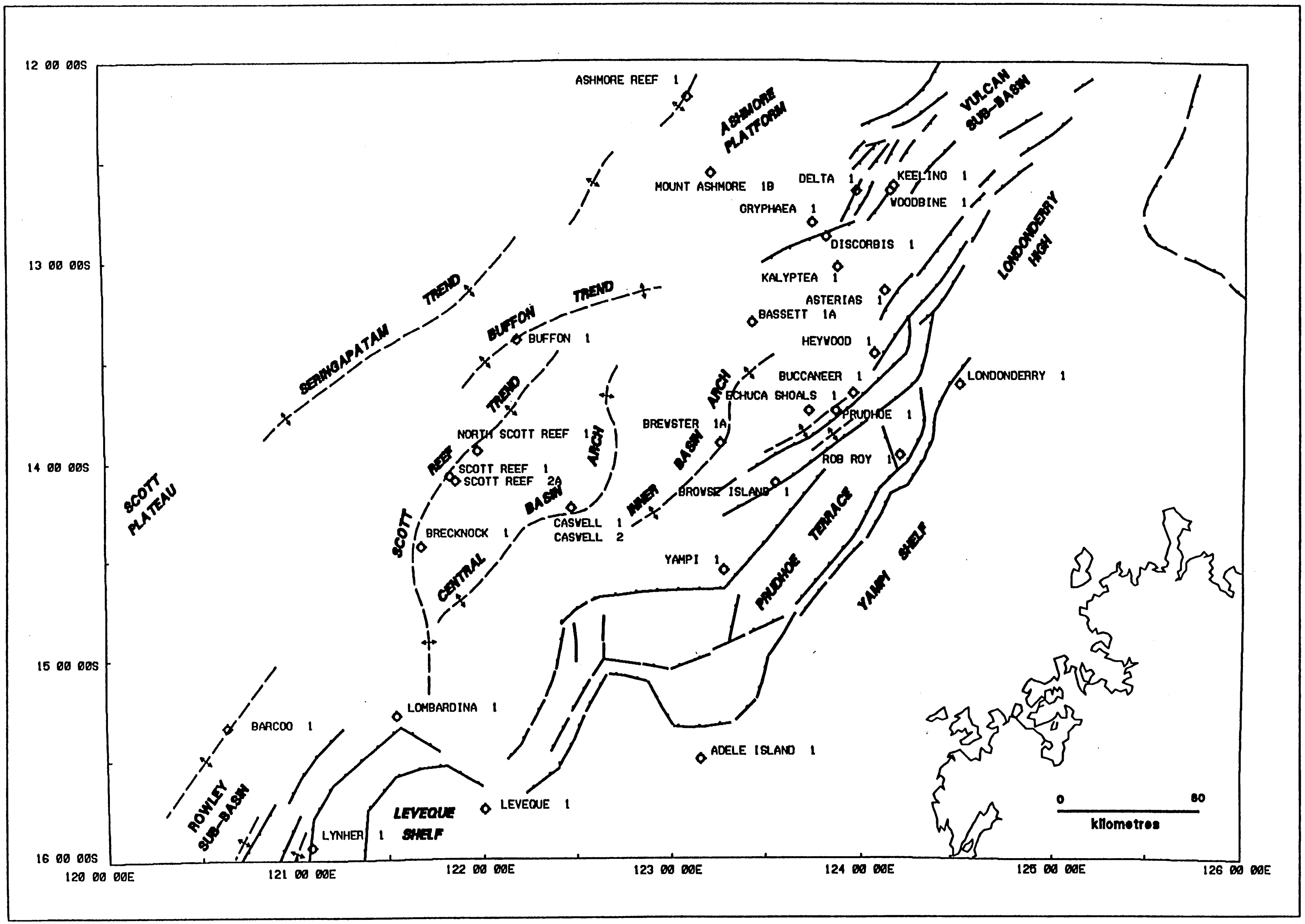


Figure 17a Browse Basin tectonic elements map (see Enclosure 1)

environment. Seismic data show the Time Slice C5 section to be relatively uniform in thickness on the Prudhoe Terrace and Yampi Shelf area. Reflection events below the metamorphosed surface intersected at Rob Roy 1 may represent part of the sedimentary section of the early Gondwana and/or late Larapintine Petroleum Systems (Bradshaw,1993 in prep.). Figure 19 shows conceptually the stages of basin evolution from early-mid Carboniferous(Time Slice C5) to late Permian(Time Slice P7).

It is uncertain as to when the metamorphism phase occurred but the deposition of the mid-Carboniferous section may be related to a major tectonic phase occurred during the early Carboniferous in the central and eastern regions of Australia, which may have been the precursor to the initiation of the Westralian Superbasin along the northwest margin of Australia (Bradshaw, J. BMR Record 1991/07).

Permian sequences of interbedded clastics and carbonates conformably overlie the mid-Carboniferous sequence. These sediments are interpreted to be deposited in a fluvio-deltaic environment during early Permian and within a shallow marine environment during the late Permian. Seismic data show divergent reflection events suggesting that the Permian sequences were deposited in a basin sag.

Regional uplift and erosion occurred during the late Permian and mostly affected the Yampi Shelf/Prudhoe Terrace areas. A preserved section of Time Slice P7 sediments in Echuca Shoals 1 suggests that the extent of the erosion around the inner basin may have been relatively minor. The Permian sequence was not intersected in the central basin area, therefore the lateral extent of late Permian structuring and erosion is uncertain. However, it is evident on well and seismic data over Whimbrel 1 and Osprey 1, that the late Permian structuring occurred as far north as the Londonderry High in the western Timor Sea area (Bradshaw, J., BMR Record 1991/07)

Extensive normal block faulting of the Permo-Carboniferous sequence is evident on seismic data. These normal fault block complexes extend from the eastern margin on the Yampi Shelf area to a major northeast to soutwest trending hinge zone located just west of Prudhoe 1. Minor fault reversals and folding associated with transpressional tectonics are also evident on seismic around the Prudhoe area.

Based on seismic interpretation, a relatively thick and conformable Triassic section overlies the Permian sequences in the central basin area. The Triassic section thins to the east and is absent due to erosion on the easternmost regions of the Yampi Shelf. Along some parts of the hinge zone, the Triassic section is truncated against major basin bounding faults (eg Buccaneer 1). Figure 20 shows conceptually the stages of basin evolution from early Triassic(Time Slice Tr1) to early Jurassic(Time Slice J1).

Early Triassic (Time Slices Tr1 to Tr4) sediments consist of marine claystones, siltstones and mudstones that are interpreted to have been deposited during a major marine transgression. These early Triassic sediments grade vertically from low energy marine sediments to shallow marine claystones and limestones during Time Slice Tr3 in the northern and western area of the basin. Late Triassic sediments of Time Slices (Tr5/Tr6) comprises fluvio-deltaic sandstones and claystones. However, the late Triassic sediments are predominantly carbonates in the Ashmore Reef and Mt Ashmore areas.

A minor erosional phase occurred during Time Slice Tr1 (Scythian) and affected mostly the inner basin (Echuca Shoals and Brewster) area. Altered volcanic tuffs intersected in Echuca Shoals 1 indicate some volcanic activity occurred during this period.

A more extensive erosional period occurred during the Carnian to Ladinian and resulted in a major unconformity near the base of Time Slice Tr5. The Carnian unconformity is easily identifiable on seismic in the Barcoo area but is less defined to the north due to poor seismic data quality and lack of well control. The unconformity marks the boundary between the Westralian and the Gondwanan Petroleum Systems (Bradshaw, 1993 in press.)

Significant regional uplift and faulting occurred towards the end of the Triassic (Time Slice Tr6) and is responsible for the development of key structural features that are part of the present day basin configuration. Thick sections of Permo-Triassic sediments were eroded and resulted in the development of a major angular unconformity between the Permian and the overlying Mesozoic sequence on the Yampi Shelf and Prudhoe Terrace.

Varying magnitudes of fault reactivation occurred along the hinge zone during Time Slice Tr6 and ranged from minor faults associated with regional flexure in the southwest to major fault displacement in the north east. The hinge zone separates the Prudhoe Terrace from the inner/central basin area and marks a major change in tectonic and depositional settings between these two areas. The structural styles range from normal fault block complexes on the Prudhoe Terrace to a series of intrabasinal Permo-Triassic horst/graben features near the inner basin and complex tilted fault blocks in the central and western areas of the basin.

Based on seismic interpretation, a thick Jurassic trough is located in the central part of the basin (near the Caswell area) and unconformably overlies the Triassic sequence. This trough extends to the southwest into the Rowley Sub Basin and to the northeast to a smaller but relatively deep trough in an area between Bassett 1 and Heywood 1. The Jurassic section gradually thins towards the basin margins and onto intrabasinal highs. Figure 21 shows conceptually the stages of basin evolution from early Jurassic(Time Slice J1) to late Jurassic(Time Slice J9).

The Jurassic sediments consist of fluvio-deltaic to marginal marine siliciclastics, claystones and minor carbonates. Volcanics intersected in the Buffon 1, Yampi 1, Brewster 1 and Lombardina 1 wells indicate that volcanic activity occurred during the Jurassic period but was mainly confined to the western and eastern margins of the basin.

Tectonic activity and erosion associated with the onset of seafloor spreading during the Callovian (Time Slice J7) resulted in a major unconformity between early-middle Jurassic (Time Slices J1 to J7) and the late Jurassic (Time Slices J8 to J10). The early-middle Jurassic sediments were eroded over some intrabasinal highs (Echuca Shoals) and over the northeastern basin margins during the Callovian. Incomplete sections of early-middle Jurassic sediments may be preserved in local depositional lows near the flanks of these intrabasinal high. A thicker and more complete section of early-middle Jurassic sediments is interpreted to be present in the deeper part of the basin where there was likely to be minimal or no erosion during the Callovian.

A second major erosional phase that occurred during the Tithonian (Time Slice J9) is identified from seismic and well data. The Tithonian Unconformity is less extensive than the Callovian Unconformity and is better defined on seismic mainly in the inner basin area and in the southern region near Barcoo 1. The entire sedimentary section of Time Slice J9 and parts of Time Slice J8 are absent in most wells on the basin margin areas. The unconformity marks a change in facies from low energy marine sediments of Time Slice J8 to the higher energy nearshore sediments of Time Slice J10.

Fluvio-deltaic and nearshore sediments of Time Slice J10 were mainly deposited over the eastern margin and regionally thin to the west and south. Predominantly low energy marine sediments are deposited over the western and southern margins of the basin during this period. However, the northeastern area surrounding the Gryphaea and Keeling wells was structurally higher and little or no sediments were deposited here during Time Slices J10 and K1. Figure 22 shows conceptually the stages of basin evolution from late Jurassic(Time Slice J10) to mid Cretaceous (Time Slice K4).

Similar fluvio-deltaic and shallow marine sandstones of Time Slice K1 were deposited over the Upper Jurassic rocks at the northeastern margin of the basin while time equivalent low energy marine facies were deposited in the southern and western regions. This was followed by the deposition of thick transgressive marine claystones of early Cretaceous age (Time Slices K2 to K4) over most parts of the basin. Seismic data show a general east west progradational configuration of Time Slice K2 and K3 sediments, draped over by a relatively thick sheet like sequence of Time Slice K4 sediments.

An Albian/Aptian unconformity near the base of Time Slice K5 is identifiable on seismic in the northeastern area of the inner basin. Seismic data show Time slices K4 to the upper K2 section truncated by the overlying Time Slice K5. The unconformity may have resulted from uplift and erosion confined to the northeastern region or from a Mid-Aptian sea level fall or a combination of both. The unconformity event marks a change in facies from a predominantly low energy marine claystone facies of Time Slice K4 to higher energy marine sandstone and siltstone sequence of Time Slice K5. A thicker section of low energy marine sediments on the western margin suggests that subsidence continued during the Albian (Time Slice K5). Figure 23 shows conceptually the stages of basin evolution from mid Cretaceous(Time Slice K5) to early Cainozoic(Time Slice Cz1).

Relatively thick low energy marine claystone and mudstone sequences with minor calcarenites, siltstones and marls were deposited over most areas of the basin during Time Slices K6 to K8 (Albian to Cenomanian). Time Slices K6 to K8 represent a highstand with the thickest deposits located in the northeast and progradationally thinning to the west and south of the basin.

Sediments within Time Slice K9 consist of marls, calcarenites and calcilutites. The increase in carbonate deposits suggests a change in oceanic circulation from a restricted marine to an open marine environment. Thicker sequences during Time Slice K9 in the Scott Reef area indicate continued subsidence on the western margin. A distinct unconformity, referred to as the Turonian event, corresponds to the change in facies from Time Slices K8 to K9. The Turonian unconformity is identifiable on seismic data over most areas of the basin, particularly in the Prudhoe area. Seismic data also show a large channel cut on the edge of a Cretaceous continental slope break on the southwest margin area near Barcoo.

During Timeslices K10 and K11, carbonate facies continued to be deposited in the western margin while a gradual regressive phase took place in the northeastern region. Considerably thicker clastic sections were deposited in the northeastern area and progressively thin towards the more distal areas located near the Caswell wells.

The development of a passive continental margin continued with several cycles of regression and transgression during the Tertiary. The base of the Cainozoic, Time Slice Cz1, corresponds to the base of a relatively thick mass flow sandstone sequence deposited mainly in the northeastern to northern areas of the basin. Clastic sedimentation decreased significantly towards the end of Time Slice Cz2 and predominantly carbonate sediments were deposited during the rest of the Cainozoic.

A significant compressional phase during the late Miocene to early Pliocene resulted in the development of several north-south trending anticlines in the southwestern portion of the Browse Basin. These structures appear to have been formed along pre-existing basin bounding faults that have been re-activated during the compressional phase. In other parts of the basin, keystone fault complexes developed over existing structures bounded by major fault zones.

BROWSE BASIN SUMMARY STRATIGRAPHIC COLUMN

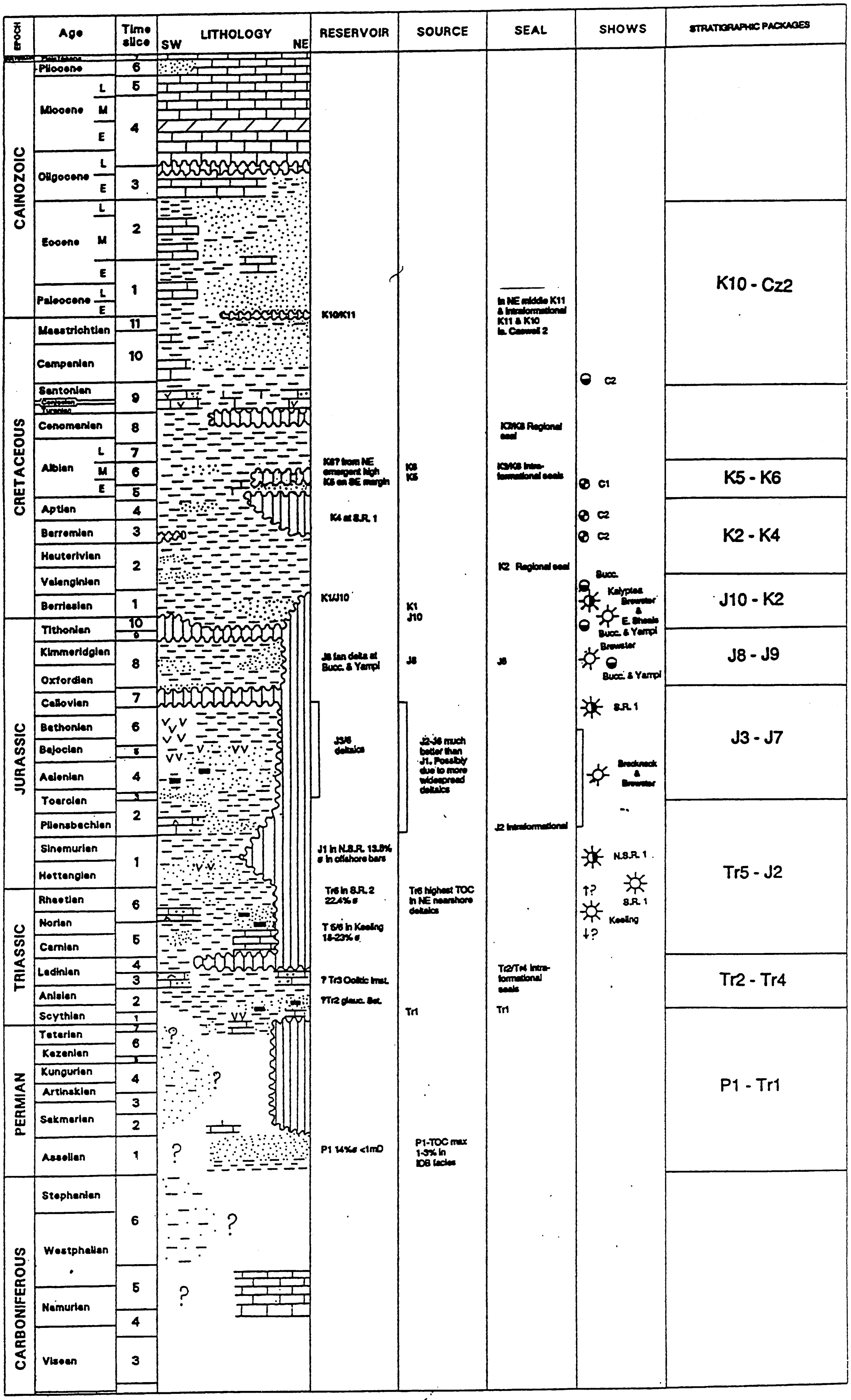


Figure 17b

BROWSE BASIN TIME SPACE DIAGRAM

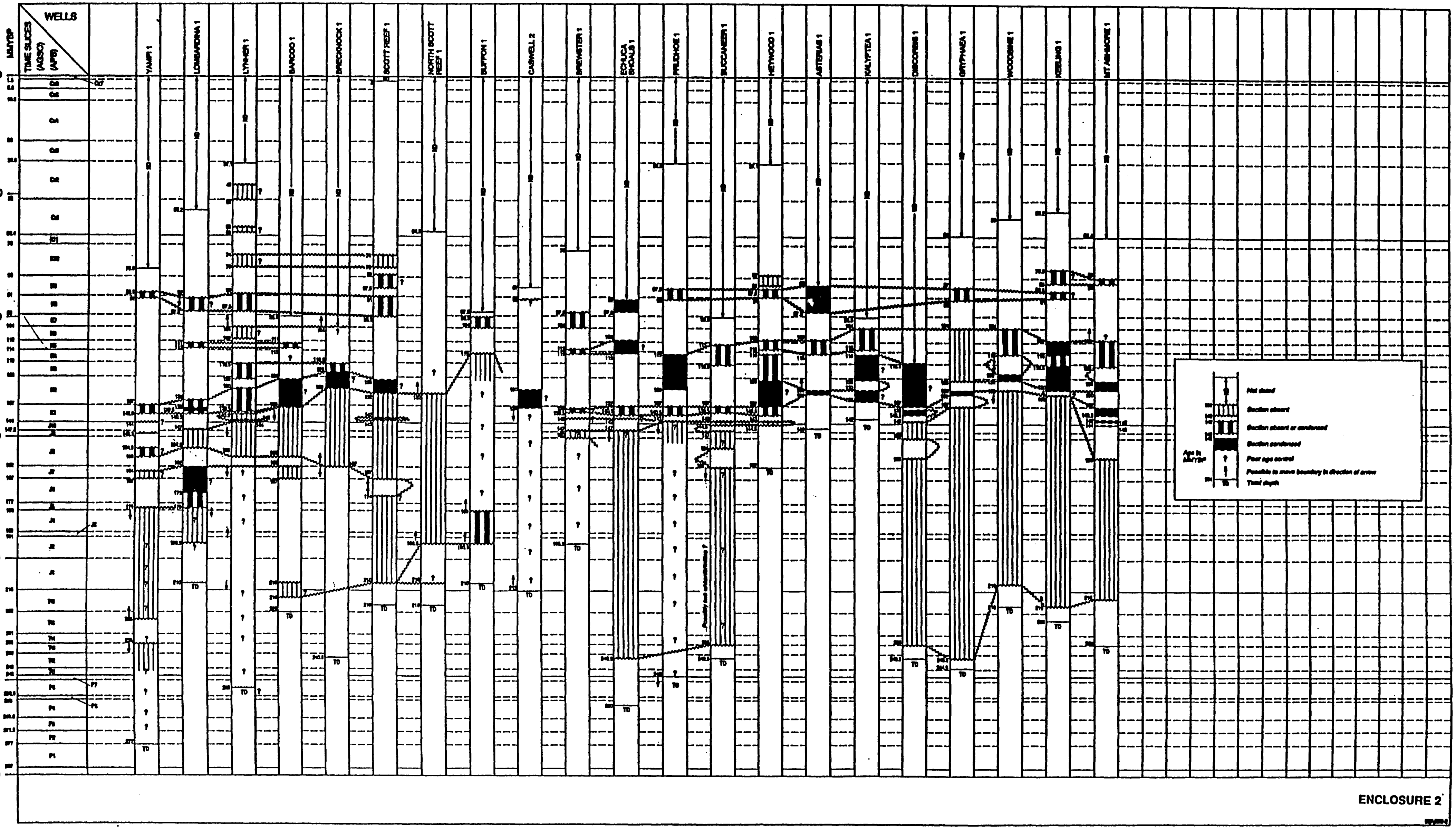


Figure 18

GENERAL OVERVIEW OF BASIN EVOLUTION

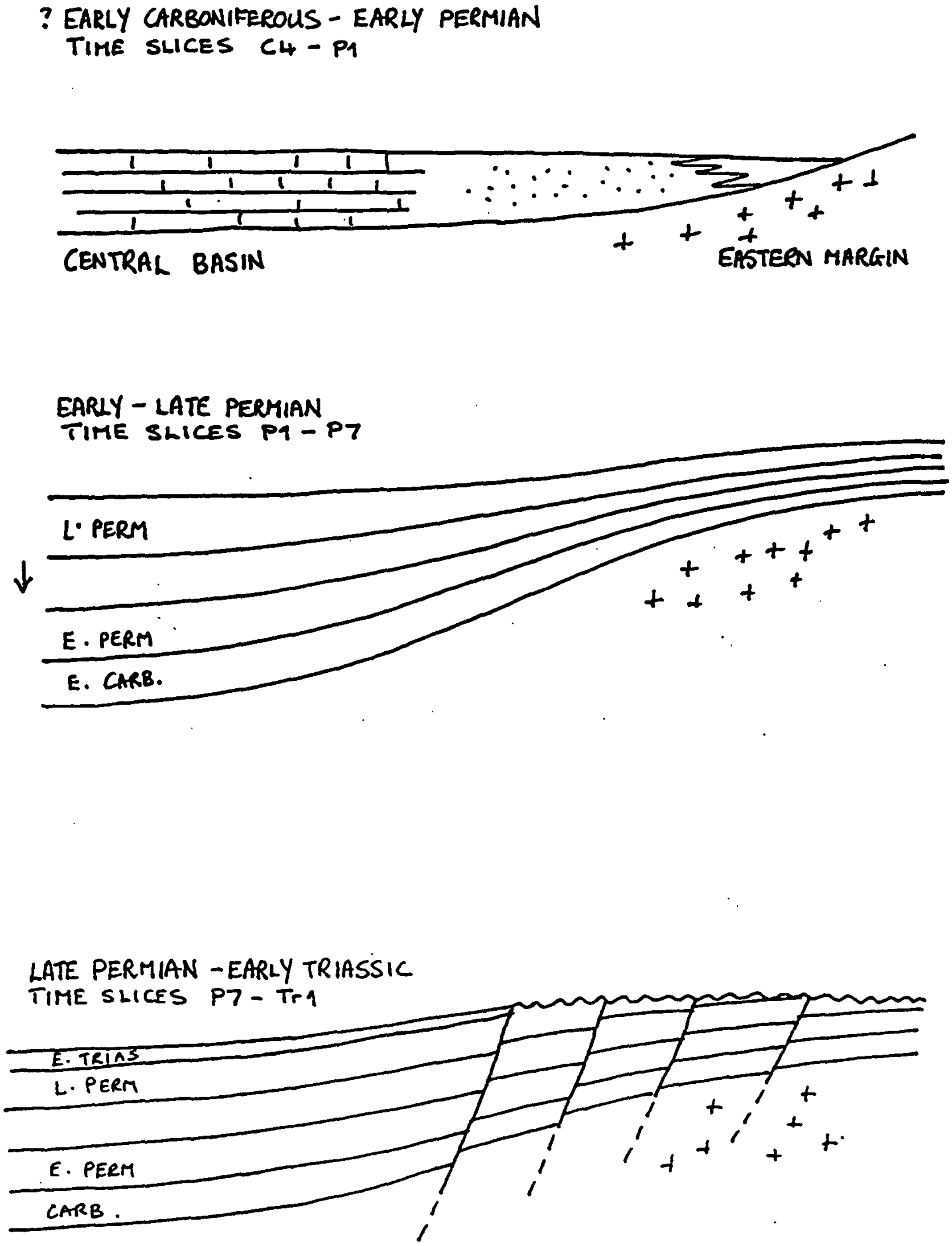


Figure 19

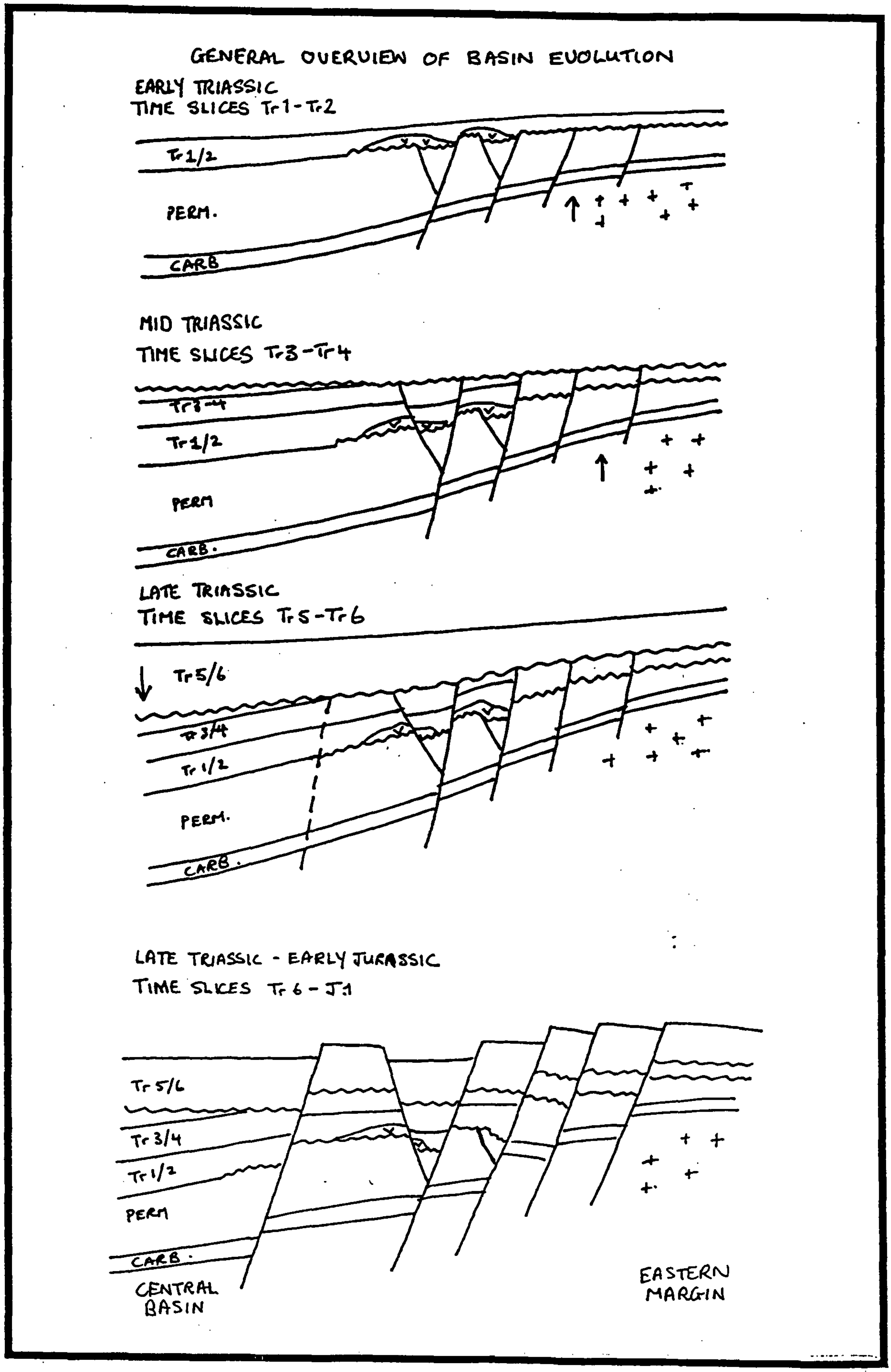

GENERAL OVERVIEW OF BASIN EVOLUTION
EARLY TRIASSIC
TIME SLICES Tr1-Tr2
Tr1/2
PERM.
CARB
MID TRIASSIC
TIME SLICES Tr3-Tr4
Tr3-4
Tr1/2
PERM
CARB.
LATE TRIASSIC
TIME SLICES Tr5-Tr6
Tr5/6
Tr3/4
Tr1/2
PERM.
CARB.
LATE TRIASSIC - EARLY JURASSIC
TIME SLICES Tr6-J1
Tr5/6
Tr3/4
Tr1/2
PERM
CARB.
CENTRAL BASIN
EASTERN MARGIN

Figure 20

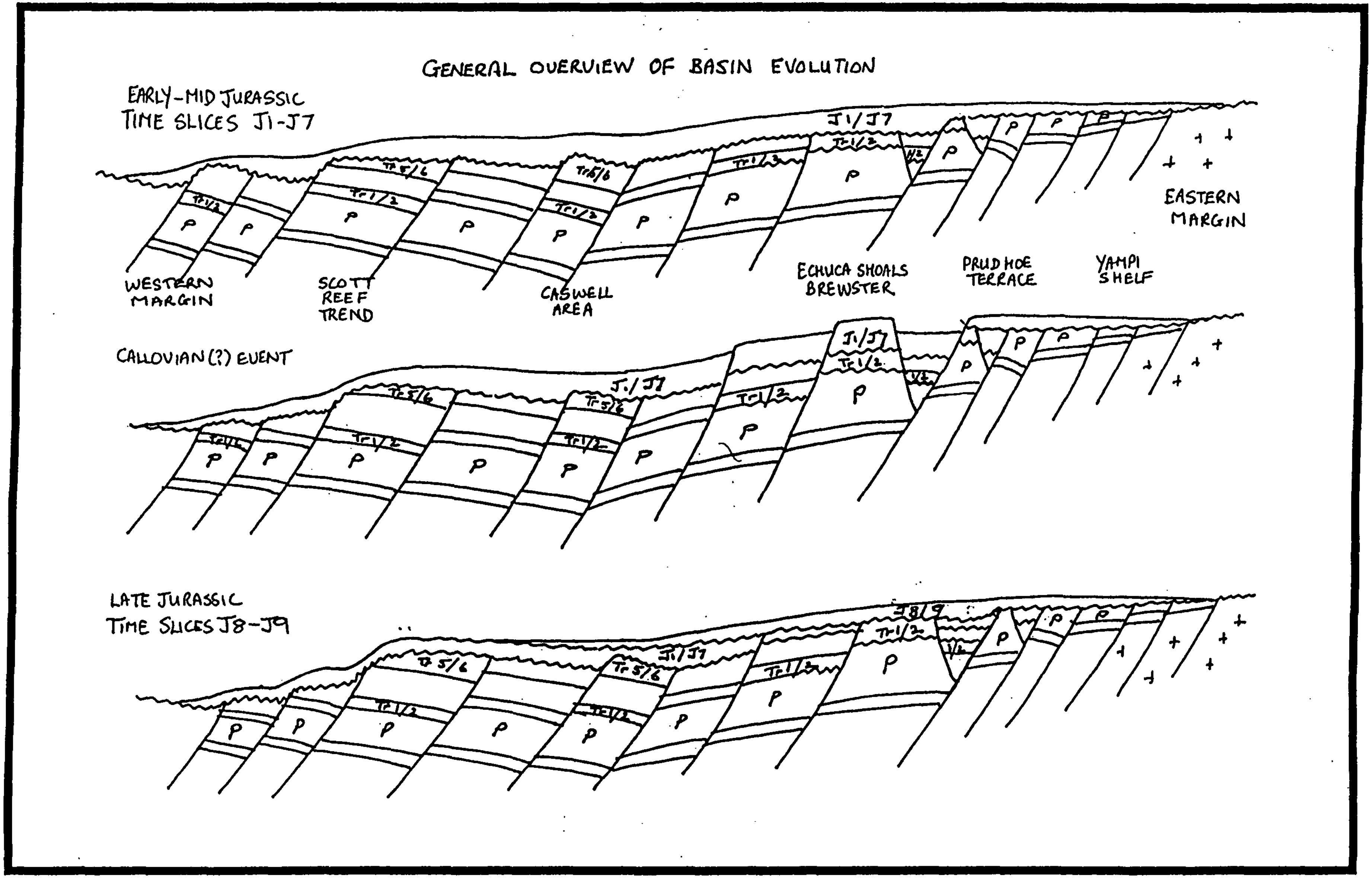

GENERAL OVERVIEW OF BASIN EVOLUTION
EARLY-MID JURASSIC
TIME SLICES J1-J7
J1/J7
Tr1/2
Tr5/6
P
EASTERN
MARGIN
WESTERN
MARGIN
SCOTT
REEF
TREND
CASWELL
AREA
ECHUCA SHOALS
BREWSTER
PRUDHOE
TERRACE
YAMPI
SHELF
CALLOVIAN (?) EVENT
LATE JURASSIC
TIME SLICES J8-J9
J8/9

Figure 21

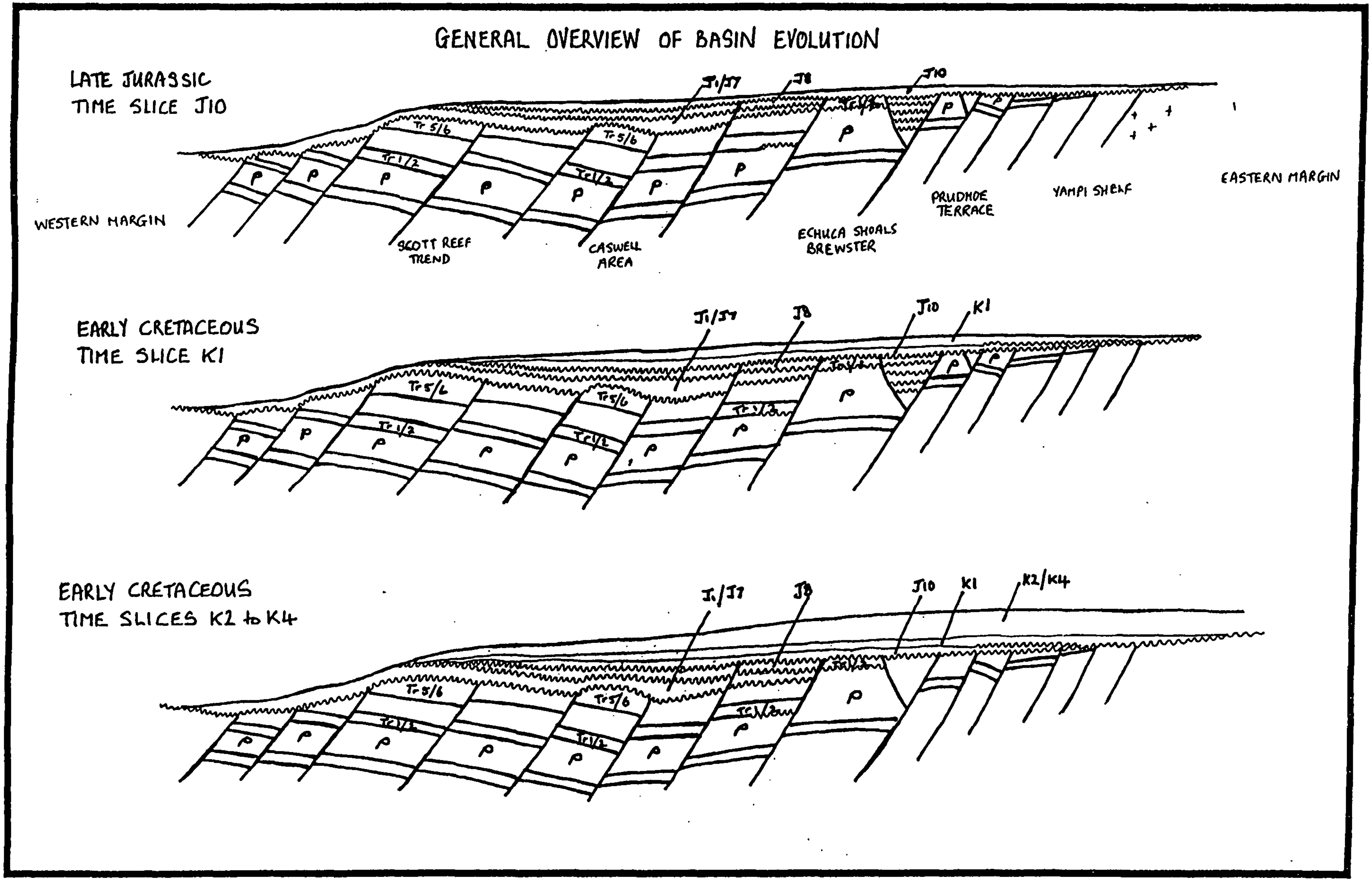

GENERAL OVERVIEW OF BASIN EVOLUTION
LATE JURASSIC
TIME SLICE J10
J1/J7
J8
J10
Tr 5/6
Tr 1/2
P
WESTERN MARGIN
SCOTT REEF
TREND
CASWELL
AREA
ECHUCA SHOALS
BREWSTER
PRUDHOE
TERRACE
YAMPI SHELF
EASTERN MARGIN
EARLY CRETACEOUS
TIME SLICE K1
K1
EARLY CRETACEOUS
TIME SLICES K2 to K4
K2/K4

Figure 22

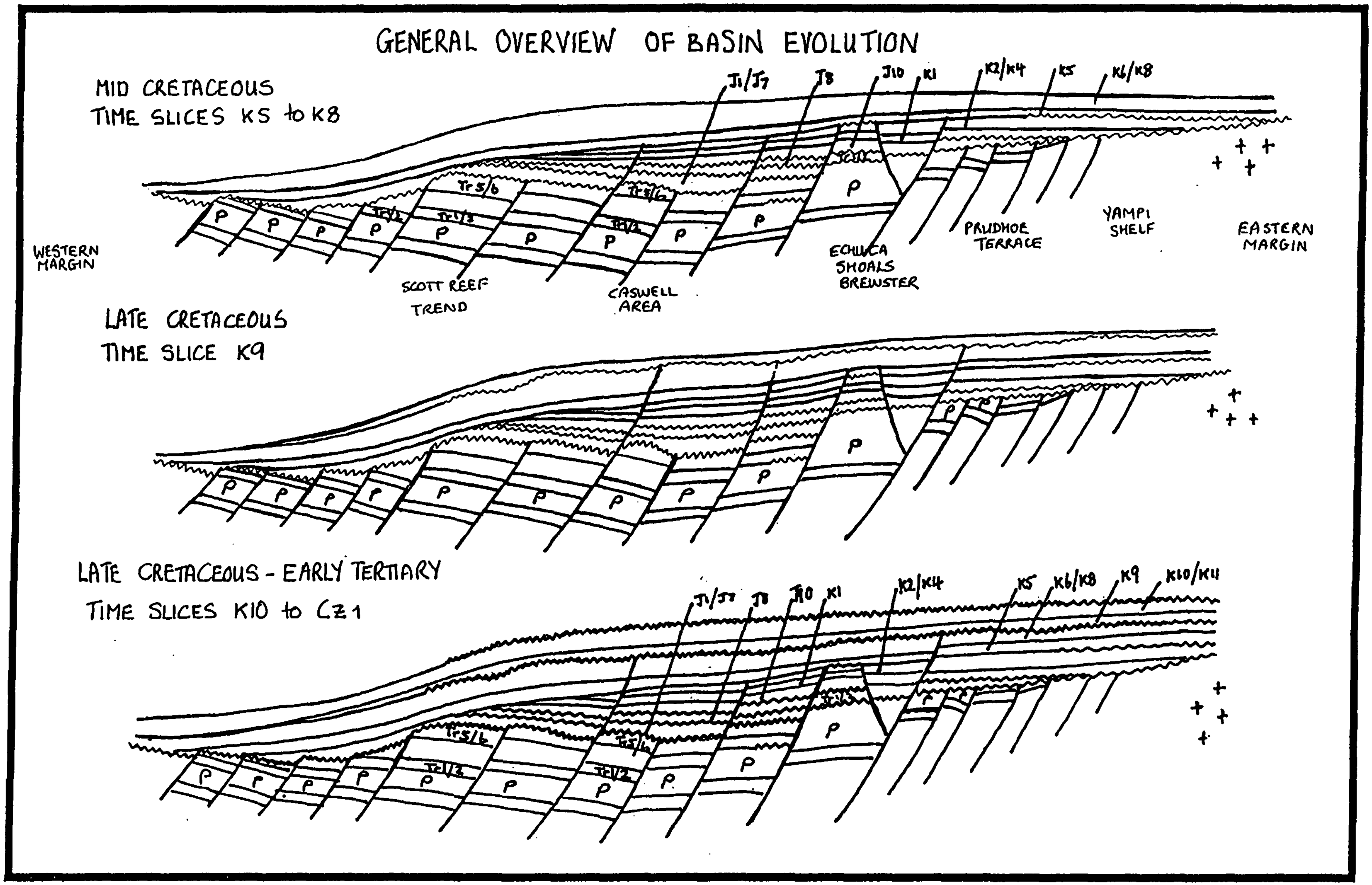

GENERAL OVERVIEW OF BASIN EVOLUTION
MID CRETACEOUS
TIME SLICES K5 to K8
J1/J7
J8
J10
K1
K2/K4
K5
K6/K8
Tr5/6
Tr1/3
P
WESTERN MARGIN
SCOTT REEF TREND
CASWELL AREA
ECHUCA SHOALS BREWSTER
PRUDHOE TERRACE
YAMPI SHELF
EASTERN MARGIN
LATE CRETACEOUS
TIME SLICE K9
LATE CRETACEOUS - EARLY TERTIARY
TIME SLICES K10 to CZ1
K9
K10/K11
Tr1/2

Figure 23

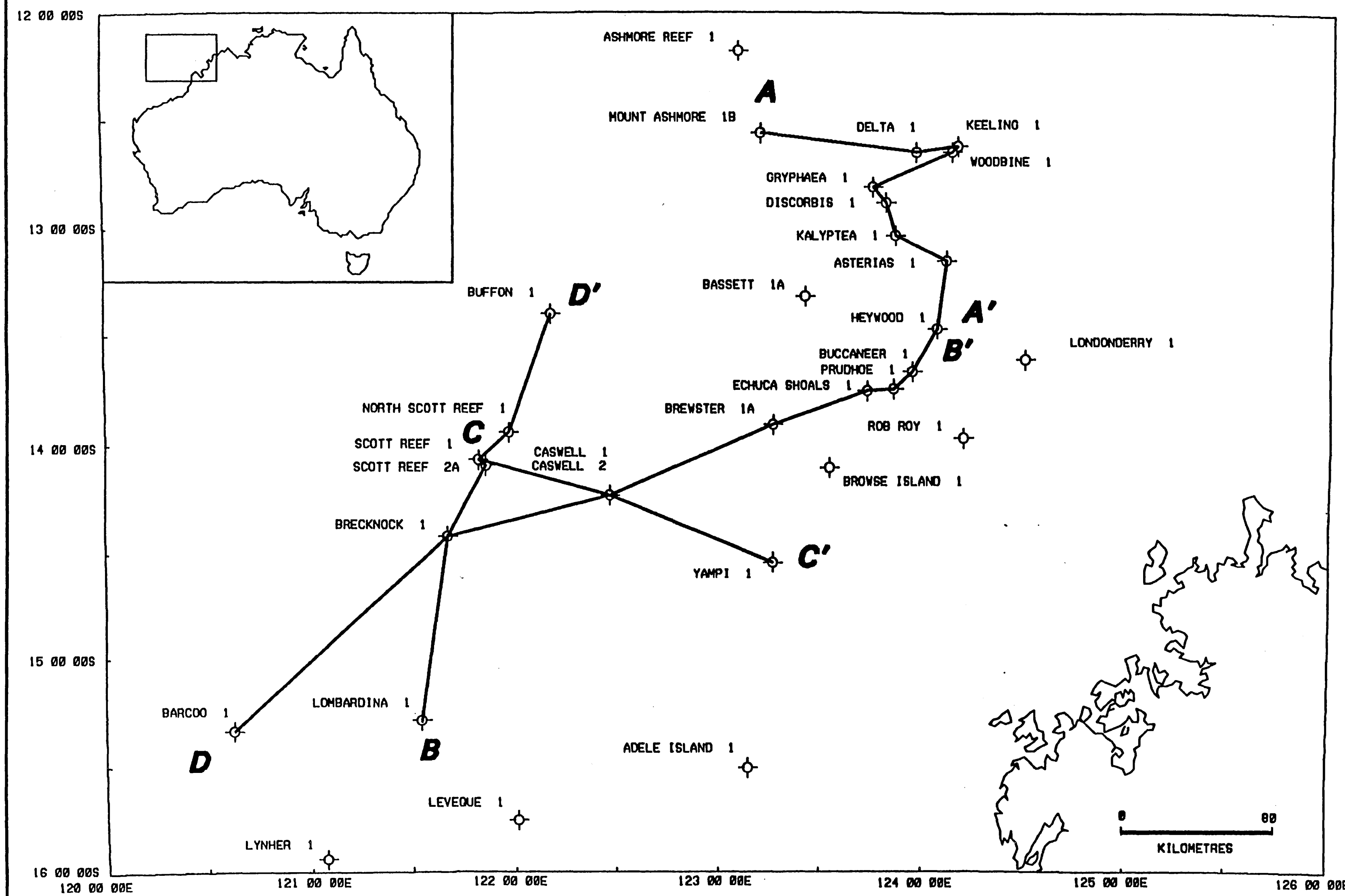


Figure 24 **Location map of well log cross sections (see Enclosures 4–7)**

PALAEOGEOGRAPHIC RECONSTRUCTION

METHODOLOGY

Twenty time slice data maps and seventeen interpretation maps have been constructed ranging from the Carboniferous (Namurian) to the Cretaceous (Maastrichtian). Four of the time slice data maps produced combine more than one time slice.

The time slice data maps consist of a gamma ray log profile at a scale of 1:10000 for each well, hydrocarbon indications, and a table listing thicknesses and depths to the top and base of the time slice (Enclosures 8 to 44). Where sufficient data exists trends of depositional environments are interpreted to produce a palaeogeographic map. Detailed descriptions on the palaeogeographic interpretation and prospectivity of each time slice are provided in the following section. A summary of the organic chemistry is provided for each time slice map. This data was synthesised from A.G.S.O's ORGCHEM database and is shown as time slice maps of Total Organic Carbon (TOC), Hydrogen Index (HI) and Vitrinite Reflectance (VR) in Appendix 9. When referring to the stages for generation of hydrocarbons, we have followed the scheme and cut-off points used by Tobin (1991).

Figure 24 shows the orientation of four well log cross sections detailing time slice correlations and time slice facies interpretations. Correlation of time slice boundaries between wells displays thickness variations and provides a visual estimate of the different rates of sedimentation, regional unconformities / disconformities and condensed sections. Interpreted environments of deposition and landform elements are provided in the form of codes (Introductory Section Figure 6 and Table 1) on the well log cross sections. The well log cross sections, which correlate 23 wells, are provided in Enclosures 4 - 7 and should be referred to in conjunction with the palaeogeographic interpretation maps and accompanying notes.

PALAEOGEOGRAPHIC INTERPRETATIONS AND PROSPECTIVITY OF TIME SLICES

TIME SLICE : Pre-Triassic (Enclosure 8)

PALEOGEOGRAPHIC INTERPRETATION

Pre-Triassic sediments are penetrated in four wells (Echuca Shoals 1, Prudhoe 1, Rob Roy 1 & Yampi 1) all of which are located on the southeastern margin between the Inner Basin Arch and the Yampi Shelf. The basal sequences in Londonderry 1 lack age control but seismic evidence on line M200-46 shows the sequences to be older than Triassic (Possibly Early Permian to Carboniferous?). No palaeogeographic map was interpreted for this time slice due to limited age and well control. Only broad regional depositional and palaeogeographic trends are recognised and discussed in the following paragraphs (see Enclosures 4 - 7 for well details to refer to these descriptions).

In Rob Roy 1, sediments of Namurian age represent the oldest known strata to have been intersected within the Browse Basin. The presence of fossil fragments and recrystallised limestone within the Carboniferous sequence suggests a relatively low energy shallow marine depositional environment. This is followed with the deposition of thin sandstones with a gradual increase in thickness and grain size in successive layers. This is interpreted to be the onset of a progradational episode in a pro-delta environment. Progradation continued throughout the basal Permian (Time Slice P1) where thicker stream mouth bar type sandstones were deposited. Similar stream mouth bar sandstones of indeterminate age are also present in the upper part of a coarsening upwards sequence in Yampi 1.

The uppermost Permian (Time Slice P7) sequence intersected in Echuca Shoals 1 consist of thin recrystallised limestone and siltstone with skeletal material and is interpreted to have been deposited in a low energy marine to near shore environment. Similar lithologies of indeterminate age are also present in Prudhoe 1. However, seismic evidence suggest the Permian section in Prudhoe 1 is older than the section in Echuca Shoals 1 but is truncated towards Rob Roy 1.

A regional angular unconformity separating the Permian from the overlying Mesozoic sequences is evident from both well information and seismic data. The Permian sequence is truncated progressively from late Permian (Time Slice P7) in Echuca Shoals 1 to early Permian (Time Slice P1) in Rob Roy 1.

PROSPECTIVITY

The early Permian fluvio-deltaic sequence in Rob Roy 1 contain several thick quartz rich sandstone layers with up to 14% porosity but with permeability of less than 1 mD. Sandstones from the undated sequence in Yampi 1 have log porosity of up to 9%. Due to the sparsity of well data, predictions on the development and distribution of other potential reservoirs will depend on detailed seismic stratigraphic interpretations.

Gas indications occur in Yampi 1 and Echuca Shoals 1.

Maximum TOC values range from 1 to over 3% in interdistributary bay facies intersected in Rob Roy 1 and Prudhoe 1. There are only a few HI values, and all are low. The VR measurements suggest the sequences are overmature in the northeast, but are in the peak oil generative stage in Lynher 1.

TIME SLICE Tr 1 to Tr 4 : Scythian to Ladinian (Enclosure 9)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from the early Triassic Tr1 to Tr4 Time Slices are absent at Rob Roy 1 and only partially present in four wells, Brecknock 1, Echuca Shoals 1, Gryphaea 1 and Discorbis 1. Sediments of probable Triassic age were also intersected in Buccaneer 1, Lynher 1 and Yampi 1 but poor biostratigraphic control prevents any detailed definition of individual time slices. The remaining wells did not intersect the Tr1 - Tr4 section.

No palaeogeographic map for the Tr1 to Tr4 Time Slices was interpreted due to limited well and biostratigraphic control (see Enclosures 4 - 7 for well details).

The earliest Triassic section (Tr1) is found in Echuca Shoals 1 and comprises a thick (306 m) mudstone dominated sequence with thin interbeds of altered tuff and occasional chert. This sequence is interpreted to be deposited in a marine environment influenced by both clastic (tuff) and chemical (chert) sedimentary processes related to subaerial volcanic activity.

The Tr2 to Tr4 sequences are dominated by interbedded low energy siltstones and mudstones. Minor glauconitic stringers and traces of coaly matter are present in Tr2 at Gryphaea 1, and thin oolitic and coralline limestones in Tr3 at Discorbis 1 and Brecknock 1. This sequence is interpreted to represent relatively proximal interdistributary bay type deposits in a shallow water estuarine environment .

The presence of oolitic and coralline limestones in Time Slice Tr3 suggests that portions of the basin were emergent during Time Slice Tr3, providing locations for reef development and a coralline and oolitic limestone source.

The absence of any sediments of Tr4 age in the northeastern portion of the basin implies that it was either emergent and failed to receive sediments during this period or that sedimentation did occur and was subsequently eroded by a localised post Tr4 tectonic event. Both scenarios are difficult to ascertain from well and seismic data due to the removal of a significant amount of Middle to Upper Triassic section by a major regional erosional phase in the Late Triassic.

However, on the western margin of the basin, the Tr3 to Tr4 section is preserved in Brecknock 1, indicating a different depositional or tectonic setting where effects of the Late Triassic erosional period was less significant.

PROSPECTIVITY

Due to limited data control of Time Slices Tr1 to Tr4, no predictions are made on the distribution and quantity of potential reservoir sands. Log porosities averaged between 2 to 9% for both Echuca Shoals 1 and Gryphaea 1. The predominance of low energy mudstones and siltstones in observed sections suggests the Tr1 to Tr4 interval should provide a reasonable seal for any Permian, or older, reservoirs.

Hydrocarbon shows are limited to the northeastern portion of the basin with gas and oil indications in Echuca Shoals 1, Gryphaea 1 and Discorbis 1.

Median TOC values are generally <1%, with the maximum ranging up to 2.8% in Lynher 1. The HI values are also low but there is only a low sampling rate. VR suggests that the wells located in the northeastern portion of the basin are mature to overmature while those in the southeast are in the peak oil generative stage.

Generally low TOC values may reflect the relatively shallow water depths and effects of the interspersed volcanics during these time slices.

TIME SLICE Tr 5 : Carnian to Early Norian (Enclosure 10)

PALAEOGEOGRAPHIC INTERPRETATION

Three wells, Brecknock 1, Ashmore Reef 1 and Mount Ashmore 1, all of which are located on the northwestern basin margin, penetrate sediments from Time Slice Tr5.
A fourth well, Keeling 1, encountered sediments near TD of Tr5 to Tr6 age. The Tr5 sequence is absent at Gryphaea 1, Discorbis 1, Echuca Shoals 1 and Rob Roy 1.

No palaeogeographic map was interpreted for this interval due to the limited number of wells that intersected sediments of Time Slice Tr5 age. The wells with biostratigraphic control are also too widely spaced to allow any meaningful interpretation of regional trends (see Enclosures 4 - 7 for well details).

Carbonate facies from the lower portion of Timeslice Tr5 at Ashmore Reef 1 show a gradual increase in fossil and oolite content up the section suggesting a progradational outbuilding of a carbonate platform/reef complex. This is further supported by the occurrence of a quartz dominated carbonaceous rich beach sand overlying the carbonate deposits. Similar aged Tr5 deposits from Mount Ashmore 1 consist of interbedded limestone, claystone and minor sandstones which are interpreted to represent reef front or interdistributary bay type deposits formed in a near shore marine environment.

The sand rich Tr5 to Tr6 sequence in Keeling 1 is interpreted to be of fluvio-deltaic origin. These sands together with a gradational coarsening upwards of clastic facies in Brecknock 1 and an absence of sediments from Time Slice Tr5 in several wells in the northeastern portion of the basin indicate a relative sea level fall and associated progradation during Time Slice Tr5.

PROSPECTIVITY

Due to limited data control in Time Slice Tr5, no reliable predictions can be made on the distribution and quantity of potential reservoir sands. However, the potential for reservoir development is better than in the Tr1 to Tr 4 Time Slices. The most porous reservoir interval from the observed Tr5 sediments occurs in the fluvio-deltaic sequences from Keeling 1 which are reported to have between 18 and 23 % log porosity. This interval corresponds to a proven gas zone.

Ashmore Reef 1, Brecknock 1 and Mount Ashmore 1 have log porosities of 2 to 13%, while Brecknock 1 also has a gas indication within this interval.

The only TOC and HI values are from Ashmore Reef 1 where maximum TOC values are up to 1.14% and the HI values are low. VR data from Barcoo 1 suggests it is in the peak oil generative stage. The values from Ashmore Reef 1 may reflect its setting in a coarse grained clastic and carbonate dominated environment.

TIME SLICE Tr 6 : Late Norian to Rhaetian (Enclosures 11 & 12)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice Tr6 are present in eight wells. Six of these are situated along the western margin of the basin and the remaining two at the northeastern end of the basin on the southeast-northwest structural extension separating the Browse Basin from the Vulcan Sub-basin. Poor biostratigraphic control in four wells (Buccaneer 1, Prudhoe 1, Yampi 1 and Lynher 1) prevents further definition of Time Slice Tr6 on the eastern margin of the basin. The thickest section is penetrated in Ashmore Reef 1 (760 m) while the thinnest complete Tr6 section (145m) occurs in Brecknock 1. The Tr6 sequence is completely absent from Echuca Shoals 1, Rob Roy 1, Discorbis 1 and Gryphaea 1.

The overall character of Time Slice Tr6 is an association with facies deposited in coastal and near shore marine environments. Wells on the western margin of the basin, with the exception of Brecknock 1, intersect variable thickness of fossiliferous and oolitic limestones, of early and middle Tr6 age. These deposits are probably related to higher rates of carbonate production around topographic highs. The presence of more clastic prone facies of similar age in Brecknock 1 could be indicative of a basinal location during Tr6 times or simply a function of poor biostratigraphic control leading to an erroneous correlation.

The upper Tr 6 sequence shows a general shift from carbonate to clastic dominated facies. The majority of wells contain relatively low energy thinly interbedded siltstones and mudstones, interpreted to be deposited in either interdistributary bay or continental shelf type settings. However, in the northeastern portion of the basin, sandstone dominated sequences (with some conglomeratic layers) are found in Ashmore Reef 1, Woodbine 1 and Keeling 1. Similar sandstone sequences with carbonaceous and coaly horizons are found in Ashmore Reef 1, Mount Ashmore 1 and Woodbine 1. These sandstone facies are interpreted to represent a fluvial deltaic environment. The distribution of these facies suggests sediment sourcing from within an arc extending to the north and southeast of this northeastern area.

The observed facies distribution together with evidence of continued sediment progradation during Time Slice Tr5 into Tr6, indicate relatively low sea levels and sediment outbuilding during Time Slice Tr6.

PROSPECTIVITY

The best potential for the development of Tr6 reservoirs is within the fluvio-deltaic sequences present in the northeastern portion of the basin. Due to the long age range of spore pollen zones which define the Tr6 time slice, and the relatively wide spacing of the wells which intersect this sequence, no interpretations are made on the distribution and quantity of this potential reservoir. The sandstones in the Latest Tr6 in Ashmore Reef 1 showed measured porosity of up to 19.5% with permeability of 857 mD. Log porosities from similar intervals in Mount Ashmore 1, Keeling 1 and Woodbine 1 are between 16 and 22%.

Limited biostratigraphic control in Keeling 1 defines the proven gas zone discussed earlier to being either Tr5 and/or Tr6 in age. More reliable biostratigraphic control in Scott Reef 1 defines a proven gas zone to be within the Upper Tr6 interval, and has measured porosity and permeability maxima of 22.4 % and 19.9 mD. Hydrocarbon indications occur at Mount Ashmore 1 and North Scott Reef 1 as gas and oil anomalies, and in Brecknock 1 and Woodbine 1 as gas anomalies.

The median TOC values increase from the southwest to the northeast where Ashmore Reef 1 has 1.13%. The HI values are low and the VR data, from the southwestern portion of the basin, suggests that the sequence is in the peak oil generative stage.

The trends in TOC values may reflect the development of nearshore deltaic facies in the northeastern portion of the basin which are more proximal to the source of organic matter than the lower energy marine sequences in the southwest.

TIME SLICE J1 : Hettangian to Sinemurian (Enclosures 13 & 14)

PALAEOGEOGRAPHIC INTERPRETATION

Time Slice J1 is penetrated in seven wells located on the southwestern margin of the basin between Buffon 1 and Lynher 1. In the northeastern portion of the basin, the sequence is completely absent in Mount Ashmore 1, Keeling 1, Woodbine 1, Gryphaea 1, Discorbis 1 and Echuca Shoals 1.

The J1 sequence in Lynher 1 contains two good stream mouth bar style coarsening upwards sequences capped with a blocky fluvial or beach sandstone with traces of coal. These sand dominated facies and similar facies at Brecknock 1 are interpreted to be deposited in a coastal to deltaic/estuarine environment. Lower energy facies in Lombardina 1, and the presence of gastropod and ostracod fragments in Barcoo 1 are interpreted to be indicative of a marine embayment separating the Lynher 1 and Brecknock 1 areas.

Sediments intersected in North Scott Reef 1 include blocky relatively high energy sands with shell fragments. These sands are interpreted to have been deposited in a relatively shallow water offshore bar complex. This interpretation is further supported by well and seismic data indicating that the area extending from Buffon 1 to Brecknock 1 was a series of topographic highs during J1.

Three probable sediment source areas are postulated for the origin of the coarser grained sediments distributed between Buffon 1 and Brecknock 1. Firstly, sands could have originated locally from emerged portions of the Buffon 1 to Brecknock 1 high. Secondly, sands could have derived from the structurally high regions to the northeast where several wells lack any J1 sediments. Thirdly, sands could have been transported from the main shelf areas in the southeast, as interpreted for the coarse grained facies in Lynher 1.

The absence of sediments from Time Slice J1 in the emergent, structurally high, northeastern portion of the basin and progradation of higher energy facies into the southwestern portion of the basin and are a result of continued low stand conditions during Time Slice J1.

PROSPECTIVITY

Interpretations of potential reservoir distribution during Time Slice J1 are difficult due to the limited well control over this interval.

Reworked offshore bar type sands in North Scott Reef 1 contained a proven gas condensate accumulation over an interval with log porosity of 13.5%. Potential exists for the development of further offshore bar reservoir sands on the flanks of the Buffon 1 to Brecknock 1 high, and possibly between the Lynher 1 and Lombardina 1 structures.

The fluvio-deltaic sands in Lynher 1 and Brecknock 1 have log porosities of 19% and 18% respectively. The potential for the development of similar sands exists along strike to the northeast and southwest of Lynher 1 and Brecknock 1. Brecknock 1 has gas and oil indications while Lynher 1 has gas indications only.

Potential for more proximal fluvial sands may exist to the southeast of Lynher 1 as well as between Buffon 1 and Brecknock 1 and the source of the sands seen in these wells.

The median TOC values range from 0.34 to 1.57% (excluding an undifferentiated Jurassic sequence penetrated in Rob Roy 1 which includes coaly material) with maximum values over 3% in North Scott Reef 1. The HI values are generally low, ranging up to a maximum of 171 in Lynher 1. The VR data varies greatly but the wells in the southwest are in the peak oil generation stage.

The observed geochemical trends suggest the nearshore deltaic facies in the southwest have better source characteristics than either the shallow water marine environments in the north or the sequences associated with the topographic highs on the eastern basin margin.

TIME SLICE J2 : Pliensbachian to Middle Toarcian (Enclosures 15 & 16)

PALAEOGEOGRAPHIC INTERPRETATION

The seven wells which intersect sediments from Time Slice J2 are identical to those which intersect sediments from Time Slice J1. Similarly, in the northeastern portion of the basin all the wells with good biostratigraphic control are missing the J2 sequence. The thickest section, some 299 m, occurs in Lynher 1 while 43 m in Brecknock 1 is the thinnest. Poor biostratigraphic control hinders the reliable definition for the top of Time Slice J2.

Lynher 1 shows a transition from the relative high energy sandstone dominated deposition of Time Slice J1 to lower energy muds and interbedded sands interpreted as interdistributary bay type deposits. Coarsening upwards sequences are interpreted to be stream mouth bar and/or crevasse splay sands which periodically invade this overall lower energy environment.

A fossiliferous calcarenite in the basal portion of the J2 sequence at Lynher 1, and thin oolitic limestones of similar age in North Scott Reef 1, Scott Reef 2 and Brecknock 1 indicate a rise in relative sea level in early J2. The rise in sea level is responsible for a landward shift of clastic facies, as seen in Lynher 1, and the development of carbonate facies around shallow water topographic highs. The gradational resumption of clastic deposition in the latter stages of Time Slice J2 resulted in the deposition of low to moderate energy facies over the basal J2 carbonates.

The predominance of low energy mudstone sequences throughout Time Slice J2 in both Lombardina 1 and Barcoo 1 indicates the continued existence of a deeper water marine embayment separating Lynher 1 and Brecknock 1.

Poor biostratigraphic control restricts the accurate dating and correlation of J2 sediments in Buffon 1.

PROSPECTIVITY

Clastic dominated upper portions of Time Slice J2 in North Scott Reef 1 include reworked quartz rich sandstones with shell fragments with a maximum porosity of 24 % and permeability of 30 mD. These offshore bar or fan sands are interpreted to be deposited in a moderate energy mid to offshore location. Potential for the development of similar reservoir sandstones exists in the vicinity of Scott Reef 2, Brecknock 1 and Lynher 1.

Coarsening upward stream mouth bar and/or crevasse splay sandstone sequence in Lynher 1 have an average log porosity of 22%. Similar sands may be developed both along strike, and to the southeast of Lynher 1.

Gas and oil indications occur in all wells which intersect sediments from Time Slice J2 except for Scott Reef 2 and Barcoo 1.

The median TOC values range from 0.3 to 2% (except in Rob Roy where coaly material is intersected). The sparse HI samples are generally low with a maximum of 129 occurring in Lynher 1. Poorly dated lower to middle Jurassic sequences in Brewster 1 have maximum TOC values of 2.44% and possibly relate to the development of nearshore deltaic environments. The VR data indicates wells in the southwest to be in the early stage of peak oil generation and the existence of overmature sequences in Buffon 1 and Brewster 1. The latter may relate to adjacent volcanics within these sequences.

TIME SLICE J3 to J6 : Late Toarcian to Early Callovian (Enclosures 17 & 18)

PALAEOGEOGRAPHIC INTERPRETATION

A total of eight wells in the central and southwestern portion of the basin intersect at least part of the sequence covered by Time Slices J3 through to J6. Barcoo 1 penetrates both the thickest (430 m) and most complete section. The top of Time Slice J6 is marked by the Callovian unconformity, except for Lynher 1 and Lombardina 1 which have limited biostratigraphic control. In the northeastern portion of the basin all of the wells with good biostratigraphic control are missing the entire J3 to J6 sequence.
Due to the limited well control and large time span , 22 Ma, of the J3 to J6 composite time slice only broad depositional trends shall be discussed in the following paragraphs.

Only three wells, Lynher 1, Barcoo 1 and Scott Reef 2, intersect the J3 sequence. Lynher 1 intersects a sharp based blocky fluvial sandstone while Scott Reef 2 and Barcoo 1 penetrate relatively low energy interdistributary bay or continental shelf style deposits.

The J4 to J6 sequences are characterised by nearshore to coastal styles of deposition. Facies include, coals in Yampi 1 and Lynher 1, flaser bedding in Scott Reef 2, stream mouth bar sands in Scott Reef 1 and Lombardina 1, and interdistributary bay deposits in Brewster 1.

The observed facies associations together with the absence of sediments from Time Slices J3 to J6 in the northeastern portion of the basin indicates the J3 to J6 interval is a period of relative low sea level associated with the widespread development of fluvio-deltaic deposits and possible emergence of structural highs in the northeast.

Andesitic tuffs and basaltic lava flows within the J4 to J6 sequence in Buffon 1, Scott Reef 1, Lombardina 1, Brewster 1 and Yampi 1 are indicative of widespread volcanic activity throughout this period. It is postulated that centres of volcanic activity existed both on the southeastern flank of the basin and around the northeast to southwest trending highs located between Scott Reef 1 and Buffon 1.

PROSPECTIVITY

The widespread occurrence of nearshore to fluvio-deltaic deposits in the central and southwestern portions of the basin during the J3 to J6 interval provides several potential reservoir intervals. Fluvial sandstones in Lynher 1 have an average log porosity of 23% while more distal stream mouth bar type deposits at Lombardina 1 and Barcoo 1 have average log porosities of between 6 and 18%. Similar stream mouth bar style sandstones penetrated in Time Slice J6 at Scott Reef 1 are associated with a proven gas condensate accumulation with a maximum log porosity of 19%. A strong gas indication is also reported in Brewster 1 from thin interdistributary bay or crevasse splay type sandstones of indeterminate J2 to J5 age.

Scott Reef 2 intersects quartz rich fine to coarse grained sandstones with flaser bedding within Time Slices J4 and J5. These storm deposits or fan sandstones have a maximum porosity and permeability of 21% and 15 mD and are associated with a gas show.

During these time slices maximum TOC values of >3% are reported (excluding coaly material in Lynher 1). The HI values are relatively low except for Lynher and Yampi 1 where they have a maximum of 409 and 135 respectively. The VR data range from overmature in Buffon 1 to the early stages of peak oil generation in wells in the southwest.

The best geochemical parameters occur in Lynher 1 which intersects coaly sediments interbedded with fluvial to nearshore clastics. There is an overall increase in the source potential during these time slices compared to Time Slice J2. This may reflect the widespread occurrence of nearshore deltaic facies during these time slices compared to the mixed low energy marine to deltaic facies of J2.

TIME SLICE J7 : Middle Callovian to Early Oxfordian (Enclosures 19 & 20)

PALAEOGEOGRAPHIC INTERPRETATION

Heywood 1, Buccaneer 1, Lombardina 1 and Lynher 1, all of which have poor biostratigraphic control, are the only wells which intersect sediments from Time Slice J7. Eight wells are missing the entire J7 sequence while a further three, Prudhoe 1, Yampi 1 and Scott Reef 2, with poor biostratigraphic control, are possibly missing sediments from this time slice.

Buccaneer 1 shows a coarsening upwards from a coaly back swamp to channel sands which are interpreted to be of fluvial origin. Overbank deposits also occur in Lynher 1 while stream mouth bar and nearshore or shallow marine sandstones are intersected in Heywood 1 and Lombardina 1. The development of nearshore to coastal depositional environments throughout Time Slice J7 together with an abundance of wells missing sediments from Time Slice J7 is interpreted to relate to a relative sea level fall. The relative sea level fall is most likely related to tectonic uplift associated with volcanic activity in Time Slices J4 to J6 and resulted in the emergence and erosion of structurally high locations and the development of the Callovian unconformity.

PROSPECTIVITY

Channel, stream mouth bar and shallow marine sands in Buccaneer 1, Heywood 1 and Lynher 1 indicate the potential for reservoir development in Time Slice J7. However, due to the limited well control, predictions on the distribution of reservoir sands will be dependent upon detailed seismic stratigraphy interpretations. Reservoir analysis is limited to Buccaneer 1 and Lombardina 1 which have log porosities of 12 to 16%.

Gas and oil indications occur in all four wells which intersect sediments from Time Slice J7. Arquebus 1, drilled approximately 10 km south west of Lombardina 1, has an inferred oil column (Haston & Farrelly, 1993) within a sequence of Jurassic sandstones which are interpreted to be within Time Slice J7 and J8 from log correlations.
Lynher is the only well in this time slice with both reasonable biostratigraphic control and geochemical data. TOC values range from 2.55 to 7% (influenced by coaly material), HI's from 74 to 163 and VR indicates it is in the early stages of oil generation.

Many of the wells with potential sediments from this time slice have poor biostratigraphic control and/or lack geochemical data. However, the potential development of similar facies to those intersected in Lynher 1 suggests the possibility for source rich intervals elsewhere in the basin.

TIME SLICE J8 : Middle Oxfordian to Kimmeridgian (Enclosures 21 & 22)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice J8 are penetrated by ten wells distributed throughout the basin. The thickest, somewhat anomalous, section (245 m) is intersected in Heywood 1 but unfortunately due to hole problems was not logged. Sediments from Time Slice J8 are completely absent from around the Scott Reef 1 / Brecknock 1 area, the Gryphaea 1 / Woodbine 1 / Keeling 1 area and the Echuca Shoals 1 area.

The J8 sequence intersected at Discorbis 1 in the northeast and Brewster 1, Lombardina 1 and Barcoo 1, located in the more central and southwestern portions of the basin, predominantly comprises low energy marine deposits.

Wells located more toward the landward basin margin, Heywood 1, Buccaneer 1, Yampi 1 and Lynher 1, show a greater proportion of coarser grained clastic facies. Thin sharply bounded sandstones with cross bedding, carbonaceous material, brachiopod moulds and load casts are penetrated in both Yampi 1 and Buccaneer 1. They are interpreted to be relatively distal fan delta type deposits. A well sorted beach sandstone with a blocky log character is penetrated in Lynher 1 and sharply overlies a sequence of coaly backswamp deposits deposited during Time Slice J7.

On the northwestern flank of the basin a calcilutite with Inoceramus prisms is intersected in Scott Reef 2 and a fine to medium grained glauconitic offshore bar sandstone in Mount Ashmore 1. The development of these shallow water slightly restrictive facies together with the absence of sediments from Time Slice J8 in Scott Reef 1 and Brecknock 1 is indicative of the relatively high and partially emergent nature of the northwestern basin margin throughout Time Slice J8.

The observed facies associations indicate the basin wide development of marine to nearshore environments within Time Slice J8 due to a relative sea level rise. The anomalously thick section in Heywood 1 relates to the development of a relatively localised graben, based on seismic evidence.

PROSPECTIVITY

The rise in relative sea level between Time Slices J7 and J8 resulted in the regression of clastic facies towards the southeastern basin margin. Consequently the best reservoir intervals occur in wells located on the southeastern basin margin at Lynher 1, Yampi 1 and Buccaneer 1.

Hydrocarbon indications are recorded from all the wells which penetrate sediments from Time Slice J8. The most significant of these occur in Yampi 1 and Buccaneer 1 which have oil shows reported within the relatively distal fan delta sands, and Arquebus 1 with an inferred hydrocarbon column (Haston & Farrelly, 1993) in sands interpreted to be within Time Slice J7 and J8 from log correlation with Lombardina 1. In addition, Brewster 1 has a strong gas anomaly associated with thin very fine sands and silts interpreted to be extremely distal fan sands. Thicker more proximal sands are interpreted to lie to the southeast of Yampi 1 and Buccaneer 1.

The increase in relative sea level between J7 and J8 coupled with the existence of relative highs to the northeast and northwest of the basin may have led to the development of a somewhat restricted sea way in the central basin. Poor circulation in such a narrow sea way together with the possibility of high organic matter input due to the flooding of previously colonised coastal areas offers potential for the development of source rich intervals within the central basin during Time Slice J8.

This time slice has median TOC values with up to 3.7% and a maximum of 5.43% (Lynher). HI values are relatively good with mean values ranging from 37 to 269. The VR in Brewster suggests it is overmature whilst the remaining wells range from the early to the peak stage of oil generation.

The absence of geochemical sampling and good biostratigraphic control from the thick mudstone sequence penetrated in Heywood 1 prevents any predictions on the potential development of a localised source interval in this region.

TIME SLICE J9 : Early Tithonian (Enclosures 23 & 24)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice J9 are intersected in only three wells, Mount Ashmore 1, Heywood 1 and Yampi 1. Both Mount Ashmore 1 and Yampi 1 have very thin sequences, 7m and 18m respectively, while Heywood 1 has in excess of 280m. The sequence is absent from eleven wells with good biostratigraphic control and at least a further two wells with poor biostratigraphic control, Prudhoe 1 and Brecknock 1.

The predominance of claystone and mudstone dominated lithologies in all three wells is indicative of deposition in a low energy marine environment. Thin interbeds of halite in the early J9 at Heywood 1 indicate the development of a period of, at least localised, restriction during early J9 time.

The thick J9 section in Heywood 1 relates to the continued reactivation and development of a localised graben as discussed earlier.

The absence of J9 sediments from a large number of wells is indicative of a phase of either regression and/or tectonic uplift causing an episode of non-deposition and possible erosion of emergent structural highs. The development of restrictive sediments in Heywood 1 offers some support for at least a localised tectonic or eustatic event during early J9 time.

PROSPECTIVITY

Due to the limited well control and total lack of reservoir analysis within sediments from Time Slice J9 no interpretations have been made on the potential for reservoir development. The thick low energy J9 mudstone sequence penetrated in Heywood 1 may have some potential as a source.

Gas and oil shows are recorded in Yampi 1 and Heywood 1.

Geochemical data control is sparse for Time Slice J9. TOC and HI data are restricted to an undifferentiated upper Jurassic sequence penetrated in Caswell 2 and described in the previous time slice. Only two VR data points exist, at Buffon 1 and Yampi 1, and indicate the respective sequences are in the higher and lower end of the peak oil generative stage.

TIME SLICE J10 : Middle and Late Tithonian (Enclosures 25 & 26)

PALAEOGEOGRAPHIC INTERPRETATION

The majority of the ten wells which intersect sediments from Time Slice J10 lie towards the southeastern basin margin. A trend is observed with section thickness decreasing towards the northwestern margin of the basin. An anomalously thick section of 553 m in Heywood 1 relates to the development of a localised graben as discussed earlier. The J10 sequence is missing from four wells located in the northeastern portion of the basin, (Gryphaea 1, Discorbis 1, Keeling 1 and Woodbine 1), two at the southwestern edge of the basin, (Lynher 1 and Barcoo 1), and one on the northwestern flank (Scott Reef 1).

The early J10 sediments penetrated in Echuca Shoals 1 consist of coarsening upwards stream mouth bar sandstones while those in Buccaneer 1 are dominated by an interbedded sequence of sands and siltstones. These facies are interpreted to represent nearshore deposits forming in response to the progradation of a deltaic complex from southeast of Prudhoe 1.

To the southwest of Echuca Shoals 1, thin sands amongst predominantly low energy fine grained sediments in Yampi 1 and Brewster 1 are interpreted to be distal fan type sandstones deposited in a nearshore environment .To the northeast, the early J10 sequence penetrated in Heywood 1 consists of a thick, mud dominated, low energy interdistributary bay sequence. The observed facies distribution during the early J10 suggests that either a deltaic feeder system entered the basin around Echuca Shoals 1 and then flowed to the southwest, or a second feeder system existed to the southeast of Yampi 1 and Brewster 1.

The late J10 sequence in Heywood 1 includes good stream mouth bar type progrades interpreted to be related to either the migration of the existing feeder system closer to Heywood 1, or the development of a new feeder system to the southeast of Heywood 1 during late J10 time.

Asterias 1 terminated drilling in a well sorted quartz rich sandstone indicating either the development of offshore bars reworking the stream mouth bar sands from around Heywood 1, or the existence of another sediment source distributing sands into this area.

A broad arc trending southwest from Mount Ashmore 1 to Leveque 1 consists of fine grained lithologies with occasional fossiliferous fragments in Scott Reef 2. This is interpreted to be a low energy marine fringe to the northeastern deltaic systems.

Overall, Time Slice J10 has an increased proportion of coarser grained clastic facies and a decreased number of wells with missing sequences than Time Slice J9. Progradation of coarser grained facies is a lag effect relating to an increased sediment flux due to the regional basin uplift during Time Slice J9 (Early Tithonian). Subsidence or a slight increase in the relative sea level during Time Slice J10 caused the partial submergence of the J9 highs and hence the more widespread preservation of sediments from Time Slice J10.

PROSPECTIVITY

Log porosity of 10 to 28%, the highest reported within Time Slice J10, occurs in offshore bar sands penetrated near the total depth drilled in Asterias 1. Oil was extracted from a sidewall core within these sands. No predictions have been made on the distribution of these potential reservoir sands due to the limited well control.

The deltaic sandstones intersected in Echuca Shoals 1 and Buccaneer 1 have average log porosities of 15% while the distal fan sands in Yampi 1 and Brewster 1 have log porosities from 8.3 to 12%. An oil show in Buccaneer 1, a strong gas indication in Brewster 1 and both gas and oil indications in Yampi 1 and Heywood 1 are associated with these intervals. More proximal fan and/or fluvio-deltaic facies with the potential for better reservoir development are interpreted to the southeast of these wells.

The median TOC values range from 0.5 to 1.71%, with a maximum value of 2% in Lombardina 1. Wells located in the central and southwestern portions of the basin have median values >1% whilst those in the northeast have median values of <1%. The HI values are low, with maximum values of 216 in Asterias 1 and 143 in Lombardina 1. The VR data shows Brewster 1 and Lombardina 1 to be overmature, while Leveque 1, Yampi 1 and Asterias 1 are in the peak oil generative stage.

Observed trends in TOC values indicate a correlation between low energy marine environments and higher values of TOC and suggest oxidation of organic matter in shallow water higher energy environments.

TIME SLICE K1 : Berriasian to Early Valanginian (Enclosures 27 & 28)

PALAEOGEOGRAPHIC INTERPRETATION

The Early Cretaceous K1 section is penetrated, at least partially, in 16 wells distributed evenly throughout the basin. Six wells have insufficient biostratigraphic control to enable the reliable definition of this Time Slice while a further four, Woodbine 1, Gryphaea 1, Buffon 1 and Londonderry 1, are missing the entire sequence. A general trend is observed with decreasing section thickness from the northeast (Asterias 1 485 m) towards the southwest (Barcoo 1 13 m).

For the purpose of description the basin is divided into two areas. Wells to the west of Caswell 2 are characterised by fine grained low energy facies while coarser grained clastic facies are present in the central and northeastern portion of the basin as far west as Yampi 1 and in the northeast as far as Kalyptea 1.

The condensed K1 section in Scott Reef 1 together with the missing sequence at Buffon 1 and the strong possibility of other missing or condensed sections on the northwestern flank of the basin (between Buffon 1 and Brecknock 1), suggest that this area was relatively high during K1. Wells lying to the south of here (Caswell 1, Lombardina 1, Lynher 1 & Barcoo 1) are characterised by low energy marine facies. Leveque 1 penetrates similar low energy facies together with thin greensands interpreted to be very distal fan sands deposited on a somewhat restrictive basin margin.

The *P.iehiense* and *K.wisemaniae* sequences in the central basin, Yampi 1, Brewster 1 and Echuca Shoals 1, consist of either mass flow or offshore bar sandstones which stratigraphically thin towards Heywood 1 (Enclosure 5). These sandstones are thought to be derived from either the southeastern basin margin as is the case at Leveque 1 or, structural highs located in the northeastern portion of the basin where the *P.iehiense* and *K.wisemaniae* sequences are absent.

In the northeastern portion of the basin the *C.delicata* sequences contain facies of fluvio-deltaic origins. A sharp based erosive channel cut in Heywood 1 together with good coarsening upward (often glauconite rich) stream mouth bar sequences in Buccaneer 1, Asterias 1, Kalyptea 1, Prudhoe 1 and Echuca Shoals 1 are interpreted to show progradation of deltaic facies from the Londonderry High towards the Inner Basin Arch. A sharp based well sorted glauconitic sandstone overlying the stream mouth bar sands in Kalyptea 1 is interpreted to represent either a mass flow sandstone or an offshore bar complex which may have reworked the *C.delicata* sands.

A pebble conglomerate above the *C.delicata* sandstones in Yampi 1 is interpreted as a transgressive lag deposit indicative of a relative sea level rise in the upper K1. This relative sea level rise is responsible for the often condensed or absent *D.lobispinosum* to *E.torynum* sequences and the development of a good flooding surface in several wells.

PROSPECTIVITY

The K1 Time Slice contains some of the thickest, most widespread and prospective reservoir intervals penetrated within the Browse Basin. A trend exists with the thickest sand development in the central basinal areas and thinning towards the northeast.
The *C.delicata* fluvio-deltaic sandstones developed in the northeastern potion of the basin have average log porosities of 10 to 17% and are associated with a gas condensate recovery from a Repeat Formation Test in Kalyptea 1 and an oil extract from a sidewall core in Buccaneer 1.

The mass flow or offshore bar sands developed around Kalyptea 1 and the more central portions of the basin have log porosities averaging between 10 to 15% and are associated with both oil and gas indications. Reservoir analysis on a core from this interval in Brewster 1 shows a maximum porosity of 16 % and permeability of 8.2 mD.

With the exception of Mount Ashmore 1, hydrocarbon indications occur in all the wells which intersect sediments from Time Slice K1.

The median TOC values range from 0.3 to 2.39%, with a maximum value of 2.57% in Lynher 1. As in the previous time slice, wells located in the southwestern portion of the basin generally have higher TOC values, in the range of 1 to >2%, while those located in the northeast are <1%. The mean HI values range from 15 to 250, with a maximum of 345 and 350 in Asterias 1 and Discorbis 1 respectively. The wells in the northeast all have mean HI values >150 while those in the central and southwestern portions of the basin are generally <100. However, some of the HI values in the northeast may be unreliable due to their low TOC values. The VR data reveals Lombardina 1 and Brewster 1 to be overmature, while the central and northeastern wells are in the peak oil generation stage and Lynher 1 and Leveque 1 are immature.

As in the previous time slice, the better TOC values correspond to low energy marine environments in the southwestern portion of the basin. However, the occurrence of some high TOC values in the northeast may indicate either localised low energy marine incursions and/or progradation of nearshore deltaics and the associated organic matter.

TIME SLICE K2 : Early Valanginian to Hauterivian (Enclosures 29 & 30)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice K2 are penetrated in twenty one wells. Of the remaining eight wells, six have insufficient biostratigraphic control to clearly define this time slice while Delta 1 and Bassett 1 were terminated prior to reaching sediments from Time Slice K2. In general, wells located in the central basin areas, between Lombardina 1 and Kalyptea 1, penetrate thicker sequences than those located around the basin margins.

The basin wide predominance of low energy marine facies throughout Time Slice K2 is a result of the relative sea level rise during the *D.lobispinosum* to *E.torynum* interval of Time Slice K1.

A thin organic rich shale is penetrated in Gryphaea 1 and unconformably overlies sediments from Time Slice Tr2 . This organic rich shale together with others in Asterias 1 and Keeling 1 are interpreted to indicate the presence of partially emerged and colonised topographic highs in the northeastern portion of the basin during, at least the early portion, of Time Slice K2.

Blocky glauconitic sandstones from the upper portion of Time Slice K2 in Asterias 1 and thin, more distal, time equivalent sands in Kalyptea 1, Lynher 1 and Leveque 1 are interpreted to represent mass flow deposits. The distribution of these sands suggests the most likely sediment source areas should lie on the basin margin to the southeast of these wells.

Thin K2 sequences along the northwestern flank of the basin between Barcoo 1 and Mount Ashmore 1 indicate the continuation of this areas relatively high nature and distal setting for clastic facies.

PROSPECTIVITY

Reservoir data is restricted to those wells with glauconitic mass flow sands located on the southeastern basin margin. The thicker, more proximal sands in Asterias 1 have both oil and gas indications from an interval with log porosities of 14 to 29%.

Thin organic rich shales in the northeastern portion of the basin offer some potential for the development of source intervals within the K2 sediments. Thicker more source prone intervals are interpreted to occur in locally restrictive troughs down dip from the early K2 slightly emergent and colonised highs.

The median TOC values range from 0.48 to 2.65%, with a maximum value of 7.93% in Caswell 2. HI's are generally low with mean values ranging from 9 to 149, with a maximum of 237 at Discorbis 1. VR data show Lombardina 1 and Brewster 1 to be in the higher end of the peak oil generative stage, whilst Scott Reef 1, Yampi 1, Discorbis 1, Asterias 1 and Prudhoe 1 are in the lower end of the peak oil generative phase. Lynher 1, Rob Roy 1 and Buccaneer 1 are in the early stage of generation.

The relatively uniform organic carbon content reflects the widespread distribution of lower energy marine environments throughout the basin due to a relative sea level rise in the upper portion of Time Slice K1.

The fine grained lithologies of Time Slice K2 have potential to seal any underlying sandstones of K1, Jurassic and Triassic age. However, the presence of numerous hydrocarbon indications in younger sequences, including live oil in Caswell 2, with both Cretaceous and Jurassic biomarkers (C. Boreham pers com ; AGSO : January 1993) suggest in areas of local thinning the K2 sequence may not be an effective seal and also in units which are thick, but faulted, (Caswell 1 and 2) there may be vertical migration through the K2 sequence.

TIME SLICE K3 : Berremian (Enclosures 31 & 32)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice K3 are intersected by nineteen wells spread throughout the basin. The K3 sediments are thickest in a central basin trough located around Brewster 1, thin to the northeast of Echuca Shoals 1 and are completely absent in both Gryphaea 1 and Lynher 1.

Time Slice K3 is similar to Time Slice K2 in that it is characterised by the widespread occurrence of facies indicative of dominantly low energy marine environments.

In the northeastern portion of the basin thin condensed K3 sediments include glauconitic sandstones in Asterias 1, Heywood 1 and Prudhoe 1. These sandstones, as in Time Slice K2, are interpreted to be mass flow sands derived from shallower water shelfal locations thought to lie to the southeast of these wells. The absence of any sediments from Time Slice K3 in Gryphaea 1 indicates its emergent nature and potential development as a local sediment source.

Condensed sequences in the relatively shallow water shelfal areas to the northeast of Echuca Shoals 1 are interpreted to relate to the local development of either a restrictive basin and / or a decreased sedimentation rate. The re-emergence of Gryphaea 1 during Time Slice K3 offers some support for the development of a restrictive "sub-basin" by either tectonic uplift or relative sea level fall.

PROSPECTIVITY

Glauconitic mass flow sands in Asterias 1 have log porosity of 14 to 29%. Some potential exists for the development of thicker more proximal sands to the southeast of Asterias 1 and possibly around localised topographic highs such as Gryphaea 1 and Lynher 1.

The predominance of fine grained lithologies in Time Slice K3 provides not only a good seal but also may have some source potential.

Hydrocarbon indications occur in the majority of wells which penetrate sediments from Time Slice K3. The most significant are two zones of live oil in Caswell 2 which range in thickness from 4 to 35 m. Organic geochemical studies conducted on the Caswell 2 oil indicate either a Cretaceous or Jurassic source (C. Boreham pers com ; AGSO : January 1993). This implies either vertical migration through the underlying K2 seals and/or an intraformational source within the organic rich K2 sequences.

Geochemical data control for Time Slice K3 is sparse. Median TOC values range from 0.04 to 2.4%, with a maximum of 2.57% in Caswell 1. Mean HI values range from 6 to 152. Leveque 1 and Yampi 1 are in the early stage of oil generation whilst the remaining wells with VR data are in the peak oil generative phase.

As in Time Slice K3, the widespread development of low energy marine environments is associated with relatively similar organic carbon content throughout the basin.

TIME SLICE K4 : Early and Middle Aptian (Enclosures 33 & 34)

PALAEOGEOGRAPHIC INTERPRETATION

Time Slice K4 is intersected by twenty wells spread throughout the basin in a similar fashion to Time Slices K2 and K3. Buccaneer 1 is interpreted to be missing the entire K4 sequence while other wells in the northeastern portion of the basin have relatively thin K4 sections. Wells located to the southwest of Echuca Shoals 1 penetrate thicker sequences, the thickest being 302 m at Lombardina 1.

A thin coarsening upwards sandstone penetrated in Prudhoe 1 is interpreted to represent either a stream mouth bar or a progradational mass flow. This sand, together with a thin organic rich shale in the basal portion of Time Slice K4 in Asterias 1 and the absence of K4 sediments in Buccaneer 1, are indicative of the establishment of relatively shallow water to emergent coastal environments in the northeastern portion of the basin during Time Slice K4.

A sharp based very fine grained well sorted sandstone with traces of glauconite and plant material is intersected in Scott Reef 1. Dip meter interpretation together with the absence of similar sands in adjacent wells indicates that the Scott Reef 1 sand body is elongate and probably striking eastnortheast to westsouthwest. This sandstone is interpreted to be either an offshore bar or beach deposit developed on the flanks of a topographic high centred around North Scott Reef 1. Fossiliferous calcarenites in Scott Reef 2, Brecknock 1 and Barcoo 1 indicate the development of shallow water low energy marine environments around a series of topographic highs located between Buffon 1 and Barcoo 1.

These facies together with up to 10% radiolaria in Leveque 1, indicate that Time Slice K4 is associated with a reduced clastic input and the development of local highs by tectonic uplift.

PROSPECTIVITY

Due to the reduced clastic input during Time Slice K4 the potential development of reservoir sandstones is restricted to the offshore bar or beach sands penetrated in Scott Reef 1. These sands have a maximum log porosity of 12% and a gas indication. Similar sandstones are interpreted to be developed along strike to the eastnortheast and westsouthwest of Scott Reef 1.

A thin organic rich shale in Asterias 1 offers some potential for the accumulation of source intervals within Time Slice K4.

The most significant hydrocarbon indication from Time Slice K4 is live oil over a 9 m claystone interval in Caswell 2.

Median TOC values range from 0.63 to 1.64%, with a maximum value of 2.32% in Lombardina 1. Mean HI's are generally low, ranging from 28 to 148, with a maximum of 237 in Lombardina 1. All wells with VR data are in the early to peak oil generation stage.

The relatively even distribution of organic carbon reflects the widespread occurrence of low energy marine environments throughout the basin during this time slice.

TIME SLICE K5 : Late Aptian to Early Albian (Enclosures 35 & 36)

PALAEOGEOGRAPHIC INTERPRETATION

Time Slice K5 is intersected by twenty wells distributed throughout the basin in a similar fashion to Time Slices K2 to K4. Asterias 1 is interpreted to be missing sediments from Time Slice K5 but due to poor biostratigraphic control may also be condensed. Wells to the south and west of Echuca Shoals 1 intersect thicker K5 sections. The thickest occur on the northwestern flank of the basin between Scott Reef 1 and Barcoo 1. In Buffon 1 sediments from Time Slice K5 represent the first sedimentary sequence to be deposited on top of a thick volcanic pile.

Glauconitic mass flow or stream mouth bar sandstones with between 25 to 50% glauconite are intersected in Heywood 1, Prudhoe 1 and Yampi 1. These sands are interpreted to be episodically deposited in a sediment starved marine environment with glauconite formation occurring either after deposition and between pulses of sand or in more shelfal locations prior to the deposition of the sand. The distribution of these sandstones indicates the main clastic source area lies toward the southeastern basin margin. However, the absence of sediments in Asterias 1 indicates the development of a topographic high in this location and its potential role as an additional and / or alternative sediment source.

A thin calcitic biomicrite at Kalyptea 1 together with similar facies in Gryphaea 1, Mount Ashmore 1 and Keeling 1 are indicative of the development of relatively shallow water marine environments in these locations. A depositional low interpreted to lie between Heywood 1 and Kalyptea 1 prevents the southeasterly derived mass flow sands reaching these carbonate prone shallow water topographic highs.

The generally thicker and less calcareous sequences on the northwestern flank of the basin together with the deposition of the first Cretaceous sediments in Buffon 1, during Time Slice

K5, are indicative of increased subsidence rates in this area and the establishment of a more open marine environment.

Similar open marine environments are also interpreted to be developed in the southwestern portion of the basin. The absence of sediments from Time Slice K5 in Leveque 1 is indicative of its structurally high basin margin setting.

PROSPECTIVITY

Glauconite rich mass flow sands penetrated at Heywood 1, Prudhoe 1 and Yampi 1 are the only potential reservoir sequence intersected in Time Slice K5. Reservoir analysis is restricted to Yampi 1 which has an average log porosity of 17%. Potential for thicker more proximal mass flow sands exists toward the southeast of these wells and thinner, more distal, sandstones are interpreted to lie towards the northwest.

Oil indications occur at Brewster 1 and Buffon 1, gas indications at Brecknock 1, Caswell 2, Heywood 1, Lynher 1, Prudhoe 1, Scott Reef 1 and Yampi 1, and both oil and gas indications in Barcoo 1, Caswell 1 and Echuca Shoals 1.

Median TOC values range from 0.87 to 2.4%, with a maximum of 4.74% in Barcoo 1. Mean HI values range from 40 to 260 with a maximum of 312 in Barcoo 1. All wells with VR data are at the peak oil generation stage.

As in Time Slices K2 to K4, the widespread occurrence of low energy marine environments corresponds to relatively uniform TOC levels.

TIME SLICE K6 to K8 : Middle Albian to Cenomanian (Enclosures 37 & 38)

PALAEOGEOGRAPHIC INTERPRETATION

The majority of the wells in the Browse Basin penetrate at least part of the K6 to K8 interval. Four wells, Ashmore Reef 1, North Scott Reef 1, Discorbis 1 and Londonderry 1, lack sufficient biostratigraphic control to enable the reliable definition of any sediments from Time Slices K6 to K8, and Delta 1 was terminated prior to intersecting sediments from Time Slice K8. Thick sections are developed in the northeastern portion of the basin between Echuca Shoals 1, Kalyptea 1, Asterias 1 and Rob Roy 1. Heywood 1 intersects the thickest , 812 m. The remaining wells, with the exception of Lombardina 1 and Barcoo 1, show a general thinning to the north and southwest of the northeastern thick.

Due to the broadly similar depositional styles throughout the 19 Ma covered by Time Slices K6 to K8 a composite data and interpretive map were created.
Sediments from the K6 to K8 time slices are characterised by low energy marine claystone and mudstone sequences with occasional calcarenites and marls. The presence of some carbonaceous material in wells to the northeast of Prudhoe 1 together with sandstones in Time Slice K8 at Rob Roy 1 is indicative of this areas proximity, relative to the remainder of the basin, to a colonised topographic high.

The absence of sediments from Time Slice K6 in Mount Ashmore 1, Gryphaea 1, Keeling 1 and Woodbine 1 is indicative of the continued topographic high nature of these wells and their emergence leading to a period of non-deposition and possible erosion during Time Slice K6. These emergent structural highs located in the north to northeasterly portion of the basin indicate that the relative sea level rise responsible for the widespread development of low energy marine deposits in Time Slices K6 to K8 occurred in either late K6 or early K7.

The thin relatively condensed K6 to K8 sequence intersected in Leveque 1 indicates the structurally high nature of this basin margin setting.

PROSPECTIVITY

Free oil is reported in distal fan or mass flow sandstones with log porosities of 7 to 17% intersected in Caswell 1. Similar thin mass flow or fan sandstones in Yampi 1 suggests a potential source area for the Caswell 1 sandstones, and associated more proximal facies, may lie towards the southeastern basin margin. However, the K6 structural highs around Gryphaea 1 and Mount Ashmore 1 offer an alternative and / or additional potential source area for the Caswell 1 sandstones and the potential for more proximal K6 sands to be developed to the northeast of Caswell 1 between Buffon 1 and Brewster 1. The absence of similar sands in Caswell 2 is interpreted to reflect its setting in a slightly shallower water location which is bypassed by the depositional low seeking distal fan or mass flow sandstones.

The median TOC values range from 0.38 to 1.96%. The mean HI values range from 23 to 269 at Buccaneer 1 in Time Slice K8. The majority of wells in the K6 to K8 composite time slice have VR values indicative of peak oil generation (except for the easternmost wells which are in the early stages of oil generation.

Relatively uniform TOC values reflect the widespread low energy marine environments during these time slices and possibly relate to a landward shift in terrigenous derived organic matter due to a relative sea level rise during Time Slice K7.

Fine grained lithologies in Time Slices K6 to K8 provide good intraformational seals for the K6 fan and / or mass flow sandstones.

TIME SLICE K9 : Turonian to Santonian (Enclosures 39 & 40)

PALAEOGEOGRAPHIC INTERPRETATION

Poor biostratigraphic control limits the definition of sediments from Time Slice K9 to twelve wells. A broad trend is observed with relatively thin sections penetrated in wells located around the basin margins to thick sections in the more central basin locations between Bassett 1, Prudhoe 1, Yampi 1 and Lombardina 1. The thickest section, 169 m, is penetrated in Bassett 1.

Event truncations and the partial absence of the *D.multispinum*, *P.infusorioides* and *C.striatoconus* palynological zones is indicative of the development of an unconformity surface at the base of Time Slice K9.

Sediments from Time Slice K9 are characterised by the development of carbonate facies which predominantly consist of marls, calcarenites and calcilutites. Abundant skeletal material in Leveque 1 and Mount Ashmore 1 is indicative of the development of reef buildups around the shallower water topographic high basin margins.

The deposition of shallow water carbonate facies and the development of an unconformity at the K8 / K9 boundary are interpreted to be a result of a relative fall in sea level between Time Slices K8 and K9.

PROSPECTIVITY

Time Slice K9 lacks any analytical reservoir data and is interpreted to have limited potential for the development of reservoir facies.

Minor gas indications occur in Bassett 1, Gryphaea 1, Lombardina 1, Lynher 1, Prudhoe 1 and Scott Reef 1.

Geochemical control for Time Slice K9 is very sparse. The median TOC values are very low and range from 0.02 to 0.98%. Mean HI values range from 11 to 15 and reach a maximum of 81 in Bassett 1. VR data range from the early to the lower stage of peak oil generation.

The limited geochemical data suggests little potential for source development during Time Slice K9 and may relate to the basin wide establishment of carbonate facies.

TIME SLICE K10 : Campanian to Early Maastrichtian (Enclosures 41 & 42)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice K10 are defined by good biostratigraphic control in ten wells. Seven of the ten, including Bassett 1 which has the thickest section, are located in the northeastern portion of the basin.

In the southwestern portion of the basin, Scott Reef 1, Lombardina 1 and Lynher 1 intersect carbonate dominated facies which gradually increase in mud content vertically through Time Slice K10. Thin fine grained calcareous sandstone In the basal portion of K10 at Lynher 1 reflects its more proximal basin margin setting.
Mount Ashmore 1 intersects a sequence of carbonate facies similar to those in the southwest. The remainder of the wells located in the northeastern portion of the basin intersect coarser grained clastic facies.

A coarsening upwards sequence intersected in Gryphaea 1 is interpreted to relate to the gradational progradation of high energy subaqueous grain flows over this area. To the northeast, Delta 1 intersects thicker blocky sand intervals interpreted as proximal grain flow deposits and hence suggesting the progradation of grain flows from the northeast towards the southwest. Micro-palaeontological data coupled with log correlations suggest similar grain flow sands in Caswell 1 and 2, which are undated over Time Slice K10, equate with this interval and indicate a considerable southwesterly progradation of grain flow sands during Time Slice K10.

The absence of grain flow sandstones in Mount Ashmore 1 coupled with the development of only thin sandstones in Keeling 1 and Woodbine 1 is indicative of the topographic high nature of these areas, preventing the deposition of substantial amounts of subaqueous grain flow sandstones.

Prudhoe 1 intersects minor grain flow sands in the upper portion of Time Slice K10. Micro-palaeontological data together with log correlations suggest similar sequences in Heywood 1, Buccaneer 1 and Echuca Shoals 1 (undated over Time Slice K10) may also equate to this interval, while Brewster 1 and Yampi 1 lack grain flow sands. The general absence of grain flow sands on the southeastern basin margin indicates both the topographic high nature of this area and its low to negligible coarse grained sediment contribution during Time Slice K10.

PROSPECTIVITY

The thick well sorted coarse grained subaqueous grain flow sandstones between Delta 1 in the northeast and Caswell 2 in the southwest provide excellent reservoir development during Time Slice K10. The grain flow sandstones have a maximum log porosity of 26%, in Delta 1, and are associated with an oil show in Caswell 2.

Interbedded mudstone sequences may provide intraformational seals for the grain flow sands.

Gas indications occur in Bassett 1, Delta 1, Gryphaea 1, Lombardina 1, Lynher 1, Prudhoe 1 and Scott Reef 1.

The TOC values are generally very low, median values range from 0.2 to 0.86%, with a maximum of 1.42% in Bassett 1. The HI data is sparse, with mean values ranging from 93 to 113 with a maximum of 143 in Bassett 1. The three wells with VR data are in the early to lower stages of oil generation.

The influx of clastic dominated facies in the central and northeastern portions of the basin during Time Slice K10 is responsible for the development of better source intervals, compared with the previous time slices, in Bassett 1.

TIME SLICE K11 : Late Maastrichtian (Enclosures 43 & 44)

PALAEOGEOGRAPHIC INTERPRETATION

Sediments from Time Slice K11 are intersected by the same ten wells which intersect sediments from Time Slice K10. The K11 sections generally decrease in thickness towards the southwest, with the exception of anomalously thick sections between Gryphaea 1 and Keeling 1.

Three wells in the southwestern portion of the basin, Scott Reef 1, Lombardina 1 and Lynher 1, penetrate facies from low energy marine environments similar to those penetrated in this location during the upper portion of Time Slice K10.

The northeastern portion of the basin is characterised by thick sequences of clastic facies which predominantly consist of high energy grain flow sands. The development of thicker sections in Time Slice K11, compared to those in Time Slice K10, is indicative of higher rates of deposition during Time Slice K11.

The early to middle portions of Time Slice K11 in Gryphaea 1, Delta 1, Keeling 1 and Woodbine 1 show a fining upwards sequence culminating in the development of a middle K11 low energy mudstone sequence. The gradational increase in the proportion of low energy fines over this interval, together with the absence of grain flow sandstones from sections thought to equate with this interval in Caswell 1 and 2, is indicative of either a relative rise in sea level, or the gradational migration of the grain flow system to a new depositional low.

In the northeastern portion of the basin the upper portion of Time Slice K11 is dominated by grain flow sandstones indicating a resumption of grain flow sedimentation in the upper portion of Time Slice K11.

PROSPECTIVITY

The widespread development of thick subaqueous grain flow sandstones in wells located in the northeastern portion of the basin offers excellent reservoir potential during Time Slice K11. Log porosities ranging from 17 to 30 % are reported over these intervals together with gas indications in Delta 1, Keeling 1, Lombardina 1, Lynher 1, Prudhoe 1 and Scott Reef 1 and both oil and gas indications in Gryphaea 1 and Woodbine 1.

Low energy mudstone lithologies interbedded within the grain flow sandstones, particularly during the middle K11, offers some potential for the development of at least local seals.

The median TOC values range from 0.32 to 1.0%. Mean values of HI are low and range from 31 to 57. Wells with VR data indicate that they are in the early stage of oil generation.

GEOPHYSICAL INTERPRETATION

A total of 41 key seismic lines were interpreted and digitized. Due to budget constraints on data copying, only twelve uninterpreted key seismic lines are provided and are located in Enclosures 45 to 56. A minimum of three seismic horizons (base Cainozoic, base Cretaceous and base Jurassic) were picked on each line and correlated across the basin. In some areas of the basin, up to eleven seismic horizons were picked and correlated on a semi-regional basis. The digitized data are displayed as two way time (TWT) horizon plots and compiled as montages. The two montages of TWT horizon plots, displayed at the same scale as the key seismic lines, are provided in Enclosures 57 and 58. Additional seismic lines were used to provide correlation ties to the key seismic lines but are not included in this report. A list of the seismic lines used in the study is provided in Table 3. Orthorhombic diagrams of digitized seismic lines are provided in Enclosures 59 to 61. Synthetic seismograms and velocity curves for most wells are located in Appendix 10 and 11.

Data quality of seismic lines ranged from good to poor. Interpretation was carried on "half-scale" versions of seismic lines with a vertical scale of 1.0secs TWT per 5cm. The emphasis of the interpretation was largely on delineating megasequences correlated to key Time Slices with some detailed seismic facies interpretation on a few lines with good data quality.

PRE-PERMIAN

Seismic data around the Prudhoe Terrace and Yampi Shelf area show a 'chaotic' reflection configuration below the mid Carboniferous event (Time Slice C5). This interval is generally devoid of continuous reflection events for most areas of the eastern margin. However, "packages" of reflection events within this interval are evident on some seismic lines which suggests that older sedimentary sequences are present but may have been subjected to low grade metamorphism during early to mid Carboniferous. Seismic line 74-1405 from the Yampi area shows a distinct set of subparallel high amplitude reflection events which are at

SEISMIC LINES USED IN THE STUDY

LINENAMES	SP RANGES	LINE LENGTH	WELL TIES
69-320	1-415	85	Yampi 1
73-1149	1-376	100	
74-1369	1-228	60	
74-1405	1-226	60	
74-1406	4-173	45	
74-1407	1-154	41	Yampi 1
74-1429	1-274	73	
76-1668	1-198	53	
76-1715	1_57	17	Echuca Shoals 1
76-1725	1-139	37	Bassett 1
79-2184	1-857	21	
79-2189	_68-1058	28	
81-2400	1-1128	28	
81-2425	1-4364	109	Caswell 1 & Brewster 1
81-2428	1-979	24	Brewster 1
82-2524	1-1644	41	
82-2557	1-3833	96	Prudhoe 1
82-2569	1-1347	34	Brewster 1
82-2577	1_1902	48	
84-2819	2-1060	28	Caswell 1
84-2820	2-970	26	Caswell 1
84-2831	1-1786	48	
85LM-02	1-3066	92	Barcoo 1 & Lynher 1
85LM-13	1-3782	113	Lynher 1 & Leveque 1
85LM-16	1-3436	103	Barcoo 1 & Lombardina 1
85LM-20	1-6951	209	Yampi 1
85LM-26	1-6070	182	Caswell 1
85LM-39	1-3043	91	Lombardina 1 & Leveque 1
86.01-20	1-2936	88	
86.01-47	1-1587	48	Delta 1
BR-3A	1-2600	78	Woodbine 1
HBW87-118	101-994	17	Buccaneer 1
HHI-134	101-2357	68	
HHI-145	36-2851	84	
HHI-325	101-1248	34	Gryphaea 1
M200-22	101-1703	43	
M200-35	100-2893	74	
M200-41	101-2604	67	Rob Roy 1
M200-44	1291-2123	22	Prudhoe 1
M200-46	101-2202	56	Rob Roy 1 & Londonderry 1
S82B-45	1938-3757	55	Brecknock 1
	TOTAL KM	2624	

TABLE 3.

4.0secs TWT at SP126 and is steeply faulted basinward to 6.0 secs TWT at SP222. Depths of these reflection events range from 6km at SP126 to 10 km at SP222. These older sedimentary sequences may possibly be part of the Gondwana and/or Larapintine Petroleum Systems (Bradshaw 1993, in prep.).

Rob Roy 1 intersected mid-Carboniferous sediments and terminated in a "quartzite" section. Seismic lines around the Prudhoe Terrace/Yampi Shelf area show reflection events that correlate to the top of the mid Carboniferous (top of Time Slice C5) and the metamorphosed surface (base of Time Slice C5). These seismic events show parallel configuration indicating relatively uniform thickness and are evident on seismic lines M200-21, M200-41, M200-44 and M200-46. Time Slice C5 reflection events are picked at about 1.5 secs TWT at Rob Roy 1 and about 3.8 secs TWT at Prudhoe 1. The Time Slice C5 section is significantly faulted west of the hinge zone and difficult to resolve on seismic data.

PERMIAN

A relatively thick section of Permian sediments conformably overlie the mid Carboniferous sequence on the Prudhoe Terrace and Yampi Shelf areas. Divergent reflection events representing the Permian sequences are evident on seismic lines M200-22 and M200-44. The direction of divergence is generally east to west and suggests that the Permian sediments were deposited in a basin sag located west of the Prudhoe terrace. Seismic data show no evidence of syndepositiional (growth) faults which suggests that deposition and subsidence is relatively slow and in equilibrium.

Late Permian structuring and erosion is evident on some seismic lines on the Prudhoe Terrace. However, the presence of Time Slice P7 in Echuca Shoals 1 suggests that uplift and erosion may have been relatively minor in the inner basin area. As yet, no wells have intersected the Palaeozoic sequences in the central basin area and hence the extent of the late Permian tectonism and erosion is unknown in this region of the basin.

Reactivation of the older Palaeozoic faults and the main development of the Permian fault blocks may have occurred during this period, as seen on seismic lines 76-1715 and 82-2557. These fault block complexes extend from the eastern margin on the Yampi Shelf area to a major northeast to southwest trending hinge zone.

TRIASSIC

The Triassic section is conformable to the Permian sequence in the central basin area where it is estimated to be about 2.0 to 2.5 km thick. The Triassic section is generally absent on the eastern area of the Yampi Shelf and an erosional edge is evident on seismic lines 74-1406 and 74-1407. In some areas, the Triassic section is truncated against major basin bounding faults and is absent on the Prudhoe Terrace, as evident on seismic lines HBW87-118 and 74-1369.

Three main episodes of regional erosion which occurred during the Triassic are identifiable on well and seismic data. These episodes occurred during Time Slices Tr1 (Scythian), Tr4 to Tr5 (Carnian to Ladinian) and late Tr6 (Rhaetian).

A minor erosional phase with some volcanic activity, mainly confined around the inner basin and the hinge zone, occurred during Time Slice Tr1 (Scythian). Seismic lines 82-2577 and 76-1715 around the Echuca Shoals area show a subparallel unconformity event with very minor angularity at about 2.8 secs TWT. This unconformity event correlates to time equivalent altered volcanic tuffs intersected in Echuca Shoals 1.

A more extensive period of structuring and erosion occurred during Time Slices Tr4 to Tr5 (Carnian to Ladinian) and resulted in an unconformity between the early to mid Triassic and the late Triassic sediments. The Carnian Unconformity is easily identifiable on seismic around the Barcoo to Lombardina area (approx. 3.85 secs TWT at SP1300 on seismic line 85LM-16) but is less defined towards the northern portions of the basin. Seismic line 85LM-02 in the southern portion of the basin shows evidence of partly listric growth faults and half grabens which suggests rifting during the Early-Mid Triassic. The Carnian unconformity event is interpreted to be related to the end of the rift phase. It is possible that some early to mid Triassic sections were removed on the Prudhoe Terrace and the Yampi Shelf during this period.

The most significant period of uplift, faulting and erosion occurred towards the end of the Triassic (Time Slice Tr6) and resulted in a major unconformity along the eastern margin. Key structural features that are also part of the present day basin configuration resulted from this late Triassic tectonism. During this period, the main development of the normal fault blocks occurred on the Prudhoe Terrace, horst/graben features developed (such as Echuca Shoals) and erosion of tilted Permo-Triassic fault blocks (such as Scott Reef, Caswell and Bassett). Vertical relief of these structures was further enhanced during later tectonic phases.

It is estimated that up to 2.5 km of Permian section and up to 1.5 km of Triassic section were removed via erosion during this period (see seismic lines M200-22 and M200-44 on Prudhoe Terrace and Yampi Shelf). However, the degree of uplift and erosion appears to be much less towards the central basin area. This is supported by the presence of Time Slice Tr1 and Tr2 sediments in Echuca Shoals 1 and Time Slice Tr6 sediments in other parts of the basin.

Permian fault blocks on the Prudhoe Terrace were reactivated during this period and resulted in additional displacement on these faults. Fault throws on the Prudhoe Terrace range up to 50ms TWT but around the hinge zone some fault throws exceed 500ms TWT. Based on seismic evidence, the Permo-Triassic faults terminate near the base of Time Slice J1 in the central basin area. Most of these faults are of much lower angle than those on the eastern margin and some were further reactivated at later episodes of structuring such as the Caswell structure.

JURASSIC

Seismic lines 74-1369, 81-2425 and 84-2820 show a trough containing a thick Jurassic sequence in the central basin area (near Caswell) . The trough extends to the southwest into the Rowley Sub Basin and to the northeast to a smaller but relatively deep trough between Bassett 1 and Heywood 1. The Jurassic section is approximately 750m to 900m thick in the deeper part of the basin and unconformably overlies the Triassic sequence.

Seismic lines 74-1406, 74-1407 and 74-1369 show the Jurassic section regionally thin towards the basin margins and is truncated in the eastern area of the Yampi Shelf. Seismic data also shows significant erosional truncation of the upper part of the Jurassic section around the Scott Reef Trend.

Parallel reflection is the dominant seismic character for the Jurassic interval. The reflection events are more continuous than the underlying Triassic sequence and display a layer cake geometry. Initial deposition of Jurassic sediments is interpreted to have occurred in the central basin area, which gradually filled the depositional lows and extended over intrabasinal and outer basin highs. Pinchout edges and "basal onlap" configuration are evident on seismic lines 74-1369 and 82-2577.

Two main Jurassic unconformities, the Callovian and Tithonian, are identifiable from seismic and well data on the eastern and western margins of the basin. The Callovian Unconformity (Time Slice J7) is well defined on seismic lines 81-2428 (Brewster 1) and HBW87-118 (Buccaneer 1) which also show minor angularity between the early to mid Jurassic and late Jurassic sequences. Seismic data show incomplete sections of early to mid Jurassic sediments on the flanks of some inner basin fault blocks but the early to mid Jurassic sediments are absent on these structures and on the Prudhoe Terrace. The Tithonian Unconformity is less defined than the Callovian on seismic and the interpretation of its areal extent relies mainly on well information.

Seismic definition of both unconformities is relatively poor in areas that have been subjected to high levels of volcanic activity, particularly in the western margin, and are less definitive in the deeper parts of the basin where little or no erosion has taken place.

CRETACEOUS

Reflection patterns of the Cretaceous sequence range from parallel to sigmoid progradational configuration. These patterns correspond to the various megasequences of the Cretaceous, ranging from highstand sequences of Time Slices K2/K4 and K6/K8 to the regressive sequences of Time Slices K1, K5 and K10/K11.

Internal reflection patterns within Time Slices range from "bland" reflection free seismic packages (which usually corresponds to massive claystone sequences) to cycles of relatively continuous high amplitude reflection events (corresponds to clastic sequences).

Seismic line 85LM-16 shows well defined sigmoid prograde configuration from Time Slices K1 to K4, and suggests a relatively slow depositional rate and basin subsidence during this period.

The Aptian/Albian Unconformity correlates to the base of Time Slice K5 and is evident on seismic line 84-2831. Seismic data show truncation of the underlying Time Slices from K4 to the upper part of K2. This unconformity is most likely to be related to local uplift and erosion in the northeastern area of the basin. Minor reactivation of pre-existing Permo-Triassic faults occurred during this period and resulted in further displacement of Permo-Triassic and Jurassic sequences as well as the early to mid Cretaceous sequence (Time Slices K1 to K4). Fault bounded structural closures within Time Slices K1 to K5 were developed during this period.

A distinct reflection event correlated to the base of Time Slice K9 is referred to as the Turonian Event. In the northeast area, the event is interpreted to be an unconformity resulting from erosion associated with semi-regional uplift, as evident on Seismic Line M200-44. In the southwest area, the event correlates to the base of channel cuts which is interpreted to be caused by strong oceanic currents, as seen on Seismic Line 85LM-16. However, in the central region of the basin, the Turonian event is relatively conformable to the underlying sequence with little evidence of erosional truncation on seismic. Small scale hummocky clinoforms can be identified near the Turonian event with a series of detached faults associated with these clinoforms. Some of these faults extend from the overlying K9 to K11 Time Slices and "sole out" in the K8 Time Slice. These faults are interpreted to be accommodation faults associated with slumping within the massive claystone sequence of Time Slice K8.

Low angle reflection events downlapping onto the Turonian event are evident on some seismic lines in the central and Inner Basin area but their definition is masked by the interference of complex scour and fill reflection patterns in Time Slices K10 and K11. These downlapping events may represent a brief transgressive cycle during Time Slice K9. Scour and fill reflection patterns indicate a higher energy depositional environment during Time Slices K10 and K11 and mark a major regressive phase during the Late Cretaceous. Low relief mounding within Time Slices K10 and K11 is also evident on seismic which is interpreted to be part of a prograding complex formed during this period.

A major unconformity between the Cretaceous and Cainozoic sequences is evident on most lines in the Browse Basin. In the northern area, the Tertiary Time Slices show parallel reflection configuration corresponding to sheet-like sandstone and carbonate sequences. Seismic data also show oblique progradational reflection patterns which correlates to the various cycles of prograding Tertiary sequences downlapping towards the western basin margin.

GEOCHEMISTRY ANALYSES

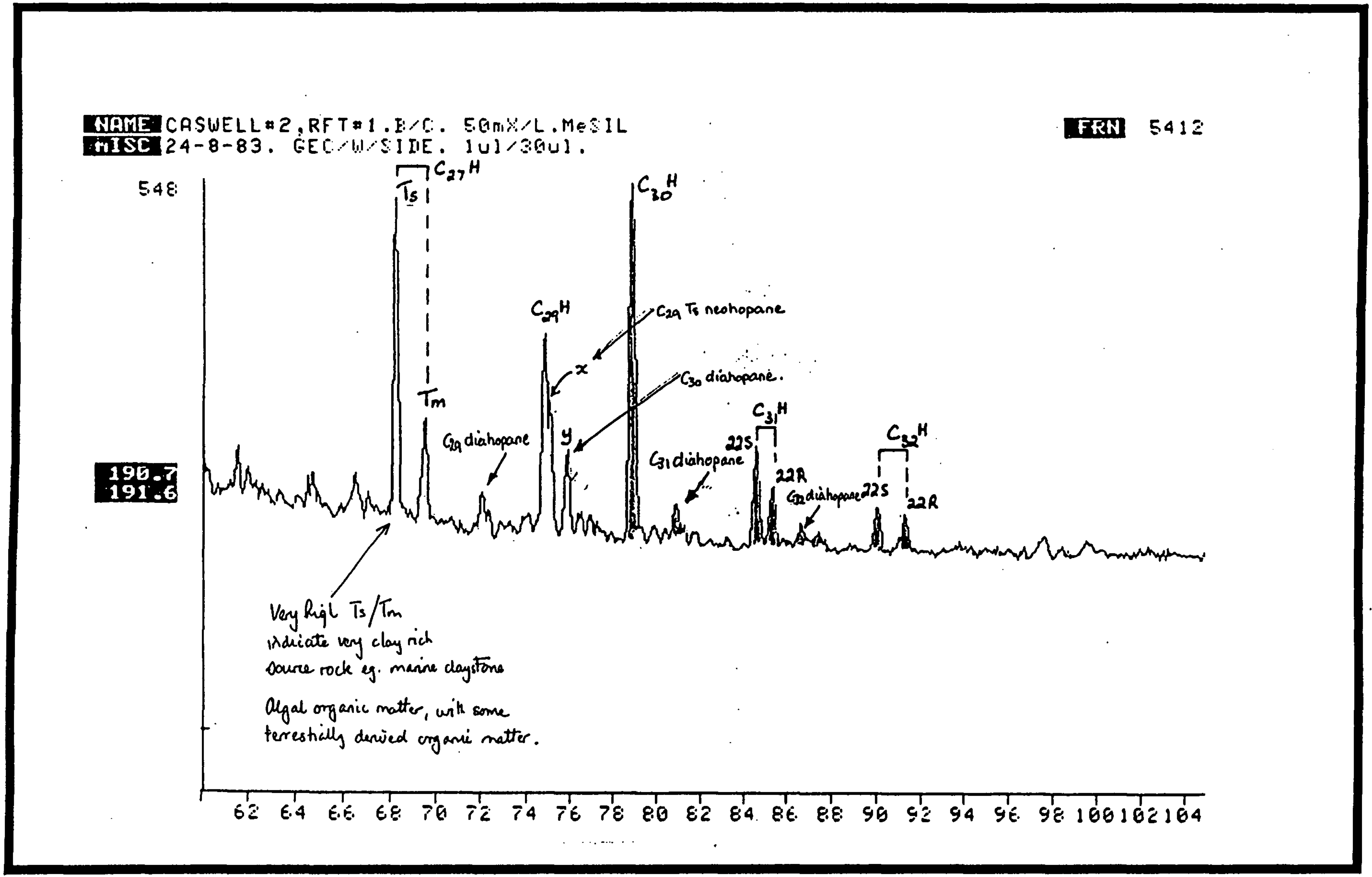
GC/MS profiles on oil recovered from an RFT in Caswell 2 and an oil extract from a sediment sample in Kalyptea 1 are shown in Figures 25 to 27. Tabulations of vitrinite reflectance values, total organic content values and hydrogen indices are provided in Tables 4 to 10. These values were extracted from ORGCHEM database and grouped in Time Slices and "stratigraphic packages".

Oil in Caswell 2 was recovered from an RFT in Time Slice K10 while the oil extract in Kalyptea 1 was recovered from cuttings in Time Slice K2. Both GC/MS profiles show C27 steranes to be more abundant than the C29 steranes, which suggests that source type is dominantly algal-rich organic matter. The relatively high Ts/Tm ratios indicate a relatively mature source. Other GC/MS profiles (not included in the report) show some indication of source type to be dominantly rich in clay material, based on the relatively high abundance of diasteranes to normal steranes. Both samples show relative high abundance of C29 Ts neohopane and C30 diahopane indicating that both oil samples were generated from the same source rock type and show similar characteristics to most of the other oil types found in the North West Shelf.

Geochemical data from ORGCHEM database (Tables 4 to 10) indicate several intervals within the Permian to Cretaceous sequences with reasonable source potential (based on TOC values greater than 1%). Source rocks with vitrinite reflectance values greater than 0.6% and hydrogen indices greater than 150 are considered to be within the oil generative window. Based on this criteria, ORGCHEM data indicate that only some sections of the Jurassic and the Cretaceous can be considered as moderate source rocks for oil and gas. However, careful consideration must be taken when using vitirinite reflectance values as a thermal maturity indicator. Some of the wells recorded vitrinite reflectance values greater than 1.2%. These values may be inaccurate due to alteration effects caused by the presence of volcanics or the relatively high abundance of inertinite to vitrinite.

The Permian sequence is considered to be mature to over mature based on the very low HI values and the overall high Ro values. The Triassic section is also considered to be mature but the corresponding Ro values are not as high as the Permian interval. Oxygen indices from ORGCHEM database (not included in tabulations) are considerably high compared to the HI values which suggests that the source rocks within the Triassic section may be gas prone. However, the increase in oxygen indices may be due the presence of carbonates and therefore caution must be taken when using oxygen indices as either a maturity and/or source type indicator The Jurassic section is considered to be mature (peak oil generation) based on Ro values averaging between 0.7% and 0.9%. Time Slice J8 is considered to be the main source rock interval based on the relatively high TOC values (1.5% to 6.76%). The Early Cretaceous section is considered to be marginally mature to mature based on Ro values averaging between 0.5% to 0.7%. The rest of the Cretaceous section is considered to be immature. The general belief on the timing of hydrocarbon generation and expulsion for the Jurassic and early Cretaceous section is around the late Cretaceous to early Tertiary (Willis, 1988).

Most of the wells were drilled on structural highs where the sedimentary sections are generally thinner. Thicker and more source-rich facies may be present in the deeper parts of the basin and therefore these ORGCHEM values may not be representative of the hydrocarbon potential of the Browse Basin. Details from a recent publication (Willis, 1988) were used as a general guideline on burial history and thermal maturation modelling of the Browse Basin. However, the study has identified additional structural events which may impinged on the interpretation of the timing of hydrocarbon generation and therefore it is recommended that a revised burial history and maturation modelling study be carried out for key areas of the basin.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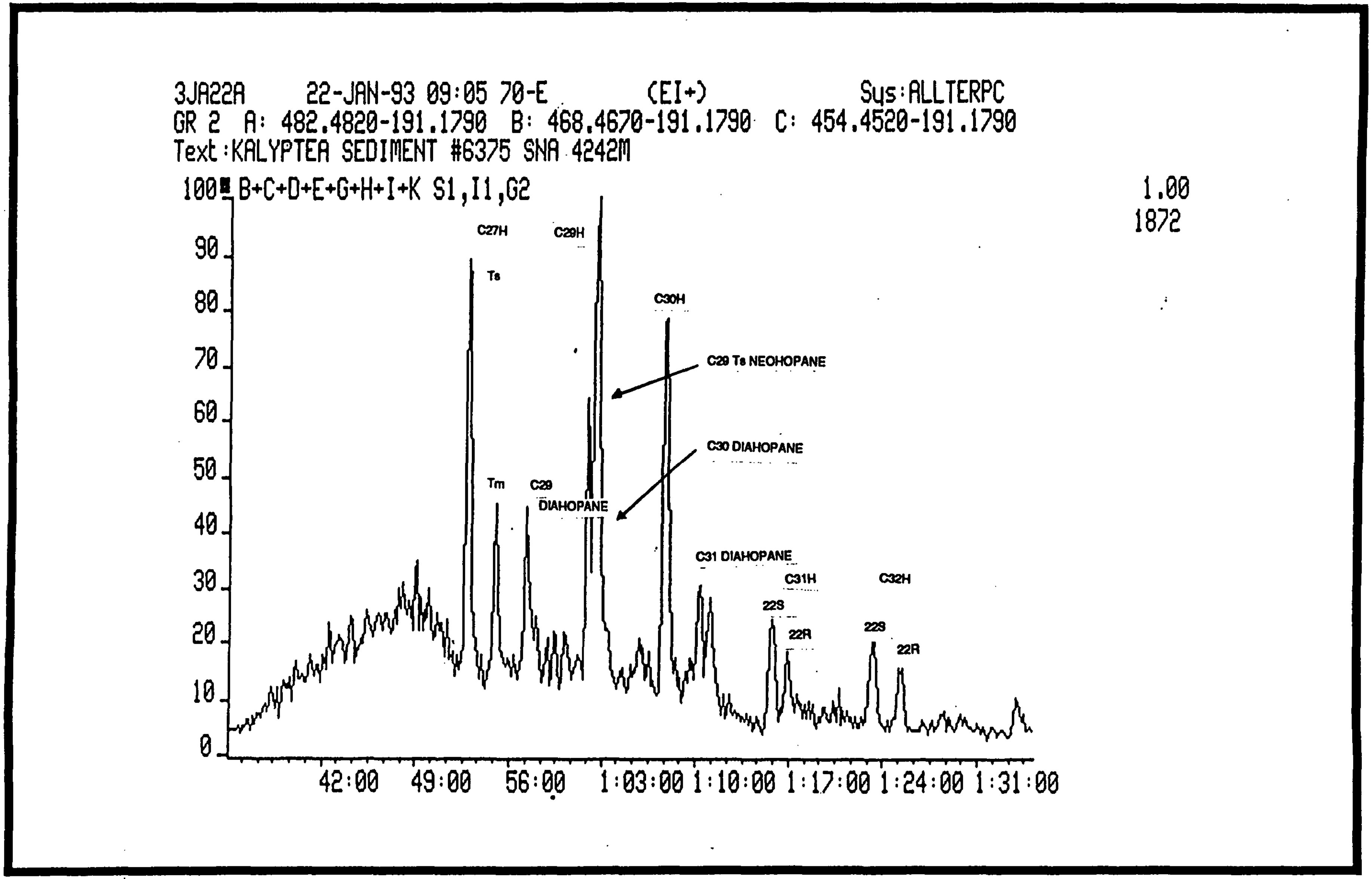
MISC 24-8-83. GEO/W/SIDE. 1ul/30ul.
FRN 5412
548
190.7
191.6
Ts
Tm
C27H
C29H
C30H
C29 Ts neohopane
x
C30 diahopane.
C29 diahopane
y
C31 diahopane
C31H
22S
22R
C32 diahopane
C32H
22S
22R
Very high Ts/Tm
indicate very clay rich
source rock eg. marine claystone
Algal organic matter, with some
terrestially derived organic matter.
62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104

Figure 25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Text:KALYPTEA SEDIMENT #6375 SNA 4242M
100 B+C+D+E+G+H+I+K S1,I1,G2
1.00
1872
C27H
Ts
C29H
C30H
C29 Ts NEOHOPANE
C30 DIAHOPANE
Tm
C29
DIAHOPANE
C31 DIAHOPANE
C31H
C32H
22S
22R
22S
22R
90
80
70
60
50
40
30
20
10
0
42:00
49:00
56:00
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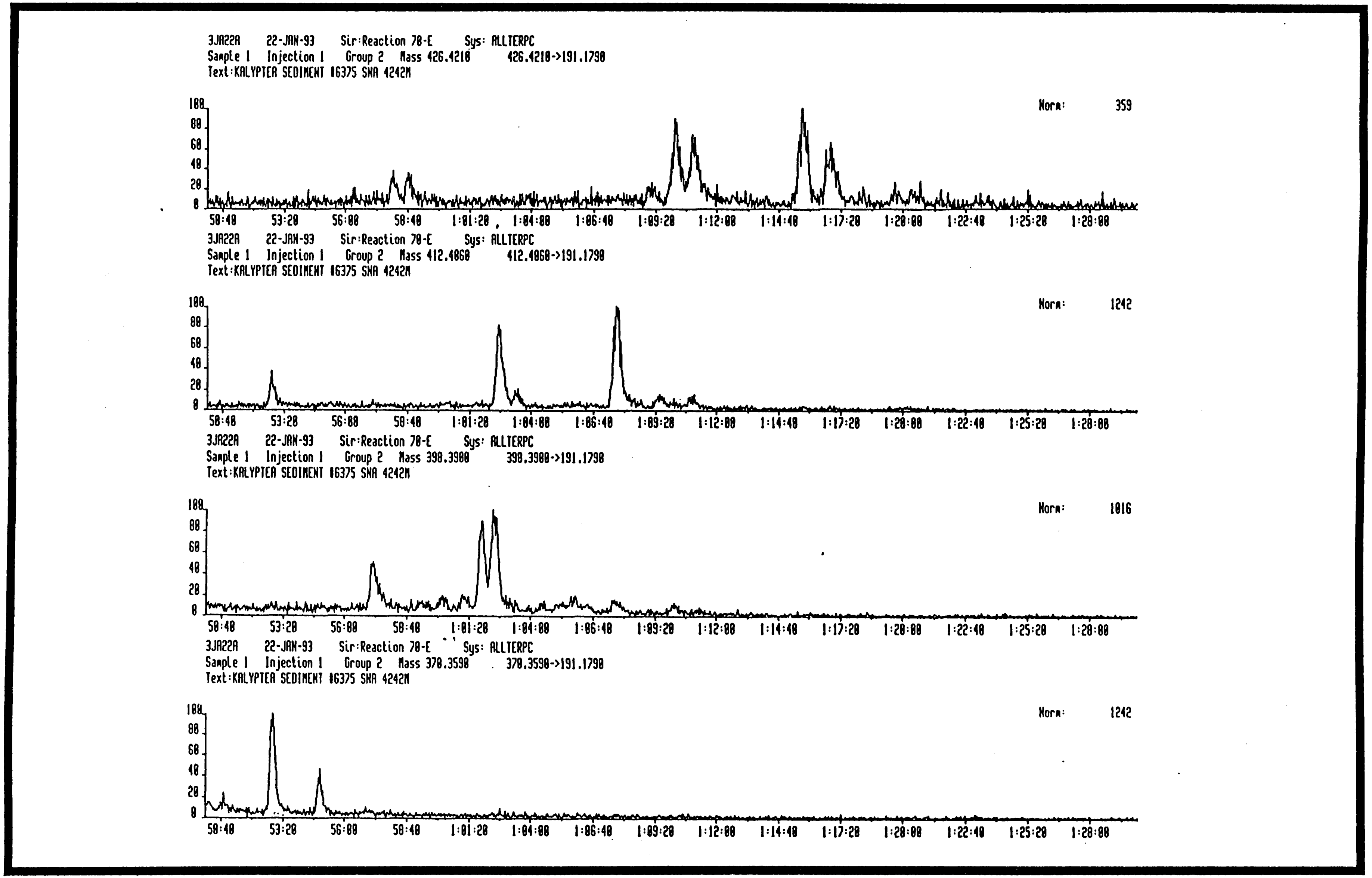
1:10:00
1:17:00
1:24:00
1:31:00

Figure 26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Sample 1 Injection 1 Group 2 Mass 426.4210 426.4210->191.1790
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Norm: 359
3JA22A 22-JAN-93 Sir:Reaction 70-E Sys: ALLTERPC
Sample 1 Injection 1 Group 2 Mass 412.4060 412.4060->191.1790
Text:KALYPTER SEDIMENT #6375 SNA 4242M
Norm: 1242
3JA22A 22-JAN-93 Sir:Reaction 70-E Sys: ALLTERPC
Sample 1 Injection 1 Group 2 Mass 398.3900 398.3900->191.1790
Text:KALYPTER SEDIMENT #6375 SNA 4242M
Norm: 1016
3JA22A 22-JAN-93 Sir:Reaction 70-E Sys: ALLTERPC
Sample 1 Injection 1 Group 2 Mass 370.3590 370.3590->191.1790
Text:KALYPTER SEDIMENT #6375 SNA 4242M
Norm: 1242
100
80
60
40
20
0
50:40 53:20 56:00 58:40 1:01:20 1:04:00 1:06:40 1:09:20 1:12:00 1:14:40 1:17:20 1:20:00 1:22:40 1:25:20 1:28:00

Figure 27

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVER	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVE	HI (NO. SAMPES)
BUCCANEER	TR3	0.22	0.41	0.32	0.65	0.85	0.75	7	59		59	1
BUCCANEER	TR2	0.44		0.44	0.66	0.79	0.72	6	84		84	1
DISCORBIS	TR1-3	0.36	0.72	0.53	0.52	0.69	0.6	22				
ECHUCA SHOALS 1	TR2	0.24	0.71	0.34								
ECHUCA SHOALS 1	TR1	0.24	0.99	0.46								
GRYPHAEA	TR2	0.26	1.06	0.53	0.46	0.9	0.66	8	21	75	45	6
LYNHER	TR/P?	0.82	2.8	1.72			0.61	20	55	86	75	5
YAMPI	Tr4	0.14	0.27	0.18	0.67	1.1	1.05	16				
YAMPI	Tr3	0.04	0.2	0.12								
YAMPI	Tr2?	0.02	2.2	0.89	1.76	2.1	1.96	49	27	73	43	7
ECHUCA SHOALS 1	P7	0.36	0.64	0.52								
LYNHER	TR/P?	0.82	2.8	1.72			0.61	20	55	86	75	5
ROB ROY	P1	0.85	3.74	1.56	0.38	1.75	0.86	91	274	291	283	2
ROB ROY	Pre Perm	0.02	1.43	0.53	0.55	1.7	1.58	68				

Table 4 - ORGCHEM Data vs Stratigraphic Packages of Time Slices Pre Permian to Tr4

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVE	VR MIN	VR MAX	VR AVE	VR # SAMPLES	HI MIN	HI MAX	HI AVER	HI # SAMPLES
BARCOO	J2						0.57	3				
BREWSTER	J7-J2	1.46	2.44	1.95	1.99	2.1	2.05	7	24	53	39	2
BUFFON	J2	0.25	0.39	0.32	1.44	1.65	1.55	4				
LOMBARDINA	J2	0.77	1.64	121			0.78	9				
LYNHER	J2	0.49	3.02	1.79			0.53	37	31	129	85	12
BARCOO	J1	0.02	0.66	0.32								
BUFFON	J1	0.61		0.61								
LOMBARDINA	J1	0.22	1.81	1.11			1.2	6	72	138	105	2
LYNHER	J1	0.77	2.32	1.61			0.58	24	64	171	98	8
NORTH SCOTT REEF	J1	0.21	3.02	1.44					19	69	37	4
SCOTT REEF 1	J1	0.3	1.25	0.73	0.71	1.29	0.91	13	69		69	1
WOODBINE	J1	0.34		0.34								
ASHMORE REEF	TR6	0.16	2.26	1.21					16	73	36	8
BARCOO	TR6	0.04	0.1	0.12			0.72	15				
NORTH SCOTT REEF	TR6	0.17	3.88	0.8					12	91	41	14
SCOTT REEF 1	Tr6	0.35	1.46	0.59	0.85	1.49	1.24	9	63		63	1
ASHMORE REEF	TR5	0.23	1.14	0.46					7	50	26	6
BARCOO	TR5						0.69	3				

Table 5 - ORGCHEM Data vs Stratigraphic Packages of Time Slices Tr5 to J2

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVER	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVER	HI (NO. SAMPES)
BREWSTER	J7-J2	1.46	2.44	1.95	1.99	2.1	2.05	7	24	53	39	2
BUFFON	J9-J7				1.15	1.16	1.15	6				
LYNHER	J7	2.85	6.72	4.86			0.44		74	163	104	3
LYNHER	J6	1.61	3.36	2.49					103	140	122	2
SCOTT REEF 1	J6	0.41	1.35	0.94	0.59	0.93	0.68	6	32	74	50	8
BARCOO	J5	1.15		1.15					44		44	1
LYNHER	J5	1.29	5.13	2.95			0.47		73	409	267	4
YAMPI	J5-6+	0.3	3.64	1.59	0.61	0.94	0.9	14	135	135	135	2
BARCOO	J4						0.51	7				
BUFFON	J3-J4	0.95	1.98	1.47			1.43	18	29		29	1
LYNHER	J4	2.52	7.61	5.23			0.49	32	93		93	1
BARCOO	J3											
BUFFON	J3-J4	0.95	1.98	1.47			1.43	18	29		29	1

Table 6 - ORGCHEM Data vs Stratigraphic Packages of Time Slices J3 to J7

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVE	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVER	HI (NO. SAMPES)
ASTERIAS	K1	0.24	1.37	0.5			0.6	8	198	345	250	3
BARCOO	K1	0.85		0.85								
BREWSTER	K1			0.38			1.37	8				
BUCCANEER	K1	0.4	0.42	0.41	0.46	0.66	0.58	12	140	195	168	2
CASWELL 2	K1	0.45	2.29	1.17					4	35	15	14
DISCORBIS	K1	0.56	2.1	1.02	0.44	0.6	0.53	19	139	350	239	15
ECHUCA SHOALS 1	K1	0.68	0.79	0.74								
LEVEQUE	K1	0.68	2.4	1.54	0.36	0.53	0.37	13				
LOMBARDINA	K1	1.87	2.42	2.22			1.22	20	108	136	122	2
LYNHER	K1	1.48	2.57	2.16			0.41	10	62	92	74	4
PRUDHOE	K1	0.03	0.43	0.25			0.81	8				
SCOTT REEF 1	K1	0.82	0.85	0.84			0.72	2	60		60	1
YAMPI	K1	0.64	2.42	1.92	0.47	0.54	0.53	20	100	100	100	2
ASTERIAS	J10	0.31	0.92	0.59			0.72	27	101	216	170	3
BREWSTER	J10			0.5			1.65	13				
BUCCANEER	J10											
CASWELL 2	J10-J8	0.27	2.81	1.47					19	56	37	2
ECHUCA SHOALS 1	J10	0.83	0.87	0.86								
LEVEQUE	J10	0.67	1.73	1.2			0.63	1				
LOMBARDINA	J10	1.43	2	1.71			1.28	47	143		143	1
YAMPI	J10	0.32	1.83	1.34	0.5	0.55	0.55	15	77	79	78	2
BUFFON	J9-J7				1.15	1.16	1.15	6				
YAMPI	J9						0.6					
BREWSTER	J8	0.85	1.51	1.19	1.72	1.74	1.73	23	38	188	91	3
BUCCANEER	J8	0.24	3.51	1.875					269		269	1
CASWELL 2	J10-J8	0.27	2.81	1.47					19	56	37	2
DISCORBIS	J8	0.86	1.4	1.09	0.44	0.67	0.58	26	103	192	145	5
HEYWOOD 1	J8						0.66	1				
LYNHER	J8	1.98	5.43	3.7			0.45	13	128		128	1
ROB ROY	J8-J1	1.9	6.76	3.77	0.35	0.45	0.38	25	167	296	237	3
YAMPI	J8	0.64	3.4	1.72	0.54	0.75	0.71	23	101	198	150	4

Table 7 - ORGCHEM Data vs Stratigraphic Packages of Time Slices J8 to K1

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVE	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVER	HI (NO. SAMPES)
ASTERIAS	K4	0.41	0.94	0.64			0.61	3	102			1
BREWSTER	K4	0.54	0.83	0.69			0.89	9				
BUCCANEER	K4	1.07		1.07	0.43	0.65	0.54	12	78		78	1
CASWELL 1	K4	0.56	2.28	1.27			0.99	2	57	131	99	3
CASWELL 2	K4	0.87	1.75	1.31					48		48	1
ECHUCA SHOALS 1	K4	0.71	1.1	0.87								
LEVEQUE	K4	0.83	2.18	1.4	0.43	0.6	0.56	4	28		28	1
LOMBARDINA	K4	0.72	2.32	1.65			0.55	7	105	237	148	4
LYNHER	K4						0.59	10				
SCOTT REEF 1	K4						0.49	6				
WOODBINE	K4	0.86		0.86								
YAMPI	K4	0.61	1.52	1.18	0.48	0.52	0.48	24	65	66	66	3
BREWSTER	K3			1.51			1.17	3	152		152	
CASWELL 1	K3	1.55	2.57	2.03			1.03	2	89	112	100	2
CASWELL 2	K3	1.06	2.14	1.55					15	36	25	7
DISCORBIS	K3	0.33	1.15	0.63								
ECHUCA SHOALS 1	K3	0.56	1.16	0.84								
GRYPHAEA	K3	0.4	0.92	0.71	0.45	0.68	0.55	25	83	109	96	2
LEVEQUE	K3	1.16		1.16	0.35	0.83	0.4	12				
LOMBARDINA	K3	2.4		2.4					118		118	1
PRUDHOE	K3	0.04		0.04			0.76	2				
ROB ROY	K3	1.43		1.43					50		50	1
SCOTT REEF 1	K3	0.97	1.34	1.17	0.72	1.02	0.9	3	6		6	1
YAMPI	K3	1.51	2.23	1.88	0.46	0.51	0.48	4	75	78	77	2
ASHMORE REEF	K2	0.71		0.71					44		44	1
ASTERIAS	K2	0.72	1.9	1.08			0.63	6	102	160	140	3
BREWSTER	K2	1.92	2.37	2.15	1.17	1.19	1.18	17	26	86	56	2
BUCCANEER	K2	0.28	0.68	0.48	0.38	0.4	0.39	3	44		44	1
CASWELL 1	K2	1.61	2.59	2.1					76	105	90	2
CASWELL 2	K2	0.93	7.93	2.03					8	60	32	10
DISCORBIS	K2	0.6	2	1.5	0.46	0.61	0.53	27	64	237	129	9
ECHUCA SHOALS 1	K2	1.13	2.3	1.51								
GRYPHAEA	K2	0.45	1.65	1.16					122	150	136	4
LEVEQUE	K2	1.16	2.29	1.66					16	17	17	2
LOMBARDINA	K2	1.87	2.85	2.55			1.12	27	90	207	149	6
LYNHER	K2	0.45	1.39	0.95			0.39	11	7	11	9	2
PRUDHOE	K2	0.71	1.24	0.9	0.71	0.73	0.72	36				
ROB ROY	K2	1.59		1.59			0.37	12	33		33	1
SCOTT REEF 1	K2	0.96	1.37	1.1			0.65	3	37	73	55	2
YAMPI	K2	1.01	2.96	2.06	0.45	0.54	0.53	2	81	83	82	4

Table 8 - ORGCHEM Data vs Stratigraphic Packages of Time Slices K2 to K4

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVER	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVER	HI (NO. SAMPES)
ASTERIAS	K6	0.35	0.65	0.53								
BREWSTER	K6			0.94			0.82	1				
BUCCANEER	K6	0.99	1.07	1.03	0.31	0.55	0.45	22	45	64	55	2
BUFFON	K6	0.71	1.71	1.07			0.85	12	47		47	1
CASWELL 1	K6	0.5	1.37	0.82					156		156	1
CASWELL 2	K6	0.82	1.2	1.04								
ECHUCA SHOALS 1	K6	0.98	1.73	1.35								
LOMBARDINA	K6	0.6		0.6			0.47	6				
PRUDHOE	K6	0.75	0.79	0.77	0.68	0.69	0.68	15				
SCOTT REEF 1	K6	0.87	0.95	0.91			1.13					
YAMPI	K6	1.34	1.74	1.48	0.45	0.46	0.46	28				
BARCOO	K5	1.42	4.74	2.85			0.49	15	132	312	222	2
BREWSTER	K5	0.75	1.14	0.95	0.89	0.92	0.91	14	171		171	1
BUFFON	K5						1.02					
CASWELL 1	K5	0.79	1.55	1.17			0.99	3	260		260	1
CASWELL 2	K5	0.78	0.94	0.87								
ECHUCA SHOALS 1	K5	0.86	1.26	1.01								
LOMBARDINA	K5	0.87		0.87								
ROB ROY	K5	0.94		0.94								
SCOTT REEF 1	K5	0.75	1.44	1.09	0.39	1.06	0.8	6	35	134	68	5
YAMPI	K5	1.28	4.4	2.28			0.43		40	40	40	2

Table 9 - ORGCHEM Data vs Stratigraphic Packages of Time Slices K5 to K6

WELL	TIME SLICE	TOC MIN	TOC MAX	TOC AVE	VR MIN	VR MAX	VR AVE	VR (NO. SAMPLES)	HI MIN	HI MAX	HI AVER	HI (NO. SAMPES)
BASSETT	K11	0.17	0.15	0.33					41	70	57	3
BUCCANEER	K11	0.65		0.65	0.34	0.48	0.4	8	31		31	1
DELTA 1	K11	0.42		0.42								
PRUDHOE	K11						0.46	1				
BASSETT	K10	0.44	1.42	0.89	0.23	0.58	0.35	91	81	143	113	2
DELTA 1	K10	0.24	0.96	0.51	0.4	0.64	0.5	53	85	101	93	2
GRYPHAEA	K10	0.15	0.25	0.2								
PRUDHOE	K10	0.06	0.21	0.17			0.53	17				
SCOTT REEF 1	K10	0.27	0.41	0.34								
BASSETT	K9	0.27	0.4	0.33	0.35	0.39	0.39	5	60	129	84	9
GRYPHAEA	K9	0.11		0.11								
LOMBARDINA	K9	0.8	1.16	0.98			0.55	2	159		159	1
PRUDHOE	K9	0.02		0.02			0.55	3				
YAMPI	K9	0.28	0.32	0.3			0.41					
ASTERIAS	K8	0.38	1.08	0.78			0.58	2	63	124	90	8
BREWSTER	K8			0.99			0.8	1				
BUCCANEER	K8	0.91	1.21	1.06	0.31	0.49	0.39	27	66	68	67	2
BUFFON	K8	0.94		0.94								
CASWELL 1	K8	0.4	0.89	0.58	0.67	0.82	0.66	46				
CASWELL 2	K8	0.25	0.8	0.53					2	8	4	5
GRYPHAEA	K8	0.36	0.83	0.65	0.4	0.66	0.57	30	83	109	96	6
LOMBARDINA	K8	0.66		0.66								
PRUDHOE	K8	0.67	1.25	0.87			0.59	15				
ROB ROY	K8	0.44	1.11	0.9	0.31	0.34	0.33	72	21	50	36	
WOODBINE	K8	0.54	0.67	0.61								
YAMPI	K8	0.56	1.47	0.94								
ASTERIAS	K7	0.5	1.24	0.75			0.63		45	119	86	4
BASSETT	K7			0.78			0.46		136		136	1
BUCCANEER	K7	1.17	1.17	1.17	0.35	0.52	0.43	42	104	104	104	2
BUFFON	K7	1.58		1.58			0.86	4	72		72	1
CASWELL 2	K7	0.62	0.94	0.83								
ECHUCA SHOALS 1	K7	0.9	1.51	1.22								
GRYPHAEA	K7				0.52	0.66	0.6	5				
LOMBARDINA	K7	0.6	1.09	0.81			0.64	3	217		217	1
PRUDHOE	K7	1.04	1.27	1.16	0.62	0.67	0.64	18				
ROB ROY	K7	0.86		0.86			0.38	20				
SCOTT REEF 1	K7	0.3	0.46	0.38	1.29	1.55	1.54	41				
WOODBINE	K7	0.55	0.61	0.58								
YAMPI	K7	1.96		1.96			0.45					

Table 10 - ORGCHEM Data vs Stratigraphic Packages of Time Slices K7 to K11

PETROLEUM SYSTEMS AND PLAY ANALYSIS

The following section is a brief summary of the Petroleum Systems and Play Analysis of the Browse Basin. A more detailed review of this work together with a synthesis of the Petroleum Systems (Bradshaw 1993, in prep.) identified in both the Browse Basin and the Dampier Sub-Basin is being compiled.

The Browse Basin is thought to be a post Alice Springs Orogeny depocentre and is associated with two "Super" Petroleum Systems, the Gondwanan and the Westralian, separated by a major regional unconformity in the late Triassic (Time Slice Tr4).

The Gondwanan System, in the Browse Basin, ranges from the Namurian to the late Triassic and has potential for plays similar to the successful discoveries in the Petrel Sub-Basin and in the onshore Perth Basin. Three potential reservoir intervals occur, the Permian deltaic sands and the early Triassic (Time Slices Tr1 to Tr4) oolitic limestones and glauconitic sandstones. The early Triassic mudstone dominated sequences provide both a seal and potential source interval while the Permian interdistributary bay facies provide an additional source interval for hydrocarbon generation.

A schematic diagram displaying the relationships of these components in a Petroleum System framework, together with the timing of trap formation and source maturation is shown in Figure 34.

To date, all the successful plays in the Browse Basin are part of the Westralian System. Giant gas and condensate discoveries of Upper Triassic to Lower Jurassic age (Time Slices Tr5 to J1) occur in nearshore to deltaic sands at Scott Reef 1, North Scott Reef 1 and Keeling 1. Other reservoirs and significant shows occur in; nearshore deltaics from Time Slice J3 to J6 with a gas / condensate zone at Scott Reef 1 and Brecknock 1, fan delta sands in Time Slice J8 with oil shows at Buccaneer 1 and Yampi 1, nearshore deltaics in Time Slice J10 to K1 with oil shows in Asterias 1 and Buccaneer 1 and a gas condensate show in Kalyptea 1, mass flow deposits in Time Slices K4 to K6 associated with oil shows at Caswell, and mass flow sands in Time Slices K10 to Cz2 with an oil show in Caswell 1. Figures 28 to 33 are schematic diagrams showing structural profiles over some of the well locations. References to the various play types tested and the potential leads are outlined on these diagrams. Detailed seismic and geologic interpretation is required to upgrade some of the leads to a drillable prospect.

The thick sequences of Middle to Late Jurassic marine oil prone source rock seen in the Barrow-Dampier, Vulcan and Papuan basins, which are characteristic of the Westralian System, are less developed in the Browse Basin. However the occurrence of significant hydrocarbon shows indicates that other valid source intervals are present.

The sands from the Westralian System are sealed, often intraformationally, and potentially sourced by two major pods of finer grained facies between Time Slices J2 to J9 (deltaic to marine) and Time Slices K2 to K8 (marine).

The relationship of these components together with the timing of potential trap formation and source maturation is displayed in a Petroleum System framework in Figure 35.

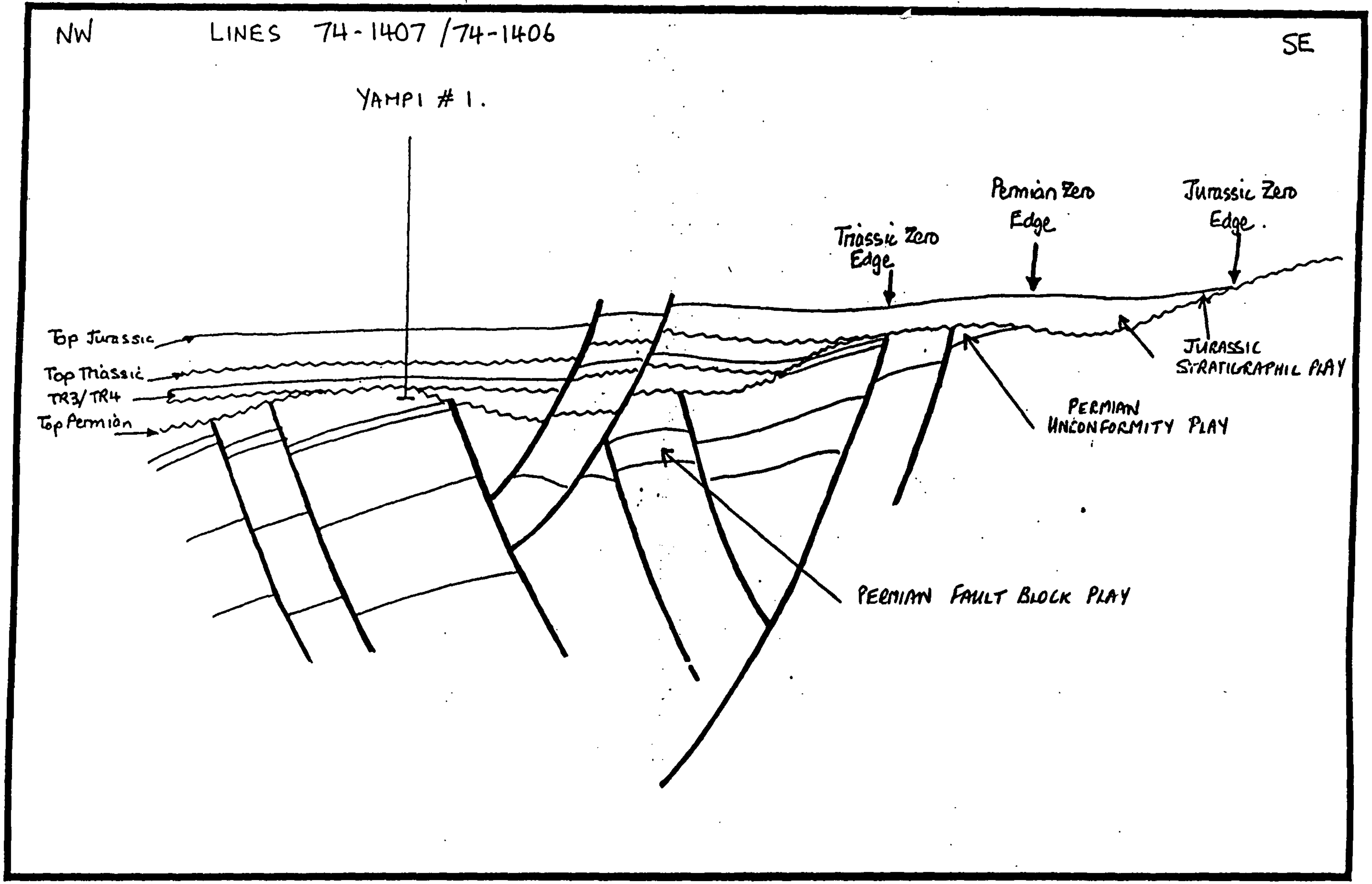
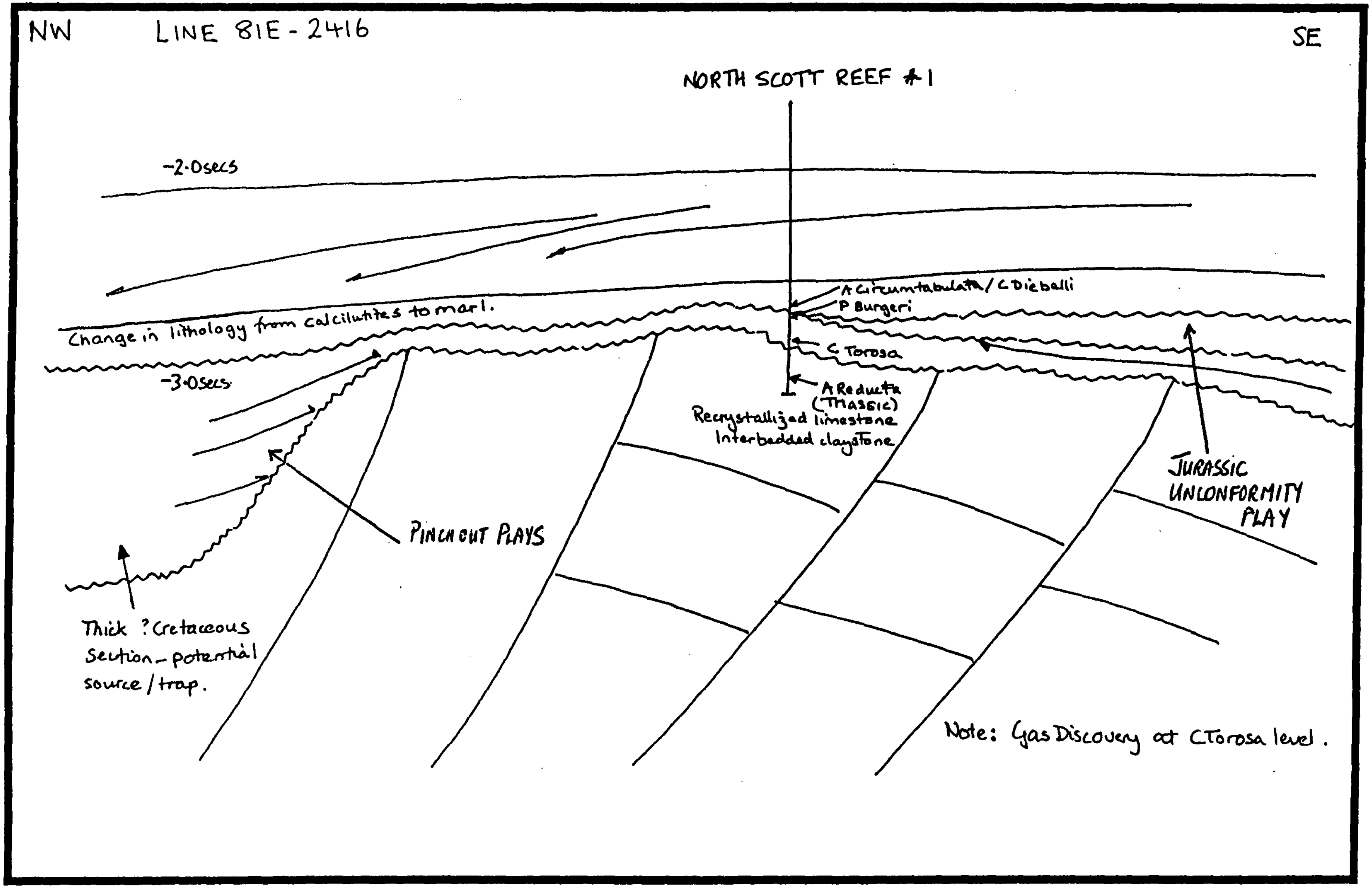
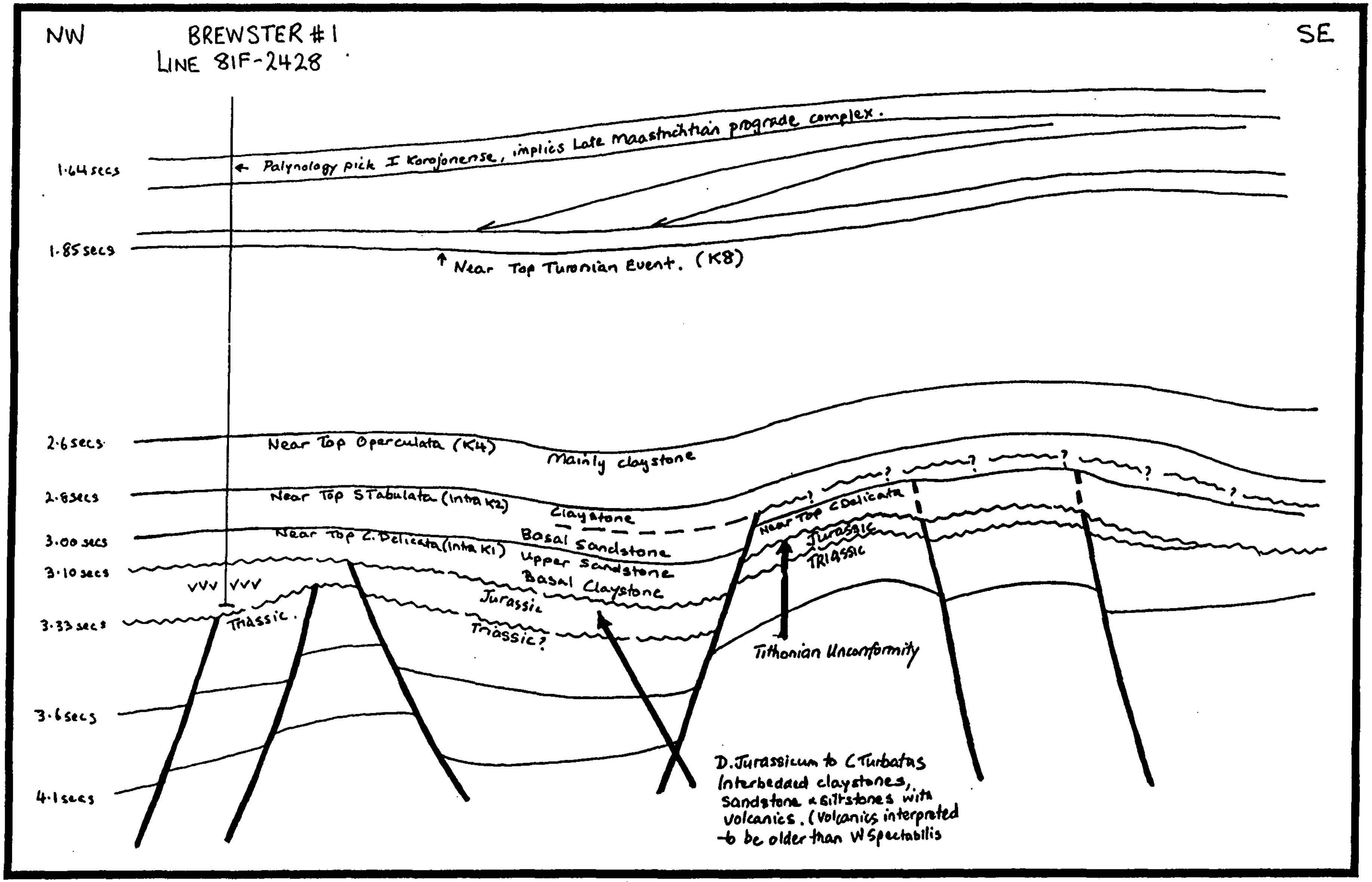

NW
LINES 74-1407 /74-1406
SE
YAMPI # 1.
Permian Zero Edge
Jurassic Zero Edge.
Triassic Zero Edge
Top Jurassic
Top Triassic
TR3/ TR4
Top Permian
JURASSIC STRATIGRAPHIC PLAY
PERMIAN UNCONFORMITY PLAY
PERMIAN FAULT BLOCK PLAY

Figure 28.



NW
LINE 81E-2416
SE
NORTH SCOTT REEF #1
-2.0secs
A Circumtabulata / C Dieballi
P Burgeri
Change in lithology from calcilutites to marl.
C Torosa
-3.0secs
A Reducta (Triassic)
Recrystallized limestone
Interbedded claystone
JURASSIC UNCONFORMITY PLAY
PINCHOUT PLAYS
Thick ?Cretaceous Section - potential source / trap.
Note: Gas Discovery at C Torosa level.

Figure 29



NW
BREWSTER #1
LINE 81F-2428
SE
1.64 secs
← Palynology pick I Korojonense, implies Late Maastrichtian prograde complex.
1.85 secs
↑ Near Top Turonian Event. (K8)
2.6 secs
Near Top Operculata (K4)
Mainly claystone
2.8 secs
Near Top STabulata (Intra K2)
Claystone
3.00 secs
Near Top Z. Delicata (Intra K1)
Basal Sandstone
Upper Sandstone
3.10 secs
Basal Claystone
VVV VVV
Jurassic
3.33 secs
Triassic.
Triassic?
Near Top C Delicata
Jurassic
TRIASSIC
Tithonian Unconformity
3.6 secs
4.1 secs
D. Jurassicum to C Turbatus
Interbedded claystones,
sandstone & siltstones with
volcanics. (Volcanics interpreted
to be older than W Spectabilis

Figure 30

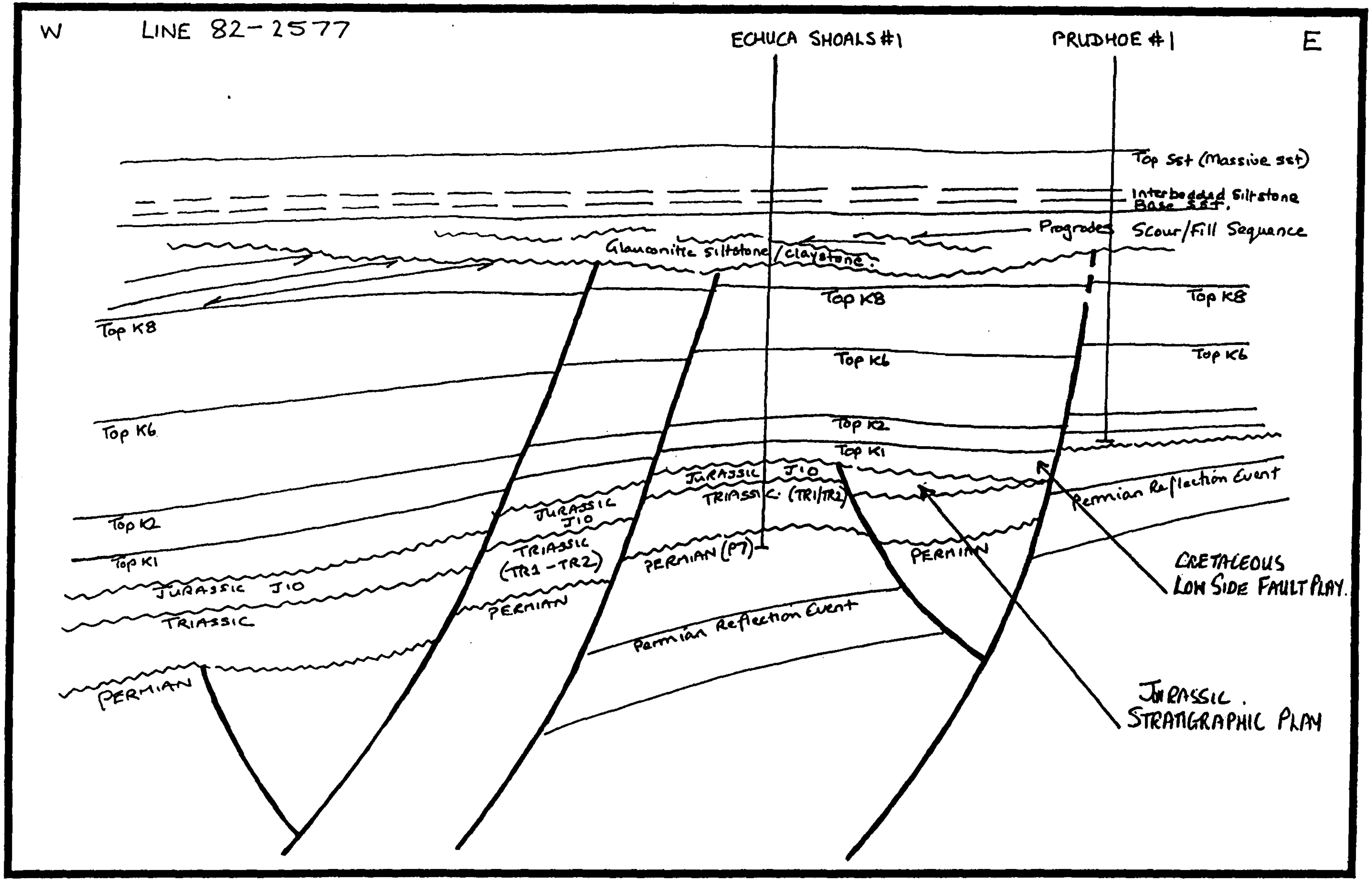

W
LINE 82-2577
ECHUCA SHOALS #1
PRUDHOE #1
E
Top Sst (Massive sst)
Interbedded Siltstone
Base Sst.
Progrades
Scour/Fill Sequence
Glauconitic siltstone/claystone.
Top K8
Top K8
Top K8
Top K6
Top K6
Top K6
Top K2
Top K2
Top K1
Top K1
JURASSIC J10
TRIASSIC (TR1/TR2)
JURASSIC J10
TRIASSIC (TR1 - TR2)
PERMIAN (P7)
PERMIAN
Permian Reflection Event
JURASSIC J10
TRIASSIC
PERMIAN
PERMIAN
Permian Reflection Event
CRETACEOUS
LOW SIDE FAULT PLAY.
JURASSIC.
STRATIGRAPHIC PLAY

Figure 31

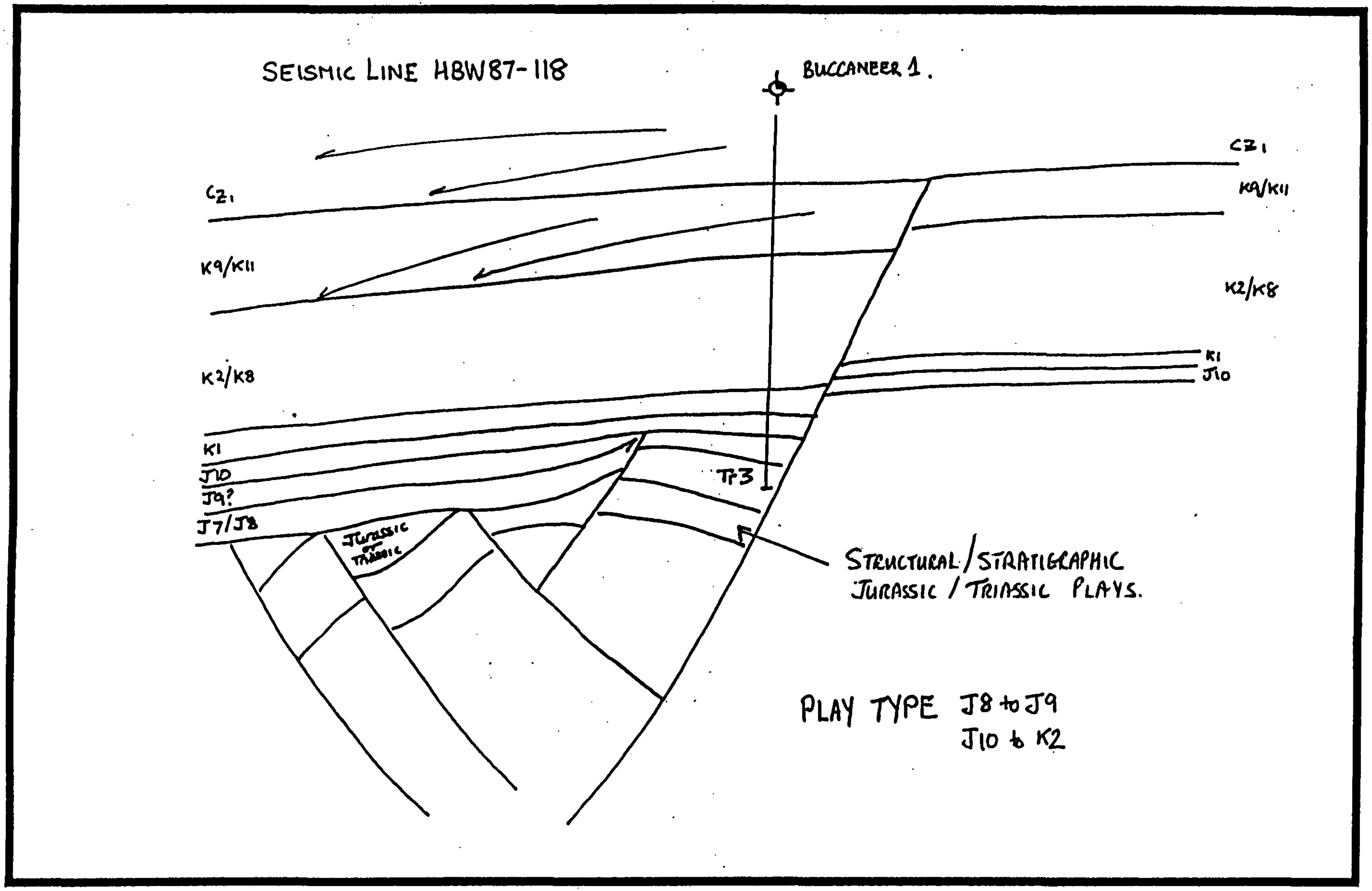

SEISMIC LINE HBW87-118
BUCCANEER 1.
CZ1
K9/K11
K2/K8
K1
J10
J9?
J7/J8
Tr3
STRUCTURAL/STRATIGRAPHIC
JURASSIC/TRIASSIC PLAYS.
PLAY TYPE J8 to J9
J10 to K2

Figure 32

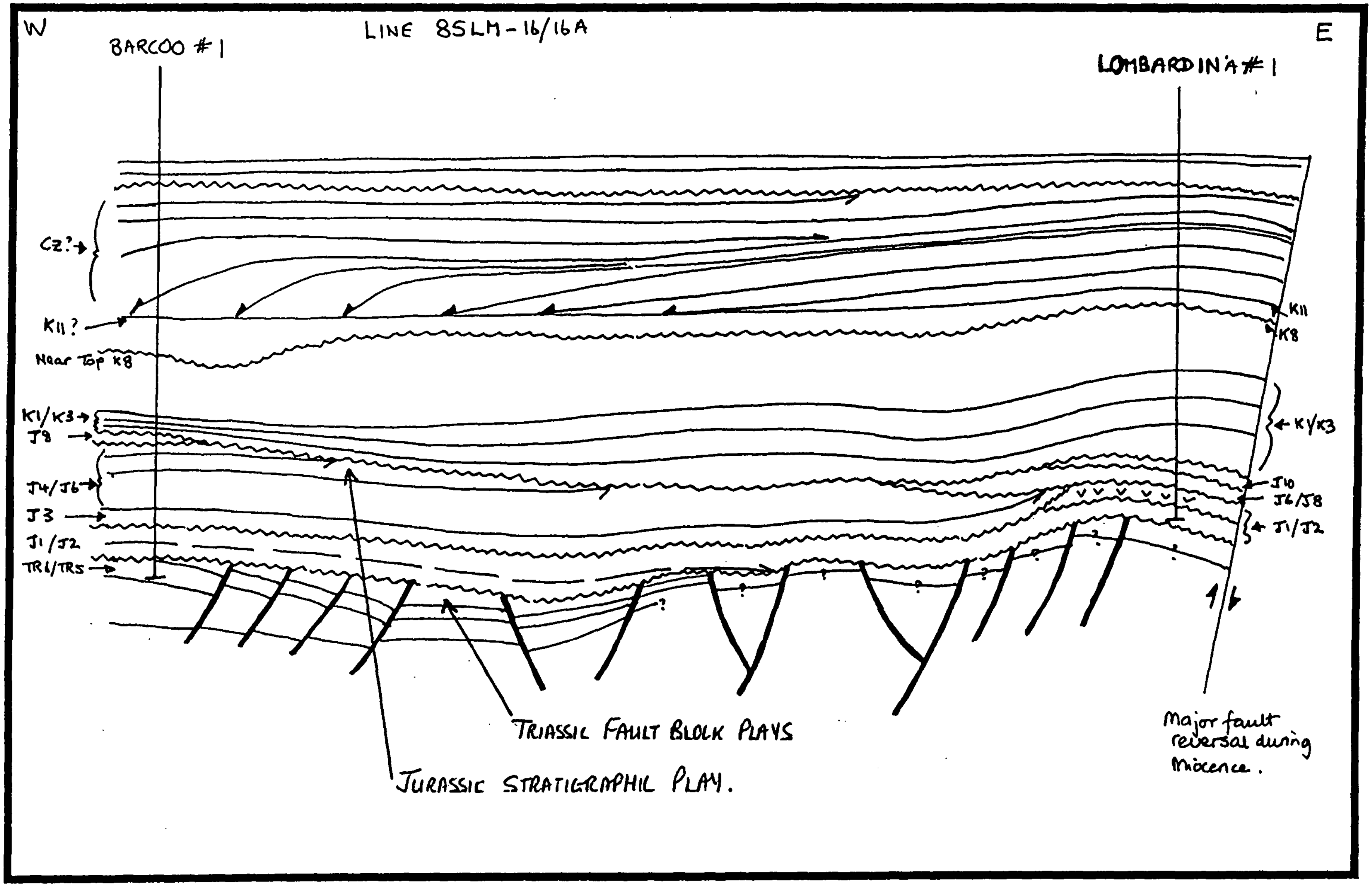

W
LINE 85LM-16/16A
E
BARCOO #1
LOMBARDINA #1
Cz? →
K11? →
Near Top K8
K1/K3 →
J8 →
J4/J6 →
J3 →
J1/J2
TR6/TR5 →
K11
K8
← K1/K3
J10
J6/J8
← J1/J2
TRIASSIC FAULT BLOCK PLAYS
JURASSIC STRATIGRAPHIC PLAY.
Major fault reversal during Miocene.

Figure 33

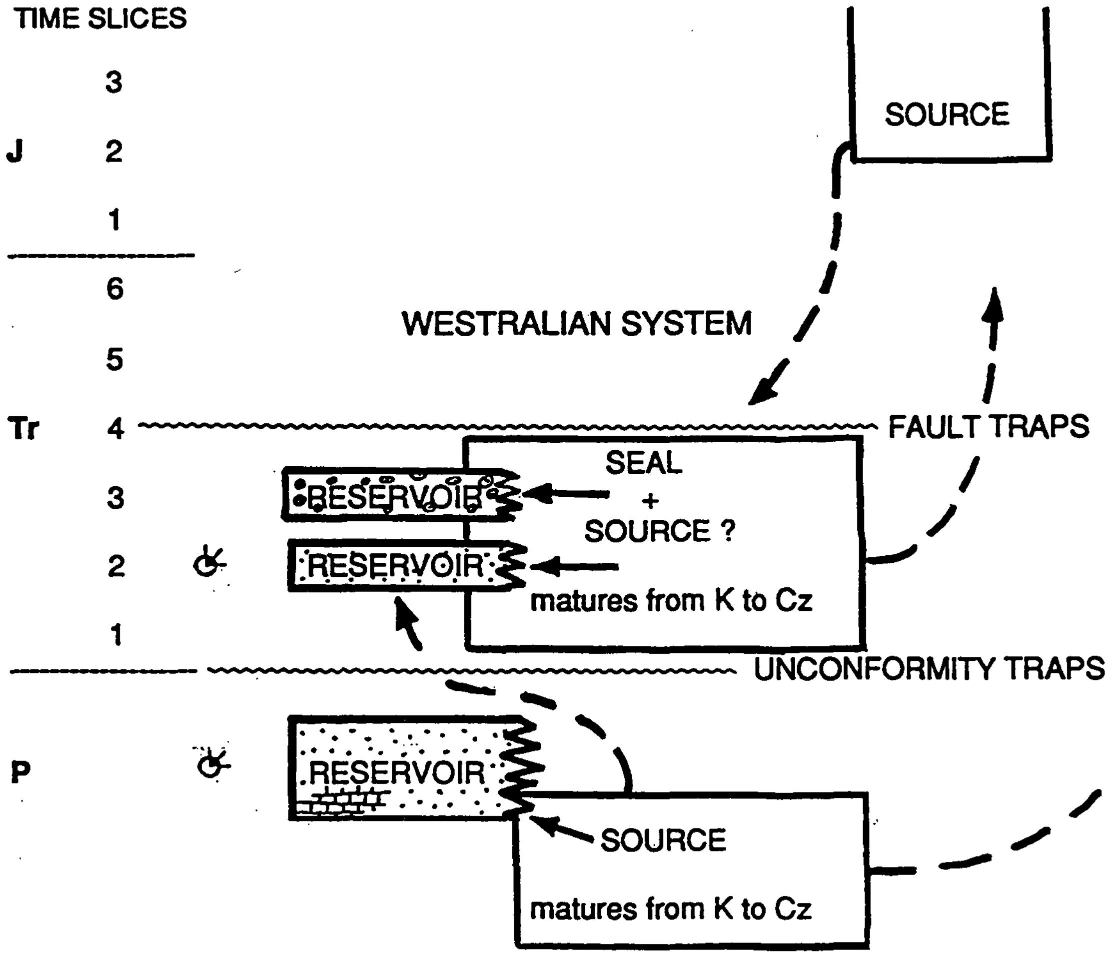


Figure 34 Schematic diagram of the Gondwanan Petroleum System in the Browse Basin.

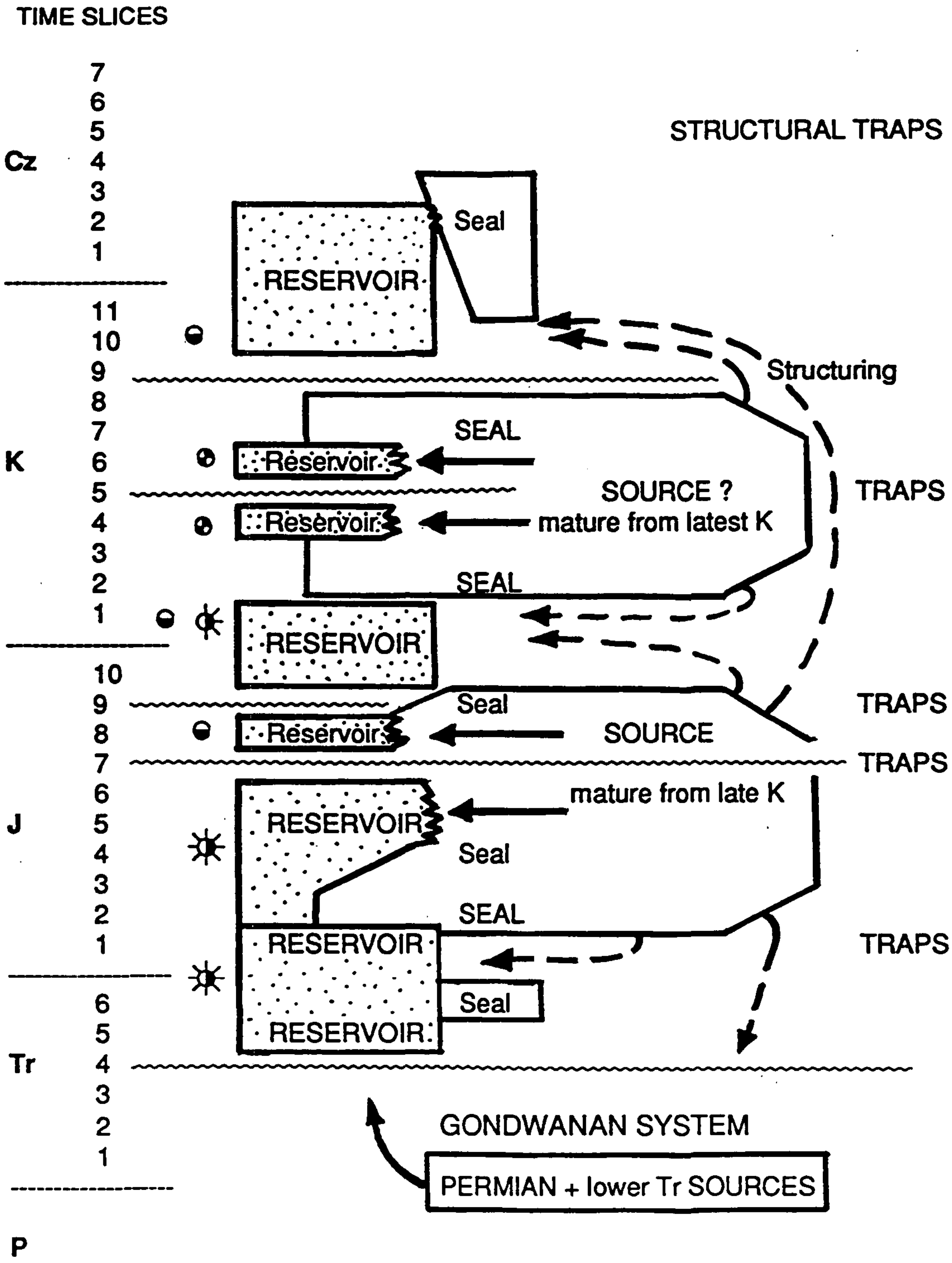


Figure 35 Schematic diagram of the Westralian Petroleum System in the Browse Basin.

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