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PETROLEUM GEOLOGY OF THE BASS BASIN – INTERPRETATION REPORT

APPENDIX - VOLUME II

An Output of the Western Tasmanian Regional Minerals Program

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APPENDIX A

LIST OF THE BASS BASIN PETROLEUM EXPLORATION WELLS AND DRILLING RESULTS

Jane Blevin, Geoscience Australia

Well Name, Operator and Year	Play Type and Target Horizon(s)	Results	Comments
Aroo-1 Hematite Petroleum 1974	Drape over basement high; Paleocene to Early Eocene sands	P&A Fluorescence, minor gas shows	Structural interpretation inaccurate due to the presence of volcanic rocks near target horizons.
Barramundi-1 Globex Far East 1999	Faulted rollover; Paleocene to Early Eocene sands	P&A CO^2 shows	Failure due to breach of regional seal.
Bass-1 Esso E & P Australia 1965	Carbonate reef complex	P&A No shows	Pre-drill interpreted reef structure was invalid. Intersected volcanic section of pyroclastic material.
Bass-2 Esso E & P Australia 1966	Anticlinal structure; Early Eocene sands	P&A No shows	No seal facies; igneous intrusion near TD.
Bass-3 Esso E & P Australia 1966	Anticlinal structure over basement fault block; Mid-Eocene sands	P&A Minor gas	Minor gas shows between 2054.05 to 2055.57 m. Deeper section was water wet. Later drilling of White Ibis-1 in 1998 showed that Bass-3 was not optimally located over the structure.
Chat-1 Bridge Oil Ltd 1986	Faulted dependent closure; Eocene and younger	P&A No shows	Lack of hydrocarbon charge; volcanics intersected near TD.
Cormorant-1 Esso E & P Australia 1970	Anticlinal structure; Paleocene to Early Eocene sands	P&A Minor gas and oil legs	Several pay zones encountered within the Eastern View Group, including a 2 m oil column, and 2 m and 3 m gas and condensate columns. Failure caused by ineffective seal due to late stage reactivation of trap.
Dondu-1 Esso E & P Australia 1973	Anticlinal structure; Paleocene to Early Eocene sands	P&A No shows	Dispersed minor gas shows associated with coals. Good reservoir quality sands above 2743 m.
Durroon-1 Esso E & P Australia 1972	Fault block with updip closure; Early Cretaceous	P&A No shows	No structural closure, lack of seal facies, variable porosity and permeability
Flinders-1 SAGASCO Resources 1992	Fault block; Early Eocene sands	P&A No shows	Water saturated; igneous intrusion near primary objective.
King-1 SAGASCO Resources 1992	Anticlinal structure; Paleocene to Early Eocene sands	P&A Fluorescence, gas shows, trace oil	Water saturated reservoir.
Konkon-1 Esso E & P Australia 1973	Four-way dip closed structure; Paleocene to Early Eocene sands	P&A No shows	Lack of reservoir and regional seal units.
Koorkah-1 Amoco Australia Exploration 1985	Anticlinal structure; Paleocene to Early Eocene sands	P&A No shows	Poor reservoir quality, possible lack of hydrocarbon charge.
Narimba-1 Esso E & P Australia 1973	Anticlinal structure; Early Eocene	P&A No shows	Lack of hydrocarbon charge.

Nangkero-1 Hematite Petroleum 1974	Fault block with overlying drape closure; Early to Middle Eocene sands	P&A No shows	Good reservoir and seal rocks encountered.
Pelican-1 Esso E & P Australia 1970	Anticlinal structure; Maastrichtian to Early Paleocene sands	P&A Gas and condensate discovery	Non-commercial accumulation with 12 gas/condensate-bearing sands between 2471 and 3162 m KB.
Pelican-2 Esso E & P Australia 1970	Anticlinal structure; Maastrichtian to Early Paleocene sands	P&A Gas and condensate	Appraisal well of gas/condensate discovery at Pelican-1. 16 gas/ condensate-bearing sands between 2272 and 3066 m KB.
Pelican-3 Esso E & P Australia 1972	Fault block; Late Paleocene sands	P&A Minor gas shows, weak fluorescence	Hydrocarbon-bearing sands encountered at Pelican-1 and -2 (Lower *M. diversus*) were absent at Pelican-3.
Pelican-4 Hematite Petroleum 1979	Anticlinal structure; Maastrichtian to Early Paleocene sands	P&A Gas and condensate shows	Further appraisal of gas/condensate-bearing sands at Pelican-1 and -2. Also aimed to test flow characteristics of reservoirs – however sands were too tight to conduct production tests. Three main gas/condensate-bearing intervals encountered, with minor gas and fluorescence recorded in thinner beds.
Pelican-5 Amoco Australia Exploration 1985	Faulted anticlinal structure; Maastrichtian to Early Eocene sands	P&A Gas and condensate flows (DST)	Further testing of Pelican structure. Six DSTs with 2 flows. Log evaluation indicates moveable hydrocarbons at various levels from 2750 to 4050 m KB. Low permeability reservoirs encountered.
Pipipa-1 Hematite Petroleum 1982	Faulted anticlinal structure; Early Eocene sands	P&A Trace gas, weak fluorescence	Good reservoir and seal rocks encountered. Water saturated.
Poonboon-1 Esso E & P Australia 1972	Anticlinal structure, drape over fault block; Late Paleocene to Eocene sands	P&A No shows	Good reservoir and seal rocks encountered. Water saturated. Minor gas kicks associated with coals.
Seal-1 Bridge Oil Ltd 1986	Anticlinal structure; Paleocene to Early Eocene sands	P&A No shows	Lack of hydrocarbon charge (access to mature source rocks).
Squid-1 Weaver Gas & Oil Corporation Australia 1984	Faulted anticlinal structure and overlying Oligocene sand lens; Late Cretaceous to Eocene sands	P&A No shows	Minor gas kicks associated with coals.
Tarook-1 Esso E & P Australia 1972	Low relief anticlinal structure; Early to Middle Eocene sands	P&A No shows	Good reservoir and seal rocks encountered.
Tasmanian Devil-1 Weaver Gas & Oil Corporation Australia 1984	Tilted fault block; Eocene and older sands	P&A No shows	Strata penetrated was significantly different to pre-drill prediction.
Tilana-1 Amoco Australia Exploration 1985	Anticlinal structure; Late Cretaceous to Eocene sands	P&A Minor oil and gas shows	Fluorescence recorded over intervals 3081 to 3096, 3260 and 3573 m KB. Overmature sediments may be due to local intrusions. Target sands had low permeability and porosity.
Toolka-1 Esso E & P Australia 1974	Anticlinal structure; Paleocene to Early Eocene sands	P&A Gas shows, Minor oil	Discontinuous reservoir sands.
White Ibis-1 Boral Energy Resources 1998	Anticlinal structure; Paleocene to Early Eocene sands	P&A Gas discovery	Suspended gas discovery.

Yolla-1 Amoco Australia Exploration 1985	Faulted basement high with dip and fault closure; Paleocene to Early Eocene sands	Suspended Condensate, gas and oil discovery	Production due to come on-line in 2004 (Origin Energy operated BassGas Project).
Yolla-2 Premier Oil Australasia 1998	Appraisal well of Yolla-1 downdip along anticline	P&A Gas shows	Successful in evaluating the Yolla accumulation.
Yurongi-1 Esso E & P Australia 1973	Anticlinal structure; Late Paleocene to Eocene sands	P&A No shows	Good reservoir and seal rocks encountered.
Narimba-1 Esso E & P Australia 1973	Anticlinal structure; Early Eocene	P&A No shows	Lack of hydrocarbon charge.

APPENDIX B.

LIST OF HORIZONS INTERPRETED IN THE BASS BASIN WELLS

Jane Blevin, Geoscience Australia

APPENDIX B. Summary of seismic horizons and sequences mapped for Bass Basin study.

Sequence	Horizon (Base)	Age (Ma) (Base)	Biozonation and Age (Base of Sequence)	Tectonostratigraphic or Depositional Event	Reference Well	Comments
Torquay	Torq-3	9	Planktic foraminifera Zone C, younger than latest Middle Miocene	Cessation of stong Miocene inversion	Cormorant-1 Konkon-1	Top of syn-inversion succession
Torquay	Torq-2	14.5	Planktic foraminifera Zone E1/D2, early Middle Miocene-to-mid-Middle Miocene	Onset of Middle Miocene inversion, End of polygonal faulting	Konkon-1 Cormorant-1 Toolka-1A	Base of syn-inversion succession
Torquay	Torq-1	17.5	Planktic foraminifera Zone G, latest Early Miocene	Polygonal faulting, Deepening marine environment	Pelican wells Durroon-1	Base of carbonate succession at Durroon-1
Torquay	Torq	28.0	Planktic foraminifera Zones I2 / I1, early Late Oligocene-to-Late Oligocene	Thermal subsidence, Mid-Oligocene unconformity, Polygonal faulting	Yurongi-1, Tarook-1, Pelican-2, -3, and -5, Aroo-1	Base of the Torquay Sequence; Regional lowstand unconformity; most continuous seismic horizon in the basin; Base of extrusive volcanic event in northern and western basin
Onset of Basin Phase – Thermal Subsidence 3, Base of Torquay Sequence (Top of Basin Phase – Thermal Subsidence 2)						
Demons Bluff	DBL-3	35	Middle *N. asperus*, early Late Eocene	Flooding surface	Nangkero-1, Narimba-1	Base of Demons Bluff shale (seal), regional flooding surface
Demons Bluff	DBL-2	39	Near base Middle *N. asperus*, late Middle Eocene	Fourth-order sequence boundary	Pelican-3, Squid-1	Base of Boonah Sandstone, local unconformity
Demons Bluff	DBL-1	42	Intra-Lower *N. asperus*, Middle Eocene	Base of Toolka Lake	Poonboon-1, Koorkah-1, Konkon-1	Base of the Toolka Lake cycle, flooding surface within the cycle can be mapped locally
Demons Bluff	DBL	43	Intra-Lower *N. asperus*, Middle Eocene	Thermal subsidence	Narimba-1, Poonboon-1, Aroo-1	Base of the Demons Bluff Sequence, unconformity
Onset of Basin Phase - Thermal Subsidence 2, Base of Demons Bluff Sequence (Top of Basin Phase – Thermal Subsidence 1)						

Sequence	Horizon (Base)	Age Ma (Base)	Biozonation and Age (Base of sequence)	Tectonostratigraphic or Depositional Event	Reference Well	Comments
Onset of Basin Phase - Thermal Subsidence 2, Base of Demons Bluff Sequence (Top of Basin Phase – Thermal Subsidence 1)						
Aroo	marker	47.5	Top *P. asperopolus*, early Middle Eocene	Flooding surface	Aroo-1	Regional flooding surface
Aroo	Aroo-1	50.5	Near base *P. asperopolus*, late Early Eocene	Fourth-order sequence boundary	Aroo-1	Unconformity
Aroo	Aroo	51.5 – 52.0	base of Upper *M. diversus*, mid-Early Eocene	Onset of post-rift subsidence. End of final stages of far-field, oblique extension, growth faulting and fault reactivation	Nangkero-1, Narimba-1, Cormorant-1	Base of the Aroo Sequence, unconformity, Most fault terminate at or near the base of the Aroo Sequence, thick coals are common at base of sequence
Onset of Basin Phase - Thermal Subsidence 1, Base of Aroo Sequence (Top of Basin Phase – Extension 3)						
Bass	marker	54.5	Intra-Lower *M. diversus*, earliest Early Eocene	Maximum flooding surface	Poonboon-1 Nangkero-1, Narimba-1	Regional flooding surface
Bass	Narimba	57	Near base Upper *L. balmei*, late Late Paleocene	Onset of growth faulting in the Pelican and Cormorant troughs, sediment loading	Pelican-5, Toolka-1A, Koorkah-1	Base of the Narimba Sequence, Volcanic intrusions into this succession are common, Koorkah Lake cycle
Bass	Tilana	68	Near base Upper *F. longus*, Late Maastrichtian	Onset of extensional phase in the western Bass Basin (Cape Wickham Sub-basin), growth faulting and sediment loading	Pelican-5, Poonboon-1, Koorkah-1	Base of the Tilana Sequence, Volcanic intrusions into this succession are common, Koorkah Lake cycle
Bass	Furneaux	77.5	Near base or Intra-*T. lillei*, mid-Campanian	Onset of extensional phase in the western Bass Basin	Pelican-5, Tilana-1	Base of the Bass Megasequence and Furneaux Sequence, unconformity
Onset of Basin Phase – Extension 3, Base of Bass Megasequence (Top of Basin Phase – Extension 2)						

Sequence	Horizon (Base)	Age Ma (Base)	Biozonation and Age (Base of sequence)	Tectonostratigraphic or Depositional Event	Reference Well	Comments
Onset of Basin Phase – Extension 3, Base of Bass Megasequence (Top of Basin Phase – Extension 2)						
Durroon	marker	81	*N. senectus*	Slow phase of syn-rift growth (transition)	Durroon-1	Breakup in the Tasman Basin at 83 Ma
Durroon	marker	83	*T. apoxyexinus*	Phase of syn-rift growth	Not interesected	Sediment of this age are absent at the Durroon-1 well, but inferred from seismic correlations
Durroon	marker	87	Intra-*P. mawsonii*	Phase of syn-rift growth	Durroon-1	Phase of syn-rift growth
Durroon	Base-2	91	Near base *P. mawsonii*	Onset of the main extensional phase in the Durroon Sub-basin	Durroon-1	Base of Durroon syn-rift succession
Onset of Basin Phase – Extension 2, Base of Durroon Megasequence (Top of Basin Phase – Extension 1)						
Otway	marker	97.5	*P. pannosus*	Top of Otway Megasequence; unconformity; pre-rift basement to the Bass Megasequence	Durroon-1	Cessation of extension was followed by Cenomanian uplift and erosion before the onset of Extension Phase 2.
Otway	Base 1	115 - 120 (inferred)	? Intra-Upper *F. wonthaggiensis*	Onset of rifting in the Bass Basin – probably localised movement along isolated fault segments	Durroon-1	Oldest sediments penetrated are Aptian (*P. notensis*, formerly *C. hughesii*)
Onset of Basin Phase - Extension 1, Base of Otway Megasequence (Pre-rift Basement)						

APPENDIX C.

BIOSTRATIGRAPHY REPORT FOR SELECTED BASS BASIN WELLS

Alan Partridge, Biostrata Pty. Ltd.

The following reports were commissioned by Geoscience Australia on behalf of Mineral Resources Tasmania, under the funding auspices of the Western Tasmanian Regional Minerals Program. Dr. Alan Partridge, Biostrata Pty Ltd, undertook the biostratigraphic analyses and prepared a series of eight reports (including a summary report). These reports have been reformatted for inclusion in this volume.

APPENDIX C1.

Palynological analysis of Eocene interval 1380 to 2036m in Cormorant-1, Bass Basin.

by

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Palynological analysis of Eocene interval 1380 to 2036m in Cormorant-1, Bass Basin

by Alan D. Partridge

Introduction

This new palynological study of the uppermost 700 metres of the Eastern View Group in Cormorant-1 is a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell basins.

The interval of interest in Cormorant-1 covers the late Early Eocene to Middle Eocene (Upper *M. diversus* to Lower *N. asperus* Zones) which, from previous palynological studies, was known to contain marine dinocysts including a single specimen of the key index species *Charlesdowniea* (al. *Kisselovia*) *edwardsii* which had been reported from a sidewall core at 1825.8m. The objective of the study was to determine the abundance and diversity of the dinocysts in the palynological assemblages and to verify the presence of, and try and recover additional specimens of the key index species. If the latter were found it would provide better correlation of the Bass Basin succession to the Gippsland Basin, New Zealand and the international time scale. Unfortunately, this second objective was not achieved.

Materials and Methods

Nineteen samples comprising 8 conventional core and 11 cuttings samples were analysed in two batches (Stages 1 and 2). Laboratory processing of the samples was performed by Geoscience Australia. However, due to miscommunication the first batch of 16 samples were given an initial coarse filtration, which had the effect of separating a significant proportion of the organic-walled microplankton (mostly dinocysts) from the finer fraction of the residue containing the majority of angiosperm pollen. This rendered unreliable the counted ratio of dinocysts to the spore-pollen in the assemblages. Separate counts of slides from the two different residue size fractions revealed that the estimated abundance of the microplankton was low (mostly <1% of combined MP + SP count) and only rarely frequent (<10%). As these values were considered unlikely to significantly increase with reprocessing, the author decided to continue the study on the available slides. Collection and reprocessing of three of the cuttings samples in Stage 2 of the project, gave quantitative results close to the estimates derived from the first batch justifying the decision.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973), and for manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

Notwithstanding difficulties with processing most samples analysed in Cormorant-1 have low concentrations of marine and non-marine dinocysts, which are used to environmentally subdivided the section as follows:

1. The most abundance and diverse marine dinocyst assemblages were recovered from the thick shale between 2012 and 2042m. The environment of deposition is suggested to be a large restricted marine lagoon. The presence of the mangrove pollen *Spinizonocolpites prominatus* (= modern *Nypa*) in the assemblages is evidence of tidal influence on the lagoon. This type of environment also applies to shales of similar thickness deeper in the well.
2. Assemblages from the interval of mixed thin coals, sands and shales between approximately 1620 and 2000m are characterised by lower concentrations of mainly cosmopolitan dinocysts. However, when all the species in the interval are listed the overall diversity is also moderate to high. The environment of deposition is also interpreted to be a large restricted marine lagoon. The thinner bedding through the interval, indicative of more rapid changes of environment, suggests the water depth in the lagoon was generally shallow. Falls in the lake water level thus frequently resulted in the deposition of widespread thin coals and thin fluvial/deltaic sands.
3. Assemblages from the cores 5 and 6 between 1505 and 1519m are characterised by mixed marine and non-marine dinocysts as well as some samples lacking any microplankton. This interval is interpreted to represent a shallow, at times ephemeral, lacustrine environments into which there were occasional marine incursions.
4. The shallowest cuttings samples from the distinctive gamma ray peak between 1322 and 1425m contain low abundance and diversity marine dinocyst assemblages which are interpreted to represent a return to a deeper lagoonal environments. This characteristic log interval is identified in eight wells in the northwest part of the basin and has informally been referred to as the Toolka unit (Partridge, 2002b). In contrast to the lagoonal environments of the underlying Early Eocene (Upper *M. diversus* to Lower *P. asperopolus* Zones) the unit lacks coals.

The hope to use marine dinocysts to further subdivide, and to improve the correlations both within and beyond the Bass Basin was not fulfilled by either this new study of Cormorant-1, or the complimentary study of the adjacent King-1 (Partridge, 2002a). Although key index species are present in the succession (eg. *Homotryblium tasmaniense* at 3033-36m and a single specimen of *Wetzeliella articulata* at 1902-05m) they are too rare to be consistently recovered by routine palynological analysis. Their further utilization awaits higher density sampling and much more intensive microscope analysis involving the searching multiple palynological slides per sample. Unfortunately these latter approaches were beyond the scope of this study.

Also unresolved from the study of this suite of samples is the issue of what part of the section in the Bass Basin corresponds to the duration of the cutting of the Marlin Channel in the Gippsland Basin, and the probable equivalent unconformity at the top of the Wangerrip Group in the Otway Basin. Aspects of the spore-pollen assemblages from cores 5 and 6 suggest that the whole package of rocks between 1425 and 1630m may not be represented in either of the adjacent basins.

Finally, at the bottom of the interval studied the shale between 2012 and 2042m is considered to correlate to the shale between 1980 and 2040m in King-1. The change, at about 2000m in both wells, from thicker shales and thicker coals below to thinner shales and thinner coals above is considered to mark the ìrealî boundary between the Upper *M. diversus* and *P. asperopolus* Zones and may also be a significant sequence boundary.

Biostratigraphy

Upper *Malvacipollis diversus* spore-pollen Zone

Interval: 2024 to 2033 metres

Age: Early Eocene.

The two deepest cuttings samples analysed are assigned to the this zone on the presence of *Proteacidites pachypolus* and absence of younger index species of the overlying *P. asperopolus* Zone. Secondary species consistent with this zone assignment are the frequent occurrence of *Intratriporopollenites notabilis*, *Proteacidites obesolabrus* ms and *Spinizonocolpites prominatus* all recorded from the deeper sample.

The associated microplankton are diagnostic of the *Homotryblium tasmaniense* Zone, which was originally defined by Harris (1985) and has subsequently been modified by Partridge (1999).

***Proteacidites asperopolus* spore-pollen Zone**

Interval: 1621.5 to 1905 metres.

Age: Early Eocene.

This zone is recognised in seven cuttings and three core samples based on the presence of *Conbaculatisporites apiculatus* ms which has a First Appearance Datum (FAD) at 1902-50m, and the somewhat delayed FADs of *Sapotaceoidaepollenites rotundus* at 1716-19m and *Proteacidites asperopolus* at 1689.2m. The top of the zone has a high confidence pick in core-7 at 1682.5m which contains Last Appearance Datums (LADs) for *C. apiculatus*, *Proteacidites ornatus* and *S. prominatus* and also contains the only occurrence in the samples of *Clavastephanocolporites meleosus* Martin *et al*., 1996, which is considered to be restricted to the zone. The next shallower cuttings is also assigned to the zone, with lower confidence, based on the LAD of *Intratriporopollenites notabilis.* This latter sample is tentatively place in an informal upper subzone, based on the lack of other index species.

The associated dinocysts in the samples are broadly consistent with a late Early Eocene age but are not zone diagnostic. The most distinctive species are single specimens of *Hystrichokolpoma spinosum* Wilson 1988 recorded at 1868-72m and *Wetzeliella articulata* Eisenack 1938 recorded at 1902-05m. Unfortunately the occurrence of *Charlesdowniea* (al. *Wetzeliella*) *edwardsii* which had previously been reported from a sidewall core at 1825.8m (Partridge, 1973; p.4), and other related zone index species from the Subfamily Wetzelielloideae were not recovered in the samples. The frequent occurrence of the non-marine dinocyst genera *Saeptodinium* in the cuttings at 1786-89m is referred to the informal *Saeptodinium* facies.

Lower *Nothofagidites asperus* spore-pollen Zone

Interval: 1381 to 1519 metres

Age: Middle Eocene.

The top seven samples are referred to the Lower *N. asperus* Zone based on the increase in abundance of *Nothofagidites* pollen (typically to >30% of SP count), and rare presence of index species. The prominence of *Proteacidites leightonii* and absence of *Nothofagidites falcatus* in the samples from cores 5 and 6 may represent a hitherto undocumented transitional zone interval between the *P. asperopolus* and *N. asperus* Zone that warrants further investigation.

The associated microplankton comprise long ranging cosmopolitan marine dinocysts and undescribed possibly endemic non-marine dinocysts neither of which are currently age or zone diagnostic. Full description and illustration of the non-marine dinocysts is needed and recommended.

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Table-1. Interpretative Palynological Data from Cormorant-1

No.	Sample Type	Depth Metres	Depth Feet	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	Cuttings	1380-84	4530-40	GA-1	Indeterminate					Indeterminate
2	Cuttings	1381-90	4530-60	GA-2	Lower *N. asperus* Zone	D4			FAD of *Nothofagidites falcatus*	Lagoonal - brackish
3	Core-5	1505.7	4940	GA-1	Lower *N. asperus* Zone	A4			FAD of *Tricolporites leuros*	Lagoonal - brackish
4	Core-5	1510.9	4957	GA-1	Lower *N. asperus* Zone	A4			FAD of *Matonisporites ornamentalis*	Lagoonal - brackish
5	Core-6	1513.3	4965	GA-1	Lower *N. asperus* Zone	A4			Frequent *Proteacidites leightonii*	
6	Core-6	1515.8	4973	GA-1	Lower *N. asperus* Zone	A4			Frequent *Proteacidites leightonii*	Lagoonal - brackish
7	Core-6	1519.0	4983.5	GA-1	Lower *N. asperus* Zone	A4			Frequent *Proteacidites recavus*	Lagoonal - brackish
8	Cuttings	1621.5	5320	GA-1	*P. asperopolus* Zone	D4			LAD of *Intratriporopollenites notabilis*	Lagoonal - brackish
9	Core-7	1682.5	5520	GA-1	*P. asperopolus* Zone	A1			LAD of *Spinizonocolpites prominatus*	Lagoonal - restricted marine
10	Core-7	1686.2	5532	GA-1	*P. asperopolus* Zone	A5				Coastal Plain - Deltaic
11	Core-7	1689.2	5542	GA-1	*P. asperopolus* Zone	A2			FAD of *Proteacidites asperopolus*	Lagoonal - restricted marine
12	Cuttings	1716-19	5630-40	GA-1	*P. asperopolus* Zone	D4			FAD of *Sapotaceoidaepollenites rotundus*	Lagoonal - restricted marine
13	Cuttings	1786-89	5860-70	GA-1	*P. asperopolus* Zone	D3	*Saeptodinium* Facies			Coastal Plain - Deltaic
14	Cuttings	1820-23	5970-80	GA-2	*P. asperopolus* Zone	D5			LAD of *Myrtaceidites tenuis*	Lacustrine - Fresh
15	Cuttings	1823-26	5980-90	GA-1	*P. asperopolus* Zone	D4				Lagoonal - restricted marine
16	Cuttings	1868-72	6130-40	GA-1	*P. asperopolus* Zone	D4				Lagoonal - restricted marine
17	Cuttings	1902-05	6240-50	GA-1	*P. asperopolus* Zone	D1			FAD of *Conbaculatisporites apiculatus*	Lagoonal - restricted marine
18	Cuttings	2024-33	6640-70	GA-2	Upper *M. diversus*	D4				Lagoonal - restricted marine
19	Cuttings	2033-36	6670-80	GA-1	Upper *M. diversus*	D2	*H. tasmaniense*	D3	FAD of *Homotryblium tasmaniense*	Lagoonal - restricted marine

ABBREVIATIONS

*CR = Confidence Ratings from STRATDAT

LAD = Last Appearance Datum

FAD = First Appearance Datum

GA-1 = Samples collected Stage-1 Work program

GA-2 = Samples collected Stage-2 Work program

CONFIDENCE RATINGS

Alpha Code Linked to Sample

A = Core

B = Sidewall core

C = Coal cuttings

D = Ditch cuttings

J = Junk basket

Numeric Code Linked to Palynomorph Assemblage

1 = Excellent confidence: High diversity assemblage **plus** key zone species.

2 = Good confidence: Moderately diverse assemblage **plus** key zone species.

3 = Fair confidence: Low diversity assemblage **plus** key zone species.

4 = Poor confidence: Moderate to high diversity **minus** key zone species.

5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Cormorant-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
1	6405867	Cuttings		4530	4540	1380.7	1383.8	Low	Very Low	Fair	9	2				
2	6406875	Cuttings		4530	4560	1380.7	1389.9	Moderate	Moderate	Poor-Fair	41	2	<2%	<1%	19%	16%
3	6405868	Core	5		4940		1505.7	Moderate	Low	Poor-Fair	27	3	<1%	<1%	<3%	>40%
4	6405869	Core	5		4957		1510.9	Moderate	Low	Poor-Fair	24	2				
5	6405870	Core	6		4965		1513.3	Moderate	Low	Poor-Fair	30					
6	6405871	Core	6		4973		1515.8	High	Moderate	Fair-Good	49	3	<1%	<1%	<10%	>30%
7	6405872	Core	6		4983.5		1519.0	Moderate	Low	Poor-Fair	36	1		<1%		>40%
8	6405873	Cuttings		5320	5320	1621.5	1621.5	Moderate	Low	Poor-Fair	38	1	<1%			<20%
9	6405874	Core	7		5520		1682.5	High	Moderate	Fair-Good	36	2	<1%			
10	6405875	Core	7		5532		1686.2	Moderate	Low	Poor	18					
11	6405876	Core	7		5542		1689.2	Moderate	Low	Fair	46	1	<1%		<1%	<10%
12	6405877	Cuttings		5630	5640	1716.0	1719.1	Moderate	Low	Poor	20					
13	6405878	Cuttings		5860	5870	1786.1	1789.2	Low	Low	Poor	19	1				
14	6406876	Cuttings		5970	5980	1819.7	1822.7	Low	Very Low	Poor-Fair	33	2	4%		6%	19%
15	6405879	Cuttings		5980	5990	1822.7	1825.8	Moderate	Low	Poor	21	4				
16	6405880	Cuttings		6130	6140	1868.4	1871.5	Moderate	Low	Poor	31	2				
17	6405881	Cuttings		6240	6250	1902.0	1905.0	Moderate	Low	Poor-Good	32	5	<1%	<1%	<3%	<10%
18	6406877	Cuttings		6640	6670	2023.9	2033.0	Moderate	Moderate	Poor-Fair	21	6	10%		6%	16%
19	6405882	Cuttings		6670	6680	2033.0	2036.1	High	Moderate	Poor-Fair	30	6	>10%		>15%	<5%

ABBREVIATIONS

MP = Microplankton

SP = Spore-Pollen

NED = Neves Effect based on *Dilwynites/Araucariacites* Percentage

Noth% = Percentage of *Nothofagidites* in SP count.

Other MP = Brackish and fresh-water species

Table 3. Abundances of major palynomorph groups from Cormorant-1.

No.	Top Metres	Base Metres	Top Feet	Base Feet	Sample Type	Residue Filter	Gleicheniidites circinidites spores	ALL OTHER spores	Dilwynites and Araucariacites pollen	ALL OTHER gymnosperm pollen	Nothofagidites spp. pollen	ALL OTHER angiosperm pollen	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		Spore-Pollen Total	Microplankton Fresh-Brackish	Microplankton Marine	**SP + MP SUM**
1	1380.7	1383.8	4530	4540	Cuttings															
2	1380.7	1389.9	4530	4560	Cuttings	Fine	1%	9%	17%	18%	17%	30%	8%		330		98%	0%	2%	311
3		1505.7		4940	Core	Fine		8%	3%	15%	47%	23%	4%		116		97%	2%	1%	114
4		1510.9		4957	Core															
5		1513.3		4965	Core									X						
6A		1515.8		4973	Core	Fine		10%	7%	17%	31%	32%	3%		115		98%	1%	1%	114
6B		1515.8		4973	Core	Coarse		20%	14%	36%	4%	19%	7%	X	124		100%			115
7		1519.0		4983.5	Core	Fine	1%	2%	2%	16%	45%	30%	5%		119		99%	1%		114
8	1621.5	1621.5	5320	5320	Cuttings	Fine		7%	2%	4%	19%	57%	11%		143		100%			127
9		1682.5		5520	Core															
10		1686.2		5532	Core															
11		1689.2		5542	Core	Fine		13%	1%	11%	9%	58%	9%		139		100%			127
12	1716.0	1719.1	5630	5640	Cuttings															
13	1786.1	1789.2	5860	5870	Cuttings															
14	1819.7	1822.7	5970	5980	Cuttings	Fine	0.4%	12%	4%	7%	11%	22%	44%		276		96%		4%	162
15	1822.7	1825.8	5980	5990	Cuttings									X						
16	1868.4	1871.5	6130	6140	Cuttings															
17	1902.0	1905.0	6240	6250	Cuttings	Fine		6%	2%	5%	9%	48%	29%		143		99%	1%		102
18	2023.9	2033.0	6640	6670	Cuttings	Fine	0.3%	5%	3%	10%	9%	29%	43%		291		90%		10%	185
19	2033.0	2036.1	6670	6680	Cuttings	Fine	2%	40%	16%	12%	4%	27%	1%		113		75%	2%	23%	149

Table 4. Cormorant-1 well - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	SPORE SPECIES	Baculatisporites spp.	Conbaculatisporites apiculatus ms	Cyathidites splendens	Cyathidites palaeospora	Foveotriletes balteus	Gleicheniidites circinidites	Ischyosporites spp.	Kuylisporites waterbolkii	Laevigatosporites major	Laevigatosporites ovatus	Latrobosporites crassus	Latrobosporites marginatus	Matonisporites ornamentalis	Peromonolites spp.	Polypodiidites/Verrucatosporites spp.	Polypodiaceoisporites varus ms	Retitriletes spp.	Rugulatisporites mallatus	Trilete spores undiff.	Tripunctisporis maastrichtiensis	Verrucosisporites kopukuensis	TOTAL SPORES
1	1380.7	1383.8	Cuttings					X				X								X						X	
2	1380.7	1389.9	Cuttings	Fine				1.0%	2.0%	0.3%	0.7%	0.3%			0.3%			0.3%	1.6%					3.3%		0.3%	10%
3		1505.7	Core	Fine					0.9%						6.3%					0.9%							8%
4		1510.9	Core			X		X	X	X	X			X	X			X							X	X	
5		1513.3	Core						X			X		X	X	X	X					X			X	X	
6A		1515.8	Core	Fine		X		X	2.7%			0.9%	X	X	1.8%		X					0.9%		1.8%		1.8%	10%
6B		1515.8	Core	Coarse		0.9%		1.7%	7.8%			3.5%			3.5%					X				1.7%	X	2.6%	22%
7		1519.0	Core	Fine				X	0.9%		0.9%	X			0.9%					X							3%
8	1621.5	1621.5	Cuttings	Fine		X		X	6.3%			X		X	1.6%					X						X	8%
9		1682.5	Core			X	X	X	X		X	X		X	X					X			X		X	X	
10		1686.2	Core			X		X												X							
11		1689.2	Core	Fine		1.6%		X	7.1%			X		X	4.7%	X				X				0.8%			14%
12	1716.0	1719.1	Cuttings			X		X	X			X	X	X	X											X	
13	1786.1	1789.2	Cuttings					X	X		X				X											X	
14	1819.7	1822.7	Cuttings	Fine				6.5%	6.5%		0.6%	0.6%			3.2%				0.6%				X	4.5%			23%
15	1822.7	1825.8	Cuttings					X	X		X	X								X						X	
16	1868.4	1871.5	Cuttings			X		X	X					X	X						X						
17	1902.0	1905.0	Cuttings	Fine			X	X	2.0%	X					5.9%					1.0%			X			X	9%
18	2023.9	2033.0	Cuttings	Fine				0.6%	4.2%		0.6%				1.2%				0.6%					1.8%		0.6%	10%
19	2033.0	2036.1	Cuttings	Fine		4.5%		11%	12%	0.9%	1.8%	2.7%		X	2.7%					2.7%	X		X	1.8%		2.7%	42%

ABBREVIATIONS

X = Present

C = Common

% = Percentage

Table 4. Cormorant-1 well - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter		GYMNOSPERM SPECIES	Gymnosperm pollen undiff.	Araucariacites australis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites mawsonii	Podocarpidites spp.	Trichotomosulcites subgranulatus	TOTAL GYMNOSPERMS		ANGIOSPERM POLLEN SPECIES	Angiosperm pollen undiff.	Banksieaeidites arcuatus	Beaupreaidites elegansiformis	Beaupreaidites trigonalis ms	Beaupreaidites verrucosus	Clavastephanocolporites meleosus	Cupanieidites orthoteichus	Dicotetradites clavatus	Ericipites crassiexinus/scabratus
1	1380.7	1383.8	Cuttings					X	X																			
2	1380.7	1389.9	Cuttings	Fine			3.9%	6.6%	11%	0.7%	1.3%		0.3%	3.9%	9.5%	1.0%	38%			3.3%						0.7%	1.3%	1.0%
3		1505.7	Core	Fine					2.7%	X	1.8%		1.8%	2.7%	8.1%	0.9%	18%			1.8%			X					
4		1510.9	Core					X	X		X			X	X													X
5		1513.3	Core					X	X	X	X			X	X	X												
6A		1515.8	Core	Fine			0.9%	3.6%	2.7%	0.9%	3.6%	0.9%		5.4%	7.1%		25%			3.6%	0.9%							X
6B		1515.8	Core	Coarse				5.2%	9.6%		9.6%	X		17%	12%		54%			0.9%							1.7%	
7		1519.0	Core	Fine					0.9%	0.9%	X			11%	6.2%		19%							X		0.9%		
8	1621.5	1621.5	Cuttings	Fine				0.8%	0.8%	0.8%					4.7%	X	7.1%			0.8%				X		X	2.4%	X
9		1682.5	Core					X	X	X				X	X										X	X		
10		1686.2	Core								X			X	X							X				X		
11		1689.2	Core	Fine					0.8%	0.8%	2.4%	0.8%		2.4%	8		13%			0.8%				X			0.8%	
12	1716.0	1719.1	Cuttings						X	X					X												X	
13	1786.1	1789.2	Cuttings					X	X	X	X			X	X													
14	1819.7	1822.7	Cuttings	Fine			1.3%	2.6%	3.9%		0.6%		0.6%	1.3%	7.1%	1.9%	19%			2.6%				X		0.6%	0.6%	
15	1822.7	1825.8	Cuttings					X	X	X	X		X	X	X													
16	1868.4	1871.5	Cuttings					X	X	X	X			X	X													
17	1902.0	1905.0	Cuttings	Fine			1.0%	1.0%	1.0%	1.0%	X				5.9%	X	9.9%			5.9%				X		2.0%	1.0%	
18	2023.9	2033.0	Cuttings	Fine			2.4%	2.4%	3.6%		1.2%			1.8%	6.0%	6.0%	23%			4.2%						1.2%		
19	2033.0	2036.1	Cuttings	Fine				1.8%	8.9%	5.4%	1.8%				9.8%		28%									1.8%		

ABBREVIATIONS

X = Present

C = Common

% = Percentage

Table 4. Cormorant-1 well - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Haloragacidites harrisii	Ilexpollenites spp.	Intratriporopollenites notabilis	Liliacidites spp.	Lymingtonia sp.	Malvacipollis diversus	Malvacipollis robustus ms	Malvacipollis subtilis	Milfordia spp.	Myrtaceidites parvus/mesonesus	Myrtaceidites tenuis	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites falcatus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites vansteenisii	Paripollis ochesis	Periporopollenites spp.	Polycolporopollenites esobalteus
1	1380.7	1383.8	Cuttings		X																X					
2	1380.7	1389.9	Cuttings	Fine	5.2%	0.7%						0.7%		1.0%		0.7%	5.9%	1.0%	7.5%	0.3%	2.6%	0.3%	0.3%		3.6%	
3		1505.7	Core	Fine	7.2%	0.9%		0.9%				0.9%				1.8%	1.8%		44%			1.8%				
4		1510.9	Core						X										X		X	X				
5		1513.3	Core		X											X			X		X	X				
6A		1515.8	Core	Fine	8.0%	0.9%		2.7%		0.9%		0.9%				0.9%	4.5%		27%							
6B		1515.8	Core	Coarse	7.0%				X		X	0.9%	X			X	1.7%		2.6%			X			0.9%	
7		1519.0	Core	Fine	8.8%	0.9%						X	0.9%				0.9%	0.9%	45%		X	X		X	0.9%	
8	1621.5	1621.5	Cuttings	Fine	11%	0.8%	X	3.9%						1.6%		0.8%	2.4%	1.6%	17%		X	X			1.6%	
9		1682.5	Core		X	X	X					X							X		X	X				
10		1686.2	Core		X	X	X												X							
11		1689.2	Core	Fine	17%		X	0.8%		X	X	1.6%		2.4%		0.8%	1.6%		7.1%		X	X				
12	1716.0	1719.1	Cuttings		X		X				X															
13	1786.1	1789.2	Cuttings		X							X			X											
14	1819.7	1822.7	Cuttings	Fine	3.9%			0.6%						6.5%			X	15%	2.6%		0.6%				0.6%	
15	1822.7	1825.8	Cuttings		X		X					X						X	X							
16	1868.4	1871.5	Cuttings		X		X				X	X							X		X					
17	1902.0	1905.0	Cuttings	Fine	24%	1%						4.0%		4.0%					12%		1.0%				1.0%	
18	2023.9	2033.0	Cuttings	Fine	18%			0.6%				4.8%		0.6%				16%							1.8%	
19	2033.0	2036.1	Cuttings	Fine	3.6%		1.8%				X	3.6%						1.8%	1.8%			X				2.7%

ABBREVIATIONS

X = Present

C = Common

% = Percentage

Table 4. Cormorant-1 well - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Proteacidites spp.	Proteacidites adenanthoides	Proteacidites alveolatus	Proteacidites annularis	Proteacidites asperopolus	Proteacidites differentipollis	Proteacidites biporus	Proteacidites crassus	Proteacidites grandis	Proteacidites incurvatus	Proteacidites kopiensis	Proteacidites latrobensis	Proteacidites leightonii	Proteacidites obesolabrus ms	Proteacidites obscurus	Proteacidites ornatus	Proteacidites pachypolus	Proteacidites prodigus ms	Proteacidites pseudomoides	Proteacidites recavus	Proteacidites reticuloscabratus	Proteacidites rugulatus
1	1380.7	1383.8	Cuttings															X								
2	1380.7	1389.9	Cuttings	Fine	9.2%																0.3%					
3		1505.7	Core	Fine	5.4%			0.9%													0.9%					
4		1510.9	Core		X													X						X		
5		1513.3	Core		X					X				X	X			X				X			X	
6A		1515.8	Core	Fine	9.8%			0.9%																		
6B		1515.8	Core	Coarse	4.3%			X					X			X		2.6%				X	X	X		
7		1519.0	Core	Fine	2.7%			6.2%									X	X	1.8%					0.9%		
8	1621.5	1621.5	Cuttings	Fine	4.7%	X									X									X		
9		1682.5	Core		X		X								X		C			X	X					
10		1686.2	Core		X												X									
11		1689.2	Core	Fine	15%	X		0.8%	0.8%	X					X	X	X	X			0.8%	X				
12	1716.0	1719.1	Cuttings		X								X				X									X
13	1786.1	1789.2	Cuttings		X												X	X	X							
14	1819.7	1822.7	Cuttings	Fine	12%		X						0.6%					X	0.6%							
15	1822.7	1825.8	Cuttings		X								X						X							
16	1868.4	1871.5	Cuttings		X						X	X					X			X	X					
17	1902.0	1905.0	Cuttings	Fine	5.0%			3.0%					X								1.0%					
18	2023.9	2033.0	Cuttings	Fine	11%																1.2%					
19	2033.0	2036.1	Cuttings	Fine	5.4%												4.5%	X			0.9%					

ABBREVIATIONS
X = Present
C = Common
% = Percentage

Table 4. Cormorant-1 well - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Proteacidites tuberculiformis	Proteacidites xestoformis ms	Pseudowinterapollis couperi	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Spinizonocolpites prominatus	Tricolp(or)ates spp.	Tricolpites phillipsii	Tricolporites adelaidensis	Tricolporites leuros	Tricolporites microreticulatus	Tricolporites paenestriatus	Tricolporites scabratus	Triporopollenites ambiguus	Triporopollenites simplis	TOTAL ANGIOSPERMS	**TOTAL SPORE-POLLEN COUNT**
1	1380.7	1383.8	Cuttings								X										
2	1380.7	1389.9	Cuttings	Fine				0.3%			5.6%									51%	305
3		1505.7	Core	Fine			X				5.4%			X			X			74%	111
4		1510.9	Core		X								X								
5		1513.3	Core						X						X						
6A		1515.8	Core	Fine							4.5%									65%	112
6B		1515.8	Core	Coarse		X			X		1.7%	X	X				X			24%	115
7		1519.0	Core	Fine				0.9%			7.1%		X			X				79%	113
8	1621.5	1621.5	Cuttings	Fine				3.9%			23%					10%				85%	127
9		1682.5	Core							X	X										
10		1686.2	Core					X			X		X		X	X		X			
11		1689.2	Core	Fine	X	X		1.6%			20%		X			0.8%				72%	127
12	1716.0	1719.1	Cuttings		X				X		X		X								
13	1786.1	1789.2	Cuttings								X		X		X						
14	1819.7	1822.7	Cuttings	Fine	X						10%									58%	155
15	1822.7	1825.8	Cuttings								X		X								
16	1868.4	1871.5	Cuttings								X		X					X			
17	1902.0	1905.0	Cuttings	Fine							13%					4.0%			X	81%	101
18	2023.9	2033.0	Cuttings	Fine							7.2%							0.6%		67%	167
19	2033.0	2036.1	Cuttings	Fine						0.9%	1.8%									30%	112

ABBREVIATIONS
X = Present
C = Common
% = Percentage

Table 5. Cormorant-1 well - microplankton distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	**MICROPLANKTON**	ACRITARCHS & ALGAE	Micrhystridium spp.	Botryococcus braunii	Pseudoschizaea spp.	ACRITARCHS & ALGAE SUM		NON-MARINE DINOCYSTS	Cubiculosphaera spp.	Morkallacysta spp.	Saeptodinium spp.	NON-MARINE DINOCYSTS SUM		MARINE DINOCYSTS	Dinocysts undiff.	Apectodinium spp.	Apteodinium sp.	Cleistosphaeridium spp.	Cordosphaeridium spp.	Eocladopyxis peniculata
1	1380.7	1383.8	Cuttings																					X
2	1380.7	1389.9	Cuttings	Fine				17%		17%									50%					
3		1505.7	Core	Fine			33%	33%		67%			33%			33%								
4		1510.9	Core																					
5		1513.3	Core																					
6A		1515.8	Core	Fine									50%			50%			50%					
6B		1515.8	Core	Coarse																				
7		1519.0	Core	Fine				100%		100%														
8	1621.5	1621.5	Cuttings	Fine																			X	
9		1682.5	Core																				X	
10		1686.2	Core																					
11		1689.2	Core	Fine										X										
12	1716.0	1719.1	Cuttings																					
13	1786.1	1789.2	Cuttings												X									
14	1819.7	1822.7	Cuttings	Fine															86%					
15	1822.7	1825.8	Cuttings					X					X											
16	1868.4	1871.5	Cuttings																					
17	1902.0	1905.0	Cuttings	Fine				X	X				100%		X	100%								
18	2023.9	2033.0	Cuttings	Fine															61%					
19	2033.0	2036.1	Cuttings	Fine									8%			8%			59%	2.7%	8%	3%		

ABBREVIATIONS
X = Present
C = Common
% = Percentage

Table 5. Cormorant-1 well -

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Homotryblium tasmaniense
1	1380.7	1383.8	Cuttings		
2	1380.7	1389.9	Cuttings	Fine	
3		1505.7	Core	Fine	
4		1510.9	Core		
5		1513.3	Core		
6A		1515.8	Core	Fine	
6B		1515.8	Core	Coarse	
7		1519.0	Core	Fine	
8	1621.5	1621.5	Cuttings	Fine	
9		1682.5	Core		
10		1686.2	Core		
11		1689.2	Core	Fine	
12	1716.0	1719.1	Cuttings		
13	1786.1	1789.2	Cuttings		
14	1819.7	1822.7	Cuttings	Fine	
15	1822.7	1825.8	Cuttings		
16	1868.4	1871.5	Cuttings		
17	1902.0	1905.0	Cuttings	Fine	
18	2023.9	2033.0	Cuttings	Fine	
19	2033.0	2036.1	Cuttings	Fine	5%

ABBREVIATIONS
X = Present
C = Common
% = Percentage

Table 5. Cormorant-1 well - microplankton distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Hystrichokolpoma spinosum	Kenleyia spp.	Paralecaniella indentata	Spinidinium spp.	Spiniferites spp.	Systematophora placanthum	Systematophora variable	Wetzeliella articulata	MARINE DINOCYSTS SUM		TOTAL MP COUNT
1	1380.7	1383.8	Cuttings				X								
2	1380.7	1389.9	Cuttings	Fine					33%				83%		6
3		1505.7	Core	Fine											3
4		1510.9	Core							X					
5		1513.3	Core												
6A		1515.8	Core	Fine									50%		2
6B		1515.8	Core	Coarse						X					
7		1519.0	Core	Fine											1
8	1621.5	1621.5	Cuttings	Fine											
9		1682.5	Core												
10		1686.2	Core												
11		1689.2	Core	Fine					X						
12	1716.0	1719.1	Cuttings												
13	1786.1	1789.2	Cuttings												
14	1819.7	1822.7	Cuttings	Fine			14%						100%		7
15	1822.7	1825.8	Cuttings								X				
16	1868.4	1871.5	Cuttings		X	X									
17	1902.0	1905.0	Cuttings	Fine								X			1
18	2023.9	2033.0	Cuttings	Fine		28%		6%	5.6%				100%		18
19	2033.0	2036.1	Cuttings	Fine		11%	X				2.7%		92%		37

ABBREVIATIONS
X = Present
C = Common
% = Percentage

APPENDIX C2.

Palynological review of Upper Cretaceous units in Durroon-1, Bass Basin.

by

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Palynological review of Upper Cretaceous units in Durroon-1, Bass Basin.

by Alan D. Partridge

Introduction

A quantitative palynological study of the informal Furneaux Group and basal Eastern View Group in Durroon-1 has been undertaken as a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

The Durroon-1 well, located in the southeastern extremity of the Bass Basin, penetrated a Tertiary succession of about 950 metres, an Upper Cretaceous succession of about 650 metres and over 1400 metres of Early Cretaceous sediment that had not been fully penetrated when the well was plugged and abandoned at a T.D. of 3024m. The focus of this study is solely on the Upper Cretaceous with the objectives of **1)** providing a quantitative reference section for the Upper Cretaceous palynological succession in the Bass Basin, **2)** quantifying the distribution, abundance and diversity of non-marine dinocysts and other microplankton, as indicators of lacustrine depositional environments, and **3)** documenting the presence and distribution of Neves effects within the terrestrial spore-pollen assemblages, as supporting palynological evidence for the presence of lacustrine depositional environments. The interval reviewed in the well represents an incomplete sequence from the Turonian *P. mawsonii* Zone to the Early Paleocene Lower *L. balmei* Zone and the spore-pollen zones are identified in a relatively good suite of sidewall core samples supplemented by 10 new cuttings samples. Although it was known beforehand that both the spore-pollen and the non-marine microplankton assemblages were worthy of full systematic description and illustration, such documentation was not the intent of this new study, and unfortunately was also beyond the scope of the overall project.

Materials and Methods

Assemblage counts were performed on 23 samples (15 SWCs and 8 cuttings samples), and species distributions were recorded for another five samples (3 SWCs and 2 cuttings), which were either unsuitable or unavailable for counting. One additional sidewall core in the sequence was barren, but is included in the samples reviewed for completeness. Most of the palynological slides examined are derived from the relinquished set prepared in the now closed laboratory operated by Esso Australia Ltd, and these were originally studied by Partridge (1973). New palynological slides needed to be prepared from the relinquished palynological residues for some samples where the original glycerin jelly mounting medium had desiccated making the slides unworkable. Two additional sidewall cores processed for the study by Morgan (1991) were also analysed. All the ten cuttings sample analysed were collected by Geoscience Australia personnel from their core library and prepared in their palynological laboratory. Three of these cuttings (at 1238-87m, 1323-29m and 1411-20m), due to miscommunication were given an initial coarse filtration, which had the effect of separating a significant proportion of the larger palynomorphs from the finer fraction of the residue containing the majority of angiosperm pollen. Separate assemblage counts of the fine and coarse fractions were made and are recorded, but the results should be treated with caution.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Dettmann (1963), Helby *et al.* (1987) and Stover & Partridge (1973), and for most of the manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

Drilled in 1972, Durroon-1 is an extremely important well in the Bass Basin as it is the only well to fully penetrates the Upper Cretaceous, even though this succession is relatively thin (<650 metres) and contains significant time gaps. The interval investigated in this palynological study extends from the base of the Turonian Durroon Formation (deepest sample at 1533.1m), through the unconformably overlying Campanian to Maastrichtian section and stops at the deepest productive Paleocene sample at 925.1m. The thick sequence of older Otway Group sediments from 1646 to 3024m, the unnamed sandstones and volcanics between 1544 and 1646m, and the Tertiary succession above 900m where not re-examined.

The section of interest comprises the Furneaux Group and lower half of the overlying Eastern View Group. The currently informal Furneaux Group (name suggested by Peter Baillie *pers comm.*), is made up of the unnamed sandstones and volcanics from 1544 to 1646m, the Durroon Formation from 1370 to 1544m, and the Boobyalla unit from 1235 to 1370m. The Durroon Formation was originally proposed by Smith (1986; p.264) with its type interval specified as from 1374 to 1545m, which is herein redefined as the interval 1370 to 1544m. The informal Boobyalla unit is proposed in the final compilation report by Partridge (2002), and derives its name from the equivalent age sedimentary section present in the onshore Boobyalla Subbasin (Moore *et al*., 1984). The Eastern View Group between 582 and 1234m is all assigned to the informal Chat unit of Partridge (2002). Only the palynological samples from the bottom half of the latter unit have been re-examined or reviewed.

Palynological assemblages from the late Turonian age (middle *P. mawsonii* Zone) Durroon Formation are characterised by significant abundances of non-marine microplankton including dinocysts referred to *Morkallacysta* and algal cysts of the *Rimosicysta* Superzone recorded from the Kipper Shale in the adjacent Gippsland Basin (Partridge, 1999; Bernecker & Partridge, 2001). The associated spore-pollen assemblages are characterised by abundant *Dilwynites* pollen (average 30%) diagnostic of a Neves effect, which is the tendency for certain more buoyant spores or pollen to have greater relative abundances in sediments deposited in more distal marine or lacustrine environments (Traverse, 1988; Partridge, 2002). The shallowest two sidewall cores from the formation are also characterised by a spike in the abundance of *Cupressacites* pollen (average 41%), which is interpreted to correlate with a similar spike in *Cupressacites* pollen in the Banoon Member at the top of the Flaxman Formation in the Otway Basin (Partridge, 2001). The 175 metre thick mudstone of the Durroon Formation is interpreted to have been deposited in distal fresh-water lacustrine facies (Palaeolake Durroon) which is coeval with the Flaxman Formation in the Otway Basin and the youngest part of the Kipper Shale in the Gippsland Basin. The moderate to high abundance of non-marine microplankton, the abundant *Dilwynites* and *Araucariacites* pollen indicating a strong Neves effect, and overall homogeneous nature of the mudstone lithology evidenced by the shaly gamma ray log and broad separation of the density and porosity logs, in combination is interpreted to mean that the Durroon Formation was deposited in a distal, and probably deep, fresh-water lacustrine environment.

The idea that the Durroon Formation was a significant fresh-water lacustrine facies was first proposed by Partridge (1973). Subsequently, in a study of cuttings samples Morgan (1985) gave an environmental range of brackish to fresh-water, which Baillie & Pickering (1991; p.14) interpreted as indicating *ì Ö the development of a least marginal marine conditionsî* . Because of this alternate interpretation it needs to be stressed that no definitive marine microplankton were found during this study, although several species or genera that were recorded are also found and can be abundant in both brackish and marine environments (eg. *Botryococcus braunii, Amosopollis cruciformis* and *Micrhystridium*). Further, the location of Durroon-1 on palaeogeographic reconstructions is remote from marine units of equivalent age to the Durroon Formation making any marine influence unlikely (eg. Partridge, 2002; fig.5).

The overlying Boobyalla unit, which is of Campanian age (upper? *N. senectus* to *T. lilliei* Zones), contains palynological assemblages characterised by *Nothofagidites* pollen (typically >20%), with markedly reduced abundances in the pollen of *Dilwynites* (average <5%) and *Cupressacites* (average <0.5%). Rare non-marine dinocysts and algae in this unit hint at the probable presence of more shaly lacustrine facies in the adjacent troughs (eg. Baillie & Pickering, 1991; fig.2). The significant time break of between 5 and 9 million years between the Durroon Formation and Boobyalla unit is correlated with the Longtom Unconformity identified in the Gippsland Basin by Bernecker & Partridge (2001).

Productive palynological samples from the Chat unit are divided between the Maastrichtian *F. longus* Zone and a single sample from the Paleocene Lower *L. balmei* Zone. The former are dominated by angiosperm pollen (notably *Nothofagidites* average 14%, *Proteacidites* average 9% and *Gambierina* average 5%), and the latter by gymnosperm pollen (notably *Phyllocladidites mawsonii* at 24%). Palynological evidence of lacustrine environments was insignificant except for the sidewall core at 1132.3m which contained indeterminate diaphanous dinocysts (identified solely by pigment spots) associated with a weak Neves effect (*Dilwynites* and *Araucariacites* pollen abundance of 16%). As this sample is associated with a distinct shale character on the gamma ray and SP logs and has a broad separation of the bulk density and neutron porosity logs it may represent an important lacustrine ì flooding horizonî . In an attempt to more precisely locate the Cretaceous/Tertiary boundary in Durroon-1 similar shale horizons identified at 948-56m, 961-69m, 990-1005m and 1058-68m where sampled by the closest suitable cuttings. Unfortunately, these cuttings samples gave meager yields, containing only a few palynomorphs, and as those recorded were all long ranging species the samples could not be reliably assigned to either the *L. balmei* or *F. longus* Zones. Further, the two sidewall cores recovered from this interval at 977.2m and 1004m were composed of lithologies unfavourable for palynology. Of these only the shallower sample was processed and that proved to be barren.

An additional time break and unconformity is interpreted between the Boobyalla and Chat units placed at the log break at 1235m. This unconformity is correlated with the Seahorse Unconformity identified in the Gippsland Basin by Bernecker & Partridge (2001), and with one or more unconformities identified within the Timboon Sandstone in the Otway Basin by Partridge (2001).

Biostratigraphy

Lower *Lygistepollenites balmei* spore-pollen Zone

Sample at: 925.1 metres

Age: Paleocene.

The shallowest sidewall core examined is assigned to the Lower *L. balmei* Zone with low confidence based on the dominance of gymnosperm pollen in the assemblage (notably *Podocarpidites* spp at 31% and *Phyllocladidites mawsonii* at 24%), combined with the frequent occurrence of *Tetracolporites verrucosus* (1.2%) a species which is both inconsistent and rare above this zone. No species that commence their ranges within the *L. balmei* Zone were identified and this feature combined with rare occurrence of *Proteacidites clinei* ms suggests a position low in the zone.

Upper *Forcipites longus* spore-pollen Zone

Interval: 1040.9 to 1095.5 metres.

Age: Late Maastrichtian.

The shallower of the two sidewall cores is assigned to the Upper *F. longus* Zone on the FAD (First Appearance Datum) of the distinctive spore *Tripunctisporis maastrichtiensis*, the primary index species of the zone. In contrast, the deeper sidewall core is assigned to the zone on the secondary definition, an increase in the abundance of *Gambierina rudata* which in this case is 16% of spore-pollen count, based on the latest zone revision by Partridge (1999). Both samples are considered to be no younger than the Upper *F. longus* Zone based on the LADs (Last Appearance Datums) of *Battenipollis sectilis* and *Pseudowinterapollis wahooensis*. The bottom sample also contains the LADs in Durroon-1 of the additional index species *Tricolporites lilliei* and *Tricolpites confessus*.

Lower *Forcipites longus* spore-pollen Zone

Interval: 1132.3 to 1219.2 metres

Age: Early Maastrichtian.

The three sample are all assigned to Lower *F. longus* Zone on the presence of the eponymous species *Forcipites longus* and lack of younger features. Other index species recorded that are considered to range no older than this zone are *Tetracolporites verrucosus* and *Proteacidites reticuloconcavus* ms which are only recorded from the shallowest sample at 1132.3m. This latter sample also contains the common occurrence (10% of combined SP + MP counts) of small diaphanous dinocysts. These forms are identified in the counts by their ìpigment spotsî, and they cannot be assigned to any known genus as their morphology is not yet resolved.

***Tricolporites lilliei* spore-pollen Zone**

Interval: 1238 to 1311 metres

Age: Late Campanian.

Two cuttings and two sidewall cores are assigned to this zone on the presence of either the eponymous species *Tricolporites lilliei* or the accessory index species *Battenipollis sectilis* neither of which range below this zone (Helby *et al.*, 1987; fig.33). The consistent presence of *Gambierina rudata* (average 3%) and rarity of *Forcipites sabulosus* supports this zone assignment. The samples are dominated by *Nothofagidites* pollen (average >25%), spore of *Cyathidites* (average >10%) and occasional abundances of the gymnosperm pollen *Trichotomosulcites subgranulatus* (from <5% to >10%). The microplankton in the samples are not considered age diagnostic but they do include the youngest recorded occurrences of the genera *Morkallacysta* and *Rimosicysta* in Durroon-1.

***Nothofagidites senectus* spore-pollen Zone**

Interval: 1323 to 1366 metres and caved down to 1384 metres

Age: Early Campanian.

The spore-pollen assemblages from both sidewall cores and cuttings are confidently assigned to the *N. senectus* Zone on the common to abundant occurrence of *Nothofagidites* pollen (typically 5% to 30%), and consistent rare to frequent presence of *Forcipites sabulosus* (typically <1% to ~5%). A position high in the *N. senectus* Zone is favoured based on *Nothofagidites* pollen being significantly more abundant than *Forcipites sabulosus*. In the lower part the zone in both the Otway and Gippsland Basin the reverse relationship occurs with *Forcipites sabulosus* often >10% and *Nothofagidites* generally rare with abundances of <1%. None of the other species recorded are considered particularly zone diagnostic, but it is worth noting that the occurrence of *Coptospora pileolus* ms in two of the four samples is consistent with the youngest occurrence of this species in the Gippsland Basin. Morgan (1991) in contrast incorrectly treats the LAD of this species as a marker for the underlying *P. mawsonii* Zone. The microplankton in the samples are not considered age diagnostic, but they do include the interpreted lacustrine genera *Morkallacysta* and *Rimosicysta*.

***Phyllocladidites mawsonii* spore-pollen Zone**

Interval: 1374.6 to 1533.1 metres

Age: Turonian.

The spore-pollen assemblages are confidently assigned to *P. mawsonii* Zone based on the very rare presence of the eponymous species in six of the seven sidewall cores analysed. Index species indicating an age no younger than this zone are the occurrence of the spores *Appendicisporites distocarinatus* at 1432.6, *Verrucosisporites admirabilis* ms at 1411-20m, 1463m and 1493.5m, and the rare presence of *Crybelosporites striatus* between 1432.6 and 1533.1m. However, the overwhelming characteristic of the zone is the dominance of gymnosperm pollen *Dilwynites* (range 8% to 55%, average 30%), and *Cupressacites* (range <5% to 56%, average 21%). Abundance of these pollen types are characteristic of the middle part of the zone in Flaxman Formation in Otway Basin and Kipper Shale in the Gippsland Basin. A two-fold subdivision of the *P. mawsonii* Zone in Durroon-1 is evident on the ratio between *Dilwynites* and *Cupressacites* pollen with the latter showing dominance in the shallowest two sidewall cores at 1374.6 to 1386.8m. This peak in the abundance of *Cupressacites* pollen is interpreted to correlate with a similar abundance spike in the Banoon Member at the top of the Flaxman Formation in the Otway Basin (Partridge, 2001). A few angiosperm species show anomalous older range extensions in Durroon-1 compared to this zone in the adjacent Otway and Gippsland Basins. These are *Forcipites* sp. possibly related to *Forcipites stipulatus* Dettmann & Jarzen 1988, *Peninsulapollis gillii* (Cookson 1957), *P. askiniae* Dettmann & Jarzen 1988 and possible specimens of *Proteacidites palisadus* Couper 1953.

***Rimosicysta* microplankton Superzone**

Interval: 1374.6 to 1533.1 metres

Age: Turonian.

The samples from the Durroon Formation are also assigned to the *Rimosicysta* Superzone proposed by Partridge (1999) based on the unusual algal assemblage described from the Kipper Shale in the Gippsland Basin by Marshall (1989). The superzone is identified by the presence of either or both the algal genera *Rimosicysta* and *Wuroia*, which occur in all but the bottom sample in the interval assigned to the superzone in Durroon-1. A three-fold subdivision of the succession is apparent (Table 5). The deepest two sidewall cores are dominated by the algal cyst *Sigmopollis carbonis* (average ~75%), the middle three sidewall cores are characterised by *Rimosicysta* (average ~50%), while in the shallowest two sidewall cores the microplankton suite is overwhelmingly dominated by the non-marine dinocyst genus *Morkallacysta* (average >95%). Morgan (1991) proposes a finer subdivision of the microplankton succession, with emphasis on the LADs of species, but his splitting of the *Rimosicysta* species and restricted range given to *Wuroia* spp. was not supported by this study. It should also be noted that Morgan (1991) does not identify *Sigmopollis carbonis* which dominates a number of the assemblages. Testing of the biostratigraphic merits of these two alternative approaches to the subdivision of the microplankton succession through the Durroon Formation awaits the drilling of further exploration wells. In the meantime critical information for this future exploration could be obtained from the full systematic description and illustration of these well-preserved and diverse non-marine microplankton assemblages.

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Table 1. Interpretative Palynological Data from Durroon-1

No.	Sample Type	Depth Metres	Depth Feet	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	SWC 1/1	925.1	3035	Esso	Lower *L. balmei*	B4			LAD of *Tetracolporites verrucosus*	Non-marine - fluvial
2	Cuttings	963-72	3160-90	GA-1	Indeterminate					Non-marine - fluvial
3	SWC 30/2	977.2	3206	Esso	Barren					
4	Cuttings	1000-08	3280-310	GA-1	Indeterminate					Non-marine - fluvial
5	SWC 28	1040.9	3415	Esso	Upper *F. longus*	B1			FAD of *Tripunctisporis maastrichtiensis*	Non-marine - fluvial
6	Cuttings	1055-64	3460-90	GA-1	Indeterminate					Non-marine - fluvial
7	SWC 26	1095.5	3594	Esso	Upper *F. longus*	B4			*Gambierina rudata* common at 16%	Non-marine - fluvial
8	SWC 25	1132.3	3715	Esso	Lower *F. longus*	B2			FAD of *Proteacidites reticuloconcavus* ms	Non-marine - lacustrine
9	SWC 24	1171.7	3844	Esso	Lower *F. longus*	B3				Non-marine - fluvial
10	SWC 23	1219.2	4000	Esso	Lower *F. longus*	B3			FAD of *Forcipites longus*	Non-marine - fluvial
11	Cuttings	1238-87	4060-90	GA-1	*T. lilliei*	D2				Deltaic - Lacustrine
12	SWC 22	1249.7	4100	Esso	*T. lilliei*	B3			LAD of *Forcipites sabulosus*	Deltaic - Lacustrine
13	SWC 30/3	1287.2	4223	Esso	*T. lilliei*	B4				Deltaic - Lacustrine
14	Cuttings	1302-11	4270-300	GA-1	*T. lilliei*	D1			FAD of *Tricolporites lilliei*	Deltaic - Lacustrine
15	SWC 20	1310.6	4300	Morgan	Indeterminate					Deltaic - Fluvial
16	Cuttings	1323-29	4340-60	GA-1	*N. senectus*	D2				Deltaic - Lacustrine
17	SWC 19	1341.1	4400	Esso	*N. senectus*	B1				Deltaic - Lacustrine
18	SWC 18	1359.4	4460	Morgan	*N. senectus*	B2			FAD of *Nothofagidites senectus* in SWC	Non-marine - fluvial
19	Cuttings	1366-75	4480-510	GA-1	*N. senectus - P. mawsonii*		*Rimosicysta* Superzone	D3	LAD of common *Morkallacysta*	Lacustrine - fresh
20	SWC 17	1374.6	4510	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3	Abundant *Morkallacysta*	Lacustrine - fresh
21	Cuttings	1375-84	4510-40	GA-1	Mostly caved *N. senectus*				Abundant *Morkallacysta*	Lacustrine - fresh
22	SWC 16	1386.8	4550	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3	Abundant *Morkallacysta*	Lacustrine - fresh
23	Cuttings	1402-11	4600-30	GA-1	*P. mawsonii*	D2	*Rimosicysta* Superzone	D3	Abundant *Morkallacysta*	Lacustrine - fresh
24	Cuttings	1411-20	4630-60	GA-1	*P. mawsonii*	D2	*Rimosicysta* Superzone	D3	Abundant *Morkallacysta*	Lacustrine - fresh
25	SWC 14	1432.6	4700	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3	LAD of *Appendicisporites distocarinatus*	Lacustrine - fresh
26	SWC 13	1463.0	4800	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3		Lacustrine - fresh
27	SWC 12	1493.5	4900	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3		Lacustrine - fresh
28	SWC 11	1510.3	4955	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B3	FAD of *Rimosicysta*	Lacustrine - fresh
29	SWC 10	1533.1	5030	Esso	*P. mawsonii*	B1	*Rimosicysta* Superzone	B4	Very abundant *Dilwynites* pollen	Lacustrine - fresh

ABBREVIATIONS

*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum
GA-1 = Samples collected Stage-1 Work program
Esso = Samples processed in Esso laboratory
Morgan = Samples processed in Roger Morgan's laboratory

CONFIDENCE RATINGS

Alpha Code Linked to Sample
A = Core
B = Sidewall core
C = Coal cuttings
D = Ditch cuttings
J = Junk basket

Numeric Code Linked to Palynomorph Assemblage
1 = Excellent confidence: High diversity assemblage **plus** key zone species.
2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
3 = Fair confidence: Low diversity assemblage **plus** key zone species.
4 = Poor confidence: Moderate to high diversity **minus** key zone species.
5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Durroon-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Other MP%	NED	Noth%	Cup%
1	NA	SWC	1/1		3035		925.1	Moderate	Moderate	Good	40			<1%	<3%	
2	6405895	Cuttings		3160	3190	963.2	972.3	Low	Low	Poor-Fair	17			<5%	~8%	
3	NA	SWC	30/2		3206		977.2	Barren	NA	NA						
4	6405896	Cuttings		3280	3310	999.7	1008.9	Very Low	Very Low	Poor	8					
5	NA	SWC	28		3415		1040.9	High	High	Fair-Good	40			11%	6%	<1%
6	6405897	Cuttings		3460	3490	1054.6	1063.8	Very Low	Very Low	Poor	3					
7	NA	SWC	26		3594		1095.5	High	High	Fair-Good	49	1	<1%	2%	19%	<1%
8	NA	SWC	25		3715		1132.3	Moderate	Moderate	Fair-Good	43	2	10%	16%	9%	1%
9	NA	SWC	24		3844		1171.7	Low	Low	Poor-Fair	32	1	<1%	<1%	23%	
10	NA	SWC	23		4000		1219.2	Moderate	Low	Poor-Fair	15					
11	6405898	Cuttings		4060	4090	1237.5	1246.6	High	Moderate	Fair	32	4	8%	9%	22%	
12	NA	SWC	22		4100		1249.7	Low	Low	Poor-Fair	17					
13	NA	SWC	30/3		4223		1287.2	Moderate	Moderate	Poor-Fair	38			1%	29%	<1%
14	6405899	Cuttings		4270	4300	1301.5	1310.6	High	High	Fair-Good	44	1	4%	4%	30%	
15	NA	SWC	20		4300		1310.6	Very Low	Very Low	Fair	13			8%	5%	
16	6405900	Cuttings		4340	4360	1322.8	1328.9	High	High	Poor-Good	33	3	4%	5%	16%	<1%
17	NA	SWC	19		4400		1341.1	Moderate	Moderate	Poor-Fair	35			<1%	34%	
18	NA	SWC	18		4460		1359.4	Very Low	Very Low	Fair-Good	18			6%	23%	
19	6405901	Cuttings		4480	4510	1365.5	1374.6	Moderate	Low	Poor-Fair	25		17%	24%	18%	<1%
20	NA	SWC	17		4510		1374.6	High	High	Poor-Good	45	10	42%	23%		27%
21	6405902	Cuttings		4510	4540	1374.6	1383.8	Moderate	Moderate	Poor-Fair	25	2	5%	6%	33%	
22	NA	SWC	16		4550		1386.8	High	High	Poor-Good	40	10	31%	21%		56%
23	6405903	Cuttings		4600	4630	1402.1	1411.2	High	High	Poor	22	4	47%	39%	2%	14%
24	6405904	Cuttings		4630	4660	1411.2	1420.4	Moderate	High	Poor-Fair	19	5	50%	41%	<1%	~10%
25	NA	SWC	14		4700		1432.6	Moderate	Moderate	Poor-Fair	50	9	4%	59%		19%
26	NA	SWC	13		4800		1463.0	Moderate	Moderate	Poor-Fair	43	12	7%	30%		17%
27	NA	SWC	12		4900		1493.5	Moderate	High	Poor-Fair	41	11	20%	51%		24%
28	NA	SWC	11		4955		1510.3	Moderate	Moderate	Poor-Fair	48	3	3%	16%		20%
29	NA	SWC	10		5030		1533.1	High	Very High	Poor-Good	40	5	27%	75%		4%

ABBREVIATIONS

NA = Not Available

MP = Microplankton

SP = Spore-Pollen

NED = Neves Effect based on *Dilwynites/Araucariacites* Pollen Percentage

Noth% = Percentage of *Nothofagidites* pollen in SP count.

Cup% = Percentage of *Cupressacites* pollen in SP count.

Table 3. Durroon-1 samples - abundances of major palynomorph groups.

No.	Depth Metres	Depth Feet	Sample Type	Gleicheniidites & Clavifera spores	ALL OTHER Spores	Dilwynites & Araucariacites pollen	ALL OTHER Gymnosperms	Nothofagidites species	ALL OTHER Angiosperms	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON Fresh & Brackish	**SP + MP SUM**
1	925.1	3035	SWC 1/1	1.5%	10%	0.4%	74%	3%	11%			259		100%		259
2	963-72	3160-90	Cuttings		38%	3%	33%	7%	19%			58		100%		58
3	977.2	3206	SWC 30/2													
4	1000-08	3280-310	Cuttings													
5	1040.9	3415	SWC 28		16%	11%	36%	6%	30%	0.4%	0.7%	270		100%		267
6	1055-64	3460-90	Cuttings													
7	1095.5	3594	SWC 26	0.4%	17%	1.6%	25%	19%	36%		0.8%	256		100%	0.4%	255
8	1132.3	3715	SWC 25		26%	16%	23%	9%	24%	2.1%	0.4%	233		90%	10%	252
9	1171.7	3844	SWC 24	0.8%	27%	0.8%	27%	23%	20%	1.2%	1.2%	251		100%	0.4%	246
10	1219.2	4000	SWC 23													
11A	1238-87	4060-90	Cuttings		38%	3%	17%	21%	20%		1.1%	95		85%	15%	110
11B	1238-87	4060-90	Cuttings	0.4%	24%	11%	29%	22%	12%	0.4%	1.2%	259		95%	5%	268
12	1249.7	4100	SWC 22													
13	1287.2	4223	SWC 30/3		28%	1%	28%	29%	15%		0.4%	240		100%		239
14	1302-11	4270-300	Cuttings	0.4%	21%	4%	28%	30%	17%	0.4%		252		96%	4%	261
15	1310.6	4300	SWC 20		27%	8%	38%	5%	11%		11%	37		100%		33
16A	1323-29	4340-60	Cuttings		17%	4%	30%	31%	18%			122		100%		122
16B	1323-29	4340-60	Cuttings		45%	10%	41%	1.0%	4%			105		94%	6%	112
17	1341.1	4400	SWC 19													
18	1359.4	4460	SWC 18		23%	6%	21%	23%	24%		3.4%	119		100%		115
19	1366-75	4480-510	Cuttings		19%	23%	25%	18%	12%	2.2%	0.6%	180		83%	17%	212
20	1374.6	4510	SWC 17	0.5%	9%	23%	57%		10%			192		58%	42%	329
21	1375-84	4510-40	Cuttings		19%	6%	23%	33%	18%			219		95%	5%	231
22	1386.8	4550	SWC 16	0.4%	4%	21%	67%		7%			232		69%	31%	334
23	1402-11	4600-30	Cuttings	0.7%	4%	38%	52%	1.4%	2.9%	0.7%		140		53%	47%	264
24A	1411-20	4630-60	Cuttings		9%	40%	47%	0.9%	1.9%	0.9%		108		57%	43%	187
24B	1411-20	4630-60	Cuttings	1.9%	7%	43%	48%					54		34%	66%	161
25	1432.6	4700	SWC 14	0.6%	8%	58%	33%		0.6%			166		96%	4%	173
26	1463.0	4800	SWC 13	0.4%	13%	30%	55%		1.7%			236		93%	7%	253
27	1493.5	4900	SWC 12	0.5%	10%	50%	40%					199		82%	18%	244
28	1510.3	4955	SWC 11	0.4%	38%	16%	45%		0.4%			225		93%	7%	242
29	1533.1	5030	SWC 10	0.5%	1%	75%	23%		0.5%			183		73%	27%	249

SAMPLES WITH COUNTS ON DIFFERENT RESIDUE SIZE FRACTIONS

11A = Counts of slide with coarse fraction.
11B = Counts of slide with fine fraction.
16A = Counts of slide with fine fraction.
16B = Counts of slide with coarse fraction.
24A = Counts of slide with coarse fraction.
24B = Counts of slide with fine fraction.

Table 4. Durroon-1 - spore-pollen distribution.

No.	Depth Metres	Depth Feet	Sample Type	SPORE SPECIES	Aequitriradites spp.	Appendicisporites distocarinatus	Arcellites disciformis	Baculatisporites & Osmundacidites spp.	Balmeisporites glenelgensis	Balmeisporites holodictyus	Camarozonosporites bullatus	Camarozonosporites heskermensis	Camarozonosporites horrendus ms	Ceratosporites equalis	Cicatricosisporites/Ruffordiaspora spp.	Coptospora pileolus ms	Crybelosporites brennerii	Crybelosporites striatus	Cyathidites splendens	Cyathidites spp. large >40µm	Cyathidites spp. small <40µm	Dictyophyllidites spp.	Foraminisporis asymmetricus	Foraminisporis dailyi	Foraminisporis wonthaggiensis	Gleicheniidites circinidites	Herkosporites elliottii	Laevigatosporites spp.	Latrobosporites amplus	Marattisporites scabratus	Monolete spores undiff.	Neoraistrickia truncata	Osmundacidites wellmanii	Peromonolites densus	Perotrilites spp.	Retitriletes spp.	Rugulatisporites mallatus
1	925.1	3035	SWC 1/1					1.2%			X								X		0.8%	1.2%				1.5%	1.2%	4.2%	X		0.4%		X	0.4%		0.4%	X
2	963-72	3160-90	Cuttings					1.7%													6.9%							26%			1.7%		X				
3	977.2	3206	SWC 30/2																																		
4	1000-08	3280-310	Cuttings																									X									
5	1040.9	3415	SWC 28					1.5%											X		3.4%	0.7%					1.9%	5.6%	X				X	X			
6	1055-64	3460-90	Cuttings																		X							X									
7	1095.5	3594	SWC 26					1.2%				X	X						X		1.2%				X	0.4%	0.8%	3.1%	X				X	X	0.8%	3.1%	
8	1132.3	3715	SWC 25					0.4%				X	X						X		2.2%	0.4%					3.1%	4.0%	0.9%				X	0.4%	4.0%	4.8%	
9	1171.7	3844	SWC 24					2.9%							0.8%				X	0.4%	4.1%					0.8%	1.2%	6.9%		1.2%						3.3%	
10	1219.2	4000	SWC 23																								X		X						X		
11A	1238-87	4060-90	Cuttings					1.1%												2.1%	18%							3.2%					X			6.4%	
11B	1238-87	4060-90	Cuttings		X			1.2%				X			1.2%					1.2%	12%					0.4%	0.4%	3.5%	0.4%					0.4%		1.2%	
12	1249.7	4100	SWC 22																								X							X	X		
13	1287.2	4223	SWC 30/3		X			2.1%					X		0.4%					1.3%	4.2%		0.4%				3.8%	6.7%					X		2.1%	4.6%	
14	1302-11	4270-300	Cuttings		0.4%		X			X					0.8%		X			0.4%	10%	0.4%	X			0.4%	0.4%	2.4%	X				X		X	2.4%	
15	1310.6	4300	SWC 20																	X	21%	3.0%						3.0%									
16A	1323-29	4340-60	Cuttings																		7.4%							5.7%			0.8%					0.8%	
16B	1323-29	4340-60	Cuttings					4.8%		X		X			3.8%	X			X	1.9%	16%		X				1.0%	1.9%		X			X		X	7.6%	
17	1341.1	4400	SWC 19		X			X						X	X	X					X					X	X	X	X		X				X	X	
18	1359.4	4460	SWC 18												X					1.7%	11%							8.7%								0.9%	
19	1366-75	4480-510	Cuttings					1.1%							0.6%					0.6%	8.6%						2.3%	2.9%							1.1%	0.6%	
20	1374.6	4510	SWC 17		X			0.5%				X		X	X	X				0.5%	3.1%	0.5%		X		0.5%	X	2.1%		0.5%					X	0.5%	
21	1375-84	4510-40	Cuttings					0.9%							X	X				1.4%	9.6%	0.9%	X					2.7%					X		X	1.4%	
22	1386.8	4550	SWC 16					0.4%						X	X	X				X	1.7%					0.4%	X	0.4%		0.9%		X			X	X	
23	1402-11	4600-30	Cuttings												X					0.7%	X	X				0.7%	0.7%	1.4%	X						X	1.4%	
24A	1411-20	4630-60	Cuttings																		6.5%						0.9%	1.9%									
24B	1411-20	4630-60	Cuttings					3.7%													1.9%	X				1.9%	X	X	X				X		X	1.9%	
25	1432.6	4700	SWC 14		X	X		1.8%				X		X	X			X		0.6%	2.4%		X			0.6%	X	0.6%					X		X	0.6%	
26	1463.0	4800	SWC 13					2.5%	X			X			0.8%	X		X		0.8%	1.7%		X		X	0.4%		2.5%		X		X	X		X	0.8%	
27	1493.5	4900	SWC 12					1.5%						X	X	X		X		1.5%	2.0%		X	X	X	0.5%	X	1.5%					X		X	1.0%	
28	1510.3	4955	SWC 11					7.1%						X	X					9.8%	4.4%	0.4%	X	X	X	0.4%		3.1%				X			X	2.2%	
29	1533.1	5030	SWC 10					0.5%						X	X	X		X		X	X		X		X	0.5%		X				X	X		X	X	

ABBREVIATIONS: X = Present % = Percentage cf. = Compare with

Table 4. Durroon-1 - spore-pollen distribution.

No.	Depth Metres	Depth Feet	Sample Type	Stereisporites antiquisporites	Stereisporites regium	Trilete spores undiff.	Triporoletes reticulatus	Tripunctisporis maastrichtiensis	Tuberculatosporites sp. A	Verrucosisporties admirabilis ms	**TOTAL Spores**	**GYMNOSPERM SPECIES**	Araucariacites australis	Corollina spp.	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites spp.	Dilwynites tuberculatus	Lygistepollenites balmei	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites eunuchus ms	Phyllocladidites mawsonii	Phyllocaldidites reticulosaccatus	Phyllocaldidites verrucosus	Podocarpidites spp.	Trichotomosulcites subgranulatus	**TOTAL Gymnosperms**	**ANGIOSPERM SPECIES**	Angiosperm pollen undiff.	Aglaoreidia sp.	Australopollis obscurus	Battenipollis sectilis
1	925.1	3035	SWC 1/1	0.8%	X			X			12%					X	0.4%			1.5%	2.3%		1.9%	34%	0.4%	1.2%	31%	1.9%	74%		1.2%			
2	963-72	3160-90	Cuttings			1.7%					38%						3.4%			8.6%		1.7%		6.9%			16%		36%					
3	977.2	3206	SWC 30/2																															
4	1000-08	3280-310	Cuttings					X					X														X							
5	1040.9	3415	SWC 28	1.1%	0.7%	0.7%	0.4%	X			16%		9.4%		0.4%	0.4%	1.5%			1.9%		8.2%		4.9%	X		19%	2.2%	48%		0.4%			X
6	1055-64	3460-90	Cuttings																								X							
7	1095.5	3594	SWC 26	2.4%	2.8%	2.0%	X				18%		1.6%	0.4%	0.8%					0.4%		0.8%		9.4%	X	0.4%	11%	2.8%	27%		1.6%			4.3%
8	1132.3	3715	SWC 25	4.4%	X	1.3%	0.4%				26%		4.0%		1.3%	0.4%	13%					1.8%		8.4%		0.4%	11%	0.4%	41%		0.9%			1.3%
9	1171.7	3844	SWC 24	2.0%	1.6%	2.9%					28%						0.4%	0.4%				2.0%		11%		1.6%	11%	2.4%	29%		1.2%			X
10	1219.2	4000	SWC 23			X	X																	X										X
11A	1238-87	4060-90	Cuttings			4.3%	2.1%	1.1%			38%		1.1%				2.1%					1.1%		2.1%			8.5%	5.3%	20%		4.3%			
11B	1238-87	4060-90	Cuttings			2.4%	0.8%				25%		3.1%	X		0.8%	8.2%					1.2%		8.6%			7.1%	12%	41%		0.4%	0.4%		
12	1249.7	4100	SWC 22			X																		X	X		X							X
13	1287.2	4223	SWC 30/3		X	1.3%	0.8%				28%		0.8%		0.4%		0.4%					2.5%	X	5.4%			16%	3.3%	29%		0.8%		X	0.8%
14	1302-11	4270-300	Cuttings	X		1.6%	1.6%	0.4%			21%		1.6%	0.8%		0.4%	2.0%		X	0.4%		1.6%		5.6%			8.8%	11%	32%		2.4%			X
15	1310.6	4300	SWC 20		X	3.0%					30%						9.1%			3.0%		X		3.0%			36%		52%					
16A	1323-29	4340-60	Cuttings					2.5%			17%				0.8%		4.1%					2.5%		7.4%			8.2%	11%	34%		2.5%			
16B	1323-29	4340-60	Cuttings			1.9%	4.8%	1.0%			45%		4.8%			X	4.8%					1.0%	1.0%	6.7%			30%	1.9%	50%					
17	1341.1	4400	SWC 19	X			X						X			X						X		X		X	X	X						
18	1359.4	4460	SWC 18	0.9%							23%		1.7%				4.3%							13%			7.8%	0.9%	28%		0.9%			
19	1366-75	4480-510	Cuttings			0.6%	1.7%				20%		13%	0.6%	0.6%	X	11%					1.7%		10%		X	9.7%	2.9%	50%		0.6%			
20	1374.6	4510	SWC 17	X		1.6%	X		X		10%		3.6%	1.6%	27%	X	19%	0.5%				3.6%		1.0%		X	22%	1.6%	80%				X	
21	1375-84	4510-40	Cuttings			1.8%	0.5%				19%		2.7%				3.7%					2.7%		3.7%		X	13%	3.7%	30%		0.5%			0.5%
22	1386.8	4550	SWC 16	X	cf.	0.9%	X		X		5%		1.3%	X	56%	X	19%					3.0%		X		X	7.8%	X	88%				X	
23	1402-11	4600-30	Cuttings								5%		4.3%		14%		34%					12%					24%	2.9%	91%		0.7%		X	
24A	1411-20	4630-60	Cuttings								9%		0.9%		20%		39%					1.9%					24%	1.9%	88%					
24B	1411-20	4630-60	Cuttings							X	9%		11%		X		31%					7.4%					37%	3.7%	91%					
25	1432.6	4700	SWC 14	0.6%		1.2%	X		X		8%		13%	X	19%		46%					2.4%		X			10%	1.2%	91%				X	
26	1463.0	4800	SWC 13	2.5%		1.3%	X		X	X	14%		11%	2.5%	17%	X	19%					8.5%	X	0.4%			26%	X	85%				X	
27	1493.5	4900	SWC 12	1.0%		1.0%	X		X	X	10%		15%	2.0%	24%		36%					3.5%	X				9.5%	0.5%	90%					
28	1510.3	4955	SWC 11	4.9%		11	0.9%				38%		8.4%	3.1%	20%	X	7.6%					1.3%	X	X			20%	1.8%	61%					
29	1533.1	5030	SWC 10	X		X	X				1.1%		20%	X	4.4%		55%					2.7%	X	X		X	16%	X	98%					

ABBREVIATIONS: X = Present % = Percentage cf. = Compare with

Table 4. Durroon-1 - spore-pollen distribution.

No.	Depth Metres	Depth Feet	Sample Type	Concolpites leptos	Dicotetradites clavatus	Forcipites longus	Forcipites renmarkensis ms	Forcipites sabulosus	Forcipites sp.	Gambierina edwardsii	Gambierina rudata	Myrtaceidites parvus/mesonesus	Nothofagidites spp.	Nothofagidites brachyspinulosus	Nothofagidites endurus	Nothofagidites senectus	Peninsulapollis askiniae	Peninsulapollis gillii	Periporopollenites polyoratus	Proteacidites spp.	Proteacidites clinei ms	Proteacidites otwayensis ms	Proteacidites pallisadus	Proteacidites reticuloconcavus ms	Pseudowinterapollis wahooensis	Retimonocolpites peroreticulatus	Tetracolporites verrucosus	Tetradopollis securus ms	Tricolp(or)ates spp.	Tricolpites confessus	Tricolpites waiparaensis	Tricolporites lilliei	Triporopollenites spp.	**TOTAL Angiosperms**	**TOTAL SPORE-POLLEN COUNT**
1	925.1	3035	SWC 1/1								0.4%		2.3%		0.4%			1.5%	4.2%	1.9%	X						1.2%		0.8%					14%	259
2	963-72	3160-90	Cuttings								6.9%			1.7%	5.2%			1.7%	1.7%	5.2%									3.4%					26%	58
3	977.2	3206	SWC 30/2																																
4	1000-08	3280-310	Cuttings										X							X															
5	1040.9	3415	SWC 28	X	0.7%						2.2%	X		0.7%	5.2%			4.9%	1.5%	9.0%	0.4%				X		4.9%		6.0%	0.4%	X			36%	267
6	1055-64	3460-90	Cuttings																																
7	1095.5	3594	SWC 26		0.4%		X			X	16%				11%	7.9%		2.4%	0.4%	9.4%			X		X			X	1.2%	0.4%	X	X	0.4%	55%	254
8	1132.3	3715	SWC 25			X	X			X	2.2%				3.5%	5.3%		3.5%		11%		X	X	1.3%	X		X		2.6%	0.4%	0.9%	0.4%		33%	227
9	1171.7	3844	SWC 24			0.4%		0.4%			1.6%			X	8.6%	15%		4.5%		7.8%					0.4%				3.3%	X	0.4%			43%	245
10	1219.2	4000	SWC 23			X								X				X		X					X				X	X		X			
11A	1238-87	4060-90	Cuttings								1.1%				5.3%	16%		4.3%		5.3%									1.1%	2.1%		2.1%		41%	94
11B	1238-87	4060-90	Cuttings		0.4%						1.6%				2.0%	20%		1.2%	0.4%	5.1%									2.7%			X		35%	
12	1249.7	4100	SWC 22		X		X	X			X					X		X		X									X	X		X			
13	1287.2	4223	SWC 30/3				X	X		X	6.7%				4.2%	25%		0.8%		2.5%								0.4%	2.5%	X				44%	239
14	1302-11	4270-300	Cuttings					0.4%			5.6%		0.4%		X	29%		2.4%		4.0%						X			1.6%	X		0.8%		47%	251
15	1310.6	4300	SWC 20										6.1%		X	X		X		6.1%									6.1%					18%	33
16A	1323-29	4340-60	Cuttings					0.8%			1.6%		31%					4.9%		6.6%										1.6%				49%	122
16B	1323-29	4340-60	Cuttings					X			X		1.0%		X			1.0%		2.9%									X	X				5%	
17	1341.1	4400	SWC 19				X	X					X	X	X	X	X	X		X									X	X	X				
18	1359.4	4460	SWC 18					7.0%					22%		1.7%			8.7%		6.1%									2.6%					49%	115
19	1366-75	4480-510	Cuttings					1.1%					18%			X		4.6%		4.0%									1.1%	0.6%				30%	175
20	1374.6	4510	SWC 17						X								X	X		1.6%			cf.						8.3%				X	10%	192
21	1375-84	4510-40	Cuttings					0.5%			1.4%		33%			X		5.5%		2.7%									6.4%	0.9%				51%	219
22	1386.8	4550	SWC 16						X								X	X		X			cf.						7.3%	X				7.3%	232
23	1402-11	4600-30	Cuttings					X					1.4%			X		0.7%		0.7%									0.7%					4.3%	139
24A	1411-20	4630-60	Cuttings										0.9%																			1.9%		2.8%	107
24B	1411-20	4630-60	Cuttings													X		X		X									X						54
25	1432.6	4700	SWC 14						X											X			cf.						0.6%					0.6%	166
26	1463.0	4800	SWC 13															cf.		0.4%									1.3%				X	1.7%	236
27	1493.5	4900	SWC 12															cf.		X									X						199
28	1510.3	4955	SWC 11																										0.4%					0.4%	225
29	1533.1	5030	SWC 10																	X						X			0.5%					0.5%	183

ABBREVIATIONS: X = Present % = Percentage cf. = Compare with

Table 5. Durroon-1 - microplankton distribution.

No.	Depth Metres	Depth Feet	Sample Type	**ACRITARCHS & ALGAE**	Cymatisphaera spp.	Micrhystridium spp.	Amosopollis cruciformis	Botryococcus braunii	Circulisporites parvus	Rimosicysta spp.	Schizosporis spp.	Sigmopollis carbonis	Sigmopollis hispidis	Tetraporina sp.	Wuroia spp.	**NON-MARINE DINOCYSTS**	Cobricosphaeridium spp.	Morkallacysta spp.	Tetrachacysta sp.	Microplankton undiff.	**TOTAL MP COUNT**
1	925.1	3035	SWC 1/1																		
2	963-72	3160-90	Cuttings																		
3	977.2	3206	SWC 30/2																		
4	1000-08	3280-310	Cuttings																		
5	1040.9	3415	SWC 28																		
6	1055-64	3460-90	Cuttings																		
7	1095.5	3594	SWC 26			100%															1
8	1132.3	3715	SWC 25														12%			88%	25
9	1171.7	3844	SWC 24															100%			1
10	1219.2	4000	SWC 23																		
11A	1238-87	4060-90	Cuttings															19%		81%	16
11B	1238-87	4060-90	Cuttings							X	8%							8%		85%	13
12	1249.7	4100	SWC 22																		
13	1287.2	4223	SWC 30/3																		
14	1302-11	4270-300	Cuttings			10%				40%								20%		30%	10
15	1310.6	4300	SWC 20																		
16A	1323-29	4340-60	Cuttings																		
16B	1323-29	4340-60	Cuttings					29%		X	14%							X		57%	7
17	1341.1	4400	SWC 19																		
18	1359.4	4460	SWC 18																		
19	1366-75	4480-510	Cuttings					3%		3%								35%		59%	37
20	1374.6	4510	SWC 17			X	X	0.7%				1.5%	0.7%		X		X	97%	X		137
21	1375-84	4510-40	Cuttings															8%		92%	12
22	1386.8	4550	SWC 16				X		X	X		X					X	100%	X	X	102
23	1402-11	4600-30	Cuttings					X		1%								99%			125
24A	1411-20	4630-60	Cuttings													8%		91%		1%	80
24B	1411-20	4630-60	Cuttings					X		3%				X		4%	X	93%			107
25	1432.6	4700	SWC 14			X	X	43%		14%		43%			X				X	X	7
26	1463.0	4800	SWC 13			X	X	6%		65%	X	24%	X					X	X	6%	17
27	1493.5	4900	SWC 12		X	2%				73%		24%			X		X		X		45
28	1510.3	4955	SWC 11			24%				X		53%								24%	17
29	1533.1	5030	SWC 10			2%						95%								3%	66

ABBREVIATIONS: X = Present % = Percentage

APPENDIX C3.

Palynological analysis of Eocene interval 1380 to 2036m in King-1, Bass Basin.

by

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Palynological analysis of Eocene interval 1380 to 2036m in King-1, Bass Basin

by Alan D. Partridge

Introduction

This palynological study of the Eastern View Group penetrated in King-1 is a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

As no previous palynological work has been undertaken on King-1 this study has the dual objectives of providing initial age dating of the Eastern View Group, and investigating the abundance and diversity of marine dinocysts in the palynological assemblages from the latest Early Eocene and Middle Eocene (Upper *M. diversus* to Lower *N. asperus* Zones). The study is also intended to compliment a new palynological study of the equivalent interval in the adjacent Cormorant-1 well (Partridge, 2002a). Most of the samples analysed in King-1 are from conventional cores 1 to 4 cut between 1397 and 1440m, from the base of a distinctive shale interval between 1315 and 1455m informally named the Toolka unit (Partridge, 2002b). This latter unit lacks both conventional and sidewall cores in the adjacent Cormorant-1 well.

Materials and Methods

Twelve samples comprising 8 conventional core and 4 cuttings samples were analysed. Laboratory processing of the samples was performed by Geoscience Australia. However, due to an unfortunate misunderstanding or miscommunication the samples were given an initial coarse filtration, which had the effect of separating a significant proportion of the organic-walled microplankton (mostly dinocysts) from the finer fraction of the residue containing the majority of angiosperm pollen. This rendered unreliable the counted ratio of dinocysts to the spore-pollen in the assemblages. Separate counts of the two different residue size fractions gave a range of microplankton abundances of 1% to 21% (of combined MP + SP count) in the coarse fractions and zero to 4% in the finer fractions. These results are interpreted to indicate that the unbiased microplankton abundance would be in the range of <1% and <10%. As these values were considered unlikely to significantly increase with reprocessing, the author decided to completed the study on the available slides. Determination of the established zones, which are based on species ranges is not significantly affected by the skewed assemblages.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples is provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973), and for manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

Notwithstanding the skewing of the assemblages by the initial coarse filtration, exacerbated by low concentration of palynomorphs on the slides, sparse microplankton assemblages were recorded from the majority of samples. The eight samples from the four cores over the narrow interval from 1398 to 1439m gave assemblages dominated in the finer fraction by *Nothofagidites* pollen (>30%) confirming assignment to Lower *N. asperus* Zone. The absence of the species *Nothofagidites falcatus* in the core assemblages suggests a position very low in the zone. The coarser fractions of the residues contained most of the microplankton, and these assemblages were dominated by the marine to brackish-water species *Paralecaniella indentata* or other undescribed species interpreted as non-marine dinocysts. The latter are assigned to the non-marine genera *Cubiculosphaera* and *Saeptodinium* described by Harris (1974) and the informal genus *Ceratertius.* The interval is interpreted to be predominantly a shallow lacustrine environment into which there were occasional marine incursions.

Three of the four deeper cuttings sample are assigned to the *P. asperopolus* Zone, while the deepest sample is assigned to the older Upper *M. diversus* Zone. Dinocysts in these samples are generally rarer but are overall of higher diversity and mostly represented by cosmopolitan marine species. The assemblages are therefore interpreted to represent a restricted marine environment typical of a large lagoon or lake. The thinly bedded aspect of the interval 1525 to 1980m is interpreted to reflect rapid changes of environment, suggesting the water depth in the lagoon was generally shallow. Falls in the lake water level thus frequently resulted in the deposition of widespread thin coals and thin fluvial/deltaic sands. The thicker 60 metre shale between 1980 and 2040m in King-1, which is sampled by the deepest cuttings is in contrast interpreted to represent a deeper lagoon. This bed is correlated with the interval 2012 to 2042m in Cormorant-1 as both shales contain the distinctive dinocyst *Homotryblium tasmaniense*.

Biostratigraphy

Upper *Malvacipollis diversus* spore-pollen Zone

Sample at: 2013-2017 metres

Age: Early Eocene.

The deepest cuttings analysed is assigned to the this zone on the presence of *Myrtaceidites tenuis* and absence of younger index species of the overlying *P. asperopolus* Zone. Secondary species recorded that are consistent with this zone assignment include *Intratriporopollenites notabilis*, *Proteacidites ornatus* and common *P. grandis*. The associated microplankton are diagnostic of the *Homotryblium tasmaniense* Zone, which was originally defined by Harris (1985), and has subsequently been modified by Partridge (1999).

***Proteacidites asperopolus* spore-pollen Zone**

Interval: 1614 to 1860 metres.

Age: Early-Middle Eocene.

The zone identified by the First Appearance Datum (FAD) of *Conbaculatisporites apiculatus* ms at 1857-60m and the Last Appearance Datums (LAD) of *Intratriporopollenites notabilis* at 1614-17m. Other key index species were not recorded. The associated marine dinocysts in the samples are broadly consistent with a late Early Eocene age but are not zone diagnostic.

Lower *Nothofagidites asperus* spore-pollen Zone

Interval: 1398 to 1439 metres.

Age: Middle Eocene.

The assemblages from the four conventional cores are all referred to the Lower *N. asperus* Zone based on the increase in abundance of *Nothofagidites* pollen (typically to >30% of SP count), and the rare presence of index species, including *Tricolporites leuros* at 1439m and *Anisotricolporites triplaxis* at 1407m. The prominence of *Proteacidites leightonii* and absence of *Nothofagidites falcatus* in these core may represent a hitherto undocumented transitional zone interval between the *P. asperopolus* and *N. asperus* Zone that warrants further investigation.

The associated microplankton comprise long ranging cosmopolitan marine dinocysts and undescribed possibly endemic non-marine dinocysts neither of which are currently age or zone diagnostic. Full description and illustration of the non-marine dinocysts is needed and recommended. The frequent occurrence of the marine to possibly brackish-water dinocyst *Paralecaniella indentata* in two of the core samples is referred to as the *Paralecaniella* facies.

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Table 1. Interpretative Palynological Data from King-1

No.	Sample Type	Depth Metres	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	Core-1	1398	GA-1	Lower *N. asperus*	D2	*Paralecaniella* Facies		LAD of *Proteacidites asperopolus*	Lagoonal - brackish
2	Core-1	1400.31	GA-1	Lower *N. asperus*	D2				Lagoonal - fresh
3	Core-2	1404	GA-1	Lower *N. asperus*	D2				Lagoonal - fresh
4	Core-2	1407	GA-1	Lower *N. asperus*	D2				Lagoonal - fresh
5	Core-3	1425.38	GA-1	Lower *N. asperus*	D2				Lagoonal - fresh
6	Core-3	1430	GA-1	Lower *N. asperus*	D2				Lagoonal - brackish
7	Core-4	1435	GA-1	Lower *N. asperus*	D2	*Paralecaniella* Facies			Lagoonal - brackish
8	Core-4	1439	GA-1	Lower *N. asperus*	D2			FAD of *Tricolporites leuros*	Non-marine
9	Cuttings	1614-17	GA-1	*P. asperopolus*	D2	*H. tasmaniense*	D5	LAD of *Intratriporopollenites notabilis*	Lagoonal - restricted marine
10	Cuttings	1794-97	GA-1	*P. asperopolus*	D5				Lagoonal - restricted marine
11	Cuttings	1857-60	GA-1	*P. asperopolus*	D2			FAD of *Conbaculatisporites apiculatus* ms	Lagoonal - restricted marine
12	Cuttings	2013-17	GA-1	Upper *M. diversus*	D2	*H. tasmaniense*	D3	FAD of *Myrtaceidites tenuis*	Lagoonal - restricted marine

ABBREVIATIONS

*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum
GA-1 = Samples collected Stage-1 Work program

***CONFIDENCE RATINGS**

Alpha Code Linked to Sample
A = Core
B = Sidewall core
C = Coal cuttings
D = Ditch cuttings
J = Junk basket

Numeric Code Linked to Palynomorph Assemblage
1 = Excellent confidence: High diversity assemblage **plus** key zone species.
2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
3 = Fair confidence: Low diversity assemblage **plus** key zone species.
4 = Poor confidence: Moderate to high diversity **minus** key zone species.
5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from King-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
1	6405883	Core	1		1398	Moderate	Low	Poor- good	38	5				
2	6405884	Core	1		1400.31	High	Moderate	Poor- good	46	4	<2%	<10%	<20%	>30%
3	6405885	Core	2		1404	High	Moderate	Fair-good	35	3				
4	6405886	Core	2	1407	1407.02	Moderate	Low	Fair-good	44	1		<1%	<20%	>30%
5	6405887	Core	3		1425.38	Moderate	Moderate	Fair-good	39	1		<1%	<10%	>40%
6	6405888	Core	3		1430	Moderate	Moderate	Fair-good	36	4	<1%	<10%	<10%	>40%
7	6405889	Core	4		1435	Moderate	Moderate	Fair-good	36	2	<1%	<1%	<5%	>30%
8	6405890	Core	4		1439	Moderate	Low	Good	23					
9	6405891	Cuttings		1614	1617	Moderate	Moderate	Fair-good	51	2	<1%		<15%	>30%
10	6405892	Cuttings		1794	1797	Moderate	Low	Poor- good	19	2	<1%			
11	6405893	Cuttings		1857	1860	Moderate	Moderate	Poor- good	33	6			<15%	<20%
12	6405894	Cuttings		2013	2017	Moderate	Moderate	Poor- good	31	4				

ABBREVIATIONS

MP = Microplankton

SP = Spore-Pollen

NED = Neves Effect based on *Dilwynites/Araucariacites* Percentage

Noth% = Percentage of *Nothofagidites* in SP count.

Other MP = Brackish and fresh-water species

Table 3. Abundance of major palynomorph groups from King-1.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Gleicheniidites spp. spores	ALL OTHER spores	Dilwynites and Araucariacites pollen	ALL OTHER gymnosperm pollen	Nothofagidites species	ALL OTHER angiosperm pollen	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON fresh to brackish	MICROPLANKTON marine	**SP + MP SUM**
1		1398	Core															
2A		1400.31	Core	Fine		8%	1%	8%	31%	44%	9%		131		100%			119
2B		1400.31	Core	Coarse	2%	33%	26%	19%	3%	15%	1%	2%	107		79%	19%	2%	131
3		1404	Core															
4A	1407	1407.02	Core	Fine		6%	3%	7%	32%	46%	5%		111		100%			105
4B	1407	1407.02	Core	Coarse		46%	19%	9%	3%	19%	1%	3%	114		99%		1%	111
5A		1425.38	Core	Fine		3%		11%	44%	33%	8%	1%	123		100%			112
5B		1425.38	Core	Coarse	1%	17%	13%	41%	4%	19%	4%		113		98%		2%	110
6A		1430	Core	Fine		14%	2%	10%	42%	28%	5%		125		99%		1%	120
6B		1430	Core	Coarse	1%	48%	14%	6%	5%	23%		4%	110		80%	7%	14%	133
7		1435	Core	Fine		9%	2%	10%	35%	37%	6%		129		99%	1%		122
8		1439	Core															
9A	1614	1617	Cuttings	Fine		8%	3%	11%	35%	39%	4%		112		100%			107
9B	1614	1617	Cuttings	Coarse		47%	16%	10%	1%	27%			124		98%		2%	126
10	1794	1797	Cuttings															
11A	1857	1860	Cuttings	Fine		8%	1%	6%	25%	53%	7%		113		96%		4%	109
11B	1857	1860	Cuttings	Coarse	1%	43%	17%	9%	1%	26%	1%	2%	135		90%	1%	9%	144
12	2013	2017	Cuttings															

Table 4. King-1 samples - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	**SPORE SPECIES**	Baculatisporites spp.	Camarozonosporites heskermensis	Conbaculatisporites apiculatus ms	Cyathidites splendens	Cyathidites palaeospora	Foveotriletes balteus	Gleicheniidites circinidites	Ischyosporites spp.	Kuylisporites waterbolkii	Laevigatosporites major	Laevigatosporites ovatus	Latrobosporites marginatus	Matonisporites ornamentalis	Monolites alveolatus	Peromonolites spp.	Polypodiaceoisporites varus ms	Polypodiidites/Verrucatosporites spp.	Retitriletes spp.	Ricciaesporites boxatus ms	Rugulatisporites mallatus	Trilete spores undiff.	Verrucatosporites attinatus ms	Verrucosisporites kopukuensis	TOTAL SPORES	
1		1398	Core			X			X	X	X	X	X	X	X	X												X		
2A		1400.31	Core	Fine						5.0%				X		3.4%			X										8.4%	
2B		1400.31	Core	Coarse		4.8%	X		1.9%	9.6%	X	1.9%	X		X	3.8%	X					2.9%	1.9%			6.7%		1.9%	36%	
3		1404	Core			X			X	X	X	X			X		X	X		X		X						X		
4A	1407	1407.02	Core	Fine						5.7%															X	1.0%			6.7%	
4B	1407	1407.02	Core	Coarse		4.5%			15%	18%					X	3.6%				0.9%		0.9%	0.9%			0.9%		3.6%	48%	
5A		1425.38	Core	Fine						0.9%						1.8%						X						0.9%	3.6	
5B		1425.38	Core	Coarse		5.6%			4.6%			0.9%	0.9%		X	1.9%												4.6%	19%	
6A		1430	Core	Fine		X			X	8.4%			X			4.2%				0.8%						0.8%			14%	
6B		1430	Core	Coarse		4.7%			12%	8.5%		0.9%	3.8%		X	8.5%						2.8%						9.4%	51%	
7		1435	Core	Fine		0.8%			X	5.8%						1.7%				0.8%		X				0.8%	X	X	9.9%	
8		1439	Core													X												X		
9A	1614	1617	Cuttings	Fine				0.9%		5.6%						1.9%													8.4%	
9B	1614	1617	Cuttings	Coarse		2.4%	X	0.8%	12%	12%	X		X		X	8.9%				1.6%		X		X	X	7.3%		1.6%	47%	
10	1794	1797	Cuttings			X			X	X			X			X														
11A	1857	1860	Cuttings	Fine				1.0%		3.8%						2.9%					X					1.0%			8.6%	
11B	1857	1860	Cuttings	Coarse		0.8%			8.5%	15%	X	0.8%	X		X	14%										2.3%	X	3.8%	45%	
12	2013	2017	Cuttings			X			X	X		X			X	X									X			X		

ABBREVIATIONS

X = Present

C = Common

% = Percentage

Table 4. King-1 samples - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	GYMNOSPERM SPECIES	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites mawsonii	Podocarpidites spp.	Trichotomosulcites subgranulatus	TOTAL GYMNOSPERMS		ANGIOSPERM SPECIES	Angiosperm pollen undiff.	Anisotricolporites triplaxis	Banksieaeidites arcuatus	Beaupreaidites verrucosus	Bluffopollis scabratus	Cupanieidites orthoteichus	Dicotetradites clavatus	Ericipites crassiexinus/scabratus	Gothanipollis bassensis	Haloragacidites harrisii	Ilexpollenites spp.
1		1398	Core			X			X		X		X	X	X								X		X				X	
2A		1400.31	Core	Fine					0.8%					2.5%	4.2%	1.7%	9.2%					0.8%			0.8%	0.8%			20%	3.4%
2B		1400.31	Core	Coarse		7.7%		1.0%	17%	1.9%	6.7%			1.9%	9.6%		46%										X		1.0%	
3		1404	Core			X			X	X	X			X	X														X	
4A	1407	1407.02	Core	Fine					2.9%			1.0%		2.9	3.8%		10%			1.0%	X			1.0%	1.9%				22%	1.9%
4B	1407	1407.02	Core	Coarse		4.5%			13%	2.7%	1.8%			0.9%	6.4%		29%			0.9%			X			0.9%			3.6%	
5A		1425.38	Core	Fine									1.8%	8.0%	1.8%		12%			2.7%					0.9%			X	13%	0.9%
5B		1425.38	Core	Coarse		4.6%	0.9%		8.3%	0.9%	12%			17%	13%		56%			0.9%					0.9%	0.9%			7.4%	
6A		1430	Core	Fine			0.8%		2.5%					0.8%	8.4%		13%					0.8%				1.7%			9%	
6B		1430	Core	Coarse		6.6%			5.7%	1.9%	1.9%			0.9%	3.8%		21%													
7		1435	Core	Fine		0.8%	0.8%		0.8%	0.8%			0.8%	2.5%	5.8%	0.8%	13%					1.7%			0.8%				12%	X
8		1439	Core																					X	X				X	X
9A	1614	1617	Cuttings	Fine					2.8%		0.9%			4.7%	5.6%		14%									0.9%			19%	0.9%
9B	1614	1617	Cuttings	Coarse		5.6%			6.5%	4.0%	1.6%		0.8%	1.6%	4.8%	0.8%	26%					0.8%				0.8%			2.4%	
10	1794	1797	Cuttings						X	X	X			X	X														X	
11A	1857	1860	Cuttings	Fine					1.0%		1.0%			1.9%	3.8%		7.6%					1.9%				1.0%			28%	1.0%
11B	1857	1860	Cuttings	Coarse		2.3%			10%	5.4%	0.8%			1.5%	6.9%		27%									0.8%			9.2%	
12	2013	2017	Cuttings						X		X				X										X				X	

ABBREVIATIONS

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% = Percentage

Table 4. King-1 samples - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Intratriporopollenites notabilis	Liliacidites spp.	Lymingtonia sp.	Malvacipollis robustus	Malvacipollis subtilis	Myrtaceidites spp.	Myrtaceidites tenuis	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites vansteenisii	Periporopollenites spp.	Polycolporopollenites esobalteus	Proteacidites spp.	Proteacidites adenanthoides	Proteacidites annularis	Proteacidites asperopolus	Proteacidites differentipollis	Proteacidites grandis	Proteacidites incurvatus	Proteacidites kopiensis	Proteacidites leightonii
1		1398	Core						X			X		X	X	X	X				X			X	X		X		C
2A		1400.31	Core	Fine					0.8%	1.7%				0.8%	28%	3.4%	2.5%				11%		X	0.8%				X	0.8%
2B		1400.31	Core	Coarse						1.9%					1.0%	1.9%					8.7%						X		2.9%
3		1404	Core				X								X	X					X						X		C
4A	1407	1407.02	Core	Fine					1.9%	1.0%		1.0%		1.0%	30%	1.9%		1.0%	1.0%		5.7%		1.0%						
4B	1407	1407.02	Core	Coarse					0.9%			0.9%					1.8%		0.9%		8.2%	X							1.8%
5A		1425.38	Core	Fine									1.8%	3.6%	40%	2.7%			1.8%	0.9%	6.3%		0.9%					X	
5B		1425.38	Core	Coarse					0.9%						2.8%	0.9%	0.9%		0.9%		0.9%		0.9%				X		
6A		1430	Core	Fine					2.5%			0.8%	0.8%	0.8%	34%	5.9%	0.8%	0.8%	0.8%		8.4%		0.8%						
6B		1430	Core	Coarse								0.9%	0.9%		0.9%	0.9%	0.9%				10%								11%
7		1435	Core	Fine				X	X			0.8%	1.7%	0.8%	28%	5.0%		0.8%	3.3%	X	9.1%		X				X		X
8		1439	Core												X	X			X	X	X	X	X						
9A	1614	1617	Cuttings	Fine		0.9%			2.8%	0.9%		0.9%	0.9%	1.9%	30%	2.8%				0.9%	4.7%		0.9%				X		
9B	1614	1617	Cuttings	Coarse	0.8%			X	0.8%							0.8%					10%				X	0.8%			5.6%
10	1794	1797	Cuttings													X					X				X				X
11A	1857	1860	Cuttings	Fine					1.0%	1.0%				2.9%	24%				1.9%		5.7%								
11B	1857	1860	Cuttings	Coarse	0.8%				0.8%						0.8%						5.4%					2.3%			3.1%
12	2013	2017	Cuttings		X			X	X		X				X	X			X		X	X			X	C			X

ABBREVIATIONS

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Table 4. King-1 samples - spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	Proteacidites nasus	Proteacidites obesolabrus ms	Proteacidites obscurus	Proteacidites ornatus	Proteacidites pachypolus	Proteacidites prodigus ms	Proteacidites pseudomoides	Proteacidites recavus	Proteacidites reticuloscabratus	Proteacidites rugulatus	Proteacidites tenuiexinus	Proteacidites tuberculiformis	Pseudowinterapollis couperi	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Tricolp(or)ates spp.	Tricolpites phillipsii	Tricolporites adelaidensis	Tricolporites leuros	Tricolporites microreticulatus	Tricolporites paenestriatus	Tricolporites scabratus	Triporopollenites ambiguus	Triporopollenites simplis	ANGIOSPERM SUM	SPORE-POLLEN TOTAL
1		1398	Core		X							X			X					X	X	X		X	X		X			
2A		1400.31	Core	Fine			X											2.5%		4.2%									82%	119
2B		1400.31	Core	Coarse			X				X									1.0%		X							18%	104
3		1404	Core				X			X		C				X				X		X								
4A	1407	1407.02	Core	Fine												X				10%				X		X		X	83%	105
4B	1407	1407.02	Core	Coarse								X						0.9%		1.8%									23%	110
5A		1425.38	Core	Fine			0.9%											2.7%		6.3%									85%	112
5B		1425.38	Core	Coarse								X								6.5%									25%	108
6A		1430	Core	Fine									X							4.2%	X							0.8%	73%	119
6B		1430	Core	Coarse								X								1.9%		X							28%	106
7		1435	Core	Fine													X	X		12%	X								77%	121
8		1439	Core									X						X	X	X		X	X	X		X				
9A	1614	1617	Cuttings	Fine					0.9%						X			0.9%		7.5%									78%	107
9B	1614	1617	Cuttings	Coarse		X						X								4.8%		X			X	X			27%	124
10	1794	1797	Cuttings											X						X		X				X				
11A	1857	1860	Cuttings	Fine					1.0%											13%					1.9%				84%	105
11B	1857	1860	Cuttings	Coarse			0.8%													3.1%		X			0.8%				28%	130
12	2013	2017	Cuttings				X	X			X	X								X										

ABBREVIATIONS

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Table 5. King-1 samples - microplankton distribution.

No.	Top Metres	Base Metres	Sample Type	Residue Filter	ACRITARCHS & ALGAE	Botryococcus braunii	Pediastum sp.	SUM ACRITARCHS & ALGAE	NON-MARINE DINOCYSTS	Ceratertius gen. et sp. nov.	Cubiculosphaera spp.	Saeptodinium spp.	SUM NON-MARINE DINOCYSTS	MARINE DINOCYSTS	Dinocysts undiff.	Apectodinium spp.	Apteodinium sp.	Cordosphaeridium spp.	Diphyes colligerum	Eocladopyxis peniculata	Homotryblium tasmaniense	Hystrichokolpoma spinosum	Impagidinium spp.	Kenleyia spp.	Operculodinium centrocarpum	Paralecaniella indentata	Spinidinium spp.	Thalassiphora pelagica	SUM MARINE DINOCYSTS	**Total Microplankton**
1		1398	Core			X				X	X	X											X			X				
2A		1400.31	Core	Fine																										
2B		1400.31	Core	Coarse		11%		11%		11%	70%		81%													7%			7%	27
3		1404	Core								X																	X		
4A	1407	1407.02	Core	Fine																										
4B	1407	1407.02	Core	Coarse											100%														100%	1
5A		1425.38	Core	Fine																										
5B		1425.38	Core	Coarse											100%														100%	2
6A		1430	Core	Fine						X					100%											X			100%	1
6B		1430	Core	Coarse						26%	7%		33%		4%					X						63%			67%	27
7		1435	Core	Fine							100%		100%							X						C				1
8		1439	Core																											
9A	1614	1617	Cuttings	Fine														X	X											
9B	1614	1617	Cuttings	Coarse											100%														100%	2
10	1794	1797	Cuttings													X									X					
11A	1857	1860	Cuttings	Fine											75%												25%		100%	4
11B	1857	1860	Cuttings	Coarse			7%	7%							93%		X					X		X					93%	14
12	2013	2017	Cuttings									X									C			C						

ABBREVIATIONS
X = Present
C = Common
% = Percentage

APPENDIX C4.

Quantitative palynological analysis of Paleocene to Middle Eocene interval Konkon-1, Bass Basin.

by

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Quantitative palynological analysis of Paleocene to Middle Eocene interval Konkon-1, Bass Basin

by Alan D. Partridge

Introduction

A quantitative palynological study of the Paleocene to Eocene Eastern View Group in Konkon-1 has been undertaken as a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

This new palynological study of the Konkon-1 well was initiated to investigate the abundance of marine microplankton in the more shaly northwestern part of the Bass Basin, which available data suggested was the most likely source direction from which marine influence entered the basin. The Konkon-1 well, drilled in 1973, was preferred to the nearby Seal-1 well, drilled in 1986, because it was better sampled by sidewall cores and the deep Paleocene section was less disturbed by igneous intrusions. The original palynological report by Stover (1973) also suggested Konkon-1 contained some of the most abundant and diverse marine microplankton assemblages recorded in the basin. Also predicted and found during this study are the presence of non-marine dinocysts and Neves effects amongst the spore-pollen assemblages. Both these features were recorded from the thick Paleocene shale section in the well. For this new study the original core and sidewall core samples between 1095.8 and 1494.7m were re-examined and six new samples collected and analysed. Although it was known beforehand that many of the microplankton assemblages were worthy of full systematic description and illustration, such documentation was not the intent of this new study, and unfortunately was also beyond the scope of the overall project.

Materials and Methods

Assemblage counts were performed on 25 samples comprising one conventional core and eighteen sidewall core samples from the relinquished set of original palynological slides, supplemented by six new infill samples. The latter, two conventional core and four cuttings samples, were collected by the author from the core library at Geoscience Australia and processed at their palynological laboratory. Most of the new samples were also counted by Dr Michael Macphail. In general the palynological slides contained high visual yields of organic residue (kerogen), and high concentrations of moderately well-preserved palynomorphs. An average of 283 specimens of both terrestrial and aquatic palynomorphs were counted per sample.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973, 1982), and for manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

The interval studied in Konkon-1 extends from the first productive sidewall core above the dolerite intrusion intersected near the T.D. of the well, to the bottom sidewall core recovered from the base of the Anglesea Formation, which forms the regional seal for the sediments of the Boonah Formation and underlying Eastern View Group. This 400m thick interval from about 1095 to 1495m ranges in age from early Paleocene (or perhaps latest Maastrichtian) to basal Late Eocene, and represents the thinnest section of the Eastern View Group penetrated in the Bass Basin. The equivalent age section in more central wells in the basin can be over four times as thick (eg. Tilana-1).

The portion of the Eastern View Group penetrated in Konkon-1 from 1173 to 1525m is also unusual in that it is largely shale (>75%). Sandy intervals are only found at the base of the section penetrated (below 1474m), and over the interval 1213 to 1270m (>60% sandstone). In the middle of the latter section the occurrence of red, brown and yellow coloured quartz sands, recorded from both the cuttings and sidewall cores, is interpreted to be the manifestation of a significant unconformity. No similar coloured sands are found at an equivalent stratigraphic level in any other well in the Bass Basin. Overall, the predominance of ì shaleî in the Konkon-1 well suggests the section is more distal, relative to the more central wells in the basin, but at the same time the more attenuated succession relative to other wells suggests Konkon-1 may also contain significant missing section or hiatuses.

Undoubtedly, the most distinctive feature of the interval studied in Konkon-1 is the 137 metre thick shale unit from 1337 to 1474m (informally named the Koorkah unit in Partridge, 2002), which is broken only by two distinctive coal seams at 1352-55m and 1402-03m. The palynological assemblages from this shale contains both marine and non-marine microplankton and a strong Neves effect which together identify the Koorkah unit as deposited in a large lake or lagoon (Partridge, 2002). The Neves effect is identified in the terrestrial spore-pollen assemblages and refers to the tendency for certain more buoyant spores or pollen to have greater relative abundances in sediments deposited in more distal marine or lacustrine environments (Traverse, 1988; Partridge, 1999).

Also within this Koorkah unit occurs a marked change in the composition of the microplankton assemblages from exclusively non-marine dinocysts below 1400m, to an increasing abundance and diversity of cosmopolitan marine dinocysts above 1400m (Table 3). This change is interpreted to document the first major marine flooding of the Bass Basin, and represent a change from a largely landlocked and fresh-water fluvial to lacustrine regime, to that of a large marine coastal lagoon surrounded by deltaic and coastal plain environments (Partridge, 2002). This environmental flip occurs in the Late Paleocene (Upper *L. balmei* Zone) and correlates with one or more major high stands of sea level during the Late Paleocene Thermal Maximum or LPTM (Aubry *et al.*, 1998). In Konkon-1 this boundary is considered to lie at a major sequence boundary located below the coal seam at 1402-03m.

The samples with non-marine dinocysts have low to moderate abundances (<1% to <25% MP relative to SP + MP count) and low diversities of microplankton (<5 species per sample), while samples with marine dinocysts have low to high abundances (<1% to >60%), with diversities of microplankton in the richer samples typically >10 species per sample (Table 2). Associated with both the marine and non-marine microplankton occurrences are the strong Neves effects amongst the spore-pollen. These Neves effects are represented by high abundance of gymnosperm pollen belonging to the species *Dilwynites granulatus*, *D. tuberculatus* and *Araucariacites australis*. The combined abundance of these three species is recorded as the NED% on Table 2, and varies from 9% to 51% (average 30%) of the spore-pollen count. Note that the NED% is <2% in the sidewall cores at 1354.8m and 1402.7m that sample the two coal seams, and averages only 10% in the two samples at 1359.4m and 1365.5m from the *Apectodinium hyperacanthum* marine transgression at the base of the Lower *M. diversus* Zone (Tables 1 & 2).

The low abundances of *Dilwynites* and *Araucariacites* pollen in the coals is considered typical of spore-pollen assemblages recovered from sediments deposited in lower coastal plain settings. The lower abundances of *Dilwynites* and *Araucariacites* pollen in the two samples at the base of the Lower *M. diversus* Zone have a different more complex explanation. The latter samples are considered to be representative of the *Apectodinium* Acme at the peak of the LPTM (Bujak & Brinkhuis, 1998; Crouch *et al*., 2001). During this short warm interval the parent plants producing the *Dilwynites* and *Araucariacites* pollen are believed to have reduced abundance in the hinterland vegetation thereby causing a proportional reduction in the NED% in the more distal lacustrine/lagoonal environments. It is considered probable based on palaeogeography that the samples at 1359.4m and 1365.5m are just as distal as the other microplankton rich samples in the Koorkah unit.

Indeed the only samples from the Koorkah unit that are considered proximal are the sidewall core samples from the two coal seams at 1354.8m and 1402.7m. The spore-pollen assemblages from these coals are characterised by with very high abundances of *Gleicheniidites circinidites* and *Clavifera triplex* spores (average >45%). Based on these very ì skewedî assemblages the coals are interpreted to represent low stands of sea level when the giant Palaeolake Koorkah drained and this part of the Bass Basin was replaced by extensive ì fern marshesî . Both coals undoubtedly overlie major sequence boundaries.

Samples analysed below the Koorkah unit (ie. SWCs at 1479.8m, 1490.5m and 1494.7m) lack microplankton or any recognisable Neves effect, and therefore this older interval is interpreted to have been deposited in a non-marine fluvial regime. The significant coal seams between 1474 and 1496m could however be

interpreted as deltaic or lower coastal plain facies lateral to Palaeolake Koorkah.
The Eastern View Group above the Koorkah unit can be divided into a 67 metre thick interval of interbedded shales and coals from 1270 to 1337m assigned to the Middle to Upper *M. diversus* Zones (Narimba unit of Partridge, 2002); a 57 metre thick sandy interval from 1257 to 1270m that is not adequately dated (equivalent to Cormorant and Poonboon units of Partridge, 2002); and a 40 metre thick shale unit from 1173 to 1213m assigned to the Lower *N. asperus* Zone (Toolka unit of Partridge, 2002). These units generally contain reduced microplankton abundances and lack any recognisable Neves effects, although this may partly reflect the limited number of palynological samples analysed.

The shaly Narimba unit may be more marine than the current sampling suggests and warrants further study. The deepest sidewall core at 1313.7m for example contains the important index dinocyst *Apectodinium homomorphum*. Unfortunately, the shallower sidewall core at 1283.2m is a coal and the lithology of the immediately overlying cuttings at 1274-80m is also coaly, and not surprisingly both samples contain non-marine palynomorph assemblages.

The overlying sandy interval from 1257 to 1270m is currently not adequately dated. The Lower *N. asperus* Zone assemblage extract from the cuttings sample collected from 1225-31m is interpreted to be largely caved. However, based on superposition, this 57 metre thick interval can be correlated with the Cormorant and Poonboon units identified in the Cormorant-1 and King-1 wells where the two units have a average thickness of over 550 metre (Partridge, 2002; fig.10). The marked difference in thickness is believed to be accounted for by a major time break or unconformity in Konkon-1. This is evidenced by recovery of ì brown to red-brown quartz sandstonesî from the sidewall cores at 1214.3m, 1240.5m and 1251.5m, and the subsequent observation by the author of yellow to orange coloured quartz grains in the cuttings below 1246m. This unconformity is interpreted to correlated to the Marlin Unconformity in the Gippsland Basin (Partridge, 1999).

The youngest unit of the Eastern View Group is the distinctive coarsening-up shale from 1173 to 1213m, which has been informally named the Toolka unit by Partridge (2002). Although the recorded microplankton abundances from this unit are low (<1%), and there is no appreciable Neves effect, the unit nevertheless contains a moderate diversity of cosmopolitan dinocysts and is therefore interpreted as deposited in a restricted marine lagoon, analogous to modern Lake Maracaibo (Partridge, 2002; fig.4). At its maximum extent the Palaeolake Toolka has a similar distribution, but shorter duration than the older Palaeolake Koorkah (Partridge, 2002; fig.9).

Only two samples have been analysed from the younger Demons Bluff Group and both belong to the Late Eocene Middle *N. asperus* Zone. The deeper is a cuttings sample at 1152-55m, which is believed to be representative of the shale spike at 1147-52m in the middle of the Boonah Formation. The shallower is the sidewall core at 1095.8m at the base of the Anglesea Formation. Both contain low abundances and low diversity assemblages of cosmopolitan marine dinocysts and are interpreted as representative of restricted marine estuarine to bay environments of deposition.

Biostratigraphy

Upper *Forcipites longus* spore-pollen Zone or younger

Interval: 1490.4 to 1494.7 metres.

Age: Latest Maastrichtian to Paleocene.

The sidewall core at 1494.7m, which is also the deepest productive palynological sample in the well, was originally assigned to the *Forcipites* (al. *Tricolpites*) *longus* Zone by Stover (1973), but unfortunately the key index species recorded in the original study could not be confirmed. Based on the high abundance of *Phyllocladidites mawsonii* (30%), and frequent occurrence of *Tripunctisporis maastrichtiensis* (2%) in the assemblage a younger *L. balmei* Zone assignment is considered more likely. In contrast, the sample at 1490.4m, which was recorded as indeterminate by Stover (1973), is dominated by *Proteacidites* species (24%) and *Nothofagidites* pollen (16%) and has a more Cretaceous aspect. As neither sample contained any species whose ranges commence in the *L. balmei* Zone the interval is best treated as Upper *F. longus* Zone or younger based on the FAD (First Appearance Datum) of *T. maastrichtiensis*

***Lygistepollenites balmei* spore-pollen Zone**

Interval: 1371.6 to 1478.9 metres.

Age: Late Paleocene.

The eight sidewall cores over this 100 metre interval are assigned to the *L. balmei* Zone based on the consistent presence of *Gambierina rudata* and the eponymous species. Within the interval the base of the Lower *L. balmei* Zone can be confidently picked on the FAD of *Polycolpites langstonii* at 1478.9m and the top at the last consistent occurrence of *Tetracolporites verrucosus* at 1417.3m. The younger Upper *L. balmei* Zone can be confidently picked by the successive FADs of the following species: *Proteacidites annularis* in the coal at 1402.7m, *Matonisporites* (al. *Cyathidites*) *gigantis* at 1386.8m, and *Cupanieidites orthoteichus* at 1371.6m. The top of the zone is picked below the incoming of diagnostic species of the *M. diversus* Zone as in this well there appears to be range extensions or reworking of key *L. balmei* Zone index species into the overlying zone.

The associated microplankton assemblages between 1417.3 and 1463m are assigned to the informal *Morkallacysta* Facies based on the dominance of the eponymous genus in the assemblage. This association is representative of a lacustrine environment of deposition but is not considered age diagnostic. A descriptive study of the species assigned to this non-marine dinocyst genus needs to be undertaken to determine whether they have any biostratigraphic significance.

The top sample in the interval is assigned to the *Apectodinium reburrus* Acme Zone of Partridge (1999) based on the FAD of the eponymous species, even though the assemblage is still dominated by *Morkallacysta*.

Lower *Malvacipollis diversus* spore-pollen Zone

Interval: 1359.4 to 1365.5 metres.

Age: Early Eocene.

The assemblages from the two sidewall cores are assigned to the basal Lower *M. diversus* Zone based on the joint occurrence of *Spinizonocolpites prominatus*, *Crassoretitriletes vanraadshooveni* and *Proteacidites pachypolus*. These three species have variably disjunct ranges across the three Bass Strait basins, but all are first recorded associated with the *Apectodinium hyperacanthum* Zone marine incursion (Partridge, 1976, 1999). After this initial occurrence the species drop out of the palynological assemblages only to reappear later in the *M. diversus* Zone. The other distinctive feature of the two samples is the prominent occurrences of *Malvacipollis diversus/subtilis* (average 15%) and *Myrtaceidites parvus/mesonesus* (average 8%), which also can be considered diagnostic of the base of the Lower *M. diversus* Zone. The samples also contain abundant (average 30%) and diverse microplankton that are confidently assigned to the *Apectodinium hyperacanthum* Zone based on the prominent occurrence of the eponymous species.

Middle *Malvacipollis diversus* spore-pollen Zone

Interval: 1313.7 to 1354.8 metres.

Age: Early Eocene.

The shallowest sample a sidewall core at 1313.7m is confidently assigned to the Middle *M. diversus* Zone on the FAD of *Polycolporopollenites esobalteus*. Note however that Stover (1973) reports a older occurrence of this species at 1359.4m which was not confirmed in this study. The deeper samples from Core-1, and also the coal sampled by the sidewall core at 1354.8m, unfortunately lack key index species, and are only assigned to the Middle subzone on absence of *Matonisporites gigantis* and *Peninsulapollis gillii* which are not known to range above, or are not consistent above the Lower subzone in the Bass Basin (Partridge, 1973).

The associated microplankton are assigned to a revised concept of the *Apectodinium homomorphum* Zone proposed by Partridge (1999), which is defined as the interval from the LAD of *Apectodinium hyperacanthum* to the FAD of *Homotryblium tasmaniense*. Further, the abundant and diverse assemblages recovered from Core-1 are considered to correlate with a position high in zone based on the common occurrence of *Rhombodinium subtile* at 1352.4m

Upper *Malvacipollis diversus* spore-pollen Zone

Sample at: 1283.2 metres.

Age: Early Eocene.

The FAD of *Santalumidites cainozoicus* in the sidewall core sample at 1283.2m assigns this sample to the upper part of the Upper *M. diversus* Zone. Other key index species recorded are the disjunct reappearance of *Proteacidites pachypolus* and the FAD of *Myrtaceidites tenuis*. The immediately overlying cuttings at 1274-

80m contain a similar assemblage but lacks the index species. An age as young as the *P. asperopolus* Zone is considered possible for this sample.

Lower *Nothofagidites asperus* spore-pollen Zone
Interval: 1188.7 to 1231 metres.
Age: Middle Eocene.

Two cuttings and two sidewall cores are assigned to the Lower *N. asperus* Zone based on the increased abundance of *Nothofagidites* pollen to >20%, combined with the FADs of *Nothofagidites falcatus*, *Matonisporites ornamentalis* and *Tricolpites simatus*. In the original study by Stover (1973) the sidewall core at 1204m was incorrectly assigned to the older *P. asperopolus* Zone, based on the LAD of *Proteacidites asperopolus*, even though contemporary studies had shown that species as ranging through the Lower *N. asperus* Zone in the Bass Basin (Partridge, 1973). The associated microplankton are not considered zone diagnostic.

Middle *Nothofagidites asperus* spore-pollen Zone
Interval: 1095.8 to 1155 metres
Age: Late Eocene.

The cuttings that sample the thin shale parting in the Boonah Formation and the sidewall core from the base of the Anglesea Formation are both assigned to the Middle *N. asperus* Zone based on the presence of the key zone index species *Triorites magnificus*. The microplankton assemblage from the sidewall core can also be assigned to the *Corrudinium incompositum* Zone of Harris (1985) based on the presence of *Schematophora speciosus* and the manuscript species *Corrudinium corrugatum*.

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Table 1. Interpretative Palynological Data from Konkon-1

No.	Depth Metres	Depth Feet	Sample Type	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	1095.8	3595	SWC 35	Esso	Middle *N. asperus*	B1	*C. incompositum*	B5	FAD of *Proteacidites rectomarginis*	Bay - restricted marine
2	1152-55	3780-90	Cuttings	GA-2	Middle *N. asperus*	D1			FAD of *Triorites magnificus*	Estuarine to Bay
3	1188.7	3900	SWC 27	Esso	Lower *N. asperus*	B1			FAD of *Tricolpites simatus*	Lagoonal - brackish
4	1192-201	3910-40	Cuttings	GA-2	Lower *N. asperus*	D1				Lagoonal - restricted marine
5	1204.0	3950	SWC 26	Esso	Lower *N. asperus*	B1			LAD of *Proteacidites asperopolus*	Lagoonal - brackish
6	1225-31	4020-40	Cuttings	GA-2	Lower *N. asperus*	D2			FAD of *Nothofagidites falcatus*	Lagoonal - brackish
7	1274-80	4180-200	Cuttings	GA-2	*P. asperopolus* or older	D5				Paralic to Non-marine
8	1283.2	4210	SWC 21	Esso	Upper *M. diversus*	B3			FAD of *Santalumidites cainozoicus*	Marsh - Peat swamp
9	1313.7	4310	SWC 19	Esso	Middle *M. diversus*	B2	*A. homomorphum*	B3	LAD of *Apectodinium homomorphum*	Lagoonal - brackish
10	1347.5	4421	Core 1	GA-2	Middle *M. diversus*	A4	*A. homomorphum*	A3		Lagoonal - restricted marine
11	1351.5	4434	Core 1	GA-2	Middle *M. diversus*	A4	*A. homomorphum*	A3		Lagoonal - restricted marine
12	1352.4	4437	Core 1	Esso	Middle *M. diversus*	A2	*A. homomorphum*	A1	FAD of *Rhombodinium subtile*	Lagoonal - restricted marine
13	1354.8	4445	SWC 17	Esso	Middle *M. diversus*	B4			*Gleicheniidites/Clavifera* = 50% of SP	Marsh - Peat swamp
14	1359.4	4460	SWC 16	Esso	Lower *M. diversus*	B1	*A. hyperacanthum*	B2	LAD of *Apectodinium hyperacanthum*	Lagoonal - restricted marine
15	1365.5	4480	SWC 15	Esso	Lower *M. diversus*	B1	*A. hyperacanthum*	B2	FAD of *Spinizonocolpites prominatus*	Lagoonal - restricted marine
16	1371.6	4500	SWC 14	Esso	Upper *L. balmei*	B1	*A. reburrus* Acme	B3	FAD of *Apectodinium reburrus* ms	Lagoonal - restricted marine
17	1386.8	4550	SWC 13	Esso	Upper *L. balmei*	B2			FAD of *Matonisporites gigantis*	Lagoonal - brackish
18	1402.7	4602	SWC 12	Esso	Upper *L. balmei*	B2			*Gleicheniidites/Clavifera* = 46% of SP	Marsh - Peat swamp
19	1417.3	4650	SWC 11	Esso	Lower *L. balmei*	B2	*Morkallacysta* Facies		LAD of *Tetracolporites verrucosus*	Lacustrine - fresh
20	1432.6	4700	SWC 10	Esso	Lower *L. balmei*	B2	*Morkallacysta* Facies			Lacustrine - fresh
21	1447.8	4750	SWC 9	Esso	Lower *L. balmei*	B2	*Morkallacysta* Facies			Lacustrine - fresh
22	1463.0	4800	SWC 8	Esso	Lower *L. balmei*	B2	*Morkallacysta* Facies		FAD of *Morkallacysta*	Lacustrine - fresh
23	1478.9	4852	SWC 7	Esso	Lower *L. balmei*	B2			FAD of *Polycolpites langstonii*	Non-marine - fluvial
24	1490.4	4890	SWC 6	Esso	Upper *F. longus* or younger	B4			LAD of *Forcipites* sp. nov.	Non-marine - fluvial
25	1494.7	4904	SWC 5	Esso	Upper *F. longus* or younger	B4			FAD of *Tripunctisporis maastrichtiensis*	Marsh - Peat swamp

ABBREVIATIONS
*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum
GA-2 = Samples collected Stage-2 Work program
Esso = Samples processed in Esso laboratory

CONFIDENCE RATINGS

Alpha Code Linked to Sample
A = Core
B = Sidewall core
C = Coal cuttings
D = Ditch cuttings
J = Junk basket

Numeric Code Linked to Palynomorph Assemblage
1 = Excellent confidence: High diversity assemblage **plus** key zone species.
2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
3 = Fair confidence: Low diversity assemblage **plus** key zone species.
4 = Poor confidence: Moderate to high diversity **minus** key zone species.
5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Konkon-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
1	NA	SWC	35		3595		1095.8	High	High	Fair-good	70	13	1%		3%	52%
2	6406889	Cuttings		3780	3790	1152.1	1155.2	High	High	Fair-good	42	4	3%		6%	26%
3	NA	SWC	27		3900		1188.7	High	High	Fair-good	60	6	<1%		11%	34%
4	6406890	Cuttings		3910	3940	1191.8	1200.9	Moderate	Moderate	Poor-fair	49	7	<1%		5%	43%
5	NA	SWC	26		3950		1204.0	Moderate	Moderate	Fair-good	60	1	<1%		2%	66%
6	6406891	Cuttings		4020	4040	1225.3	1231.4	Moderate	Low-Moderate	Fair	36	3	5%	<1%	5%	36%
7	6406892	Cuttings		4180	4200	1274.1	1280.2	Low	Low	Poor-fair	20	1		<1%	4%	26%
8	NA	SWC	21		4210		1283.2	Low	Low	Poor-fair	31				1%	20%
9	NA	SWC	19		4310		1313.7	High	High	Fair-good	46	1	2%		6%	14%
10	6406893	Core	1		4421		1347.5	High	High	Poor-fair	28	3	40%	<1%	21%	5%
11	6406894	Core	1		4434		1351.5	High	High	Poor-good	35	5	17%	1%	19%	8%
12	NA	Core	1		4437		1352.4	High	High	Poor	34	15	61%		29%	10%
13	NA	SWC	17		4445		1354.8	High	High	Fair-good	29	1		5%	1.9%	1%
14	NA	SWC	16		4460		1359.4	Low	Low	Fair	53	12	27%	1%	10%	2%
15	NA	SWC	15		4480		1365.5	Moderate	High	Poor-fair	48	12	33%	<1%	12%	1%
16	NA	SWC	14		4500		1371.6	High	High	Poor-fair	51	8	4%	1%	33%	6%
17	NA	SWC	13		4550		1386.8	High	High	Fair	42	1	1%		43%	6%
18	NA	SWC	12		4602		1402.7	High	High	Poor-fair	35				<0.5%	3%
19	NA	SWC	10		4650		1417.3	High	High	Fair-good	34	3		23%	49%	7%
20	NA	SWC	11		4700		1432.6	High	High	Fair-good	34	2		2%	40%	4%
21	NA	SWC	9		4750		1447.8	High	High	Fair-good	37	1		13%	48%	4%
22	NA	SWC	8		4800		1463.0	High	High	Fair-good	35	2		7%	53%	5%
23	NA	SWC	7		4852		1478.9	Moderate	Moderate	Fair	28				13%	24%
24	NA	SWC	6		4890		1490.5	Low	Low	Fair	27				11%	16%
25	NA	SWC	5		4904		1494.7	High	Very High	Poor	28					1%

ABBREVIATIONS
MP = Microplankton
SP = Spore-Pollen
NA = Not Available
NED = Neves Effect based on Dilwynites/Araucariacites Percentage
Noth% = Percentage of Nothofagidites in SP count.

Table 3. Konkon-1 - Abundances of major palynomorph groups.

No.	Top Metres	Base Metres	Top Feet	Base Feet	Sample Type	Gleicheniidites & Clavifera spores	ALL OTHER spores	Dilwynites & Araucariacites pollen	ALL OTHER gymnosperms	Nothofagidites species	ALL OTHER angiosperms	SPORE-POLLEN TOTAL	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON fresh-brackish	MICROPLANKTON marine	**SP + MP SUM**
1		1095.8		3595	SWC 35		5%	3%	9%	47%	27%	91%	9%		260		99%		1.3%	240
2	1152.1	1155.2	3780	3790	Cuttings	0.3%	10%	3%	29%	25%	30%	98%	2%	0.3%	362		98%		2.2%	362
3		1188.7		3900	SWC 27	0.4%	5%	10%	20%	32%	25%	92%	8%		252		100%		0.4%	234
4	1191.8	1200.9	3910	3940	Cuttings	0.8%	7%	5%	10%	43%	33%	100%	0%		261		99%		0.8%	262
5		1204.0		3950	SWC 26		6%	1.4%	7%	38%	43%	96%	3%	0.7%	279		100%		0.4%	270
6	1225.3	1231.4	4020	4040	Cuttings	0.9%	6%	4.4%	22%	34%	25%	91%	8%	0.6%	338		95%	0.3%	4.9%	326
7	1274.1	1280.2	4180	4200	Cuttings	0.9%	7%	3.6%	23%	23%	31%	89%	10%	0.9%	112		99%		1.0%	101
8		1283.2		4210	SWC 21		1%	0.8%	3%	18%	69%	91%	9%		118		100%			107
9		1313.7		4310	SWC 19		4%	3.7%	4%	8%	36%	56%	44%		356		98%		2.0%	204
10		1347.5		4421	Core 1	2.9%	7%	16%	25%	4%	22%	77%	23%		244		59%	0.3%	40%	315
11		1351.5		4434	Core 1	1.4%	9%	16%	40%	7%	12%	85%	15%		280		82%	1.4%	17%	292
12		1352.4		4437	Core 1	5.7%	15%	28%	12%	9%	28%	98%	1.9%		158		39%		61%	393
13		1354.8		4445	SWC 17	50%	16%	1.9%	10%	1%	21%	100%			260		95%	4.8%		273
14		1359.4		4460	SWC 16	5.5%	20%	9%	8%	3%	47%	93%	6.3%	0.8%	237		73%	0.7%	27%	303
15		1365.5		4480	SWC 15	2.3%	13%	11%	10%	2%	53%	92%	7.9%	0.6%	177		67%	0.4%	32%	241
16		1371.6		4500	SWC 14	5.1%	11%	33%	26%	7%	15%	97%	2.6%		272		95%	1.1%	3.9%	279
17		1386.8		4550	SWC 13	7.1%	12%	41%	18%	6%	11%	95%	4.9%		266		99%		0.8%	255
18		1402.7		4602	SWC 12	42%	12%	0.4%	35%	3%	7%	100%			257		100%			257
19		1417.3		4650	SWC 11	2.9%	6%	47%	20%	7%	13%	95%	4.9%		204		77%	22%	1.2%	253
20		1432.6		4700	SWC 10	0.7%	4%	38%	29%	5%	19%	95%	5.3%		284		98%	2.2%		275
21		1447.8		4750	SWC 9	0.3%	5%	42%	19%	3%	18%	89%	11%		290		87%	13%		295
22		1463.0		4800	SWC 8	0.7%	5%	51%	21%	5%	13%	95%	4.8%		290		93%	7.1%		297
23		1478.9		4852	SWC 7		8%	11%	24%	21%	25%	89%	11%		256		100%			228
24		1490.5		4890	SWC 6	1.3%	13%	11%	26%	16%	32%	98%	2.1%		238		100%			233
25		1494.7		4904	SWC 5	5.3%	14%		51%	2%	28%	100%			264		100%			264

Table 4. Konkon-1 - spore-pollen distribution.

No.	Depth Metres	Sample Type	SPORES	Baculatisporites spp.	Camarozonosporites bullatus	Camarozonosporites heskermensis	Clavifera triplex	Cyathidites spp. large	Cyathidites spp. small	Dictyophyllidites spp.	Echinosporis echinatus	Gleicheniidites circinidites	Herkosporites elliottii	Ischyosporites spp.	Kuylisporites waterbolkii	Laevigatosporites spp.	Latrobosporites spp.	Marattisporites scabratus	Matonisporites gigantis comb. nov.	Matonisporites ornamentalis	Peromonolites spp.	Polypodiaceoisporites varus ms	Polypodiidites/Verrucatosporites spp.	Retitriletes spp.	Ricciaesporites boxatus ms	Rugulatisporites mallatus	Stereisporites antiquisporites	Stereisporites regium	Trilete spores undiff.	Tripunctisporis maastrichtiensis	Verrucosisporites kopukuensis	Total spores:
1	1095.8	SWC 35				X		X	3.0%					X		1.7%					X			0.4%	X		0.4%		0.4%		X	6%
2	1152-55	Cuttings		0.8%				1.4%	2.5%			0.3%				3.1%					0.3%		0.8%	0.3%			0.8%		0.6%			11%
3	1188.7	SWC 27		0.9%					2.1%			0.4%	X			0.9%									X	X	0.4%		0.9%		X	6%
4	1192-01	Cuttings		0.8%			0.4%		2.7%			0.4%				0.4%				0.4%	X		1.2%	0.4%			0.4%		0.8%		X	8%
5	1204.0	SWC 26		0.4%				X	1.9%		0.7%			0.4%		1.1%				X	0.4%						0.4%		1.1%	0.4%	X	7%
6	1225-31	Cuttings		0.3%				0.6%	0.3%			1.0%		1.0%		1.6%					1.0%	0.3%						0.3%	0.6%			7%
7	1274-80	Cuttings						1.0%	1.0%			1.0%				1.0%													5.0%			9%
8	1283.2	SWC 21																													0.9%	1%
9	1313.7	SWC 19		0.5%				X	4.0%					0.5%	X	3.0%														X		8%
10	1347.5	Core 1		0.5%			0.5%	0.5%	0.5%			3.2%									1.6%						1.1%		4.3%			12%
11	1351.5	Core 1		1.3%					1.7%			1.7%		0.4%		4.6%					0.4%			0.4%			0.4%		1.3%			12%
12	1352.4	Core 1		0.6%					9.0%			5.8%				0.6%											3.9%			0.6%		21%
13	1354.8	SWC 17					5.4%		0.8%			45%				2.3%	1.2%										9.2%			0.4%	1.9%	66%
14	1359.4	SWC 16		0.5%	X	X		4.1%	7.7%		0.9%	5.9%		0.9%		3.6%	0.5%					X		0.5%		X	1.4%	X	1.4%	X	X	27%
15	1365.5	SWC 15						1.9%	8.0%			2.5%		0.6%		2.5%		0.6%	X			X				X			0.6%	X		17%
16	1371.6	SWC 14		0.8%	X		0.4%	X	2.3%	0.4%		4.9%	X			1.1%			0.4%				0.4%	1.1%			3.8%	0.4%	0.8%	X		17%
17	1386.8	SWC 13		0.8%	X			X	3.2%	0.4%		7.5%	X			3.6%			X		X						4.0%	X		0.8%		20%
18	1402.7	SWC 12						1.2%	4.3%			42%	X			3.5%					X						1.9%		0.8%	X		54%
19	1417.3	SWC 11		X				X	2.1%	0.5%		3.1%	X	0.5%		1.5%					X						2.1%			X		10%
20	1432.6	SWC 10						X	3.0%	0.4%		0.7%	X								X		0.4%				0.4%			X		5%
21	1447.8	SWC 9		0.4%				X	3.1%	0.8%		0.4%	0.4%			1.2%					X											6%
22	1463.0	SWC 8		0.4%					1.8%	0.4%		0.7%	X			0.4%					0.7%						1.1%		0.4%	X		6%
23	1478.9	SWC 7		0.9%						0.4%						6.1%					X		0.4%				0.9%			X		9%
24	1490.5	SWC 6		0.4%					0.4%			1.3%	0.4%			9.4%		0.4%			0.4%			0.4%			0.4%	X	0.4%			14%
25	1494.7	SWC 5						0.8%	0.4%			5.3%	X			4.2%							0.4%	1.5%			4.9%			1.9%		19%

ABBREVIATIONS: X = Present % = Percentage

Table 4. Konkon-1 - spore-pollen distribution.

No.	Depth Metres	Sample Type	GYMNOSPERM POLLEN	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites balmei	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachyridites antarticus	Phyllocladidites mawsonii	Phyllocaldidites reticulosaccatus	Phyllocaldidites verrucosus	Podocarpidites spp.	Trichotomosulcites subgranulatus	Total Gymnosperms:	ANGIOSPERM POLLEN	Angiosperm pollen undiff.	Arecipites spp.	Australopollis obscurus	Banksieaeidites arcuatus	Beaupreaidites elegansiformis	Beaupreaidites trigonalis ms	Beaupreaidites verrucosus	Bluffopollis scabratus	Concolpites leptos	Cupanieidites orthoteichus	Dicotetradites clavatus	Dryptopollenites semilunatus	Ericipites notensis	Ericipites crassiexinus/scabratus
1	1095.8	SWC 35		0.4%	0.4%	0.4%	2.1%	0.4%		0.8%			2.5%			5.5%	0.4%	13%					X			X		0.4%	X	X			X
2	1152-55	Cuttings		1.1%	0.6%		2.0%			3.7%	0.3%	0.6%	3.7%			19%	2.0%	33%		5.6%							X		0.3%		X		0.6%
3	1188.7	SWC 27		1.3%		X	8.6%	0.9%		2.6%		1.3%	12%			4.3%	1.3%	33%		0.4%			X	X	X	X			1.3%	0.4%		X	X
4	1192-01	Cuttings		1.2%	1.2%		3.5%	0.8%		1.5%		0.4%	3.1%			3.5%	0.4%	15%		1.2%									1.9%	0.4%			X
5	1204.0	SWC 26		0.4%			1.1%			2.6%	0.7%		2.2%			1.9%		9%		1.1%			X			X			1.9%	0.7%			0.4%
6	1225-31	Cuttings		1.3%			3.6%			1.0%	0.6%		2.3%			17%	3.6%	29%		2.9%									0.6%	0.3%			
7	1274-80	Cuttings		1.0%			3.0%					2.0%	12%			12%		30%		4.0%													
8	1283.2	SWC 21		0.9%						1.9%			X			0.9%		4%		0.9%									0.9%				
9	1313.7	SWC 19		0.5%			5.5%	0.5%		0.5%						5.5%	0.5%	13%											2.0%	2.5%	0.5%	X	
10	1347.5	Core 1		3.2%			18%			2.1%		0.5%	1.6%			22%	5.9%	54%		4.3%									0.5%				
11	1351.5	Core 1		2.5%	0.4%	0.4%	16%			3.8%		0.4%	2.5%			26%	13%	66%		3.4%	0.4%								0.4%			0.4%	
12	1352.4	Core 1		3.2%	1.3%		25%	1.3%		1.9%		0.6%	1.3%			5.2%	1.9%	41%		1.3%									X				
13	1354.8	SWC 17					1.9%			1.2%		1.2%	X			5.8%	1.9%	12%		1.2%						X							
14	1359.4	SWC 16		1.8%			8.2%			1.4%		0.5%	0.9%			5.5%	0.9%	19%		1.8%		X							X	0.5%		X	
15	1365.5	SWC 15		2.5%	3.7%		9.3%	0.6%	0.6%	1.2%			0.6%			4.9%		23%		0.6%	2.5%	1.9%							X			X	
16	1371.6	SWC 14		3.0%	9.4%		30%	0.4%	0.8%	0.8%	0.4%	0.4%	2.3%			9.8%	3.4%	61%		X		X							0.8%				
17	1386.8	SWC 13		1.2%	4.0%		39%	2.8%	0.4%	0.8%		0.8%	5.5%	0.4%		5.1%	1.6%	61%		0.4%		X											
18	1402.7	SWC 12					0.4%		X	1.9%	12%	2.3%	4.3%	X	X	14%	0.8%	36%		0.8%		0.4%											
19	1417.3	SWC 11		1.0%	6.2%		44%	3.6%	X	1.5%			0.5%	X		9.3%	3.1%	70%		X													
20	1432.6	SWC 10		3.0%	5.9%		36%	1.1%	0.7%	2.2%	0.7%	2.6%	1.1%	X		16%	1.5%	70%		1.5%													
21	1447.8	SWC 9		3.1%	3.1%	0.4%	43%	1.9%	X	1.6%	1.2%	2.3%	0.4%	X		12%	0.4%	70%		1.6%		X										0.4%	1.2%
22	1463.0	SWC 8		3.3%	6.5%		48%	2.2%	0.4%	1.8%		1.8%	2.9%	X	X	8.7%		75%		X										X			
23	1478.9	SWC 7		1.8%	0.9%		11%	0.4%			0.4%	0.4%	3.5%	1.3%	X	18%	2.2%	40%		0.4%													
24	1490.5	SWC 6		3.0%			7.7%			1.3%	0.4%	3.4%	0.4%			19%	1.7%	37%		1.7%													
25	1494.7	SWC 5							X	0.8%	0.4%	1.1%	30%	0.4%	X	16%	3.0%	51%		1.1%										11%			

ABBREVIATIONS: X = Present % = Percentage

Table 4. Konkon-1 - spore-pollen distribution.

No.	Depth Metres	Sample Type	Gambierina rudata/edwardsii	Haloragacidites harrisii	Ilexpollenites sp.	Juxtacolpus pieratus ms	Intratriporopollenites notabilis	Liliacidites spp.	Malvacipollis diversus	Malvacipollis subtilis	Milfordia spp.	Myrtaceidites parvus/mesonesus	Myrtaceidites tenuis	Myrtaceidites verrucosus	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites endurus	Nothofagidites falcatus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites vansteenisii	Peninsulapollis gillii	Periporopollenites demarcatus	Periporopollenites polyoratus	Polycolpites langstonii	Polycolporopollenites esobalteus	Proteacidites spp.	Proteacidites annularis	Proteacidites crassus	Proteacidites grandis	Proteacidites incurvatus
1	1095.8	SWC 35		5.9%	0.4%			X		1.3%	X	5.1%		X	0.4%	3.8%	2.1%	43%		0.4%	0.4%	0.4%	1.7%		1.7%				3.0%	0.4%	X		X
2	1152-55	Cuttings		13%	0.6%			0.6%		0.8%		1.7%		X		3.7%	2.0%	19%	0.3%	0.6%					1.1%				2.0%	0.8%			
3	1188.7	SWC 27		7.3%					0.4%	0.4%		2.1%		X		6.0%	5.2%	20%		0.4%	1.7%	0.4%	0.4%		X	X			9.9%	1.7%	X		X
4	1192-01	Cuttings		12%	0.8%					1.2%		0.8%			0.8%	1.5%	4.6%	33%		1.2%	0.4%		1.5%		1.5%				5.4%	1.2%			
5	1204.0	SWC 26		10%	0.4%			X		1.9%	0.4%	3.3%			0.4%	1.1%	1.5%	31%			1.9%	1.1%	2.6%		0.4%	X			13%	1.5%	X	X	
6	1225-31	Cuttings		7.8%	0.3%			0.3%		1.0%		0.3%			0.6%	7.1%	2.3%	25%		0.6%	0.3%	0.3%	0.6%		2.6%			0.3%	3.6%	0.3%			
7	1274-80	Cuttings		12%				1.0%		1.0%						8.0%	8.0%	10%							1.0%				13%				
8	1283.2	SWC 21		20%	0.9%				3.7%	X			2.8%			0.9%	1.9%	17%							4.7%			0.9%	10%	6.5%	X	X	
9	1313.7	SWC 19		6.5%	1.0%		0.5%	1.0%	X	1.0%	1.0%	6.0%					1.0%	13%			0.5%		0.5%		X	X		X	15%	0.5%		X	
10	1347.5	Core 1		1.1%				1.6%				0.5%				1.1%	1.1%	2.1%			0.5%				2.1%				7.5%				
11	1351.5	Core 1		1.7%								0.4%				0.8%	0.8%	5.5%			0.8%	0.4%			1.7%				2.1%			0.8%	
12	1352.4	Core 1		3.9%					X	0.6%		0.6%				6.5%		1.3%			1.9%				2.6%	X			14%	1.3%		X	
13	1354.8	SWC 17		0.8%					X	X		3.5%						1.2%							X	X			2.7%	0.4%			X
14	1359.4	SWC 16	X	0.9%	0.5%		X		10%	5.5%		6.4%				0.9%		1.4%	0.5%		0.5%				0.5%	X			5.9%	X			
15	1365.5	SWC 15	0.6%	4.9%	0.6%			0.6%	11%	4.3%		9.9%						0.6%	0.6%		0.6%				0.6%				3.7%	X			X
16	1371.6	SWC 14	0.4%	0.4%	0.4%							X			0.4%	1.1%		2.6%	0.4%		2.3%			0.8%	0.4%	X	0.4%		7.2%	X			X
17	1386.8	SWC 13	0.8%	0.8%											0.4%	0.8%		1.6%	3.6%		0.4%			0.8%		X	0.4%		6.3%				
18	1402.7	SWC 12	X	X		X						X				0.4%		1.6%	0.8%		0.4%					X			1.9%	X			
19	1417.3	SWC 11	1.0%													1.5%		1.5%	3.6%		0.5%			X		X	X		8.2%				
20	1432.6	SWC 10	0.4%													0.4%		0.4%	4.1%					X		1.1%	X		7.8%				
21	1447.8	SWC 9	X		0.4%													0.4%	3.5%							1.6%	0.8%		7.0%				
22	1463.0	SWC 8	0.7%		0.4%				0.4%									2.9%	2.2%							0.7%	0.4%		5.1%				
23	1478.9	SWC 7														0.4%		0.4%	23%							1.8%	0.4%		20%				
24	1490.5	SWC 6																0.4%	16%							0.4%			24%				
25	1494.7	SWC 5	X					0.4%										0.4%	1.1%					3.8%		1.1%			6.1%				

ABBREVIATIONS: X = Present % = Percentage

Table 4. Konkon-1 - spore-pollen distribution.

No.	Depth Metres	Sample Type	Proteacidites kopiensis	Proteacidites latrobensis	Proteacidites leightonii	Proteacidites obesolabrus ms	Proteacidites obscurus	Proteacidites pachypolus	Proteacidites pseudomoides	Proteacidites recavus	Proteacidites rectomarginis	Proteacidites reticulatus	Proteacidites reticuloscabratus	Proteacidites rugulatus	Proteacidites tenuiexinus	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Spinizonocolpites prominatus	Tetracolporites multistrixus ms	Tetracolporites textus ms	Tetracolporites verrucosus	Tricolpate pollen undiff.	Tricolpites phillipsii	Tricolpites simatus	Tricolpites thomasii	Tricolporites adelaidensis	Tricolporites leuros	Tricolporites marginatus ms	Tricolporites paenestriatus	Triorites magnificus	Triporopollenites ambiguus	Triporopollenites simplis	Triporopollenites spp.	Total Angiosperms	Total Spore-Pollen Count
1	1095.8	SWC 35		X	X	X	0.8%	X		X	X	X	X		X	X	X					8.9%							X	X	0.4%	0.8%		81%	237
2	1152-55	Cuttings					0.3%	0.3%		0.3%						0.3%						1.7%								0.3%				56%	354
3	1188.7	SWC 27	X		X				X	X			X		X	X						2.6%	X	0.4%		X						0.4%		62%	233
4	1192-01	Cuttings					0.4%							X		0.4%						6.2%		0.4%		X					0.4%			77%	260
5	1204.0	SWC 26	X		0.4%	X	X	X	X				X		X	0.7%	0.4%					5.9%		0.4%	0.4%								0.7%	84%	269
6	1225-31	Cuttings																				6.8%												64%	309
7	1274-80	Cuttings																				3.0%												61%	100
8	1283.2	SWC 21			X	X	3.7%	X							X	X						8.4%				2.8%	3.7%		4.7%		X		0.9%	95%	107
9	1313.7	SWC 19			0.5%	X	0.5%		X				X									19%							1.5%				5.5%	79%	200
10	1347.5	Core 1																				11%												34%	187
11	1351.5	Core 1																				2.5%												22%	238
12	1352.4	Core 1			X	X	X		X				X									3.9%											0.6%	38%	155
13	1354.8	SWC 17					5.0%															7.3%									0.4%			22%	260
14	1359.4	SWC 16						X										0.9%	X			18%												54%	220
15	1365.5	SWC 15					X	0.6%	X									1.2%				14%						X	0.6%		X			60%	162
16	1371.6	SWC 14													X							3.0%						X					2.3%	23%	265
17	1386.8	SWC 13											X		X							0.4%						X					2.0%	19%	253
18	1402.7	SWC 12													X				X	3.5%		0.8%												11%	257
19	1417.3	SWC 11													X				X		0.5%	2.6%											1.0%	21%	194
20	1432.6	SWC 10											X									7.8%											1.5%	25%	269
21	1447.8	SWC 9													X						0.4%	4.3%						X			X		2.7%	24%	257
22	1463.0	SWC 8													X							3.6%											2.5%	19%	276
23	1478.9	SWC 7																				3.9%											1.3%	51%	228
24	1490.5	SWC 6																				6.0%											0.4%	49%	233
25	1494.7	SWC 5													X							4.5%											0.8%	30%	264

ABBREVIATIONS: X = Present % = Percentage

Table 5. Konkon-1 - microplankton distribution.

No.	Depth Metres	Sample Type	ACRITARCHS & ALGAE	Botryococcus braunii	Lecaniella sp.	Pediastrum sp.	Pseudoschizaea spp.	DINOCYSTS ó NON-MARINE	Cobricosphaeridium spp.	Morkallacysta spp.	DINOCYSTS ó MARINE	Dinocysts undiff.	Acomosphaera spp.	Apectodinium homomorphum	Apectodinium hyperacanthum	Apectodinium reburrus ms	Apteodinium spp.	Areoligera sp.	Batiacasphaera spp.	Cleistosphaeridium spp.	Cordosphaeridium spp.	Corrudinium corrugatum ms	Deflandrea spp.	Diphyes colligerum	Enneadocysta spp.	Fibrocysta bipolar	Glaphyrocysta spp.	Heteraulacacysta sp. A
1	1095.8	SWC 35										33%	X					X		X	X	X	X					33%
2	1152-55	Cuttings										63%													13%			
3	1188.7	SWC 27																X		X	X							
4	1192-01	Cuttings																										
5	1204.0	SWC 26										100%																
6	1225-31	Cuttings		6%								88%																
7	1274-80	Cuttings										100%																
8	1283.2	SWC 21																										
9	1313.7	SWC 19										50%		50%														
10	1347.5	Core 1		2%								98%																
11	1351.5	Core 1				7%						80%					2%						2%					
12	1352.4	Core 1										15%		X			11%	X		4%	5%			X		1%		
13	1354.8	SWC 17										100%																
14	1359.4	SWC 16		1%			1%					12%			27%			33%		1%	1%		4%	7%		X		
15	1365.5	SWC 15								1%		24%		6%	33%	1%		X		10%	1%			4%			11%	
16	1371.6	SWC 14								66%		18%				2%			5%	3%	2%							
17	1386.8	SWC 13										100%																
18	1402.7	SWC 12																										
19	1417.3	SWC 11			2%					93%		2%							3%									
20	1432.6	SWC 10							17%	83%																		
21	1447.8	SWC 9								100%																		
22	1463.0	SWC 8							14%	86%																		
23	1478.9	SWC 7																										
24	1490.5	SWC 6																										
25	1494.7	SWC 5																										

ABBREVIATIONS: X = Present % = Percentage

Table 5. Konkon-1 - microplankton distribution.

No.	Depth Metres	Sample Type	Heteraulacacysta sp. B	Hystrichokolpoma rigaudiae	Impagidinium spp.	Kenleyia spp.	Muratodinium fimbriatum	Operculodinium centrocarpum	Paralecaniella indentata	Phthanoperidinium comatum	Rhombodinium subtile	Rivernookia septata	Schematophora speciosus	Senegalinium dilwynensis	Spinidinium spp.	Spiniferites spp.	Systematophora spp.	Wetzeliella sp. cf W. symmetrica	Xenikodinium sp.	Total Microplankton: (sum)
1	1095.8	SWC 35		X				X	X	33%			X			X				3
2	1152-55	Cuttings			13%											13%				8
3	1188.7	SWC 27						X								100%				1
4	1192-01	Cuttings		50%												50%				2
5	1204.0	SWC 26																		1
6	1225-31	Cuttings			6%															17
7	1274-80	Cuttings																		1
8	1283.2	SWC 21																		
9	1313.7	SWC 19																		4
10	1347.5	Core 1																		66
11	1351.5	Core 1						4%								6%				54
12	1352.4	Core 1	22%			12%	X	1%	4%		7%					8%	4%	4%	1%	228
13	1354.8	SWC 17																		13
14	1359.4	SWC 16				X	X	4%				1%				8%				83
15	1365.5	SWC 15				X	X	3%				3%				3%				79
16	1371.6	SWC 14												5%	X					62
17	1386.8	SWC 13													X					2
18	1402.7	SWC 12																		
19	1417.3	SWC 11																		59
20	1432.6	SWC 10																		6
21	1447.8	SWC 9																		38
22	1463.0	SWC 8																		21
23	1478.9	SWC 7																		
24	1490.5	SWC 6																		
25	1494.7	SWC 5																		

ABBREVIATIONS: X = Present % = Percentage

APPENDIX C5.

Quantitative palynological analysis of eleven cuttings samples from 2266 to 3115m in Koorkah-1, Bass Basin.

by

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Quantitative palynological analysis of eleven cuttings samples from 2266 to 3115m in Koorkah-1, Bass Basin

by Alan D. Partridge

Introduction

A quantitative palynological study of cuttings samples over the bottom 900 metres of the Eastern View Group penetrated in Koorkah-1 has been undertaken as a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

This new palynological study of the Koorkah-1 well (drilled in 1985) is focussed on the thick shale unit identified between 2250 and 2692m, and the underlying interbedded sands and shale section from 2692 to 3149mTD. The upper shale unit contains only minor sandstones (<14% of section) and possibly three thin coal seams (at 2390m, 2428m and 2441m). The bottom interbedded unit is composed of approximately 56% shales and 44% sandstone and lacks any coal based on the sonic log and personal inspection of the cuttings. Rare, putative non-marine dinocysts recorded in the original palynological report by Morgan (1986), plus the similarity of the log character to the established lacustrine facies in the older Durroon Formation, in the southwest portion of the Bass Basin, and to the similar age Kipper Shale in the Gippsland Basin, suggested that the thicker shale intervals in Koorkah-1 could also represent significant lacustrine facies. The objective of the study was to quantify the abundance of the non-marine dinocysts and other microplankton through the older units in Koorkah-1 and to confirm whether the spore-pollen assemblages displayed Neves effects as had previously been found in the Durroon and Kipper formations.

Materials and Methods

The study was undertaken on eleven new cuttings samples as unfortunately neither the original palynological slides studied by Morgan (1986), nor any of the remaining sidewall cores from Koorkah-1 were available for re-examination. The new samples were collected by the author from the core library at Geoscience Australia and processed at their palynology laboratory. The samples which were comprised mostly of relatively homogeneous medium grey mudstone or shale, gave moderated yields of organic residue which contained generally high concentrations of very poorly preserved palynomorphs. An average of 250 specimens of both terrestrial and aquatic palynomorphs were counted per sample.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Brief lithological description of the samples are provided on Table 3. Species abundance and range data are provided in Tables 4 to 6. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973), and for manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

The interval studied in Koorkah-1 extends from the Early Maastrichtian to possibly the Late Paleocene (Lower *F. longus* to Upper *L. balmei* Zones). Microplankton abundances ranged from <1% to 27% (average 6%) of the combined spore-pollen and microplankton count. Although not particularly abundant both non-marine dinocysts (eg. *Morkallacysta*), and non-marine algae (eg. *Debarya*, *Pediastrum*, *Rimosicysta*) were recorded along with other genera known to occur in both environments (eg. *Amosopollis cruciformis* and *Horologinella*). Marine dinocysts were only identified from the shallowest cuttings at 2266-75m and are most likely caved. The associated spore-pollen assemblages are characterised by abundant *Dilwynites* and *Araucariacites* pollen (average 29%) that are interpreted to be representative of a strong Neves effect. The latter reflects the tendency for certain more buoyant spores or pollen to have greater relative abundances in sediments deposited in more distal marine or lacustrine environments (Traverse, 1988; Partridge, 2002b). The combination of these palynological features is interpreted to indicate a fresh-water lacustrine environments of deposition. The more pronounced Neves effect in the thicker shales is taken as evidence that the depositional environments were more distal and probably also deeper water.

It is also noted that the Well Completion Report placed an ìIntra Late Cretaceous Angular Unconformityî at 2690m at the base of the major shale section, and the presence of a major unconformity in the section is supported by the latest studies of the seismic data for the Bass Project. Although no obvious time break can be identified in the palynology succession the most likely position would be between the Upper and Lower *F. longus* Zones, and the palynological results would favour placing the boundary between these zones within the underlying interbedded unit rather than precisely at the base of the thickest shale. The preferred position for the zone boundary is below 2959m, where a sidewall core contains the oldest recorded occurrence by Morgan (1986) of the key index species *Tripunctisporis maastrichtiensis*.

The palynological data also indicates the Cretaceous/Tertiary boundary lies within the Koorkah unit but the precise position is equivocal. The boundary could lie above 2490m based on the youngest occurrence of *Battenipollis sectilis* and other secondary index species for the *F. longus* Zone, or alternatively deeper, just above youngest occurrence of the primary index species *Forcipites longus* at 2626m. The deeper pick is favour by the author based primarily on the similarity of the log character over the interval 2470 to 2692m to the thicker sections of the Kate Shale in the Gippsland Basin (Partridge, 1999a-b). The anomalous shallower occurrences of the secondary index species in the Koorkah-1 well being interpreted as younger extensions of the species ranges or reworking.

Biostratigraphy

***Forcipites longus* spore-pollen Zone**

Interval: 2677 to 3115 metres

Age: Maastrichtian.

The occurrence of multiple specimens of the eponymous species *Forcipites longus* in the deepest cuttings analysed is considered to be reliable evidence that Koorkah-1 has penetrated sediments no older than Early Maastrichtian. *Forcipites longus* is typically a rare species in assemblages and therefore is not normally recorded as either reworked or caved. The earlier study of Morgan (1986) recorded a similar range for the species from 2626 to 3148m, although it is noted that his deepest record is from the sidewall at 2728m. Similarly, the top of the zone is confidently placed at 2677m on the youngest occurrence of *F. longus* in the cuttings at 2677-80m, or perhaps slightly higher in the cuttings at 2626-35m examined by Morgan (1986). Shallower but less confident tops for the zone could lie at 2560-63m based on the LAD (Last Appearance Datum) of *Battenipollis sectilis*, or even higher at 2491m based on LAD of *Tricolpites confessus* recorded by Morgan (1986). Arguing against these shallower picks is the relative thinness of the *L. balmei* Zone (from ~2250 to 2470m) compared to other wells in the basin centre, and the similarity of the log character between 2470 and 2692m to that of the Kate Shale in the Gippsland Basin (Partridge, 1999a-b). The samples examined at 2560-63m and 2632-35m are therefore designated as undifferentiated *L. balmei* to *F. longus* Zones (Table 1).

Subdivision of the *F. longus* Zone is based on the FAD of *Tripunctisporis maastrichtiensis* which is first recorded at 2959m in a sidewall core by Morgan (1986), and from the shallower cuttings at 2731-34m in this study. Supporting a thick Upper subzone is the frequent to common occurrence of *Gambierina rudata* (average >6%) and mostly low abundances of *Nothofagidites*, which are normally more abundant in the lower subzone. Other key index species diagnostic of the broader zone recorded in the samples are *Grapnelispora evansii* at 2857-60m, and *Proteacidites palisadus, Pseudowinterapollis wahooensis* and *Tricolporites lilliei* at 2953-56m.

Lower *Lygistepollenites balmei* spore-pollen Zone

Interval: 2266 to 2491 metres.

Age: Early Paleocene.

The top of the zone is identified on the LADs of *Gambierina rudata* and *Lygistepollenites balmei* while the base of the zone is placed above the LADs of index species for the *F. longus* Zone. The shallowest sample at 2266-75m could however belong to the Upper *L. balmei* Zone as Morgan (1986) records *Proteacidites grandis*, a key index species for the Upper subzone, from the sidewall core at 2266.5m. The samples also contains the dinocysts *Apectodinium hyperacanthum* and *Diphyes colligerum*, but both are believed to be caved as the dinocyst assemblages is dominated by the non-marine genus *Morkallacysta*. The next deeper cuttings at 2338-41m has a higher confidence zone assignment based on the occurrence of *Polycolpites langstonii* which is not known to range below the upper part of the Lower subzone. The sample at 2488-91m is probably still within the Lower subzone based on presence of *Haloragacidites harrisii,* but as this species is frequently caved the confidence in the zone assignment is low. Finally, the samples at 2560-63m and 2632-35m could belong to either the Lower *L. balmei* or *F. longus* Zones depending whether the rare occurrences of older index species are interpreted as reworked.

***Morkallacysta* Facies**

Notwithstanding the general low numbers of microplankton in the majority of the counts most assemblages are dominated by the non-marine dinocyst genus *Morkallacysta* originally described by Harris (1974). Although Morgan (1986) referred the specimens he recorded to the type species *Morkallacysta pyramidalis* the specimens recorded in this study have much less pronounced apical and antapical horns than the type species and have been left in open nomenclature pending illustration and description. Those samples were this genus is particularly prominent are referred to the *Morkallacysta* Facies. This facies is considered to be diagnostic of lacustrine depositional environments but does not as yet have demonstrable biostratigraphic significance. The *Morkallacysta* Facies may be more extensive than indicated on Table 1 as a large proportion of the microplankton in a number of the samples are too poorly preserved to be confidently identified.

Most significant of the other microplankton recorded in the samples the were specimens of the algal cyst *Rimosicysta*, which originally was described from Turonian age assemblages (Marshall, 1989) and has been previously been recorded in the Durroon Formation in the Bass (Partridge, 2002a). The occurrences in Koorkah-1 are believed to be a genuine extension in the range of this form and not a product of reworking.

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Table 1. Interpretative Palynological Data from Koorkah-1

No.	Sample Type	Depth Metres	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	Cuttings	2266-75	GA-2	Lower *L. balmei*	D4	*Morkallacysta* Facies		LAD of *Gambierina rudata*	Lacustrine - brackish
2	Cuttings	2338-41	GA-2	Lower *L. balmei*	D1	*Morkallacysta* Facies		FAD of *Polycolpites langstonii*	Lacustrine - fresh
3	Cuttings	2488-91	GA-2	Lower *L. balmei*	D4				Lacustrine - fresh
4	Cuttings	2560-63	GA-2	*L. balmei/F. longus*	D5	*Morkallacysta* Facies		LAD of *Battenipollis sectilis*	Lacustrine - fresh
5	Cuttings	2632-35	GA-2	*L. balmei/F. longus*	D6	*Morkallacysta* Facies			Lacustrine - fresh
6	Cuttings	2677-80	GA-2	Upper *F. longus*	D1	*Morkallacysta* Facies		LAD of *Forcipites longus*	Lacustrine - fresh
7	Cuttings	2731-34	GA-2	Upper *F. longus*	D1			FAD of *Tripunctisporis maastrichtiensis*	Lacustrine - fresh
8	Cuttings	2857-60	GA-2	Upper *F. longus*	D1			*Grapnelispora evansii* present	Deltaic - Lacustrine
9	Cuttings	2953-56	GA-2	Upper *F. longus*	D4			FAD of common *Gambierina rudata*	Deltaic - Lacustrine
10	Cuttings	3022-25	GA-2	Lower *F. longus*	D1	*Morkallacysta* Facies?			Lacustrine - fresh
11	Cuttings	3112-15	GA-2	Lower *F. longus*	D1			FAD of *Forcipites longus*	Deltaic - Lacustrine

ABBREVIATIONS

*CR = Confidence Ratings

LAD = Last Appearance Datum

FAD = First Appearance Datum

GA-2 = Samples collected Stage-2 Work program

CONFIDENCE RATINGS

Alpha Code Linked to Sample

A = Core

B = Sidewall core

C = Coal cuttings

D = Ditch cuttings

J = Junk basket

Numeric Code Linked to Palynomorph Assemblage

1 = Excellent confidence: High diversity assemblage **plus** key zone species.

2 = Good confidence: Moderately diverse assemblage **plus** key zone species.

3 = Fair confidence: Low diversity assemblage **plus** key zone species.

4 = Poor confidence: Moderate to high diversity **minus** key zone species.

5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Koorkah-1

No.	PalLab Spl.No.	Sample Type	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%	Gamb%
1	6406878	Cuttings	2266	2275	Moderate-High	High	Very poor	45	4	<2%	<3%	23%	8%	2%
2	6406879	Cuttings	2338	2341	Moderate-High	Moderate-high	Very Poor	33	2		<2%	44%	7%	2%
3	6406880	Cuttings	2488	2491	Moderate-High	Moderate-high	Poor	34	4		<2%	30%	3%	8%
4	6406881	Cuttings	2560	2563	Moderate-High	Moderate-high	Very poor	31	6		9%	38%	3%	7%
5	6406882	Cuttings	2632	2635	Moderate-High	High	Very poor	32	3		<1%	31%	2%	9%
6	6406883	Cuttings	2677	2680	Moderate-High	Moderate	Very poor	30	3		4%	42%	1%	7%
7	6406884	Cuttings	2731	2734	Moderate-High	Moderate-high	Very poor	32	1		3%	36%	5%	4%
8	6406885	Cuttings	2857	2860	Moderate-High	Moderate	Very poor	34	3		2%	18%	17%	4%
9	6406886	Cuttings	2953	2956	Moderate-High	High	Very very poor	32	4		6%	18%	8%	10%
10	6406887	Cuttings	3022	3025	Moderate-High	High	Very very poor	32	4		27%	28%	5%	6%
11	6406888	Cuttings	3112	3115	Moderate-High	Moderate	Very poor	29	1		2%	13%	20%	4%

ABBREVIATIONS

MP = Microplankton

SP = Spore-Pollen

NED = Neves Effect based on *Dilwynites/Araucariacites* Percentage

Noth% = Percentage of *Nothofagidites* in SP count.

Gamb% = Percentage of *Gambierina rudata/edwardsii* in SP count.

Table 3. Basic Sample Data from Koorkah-1

No.	SAMPLE TYPE	DEPTH Metres	Weight Grams	LITHOLOGY	SAMPLE TEXTURE
1	Cuttings	2266-75	17.0	SHALE: medium grey	Powder to fine
2	Cuttings	2338-41	18.0	SHALE: medium grey	Powder to medium
3	Cuttings	2488-91	17.0	SHALE: medium grey	Powder to medium
4	Cuttings	2560-63	17.5	SHALE: medium grey	Powder to medium
5	Cuttings	2632-35	18.5	SHALE: medium grey	Powder to medium
6	Cuttings	2677-80	20.5	SHALE: medium grey	Powder to medium
7	Cuttings	2731-34	23.7	SHALE 60%: medium-dark grey; SANDSTONE 40%: white, fine-grained.	Powder to medium
8	Cuttings	2857-60	27.7	SHALE 40%: medium grey; SANDSTONE 60%: white, fine-grained.	Powder to medium
9	Cuttings	2953-56	20.5	SHALE 70%: medium grey; SANDSTONE 30%: white, fine-grained.	Powder to medium
10	Cuttings	3022-25	20.4	SHALE 50%: medium grey; SANDSTONE 50%: white, fine-grained.	Powder to medium
11	Cuttings	3112-15	23.4	SHALE 80%: light-medium grey; SANDSTONE 20%: light-grey.	Powder to medium

Table 4. Abundances of major palynomorph groups from Koorkah-1.

No.	Depth Metres	Sample Type	Glecheniidites & Clavifera spores	ALL OTHER spores	Dilwynites & Araucariacites pollen	ALL OTHER gymnospoerm pollen	Nothofagidites spp.	Gambierina spp.	ALL OTHER angiospoerm pollen	**SPORE-POLLEN TOTAL**	Total fungal microfossils	Reworked Spore-Pollen	**TOTAL TERRESTRIAL SUM**		**SPORE-POLLEN TOTAL**	**MICROPLANKTON TOTAL**	SP + MP COUNT
1	2266-75	Cuttings	12%	14%	23%	18%	8%	2%	12%	90%	10%	0.4%	252		95%	4.6%	238
2	2338-41	Cuttings	4%	16%	44%	19%	7%	2%	6%	98%	2%	0.4%	256		98%	1.6%	255
3	2488-91	Cuttings	3%	9%	30%	32%	3%	8%	15%	98%	2%		262		98%	1.5%	262
4	2560-63	Cuttings	1%	15%	38%	15%	3%	7%	16%	95%	5%		245		91%	9.0%	256
5	2632-35	Cuttings	2%	9%	31%	30%	2%	9%	12%	95%	5%	0.4%	264		99%	0.8%	253
6	2677-80	Cuttings	0.4%	18%	42%	16%	1%	7%	13%	98%	2%	0.4%	248		96%	4.3%	253
7	2731-34	Cuttings	1%	14%	36%	14%	5%	4%	22%	96%	4%	0.4%	245		97%	2.9%	241
8	2857-60	Cuttings	1%	13%	18%	25%	17%	4%	19%	98%	2%	1%	240		98%	2.1%	239
9	2953-56	Cuttings	2%	18%	18%	22%	8%	9%	15%	91%	9%	1%	194		94%	6.4%	188
10	3022-25	Cuttings	1%	16%	28%	18%	5%	5%	20%	94%	6%		153		73%	26.9%	197
11	3112-15	Cuttings	2%	20%	13%	21%	20%	4%	15%	95%	5%		260		98%	2.4%	254

Table 5. Koorkah-1 - spore-pollen distribution

No.	Depth Metres	Sample Type	**SPORES SPECIES**	Ariadnaesporites sp.	Baculatisporites spp.	Camarozonosporites apiculatus ms	Cicatricosisporites spp.	Clavifera triplex	Cyathidites spp. large >40µm	Cyathidites spp. small <40µm	Dictyophyllidites spp.	Foraminisporis asymetricus	Foveotriletes balteus	Gleicheniidites circinidites	Grapnelispora evansii	Herkosporites elliottii	Laevigatosporites major	Laevigatosporites ovatus	Latrobosporites spp.	Latrobosporites amplus	Marattisporites scabratus	Osmundacidites wellmanii	Peromonolites densus
1	2266-75	Cuttings			1.3%			X	0.4%	4.8%			X	13.7%				0.9%	0.4%	X	0.4%		X
2	2338-41	Cuttings			0.8%			0.4%	0.4%	4.4%	0.8%			3.2%		X		2.0%		X			0.8%
3	2488-91	Cuttings			0.4%			0.4%		2.3%	0.8%			2.7%		1.2%		1.2%		X			
4	2560-63	Cuttings			1.7%				1.3%	2.1%	1.3%			0.9%		0.4%		1.3%					
5	2632-35	Cuttings			0.4%	X				0.8%	X			2.0%		1.2%		1.2%				0.4%	
6	2677-80	Cuttings		X	1.7%				0.4%	2.5%				0.4%		3.7%		0.8%		X		0.8%	
7	2731-34	Cuttings			2.6%				X	1.3%				0.9%		3.0%	X	1.7%		X		0.4%	
8	2857-60	Cuttings			0.9%				0.9%	2.6%		X		0.9%	0.4%	0.9%		1.3%	0.4%	X			
9	2953-56	Cuttings			X				0.6%	4.5%				1.7%		3.4%	X	1.1%	1.1%	X	0.6%	X	
10	3022-25	Cuttings			3.5%		X		0.7%	2.1%	1.4%			1.4%		0.7%		1.4%	0.7%	X			
11	3112-15	Cuttings			1.2%				1.6%	9.7%				2.4%		0.8%		0.8%	1.2%	X	0.4%	0.4%	

ABBREVIATIONS

X = Present

% = Percentage

Table 5. Koorkah-1 - spore-pollen distribution

No.	Depth Metres	Sample Type	Perotrilites spp.	Retitriletes spp.	Rugulatisporites mallatus	Stereisporites antiquisporites	Stereisporites regium	Stereisporites viriosus	Trilete spores undiff.	Triporoletes spp.	Tripunctisporis maastrichtiensis	TOTAL SPORES		**GYMNOSPERM SPECIES**	Gymnosperm pollen undiff.	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites balmei	Lygistepollenites florinii	Microalatidites paleogenicus
1	2266-75	Cuttings	X	0.4%		5.3%			1.8%		X	30%				4.4%	4.4%		22%	X	0.4%	0.9%	0.4%
2	2338-41	Cuttings		0.4%	X	4.0%			2.4%		0.4%	20%				5.2%	2.8%		40%	X	0.8%	0.8%	
3	2488-91	Cuttings		X		2.7%			0.4%		X	12%				2.3%	3.9%		28%	X		X	0.4%
4	2560-63	Cuttings		X	0.4%	5.6%			1.3%		X	16%				10.7%	1.3%		30%			0.4%	
5	2632-35	Cuttings	X	1.2%		2.0%	1.2%		1.6%		X	12%				3.2%	6.4%	X	30%		0.4%	X	
6	2677-80	Cuttings	X	1.2%		4.5%	X	X	2.5%			19%				20.2%	2.9%		23%		0.4%		
7	2731-34	Cuttings	X	1.7%		0.9%	0.4%		2.1%		0.9%	16%				17.9%	X		19%	X	0.4%		
8	2857-60	Cuttings	1.3%	1.7%		1.3%			1.7%	0.4%		15%				7.7%	0.4%	0.4%	11%		X		
9	2953-56	Cuttings	0.6%	1.7%		2.3%	1.7%		1.7%			21%				6.3%	1.7%		13%		0.6%		
10	3022-25	Cuttings	1.4%	1.4%		3.5%			0.7%			19%				1.4%	4.9%		28%		0.7%		
11	3112-15	Cuttings		0.4%		1.2%			2.8%	0.8%		24%			0.4%	3.2%	2.4%		10%		0.4%	0.4%	

ABBREVIATIONS

X = Present

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Table 5. Koorkah-1 - spore-pollen distribution

No.	Depth Metres	Sample Type	Microcachryidites antarcticus	Phyllocladidites mawsonii	Phyllocaldidites verrucosus	Podocarpidites spp.	Trichotomosulcites subgranulatus	TOTAL GYMNOSPERM POLLEN		**ANGIOSPERM SPECIES**	Angiosperm pollen undiff.	Australopollis obscurus	Battenipollis sectilis	Beaupreaidites orbiculatus	Dicotetradites clavatus	Forcipites longus	Gambierina rudata/edwardsii	Haloragacidites harrisii	Liliacidites spp.	Malvacipollis subtilis	Myrtaceidites parvus/mesonesus	Nothofagidites brachyspinulosus	Nothofagidites emarcidus
1	2266-75	Cuttings	0.4%	4.8%		7%	1.3%	46%				0.4%					1.8%	0.4%		0.4%	0.4%	2.2%	4.4%
2	2338-41	Cuttings		6.0%		8%	0.8%	64%			0.8%						2.4%	X				1.6%	2.4%
3	2488-91	Cuttings	0.8%	8.5%		17%	1.9%	63%							0.4%		7.8%	X	0.8%				
4	2560-63	Cuttings	0.4%	6.0%		7%	0.4%	56%			0.9%		0.4%	X			6.9%						
5	2632-35	Cuttings	0.8%	8.0%	0.8%	12%	2.4%	64%									9.2%	0.4%				0.4%	
6	2677-80	Cuttings	1.2%	4.5%		5%	1.7%	60%			0.8%					X	7.4%						
7	2731-34	Cuttings	0.4%	7.7%		5%	0.9%	52%			2.1%		1.3%				3.8%						
8	2857-60	Cuttings	0.9%	10.7%		10%	3.0%	44%			1.7%		1.7%				4.3%						
9	2953-56	Cuttings	0.6%	3.4%		16%	1.7%	43%			0.6%		1.1%				9.7%						
10	3022-25	Cuttings	0.7%	1.4%		10%	1.4%	49%					X			X	5.6%						
11	3112-15	Cuttings	0.4%	1.6%		14%	2.4%	35%			0.8%					1.2%	4.0%						

ABBREVIATIONS

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% = Percentage

Table 5. Koorkah-1 - spore-pollen distribution

No.	Depth Metres	Sample Type	Nothofagidites endurus	Nothofagidites flemingii	Nothofagidites senectus	Peninsulapollis gillii	Periporopollenites polyoratus	Polycolpites langstonii	Proteacidites spp.	Proteacidites clinei ms	Proteacidites palisadus	Pseudowinterapollis wahooensis	Tetracolporites verrucosus	Tetradopollis securus ms	Tricolp(or)ates spp.	Tricolpites waiparaensis	Tricolporites lilliei	Tricolporites marginatus ms	Triporopollenites spp.	TOTAL ANGIOSPERM POLLEN	**TOTAL spore-pollen COUNT**
1	2266-75	Cuttings	2.6%	X		1.3%	0.4%		8%						X				1.8%	25%	227
2	2338-41	Cuttings	3.2%			1.2%	0.4%	0.4%	3%						0.4%					16%	251
3	2488-91	Cuttings	1.9%		0.8%	5.0%			6%						2.3%				0.4%	25%	258
4	2560-63	Cuttings	3.0%		0.4%	5.6%			6%				0.4%		2.1%			X	1.3%	27%	233
5	2632-35	Cuttings	X		2.0%	2.0%			8%						2.4%					24%	251
6	2677-80	Cuttings	X		1.2%	3.7%			7%	0.4%					X				0.8%	22%	242
7	2731-34	Cuttings	4.3%		1.3%	4.3%			12%				0.4%		2.6%				0.9%	32%	234
8	2857-60	Cuttings	2.1%		15.0%	3.8%			9%					0.4%	0.9%	0.9%	0.4%		0.4%	41%	234
9	2953-56	Cuttings	6.3%		2.8%	4.5%			9%		X	0.6%			X	1.1%	X			36%	176
10	3022-25	Cuttings	1.4%		3.5%	5.6%			13%						2.8%	0.7%				32%	144
11	3112-15	Cuttings	2.4%		18.5%	1.2%			10%						2.8%				0.4%	41%	248

ABBREVIATIONS

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Table 6. Koorkah-1 - microplankton and fungal distribution

No.	Depth Metres	Sample Type	**MICROPLANKTON**	ACRITARCHS & ALGAE	Micrhystridium spp.	Amosopollis cruciformis	Botryococcus braunii	Circulosporites parvus	Debarya sp.	Lecaniella sp.	Pediastum sp.	Sigmopollis carbonis	Rimosicysta sp.	DINOCYSTS	Dinocysts undiff.	Apectodinium hyperacanthum	Cleistosphaeridium spp.	Diphyes colligerum	Horologinella n.sp.	Morkallacysta spp.	**TOTAL MP COUNT**		Fungal spores & hyphae	Fungal fruiting bodies	Fungal germlins	Persavis sp.	REWORKED spores & pollen
1	2266-75	Cuttings													26%	5%		5%		63%	19		X	X	X		X
2	2338-41	Cuttings													50%		25%			25%	4		X				X
3	2488-91	Cuttings			25%	X	25%		25%											25%	4		X			X	
4	2560-63	Cuttings				X		X		X	5%				68%					26%	19		X	X			
5	2632-35	Cuttings				40%							X		20%					40%	5		X	X		X	X
6	2677-80	Cuttings					8%					8%			42%				8%	33%	12		X				X
7	2731-34	Cuttings					14%								86%						7		X				X
8	2857-60	Cuttings										20%			20%					60%	5		X				X
9	2953-56	Cuttings					8%					8%	X		85%					X	13		X				X
10	3022-25	Cuttings										6%	2%		70%		2%			21%	53		X				
11	3112-15	Cuttings													67%					33%	6		X				

ABBREVIATIONS

X = Present

% = Percentage

APPENDIX C6.

Quantitative palynological analysis of Eastern View and Demons Bluff Groups in Poonboon-1, Bass Basin.

by

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Quantitative palynological analysis of Eastern View and Demons Bluff Groups in Poonboon-1, Bass Basin

by Alan D. Partridge

Introduction

A quantitative palynological study of the Eastern View and basal Demons Bluff Groups in Poonboon-1 has been undertaken as a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

This new palynological study of the Poonboon-1well was initiated to **1)** establish a quantitative reference section for the palynological succession from Late Cretaceous to Miocene in the central part of the Bass Basin, **2)** help quantify the distribution, abundance and diversity of marine and non-marine dinocysts and other microplankton in the basin, to aid in mapping the geographic and temporal extend of lacustrine and marine palaeoenvironments, and **3)** document the presence and distribution of Neves effects within the terrestrial spore-pollen assemblages, as supporting palynological evidence for the presence of large palaeolakes and lagoons. The early Poonboon-1 well (spudded in 1972), was chosen because it was known to contain well-preserved microfloras and some of the best sidewall core sampling of all the wells in the basin, and was also believed to be unaffected by any volcanic intrusion, which disrupt the quality of the palynological successions in many of the other wells. In addition, relinquished palynological slides were available from the well and were immediately accessible. The interval reviewed in the well represents an essentially complete sequence from the latest Maastrichtian to Late Oligocene (Upper *F. longus* to Middle *P. tuberculatus* Zones). Although it was known beforehand that both the spore-pollen and microplankton assemblages were worthy of full systematic description and illustration, such documentation was not the intent of this new study, and unfortunately was also beyond the scope of the overall project.

Materials and Methods

Assemblage counts were performed on 65 samples and species lists were recorded for another eight samples from which the original palynological slides were either unsuitable or unavailable for quantitative analysis. Most of the material examined is derived from the relinquished palynological slides prepared in the now closed laboratory operated by Esso Australia Ltd and were originally studied by Partridge (1972). Materials re-examined from this original collection consists of 39 sidewall cores, 6 conventional core and 6 cuttings samples. The density of samples in some of the poorly sampled intervals in this early collection was improved by a new collection of an additional sample from conventional core-2 and 13 cuttings (GA-2 samples on Table 1). These samples were collected by the author from the core library at Geoscience Australia and processed at their palynological laboratory. The assemblages counts on most of the new samples were performed by Dr Michael Macphail. An average of 265 specimens of both terrestrial and aquatic palynomorphs were counted per sample.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973, 1982), or Helby *et al.* (1987), while many of the manuscript species can be found in Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

Geological Discussion

The interval studied in Poonboon-1 has a thickness of 2030 metres extending from the bottom hole core at 3259 to 3266m to a sidewall core at 1233.2m, and ranges in age from latest Maastrichtian (Upper *F. longus* Zone) to Late Oligocene or possibly Early Miocene (Middle *P. tuberculatus* Zone or younger). The stratigraphic sequence analysed consists of 1272 metres of the Eastern View Group (containing 53 samples at an average spacing of 24 metres), all of the 590 metres thick Demons Bluff Group (containing 18 samples at an average spacing of 35 metres) and the basal 171 metres of the Torquay Group (containing just two samples at an average spacing of >85 metres).

The older Eastern View Group succession commences with interpreted fresh-water lacustrine shales at 3107-3140m and 3205-3245m near the bottom of the well. These shales represents the most southerly known extent of interbeds or tongues of the lacustrine Koorkah unit proposed by Partridge (2002d). The latter unit has been more fully analysed in Konkon-1 and Koorkah-1 (Partridge, 2002a-b). The remaining overlying Eastern View Group is comprised of 1113 metres of mixed sandstones, shales and coals (from 1994 to 3107m) that can be subdivided between the Narimba, Cormorant and Poonboon units proposed in Partridge (2002d). A predominantly lower coastal plain or deltaic depositional environment is indicated by the consistent presence of thin coal seams, and sporadic incursions of marine dinocysts. A total of 65 thin coal seams, from <1 to ~3 metres thick, with an average spacing ~19 metres, are evident on the sonic log. The coal seams are relatively widely spaced through the Paleocene to basal Early Eocene (*L. balmei* to Lower *M. diversus* Zones) and again through the Middle Eocene (Lower *N. asperus* Zone), and most closely spaced in the late Early Eocene (Middle *M. diversus* to *P. asperopolus* Zones).

The occurrences of non-marine and marine dinocysts through the Eastern View Group confirms the presence of short duration lacustrine, lagoonal and paralic palaeoenvironments. The most significant of these events are:

1. Non-marine dinocysts referred to the genus *Morkallacysta* Harris 1974 are recorded from the thicker shales (3107-3140m and 3205-3245m) near the bottom of the well that are associated with the most

prominent Neves effects. These shales are interpreted to be tongues of the lacustrine Koorkah facies extending into the southeastern part of the basin during episodes of maximum lake level.

2. Marine dinocysts recorded from sidewall cores that are diagnostic of the *Apectodinium reburrus* Acme Zone (2678.6m) and the succeeding *Apectodinium hyperacanthum* Zone (at 2651.8m). These zones represent the first major marine incursion into the Bass Basin at the time of the late Paleocene thermal maximum (LPTM), and have also been recorded in Konkon-1 (Partridge, 2002a)
3. Sporadic occurrences of the *Apectodinium homomorphum* Zone in the Lower and Middle *M. diversus* Zones. The older assemblage from a sidewall core at 2529.8m has an microplankton (MP) abundance of 3% and a low diversity of 5+ species. The younger from core-2 at 2472.5m has an MP abundance of 43% with a moderate diversity of 11+ species. The latter is tentatively correlated with the dinocyst assemblages recovered from between 1347.5 and 1352.4m in core-1 in Konkon-1 (Partridge, 2002a). With more detailed study these horizons could potentially be linked to microplankton flooding events within the Dilwyn Formation in the Otway Basin.
4. Sporadic occurrences of dinocysts diagnostic of the *Homotryblium tasmaniense* Zones are found through the Upper *M. diversus* and *P. asperopolus* Zones. Although both abundance and diversity are low (<6% and <5 species per sample) they nevertheless confirm that diluted marine influence had extended across most of the basin during the Early Eocene.

Prominent or strong Neves effects in the associated spore-pollen assemblages from the Eastern View Group were only recorded from distinctive shale (Koorkah unit) at the bottom of the well sampled between 3223.9 and 3262.3m. In the conventional and sidewall core samples from this section the combined abundance of the gymnosperm pollen *Dilwynites granulatus*, *D. tuberculatus* and *Araucariacites australis* have an average of 35% (referred to as the NED% in Table 2). This abundance spike is interpreted as a Neves effect, which is the tendency for certain more buoyant spores or pollen to have greater relative abundances in sediments deposited in more distal marine or lacustrine environments (Traverse, 1988; Partridge, 2002d). In the Bass Basin the joint occurrence in the thicker shales of non-marine dinocysts associated with strong Neves effects in the spore-pollen assemblages is interpreted to indicate distal lacustrine depositional environments for those shales (Partridge, 2002d). Weak Neves effects, represented by NED% of approximately 20% are also postulated to occur in the shale sampled (in ascending order) by the sidewall cores at 3116.9m, 2651.8m to 2678.6m, and core-2 at 2472.5m. Each of these events has associated peaks in the abundance or diversity of marine or non-marine dinocysts. The lower NED% being interpreted to indicate a somewhat more proximal environment of deposition within the palaeolake or lagoon.

The younger Demons Bluff Group succession can be subdivided into the 102 metre thick Boonah Formation (from 1892 to 1994m), the 137 metres thick Anglesea Formation (from 1755 to 1892m), and a 351 metre thick section assigned to an undifferentiated interval equivalent to both the Addiscot and Angahook Formation (from 1404 to 1755m). The use of these formation names follows the recent revision of the Demons Bluff Group in the adjacent Torquay Sub-basin by Holdgate *et al.* (2001). In contrast to the Eastern

View Group marine dinocysts are consistently recorded from the Late Eocene to Early Oligocene sediments of the Demons Bluff Group. Although the microplankton abundance (range <1% to 26%, average 7%) and diversity (range 1 to 11, average <6 species per sample) are both low the total recorded diversity through the section is >30 species (Table 5), and could easily be double that if greater effort was applied to the study of the microplankton. This consistent presence of marine dinocysts and lack of coals through the Demons Bluff Group indicates a markedly different depositional regime compared to the older Eastern View Group. Commencing with the Boonah Formation it is suggested that there is a progressive change in the deposition environments from estuarine to bay facies in the Anglesea Formation and then to a marginal marine sea in the younger formations. Surprisingly, even though palaeogeographic mapping indicates that the Anglesea and succeeding Addiscot/Angahook Formations represent large bays or marginal seas there is no obvious Neves effects observed in the spore-pollen assemblages (average NED% is <4%). The rise in abundance of *Nothofagidites* pollen to >50% of the spore-pollen could partly account for this as *Nothofagus* forests may have replaced the Araucariaceae forests (which produced the *Dilwynites* and *Araucariacites* pollen), as the dominant component of the hinterland vegetation.

At the top of the stratigraphic succession is the 1315m thick and carbonate-rich Torquay Group (from seafloor to 1404m) representing open marine sediments. Deposition of this unit could only have commenced after the Bass Strait became a through going marine seaway. Only two samples from the base of this unit were analysed, although significant caved sediments are also present in the underling cuttings at 1551-70m (Table 1). The assemblages examined contain abundant marine dinocysts (>25% of count) which are consistent with deposition in an open marine environment.

Biostratigraphy

Upper *Forcipites longus* spore-pollen Zone

Interval: 3223.9 to 3262.3 metres

Age: Late Maastrichtian.

The youngest Cretaceous spore-pollen zone is confidently identified in the bottom ~40 metres of Poonboon-1 but could potentially extend another ~160 metres higher through the interval 3066 to 3183.6m, which contain assemblages transitional with overlying *L. balmei* Zone. The presence of the distinctive spore *Tripunctisporis maastrichtiensis* in the bottom hole core confirms that the well did not penetrate deeper than the Upper *F. longus* Zone, while the LADs (Last appearance Datums) of *Ornamentifera sentosa*, *Quadraplanus brossus* and *Tricolporites lilliei* in the bottom core sample, *Grapnelispora evansii* and *Battenipollis sectilis* in the SWC at 3247.3m, and *Proteacidites reticuloconcavus* ms slightly higher in the SWC at 3223.9m confirms an age no younger than the zone following the latest revision by Partridge (1999). The possibility that the zone might extend higher is based on the shallower occurrences of *Nothofagidites senectus* to 3183.6m, and *Proteacidites clinei* ms and *Tricolpites waiparaensis* in core-4 at 3024.2m where they overlap with the FAD (First Appearance Datum) of *Haloragacidites harrisii* an index species for the *L. balmei* Zone.

Unfortunately, the assemblages in this transition interval are poorly preserved and not particularly diverse making confident zone assignments difficult. The samples between 3066 and 3183.6m are therefore given a composite *F. longus/L. balmei* Zone assignment pending more detailed study.

The sidewall cores at 3223.9m and 3233.3m contain common non-marine dinocysts that are assigned to the *Morkallacysta* facies which has also been recorded from similar age sediments in Koorkah-1 (Partridge, 2002b). These dinocysts are considered to be representative of lacustrine deposition but have not yet proved to be of biostratigraphic significance.

Lygistepollenites balmei **spore-pollen Zone**
Interval: 2678.6 to 3042.2 metres
Age: Paleocene.
The suite of six conventional and sidewall core samples and ten cuttings samples can all be assigned to the broad *L. balmei* Zone on the consistent presence of the eponymous species (average <1%). The bottom of the zone is picked at the FAD of *Haloragacidites harrisii* while the top of the zone picked at the mutual extinctions or LADs of *Gambierina rudata, Nothofagidites endurus* and *Stereisporites regium.* In addition, the species *Lygistepollenites balmei* and *Australopollis obscurus* are last recorded from the basal sample of the Lower *M. diversus* Zone. This range extension of the last two species has traditionally been interpreted as reworking (eg. Partridge, 1973).

The Upper and Lower subdivision of the *L. balmei* Zone proposed by Partridge (1973) can be recognised but not the more detailed five-fold subdivision recently proposed in the Gippsland Basin by Partridge (1999). The lack of success in distinguishing the latter subdivisions is attributed to the rarity of the critical index species in the poorly preserved assemblages and limited number of core and sidewall cores available through the >400 metre thick zone. Unfortunately, all subdivisions of the zone are based primarily on FADs making them difficult to apply in cuttings. The top of the Lower *L. balmei* Zone is picked at 2737-40m on the LAD of *Tetracolporites verrucosus*, but it should be noted that the species is inconsistent and very rare through the zone, and as well this particular cuttings sample is also badly contaminated by caved Early Eocene species. The base of the overlying Upper *L. balmei* Zone is confidently identified in conventional core-3 by the oldest occurrences in the core samples of the species *Cupanieidites orthoteichus*, *Proteacidites grandis*, *P. incurvatus* and *Matonisporites* (al. *Cyathidites*) *gigantis*. The zone may extend to the next deeper cuttings but confidence in that assignment is low because of the likelihood of cavings.

Microplankton are represented through the *L. balmei* Zone by the sporadic occurrences of non-marine acritarchs, algae, and dinocysts (Table 5). The only reliable marine assemblage recorded is the occurrence of the *Apectodinium reburrus* Acme Zone in the sidewall core at 2678.6m, which is dominated by the eponymous species.

***Malvacipollis diversus* spore-pollen Zone**

Interval: 2362 to 2651.8 metres

Age: Latest Paleocene to Early Eocene.

A suite of 12 conventional and sidewall core samples, and three cuttings samples are assigned to the board *M. diversus* Zone. The assemblages are characterised by the consistent presence of *Haloragacidites harrisii* pollen (range <1% to 19%), and rare to common *Malvacipollis diversus* and *M. subtilis.* The Lower, Middle and Upper subzones are distinguished by the oldest and youngest occurrences of key species.

The base of the Lower *M. diversus* Zone is picked at 2651.8m on the FADs of *Spinizonocolpites prominatus* and *Crassoretitriletes vanraadshooveni*, while the most reliable pick for the top of the zone is at 2529.8m based on the LADs of *Matonisporites gigantis* and *Peninsulapollis gillii*, even though the zone could extend as high as the overlying less diagnostic sample at 2514.6m.

The base of the Middle *M. diversus* Zone is most confidently place at 2474.4m in core-2, based on the FAD of the principal index species *Proteacidites tuberculiformis*, although the zone could extend slightly deeper into the underlying cuttings (Table 1). The top of the zone is placed below the oldest occurrence of the index species for the overlying Upper *M. diversus* Zone, which are the FAD of *Myrtaceidites tenuis* in the cuttings at 2408-17m and the FAD of *Proteacidites pachypolus* in the next sidewall core at 2377.4m. The top of this subzone and the *M. diversus* Zone is placed at the sample below the incoming of index species of the *P. asperopolus* Zone.

Sporadic occurrences of marine microplankton occur through the *M. diversus* Zone. At 2651.8m from the base of the interval the *Apectodinium hyperacanthum* Zone is identified by the common occurrence of the eponymous species. In the sidewall core at 2529.8m and in the new sample from core-2 at 2427.5m the revised *Apectodinium homomorphum* Zone of Partridge (1999) is likewise identified on the presence of the eponymous species. The palynomorph assemblage from the latter sample is interesting because organic microforaminiferal liners are recorded associated with the marine dinocysts. Finally, from the cuttings at 2408-17m is assigned to the *Homotryblium tasmaniense* Zone of Harris (1985) based on the FAD of the eponymous species.

***Proteacidites asperopolus* spore-pollen Zone**

Interval: 2225 to 2317.1 metres

Age: Early Eocene.

The assemblages from the *P. asperopolus* Zone are characterised by highly diverse assemblages (typically >50 species per sample) containing common *Nothofagidites* (average 18%), *Haloragacidites harrisii* (average 13%), *Proteacidites* (average 17%), tricolpate/tricolporate pollen (average 17%) and *Myrtaceidites* (average 8%). The base of the zone is picked at 2317.1m on the FADs of *Proteacidites asperopolus* and *Conbaculatisporites apiculatus* ms, while the top of the zone is picked at the LADs of *Myrtaceidites tenuis* at

2225m and *Intratriporopollenites notabilis* in the underlying sidewall core at 2237.2m. No significant abundances or species of microplankton were recorded from this zone.

Lower *Nothofagidites asperus* spore-pollen Zone
Interval: 2009 to 2194.6 metres
Age: Middle Eocene.

The Lower *N. asperus* Zone is identified by the marked increase in the abundance of *Nothofagidites* pollen (average 35%) and decline in *Haloragacidites harrisii* (average 6%). The gymnosperm pollen *Phyllocladidites mawsonii* also becomes more common (range 4% to 19%, average 9%), compared to average abundance of <1% in the underlying zone. Index species supporting these gross assemblage changes are the FADs of *Matonisporites ornamentalis* at 2194.6m, *Tricolpites simatus* at 2047.6m, and *Proteacidites reflexus* at 2011.7m. Relative to the Gippsland Basin succession the FADs of *Nothofagidites vansteenisii* at 2047.6m, and *N. falcatus* at 1935.5m are both delayed. The top of the Lower subzone is placed at the sample below the incoming of index species for the Middle *N. asperus* Zone. No significant abundances or species of dinocysts were recorded from this zone.

Middle *Nothofagidites asperus* spore-pollen Zone
Interval: 1801.4 to 1988.8 metres
Age: Late Eocene.

The Middle *N. asperus* Zone shows similar gross characteristics to the Lower subzone, although *Nothofagidites* pollen is much more dominant (average 47%), and *Haloragacidites harrisii* very much secondary (average 8%). Also, with the cessation of coal deposition at the top of the Lower *N. asperus* Zone the gymnosperm pollen *Phyllocladidites mawsonii* is much less prominent (range 1% to 5%, average 2%). The zone is identified on the total range of the primary index species *Triorites magnificus* which is recorded from four of the seven samples. Other important markers are the FAD of *Proteacidites rectomarginis* at 1859.3m and the LADs of *Anacolosidites sectus* and *Proteacidites pachypolus* in the shallowest sample assigned to the zone.

Marine microplankton occur in all samples in the zone, varying in abundance from <1% to 26% (average 8%) of the combined SP and MP count (Table 3). Unfortunately recorded diversity in the standardised counts and slide scanning employed in this study only recorded a low average diversity of <5 species per sample (Table 2), and consequently the assemblages could not be confidently assigned to established zones. Although I am confident more diverse assemblages could be extracted by examining more microscope slides per sample, this could not be accomplished in the time allocated to the project.

Upper *Nothofagidites asperus* spore-pollen Zone
Interval: 1600.2 to 1767.8 metres
Age: Latest Eocene? to Early Oligocene.

The Upper *N. asperus* Zone has always been difficult to precisely identify because it represents a zone interval defined by negative criteria. These are the extinction of a group of key species at the top of the Middle *N. asperus* Zone, and the first appearance of the distinctive spore *Cyatheacidites annulatus* at the base of the overlying *P. tuberculatus* Zone (Stover & Partridge, 1973). In Poonboon-1 the identification of the zone is made more difficult by the reworking of Eocene spore-pollen, including many of the marker species for the base of the zone. Similar reworking has been recorded from this zone in Squid-1 (Partridge, 2002c). Identification of the zone is therefore based on secondary index species, which can be very rare or have poorly known stratigraphic ranges (Partridge, 1973). Applying these in Poonboon-1 the base of the zone is picked at 1767.8m on the FADs of *Granodiporites nebulosus*, *Proteacidites stipplatus* and the spore *Verrucosisporites cristatus*, while the top of the zone is picked below the FAD of *Cyatheacidites annulatus* in the sidewall core at 1505.7m. The FADs of *Foveotriletes crater* at 1737.4m and *Malvacipollis grandis* ms at 1600.2m are in general consistent with these picks. The assemblages are dominated by *Nothofagidites* pollen (average 58%), with secondary *Haloragacidites harrisii* (average 6%) and *Myrtaceidites* pollen (average 5%).

With the exception of the low recovery sidewall cores at 1691.6m and 1722.1m marine microplankton were recorded in all samples. Although both abundance (range <1% to 7%, average <4%) and recorded species diversity is low (average 6 species sample, excluding caved cuttings assemblage), some of the samples can be assigned to established zones based on the occurrence of key index species. The samples at 1706.9m and 1763m are assigned to the *Phthanoperidinium comatum* Acme Zone based on the common occurrence of the eponymous species, while the samples between 1505.7 and 1670m are assigned to the *Fromea leos* Zone based on the presence of the manuscript species *Fromea leos* and *Fromea neochytra* (Table 5).

***Proteacidites tuberculatus* spore-pollen Zone**
Interval: 1233.2 to 1505.7metres
Age: Early to Late Oligocene.

The three shallowest sidewall cores analysed are assigned to the *P. tuberculatus* Zone based on the FAD of *Cyatheacidites annulatus* at 1505.7m following the original zone definition of Stover & Partridge (1973). This sample is no younger than the Lower *P. tuberculatus* Zone based on the LAD of *Tripunctisporis maastrichtiensis*, while the shallowest sidewall core at 1233.2m is no older than the Middle *P. tuberculatus* Zone based on the FAD of *Cyathidites subtilis*. The assemblages are again dominated by *Nothofagidites* (average 38%), but they also contain common *Myrtaceidites* pollen (average 10%).

Marine dinocysts characteristic of the *Operculodinium* Superzone are abundant in all the samples (average >25%). The two shallower samples from the Torquay Group are dominated by *Spiniferites* while the sample at 1505.7m from the top of the Demons Bluff Group is dominated by undifferentiated dinocysts.

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Table 1. Interpretative Palynological Data from Poonboon-1

No.	Depth Metres	Depth Feet	Sample Type	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	1233.2	4046	SWC 27a	Esso	Middle *P. tuberculatus*	B2	*Operculodinium* Sz	B2	FAD of *Cyathidites subtilis*	Open Marine
2	1325.9	4350	SWC 26a	Esso	*P. tuberculatus*	B4	*Operculodinium* Sz	B2	FAD of *Foraminisporis ozotus* ms	Open Marine
3	1505.7	4940	SWC 24a	Esso	Lower *P. tuberculatus*	B1	*F. leos*	B3	FAD of *Cyatheacidites annulatus*	Open Marine
4	1551-70	5090-150	Cuttings	GA-2	*P. tuberculatus* (caved)	D1	*P. simplex* (caved)	D4		Open Marine
5	1600.2	5250	SWC 23a	Esso	Upper *N. asperus*	B1	*F. leos*	B5	FAD of *Malvacipollis grandis* ms	Marginal Marine
6	1652-70	5420-80	Cuttings	GA-2	Upper *N. asperus*	D4	*F. leos*	D2	FAD of *Fromea leos* ms	Marginal Marine
7	1691.6	5550	SWC 22a	Esso	Upper *N. asperus*	B4			LAD of *Dryptopollenites semilunatus*	Marginal Marine
8	1706.9	5600	SWC 21a	Esso	Upper *N. asperus*	B1	*P. comatum* Acme	B3	LAD of *Phthanoperidinium comatum*	Marginal Marine
9	1722.1	5650	SWC 20a	Esso	Upper *N. asperus*	B5				Marginal Marine
10	1737.4	5700	SWC 19a	Esso	Upper *N. asperus*	B4			FAD of *Foveotriletes crater*	Marginal Marine
11	1749.6	5740	SWC 18a	Esso	Upper *N. asperus*	B4				Marginal Marine
12	1763.0	5784	SWC 16a	Esso	Upper *N. asperus*	B4	*P. comatum* Acme	B3	LAD of *Deflandrea heterophlycta*	Bay - restricted marine
13	1767.8	5800	SWC 15a	Esso	Upper *N. asperus*	B4			FAD of *Granodiporites nebulosus*	Bay - restricted marine
14	1801.4	5910	SWC 14a	Esso	Middle *N. asperus*	B1			LAD of *Triorites magnificus*	Bay - restricted marine
15	1859.3	6100	SWC 12a	Esso	Middle *N. asperus*	B1			LAD of *Proteacidites pachypolus*	Bay - restricted marine
16	1889.8	6200	SWC 30	Esso	Middle *N. asperus*	B1				Bay - restricted marine
17	1935.5	6350	SWC 6a	Esso	Middle *N. asperus*	B1			FAD of *Anacolosidites sectus*	Estuarine to Bay
18	1953.8	6410	Core 1	Esso	Middle *N. asperus*	B1				Estuarine to Bay
19	1958.9	6427	Core 1	Esso	Middle *N. asperus*	B4			Common *Enneadocysta pectiniformis*	Estuarine to Bay
20	1988.8	6525	SWC 4a	Esso	Middle *N. asperus*	B1			FAD of *Triorites magnificus*	Estuarine to Bay
21	2009-18	6590-620	Coal Cts	Esso	Lower *N. asperus*	D5				Marsh - Peat swamp
22	2011.7	6600	SWC 26	Esso	Lower *N. asperus*	B1			LAD of *Proteacidites asperopolus*	Coastal Plain - Deltaic
23	2047.6	6718	SWC 25	Esso	Lower *N. asperus*	B1			LAD of *Proteacidites reflexus*	Coastal Plain - Deltaic
24	2072.6	6800	SWC 24	Esso	Lower *N. asperus*	B5				Coastal Plain - Deltaic
25	2091-97	6860-80	Coal Cts	Esso	Lower *N. asperus*	B4				Marsh - Peat swamp

Table 1. Interpretative Palynological Data from Poonboon-1

No.	Depth Metres	Depth Feet	Sample Type	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
26	2134.8	7004	SWC 22	Esso	Lower *N. asperus*	B4			LAD of *Proteacidites obesolabrus*	Coastal Plain - Deltaic
27	2169.6	7118	SWC 21	Esso	Lower *N. asperus*	B4			Common *Phyllocladidites mawsonii*	Coastal Plain - Deltaic
28	2194.6	7200	SWC 20	Esso	Lower *N. asperus*	B4			FAD of *Matonisporites ornamentalis*	Lacustrine -fresh?
29	2225.0	7300	SWC 19	Esso	*P. asperopolus*	B1			LAD of *Myrtaceidtes tenuis*	Coastal Plain - Lagoonal
30	2237.2	7340	SWC 18	Esso	*P. asperopolus*	B1			LAD of *Intratriporopollenites notabilis*	Coastal Plain - Deltaic
31	2257.3	7406	SWC 17	Esso	*P. asperopolus*	B2				Coastal Plain - Lagoonal
32	2287.2	7504	SWC 16	Esso	*P. asperopolus*	B1				Coastal Plain - Deltaic
33	2317.1	7602	SWC 15	Esso	*P. asperopolus*	B1			FAD of *Proteacidites asperopolus*	Coastal Plain - Lagoonal
34	2362-74	7750-90	Cuttings	GA-2	Upper *M. diversus*	D2				Coastal Plain - Lagoonal
35	2377.4	7800	SWC 13	Esso	Upper *M. diversus*	B1			FAD of *Proteacidites pachypolus*	Coastal Plain - Lagoonal
36	2408-17	7900-30	Cuttings	GA-2	Upper *M. diversus*	D2	*H. tasmaniense*	D3	FAD of *Homotryblium tasmaniense*	Coastal Plain - Lagoonal
37	2426.2	7960	SWC 11	Esso	Middle *M. diversus*	B1			*Spinizonocolpites prominatus* present	Coastal Plain - Lagoonal
38	2438.4	8000	SWC 10	Esso	Middle *M. diversus*	B4			FAD of *Proteacidites nasus*	Coastal Plain - Lagoonal
39	2472.5	8112	Core 2	GA-2	Middle *M. diversus*	A1	*A. homomorphum*	B3	Rare microforaminiferal liners present!	Lagonal - restricted marine
40	2474.4	8118	Core 2	Esso	Middle *M. diversus*	A1			FAD of *Proteacidites tuberculiformis*	Coastal Plain - Lagoonal
41	2499-508	8200-30	Cuttings	GA-2	Middle *M. diversus*	D4			FAD of *Polycolporopollenites esobalteus*	Coastal Plain - Lagoonal
42	2499.4	8200	SWC 8	Esso	Indeterminate					Coastal Plain - Deltaic
43	2514.6	8250	SWC 7	Esso	Lower *M. diversus*	B5			FAD of *Intratriporopollenites notabilis*	Coastal Plain - Deltaic
44	2529.8	8300	SWC 6	Esso	Lower *M. diversus*	B1	*A. homomorphum*	B3	LAD of *Matonisporites gigantis*	Coastal Plain - Lagoonal
45	2560.3	8400	SWC 5	Esso	Indeterminate					Fluvial?
46	2590.8	8500	SWC 4	Esso	Indeterminate					Fluvial?
47	2624.3	8610	SWC 3	Esso	Lower *M. diversus*	B4				Coastal Plain - Deltaic
48	2651.8	8700	SWC 2	Esso	Lower *M. diversus*	B1	*A. hyperacanthum*	A3	FAD of *Spinizonocolpites prominatus*	Coastal Plain - Lagoonal
49	2678.6	8788	SWC 1	Esso	Upper *L. balmei*	B1	*A. reburrus* Acme	A3	LAD of *Gambierina rudata*	Coastal Plain - Lagoonal
50	2688.0	8819	Core 3	Esso	Upper *L. balmei*	A1			FAD of *Cupanieidites orthoteichus*	Coastal Plain - Deltaic
51	2689.3	8823	Core 3	Esso	Upper *L. balmei*	A1			FAD of *Proteacidites grandis*	Coastal Plain - Deltaic
52	2713-25	8900-40	Cuttings	GA-2	Upper *L. balmei*	D4			FAD of *Matonisporites gigantis*	Coastal Plain - Deltaic

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No.	Depth Metres	Depth Feet	Sample Type	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
53	2737-40	8980-90	Coal Cts	Esso	Lower *L. balmei*	C3			LAD of *Tetracolporites verrucosus*	Marsh - Peat swamp
54	2758-61	9050-60	Coal Cts	Esso	Lower *L. balmei*	C4				Marsh - Peat swamp
55	2795-801	9170-90	Cuttings	GA-2	Lower *L. balmei*	D4				Coastal Plain - Deltaic
56	2838-44	9310-30	Cuttings	GA-2	Lower *L. balmei*	D4				Coastal Plain - Deltaic
57	2847-50	9340-50	Coal Cts	Esso	Lower *L. balmei*	C4			*Phyllocadidites mawsonii* 43% of SP	Marsh - Peat swamp
58	2877-80	9440-50	Coal Cts	Esso	Lower *L. balmei*	C4			*Phyllocadidites mawsonii* 32% of SP	Marsh - Peat swamp
59	2896-902	9500-20	Cuttings	GA-2	Lower *L. balmei*	D4				Non-marine - fluvial
60	2951-57	9680-700	Cuttings	GA-2	Lower *L. balmei*	D5				Non-marine - fluvial
61	2975-84	9760-90	Cuttings	GA-2	Lower *L. balmei*	D4				Non-marine - fluvial
62	2995.6	9828	SWC 28	Esso	Lower *L. balmei*	B5			Reworking common 19% of SP	Non-marine - fluvial
63	2997.4	9834	SWC 27	Esso	Lower *L. balmei*	B3			*Phyllocadidites mawsonii* 69% of SP	Non-marine - fluvial
64	3042.2	9981	Core-4	Esso	Lower *L. balmei*	A1			FAD of *Haloragacidites harrisii*	Non-marine - fluvial
65	3066-69	10060-70	Cuttings	GA-2	*L. balmei/F. longus*	D4				Non-marine - fluvial
66	3116.9	10226	SWC 22	Esso	*L. balmei/F. longus*	B4				Lacustrine -fresh
67	3154.7	10350	SWC 18	Esso	*L. balmei/F. longus*	B4			*Proteacidites clinei* present	Non-marine - fluvial
68	3183.6	10445	SWC 12	Esso	*L. balmei/F. longus*	B4			LAD of *Nothofagidites senectus*	Non-marine - fluvial
69	3223.9	10577	SWC 33	Esso	Upper *F. longus*	B2	*Morkallacysta* Facies		LAD of *Proteacidites reticuloconcavus*	Lacustrine -fresh
70	3231-40	10600-30	Cuttings	GA-2	Upper *F. longus*	D4				Non-marine - fluvial
71	3233.3	10608	SWC 5	Esso	Upper *F. longus*	B3	*Morkallacysta* Facies			Lacustrine - fresh
72	3247.3	10654	SWC 34	Esso	Upper *F. longus*	B1			LAD of *Grapnelispora evansii*	Lacustrine - fresh
73	3262.3	10703	Core 5	Esso	Upper *F. longus*	B1			FAD of *Tripunctisporis maastrichtiensis*	Lacustrine - fresh

ABBREVIATIONS
*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum
GA-2 = Samples collected Stage-2 Work program
Esso = Samples processed in Esso laboratory
Sz = Superzone

CONFIDENCE RATINGS

Alpha Code Linked to Sample
A = Core
B = Sidewall core
C = Coal cuttings
D = Ditch cuttings
J = Junk basket

Numeric Code Linked to Palynomorph Assemblage
1 = Excellent confidence: High diversity assemblage **plus** key zone species.
2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
3 = Fair confidence: Low diversity assemblage **plus** key zone species.
4 = Poor confidence: Moderate to high diversity **minus** key zone species.
5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Poonboon-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
1	NA	SWC	27a		4046		1233.2	Moderate	High	Poor-good	30	10	20%	4%	9%	26%
2	NA	SWC	26a		4350		1325.9	Moderate	High	Poor-good	27	8	31%	11%	4%	22%
3	NA	SWC	24a		4940		1505.7	Moderate	High	Poor-fair	58	10	20%	2%	11%	41%
4	6406894	Cuttings		5090	5150	1551.4	1569.7	High	High	Poor-good	41	18	47%		12%	42%
5	NA	SWC	23a		5250		1600.2	Moderate	High	Poor-fair	62	7	5%	<1%	1%	50%
6	6406895	Cuttings		5420	5480	1652.0	1670.3	High	High	Poor-fair	40	14	16%		7%	60%
7	NA	SWC	22a		5550		1691.6	Low	Low	Poor-fair	41					
8	NA	SWC	21a		5600		1706.9	High	High	Fair-good	57	5	5%		1%	56%
9	NA	SWC	20a		5650		1722.1	Low	Low	Poor-fair	24	1				
10	NA	SWC	19a		5700		1737.4	Moderate	Moderate	Fair	53	1	<1%		2%	67%
11	NA	SWC	18a		5740		1749.6	High	High	Fair-good	53	6	<1%		2%	70%
12	NA	SWC	16a		5784		1763.0	High	High	Fair-good	55	9	7%		2%	47%
13	NA	SWC	15a		5800		1767.8	High	Very High	Poor-good	58	8	4%	1%	3%	47%
14	NA	SWC	14a		5910		1801.4	High	High	Fair-good	47	9	8%		7%	53%
15	NA	SWC	12a		6100		1859.3	High	High	Good	49	11	16%		5%	55%
16	NA	SWC	30		6200		1889.8	High	High	Poor-good	51	2	2%		4%	58%
17	NA	SWC	6a		6350		1935.5	High	High	Fair-good	47	1	1%		1%	47%
18	NA	Core	1		6410		1953.8	Moderate	Low	Poor-good	52	1	2%		2%	29%
19	NA	Core	1		6427		1958.9	Moderate	Moderate	Poor	27	9	26%	2%	3%	26%
20	NA	SWC	4a		6525		1988.8	High	High	Fair-good	64	1	1%		1%	49%
21	NA	Cuttings		6590	6620		2017.8	High	High	Fair	33					50%
22	NA	SWC	26		6600		2011.7	High	High	Poor-good	64				1%	20%
23	NA	SWC	25		6718		2047.6	Moderate	High	Poor-fair	56	1	<1%		6%	32%
24	NA	SWC	24		6800		2072.6	Low	Very Low	Poor-fair	11					
25	NA	Cuttings		6860	6880		2097.0	High	High	Fair	31				1%	50%
26	NA	SWC	22		7004		2134.8	High	High	Fair-good	45				2%	21%

Table 2. Basic Palynological Data from Poonboon-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
27	NA	SWC	21		7118		2169.6	High	High	Fair-good	34					17%
28	NA	SWC	20		7200		2194.6	High	High	Fair	54	2		1%	1%	29%
29	NA	SWC	19		7300		2225.0	High	High	Fair	49	1		<1%	1%	12%
30	NA	SWC	18		7340		2237.2	High	High	Fair-good	65	1	<1%		2%	18%
31	NA	SWC	17		7406		2257.3	Moderate	High	Poor-fair	57	1		<1%	2%	21%
32	NA	SWC	16		7504		2287.2	Low	Low	Poor	26				1%	5%
33	NA	SWC	15		7602		2317.1	Moderate	Moderate	Poor-fair	50	1		<1%	3%	18%
34	6406896	Cuttings		7750	7790	2362.2	2374.4	Moderate	Moderate	Poor -fair	30	6	4%		2%	8%
35	NA	SWC	13		7800		2377.4	Moderate	Moderate	Fair	47	2	1%		2%	17%
36	6406897	Cuttings		7900	7930	2407.9	2417.1	Moderate	Moderate	Poor -fair	29	3	6%		6%	10%
37	NA	SWC	11		7960		2426.2	Moderate	Moderate	Fair	49	5	3%	4%	11%	29%
38	NA	SWC	10		8000		2438.4	High	High	Fair-good	46	1		<1%	13%	8%
39	6406898	Core	2		8112		2472.5	High	Moderate	Very Poor-Poor	34	11	43%		19%	9%
40	NA	Core	2		8118		2474.4	Moderate	Moderate	Poor -fair	42	1				
41	6406899	Cuttings		8200	8230	2499.4	2508.5	High	High	Poor -fair	35	4	22%		9%	20%
42	NA	SWC	8		8200		2499.4	Very Low	Very Low	Poor	5					
43	NA	SWC	7		8250		2514.6	Low	Low	Poor	21					
44	NA	SWC	6		8300		2529.8	High	High	Fair	41	5	3%	1%	11%	17%
45	NA	SWC	5		8400		2560.3	Very Low	Very Low	Poor	3					
46	NA	SWC	4		8500		2590.8	Very Low	Very Low	Poor	4					
47	NA	SWC	3		8610		2624.3	Low	Low	Poor	33	1		<1%	13%	15%
48	NA	SWC	2		8700		2651.8	Moderate	Moderate	Poor	44	1	5%		23%	2%
49	NA	SWC	1		8788		2678.6	Moderate	High	Poor -fair	49	6	4%	<1%	19%	10%
50	NA	Core	3		8819		2688.0	High	High	Poor	51	2		1%	19%	18%
51	NA	Core	3		8823		2689.3	Moderate	Moderate	Poor	34	2	<1%	1%	16%	13%
52	6406900	Cuttings		8900	8940	2712.7	2724.9	High	Moderate	Poor	30	1	2%		10%	10%

Table 2. Basic Palynological Data from Poonboon-1

No.	PalLab Spl.No.	Sample Type	Core No.	Top Feet	Base Feet	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
53	NA	Cuttings		8980	8990	2737.1	2740.2	High	High	Poor	36				<1%	19%
54	NA	Cuttings		9050	9060	2758.4	2761.5	High	High	Poor	33				1%	23%
55	6406901	Cuttings		9170	9190	2795.0	2801.1	Moderate	Moderate	Very Poor	30	2	7%		15%	9%
56	6406902	Cuttings		9310	9330	2837.7	2843.8	Moderate	Low	Very Poor	28	2	5%	<1%	10%	3%
57	NA	Cuttings		9340	9350	2846.8	2849.9	High	High	Poor	16					3%
58	NA	Cuttings		9440	9450	2877.3	2880.4	High	High	Poor	33	2		<1%	<2%	7%
59	6406903	Cuttings		9500	9520	2895.6	2901.7	Low	Low	Very Poor	29	1		2%	11%	8%
60	6406904	Cuttings		9680	9700	2950.5	2956.6	High	Moderate	Poor	25	1		<1%	9%	2%
61	6406905	Cuttings		9760	9790	2974.8	2984.0	High	High	Poor	23	1		<1%	2%	4%
62	NA	SWC	28		9828		2995.6	Low	Very Low	Poor	20	1		1%	11%	15%
63	NA	SWC	27		9834		2997.4	Moderate	Moderate	Poor	20					3%
64	NA	Core	4		9981		3042.2	High	Moderate	Poor -fair	33	2		1%	6%	5%
65	6406906	Cuttings		10060	10070	3066.3	3069.3	High	Moderate	Poor	28	1		2%	6%	2%
66	NA	SWC	22		10226		3116.9	High	High	Poor	35	2		1%	23%	3%
67	NA	SWC	18		10350		3154.7	High	High	Poor	32	1		1%	12%	9%
68	NA	SWC	12		10445		3183.6	Moderate	Low	Poor	20				1%	9%
69	NA	SWC	33		10577		3223.9	High	Moderate	Poor	27	2		13%	22%	4%
70	6406907	Cuttings		10600	10630	3230.9	3240.0	High	Moderate	Poor	26	1		<1%	3%	3%
71	NA	SWC	5		10608		3233.3	High	Moderate	Poor	28	4		5%	44%	2%
72	NA	SWC	34		10654		3247.3	High	High	Poor	32				29%	1%
73	NA	Core	5		10703		3262.3	High	High	Poor	43	3		2%	44%	

ABBREVIATIONS

MP = Microplankton

SP = Spore-Pollen

NA = Not Available

NED = Neves Effect based on *Dilwynites/Araucariacites* pollen percentage

Noth% = Percentage of *Nothofagidites* pollen in SP count.

Table 3. Poonboon-1 — abundances of major palynomorph groups.

No.	Depth metres	Depth feet	Sample Type	Gleicheniidites & Clavifera spores	ALL OTHER Spores	Dilwynites & Araucariacites pollen	ALL OTHER Gymnosperms	Nothofagidites species	ALL OTHER Angiosperms	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON Fresh & Brackish	MICROPLANKTON Marine	**SP + MP SUM**
1	1233.2	4046	SWC 27a	0.8%	15%	11%	4.7%	29%	26%	14%		253		75%	4%	20%	288
2	1325.9	4350	SWC 26a	2.3%	13%	4.1%	12%	25%	28%	14%	0.9%	221		57%	11%	31%	327
3	1505.7	4940	SWC 24a		8.0%	12%	7.0%	45%	19%	8.5%		201		78%	0.8%	22%	237
4	1551-70	5090-150	Cuttings	0.7%	19%	12%	10%	41%	14%	2.9%		139		53%	0.4%	47%	256
5	1600.2	5250	SWC 23a	0.5%	4.9%	2.0%	12%	51%	28%	1.5%		203		95%	0.5%	5%	211
6	1652-70	5420-80	Cuttings	0.5%	5.9%	6.8%	9.1%	60%	17%	1.4%		220		84%		16%	257
7	1691.6	5550	SWC 22a														
8	1706.9	5600	SWC 21a	2.1%	5.0%	1.7%	5.4%	57%	26%	2.9%		240		95%		5%	246
9	1722.1	5650	SWC 20a														
10	1737.4	5700	SWC 19a	1.6%	11%	2.0%	10%	67%	8%			254		100%		0.4%	255
11	1749.6	5740	SWC 18a	0.5%	4.1%	2.3%	9.6%	70%	13%	0.5%		218		100%		0.5%	218
12	1763.0	5784	SWC 16a	0.4%	14%	1.6%	13%	47%	23%	1.2%		250		93%		7%	265
13	1767.8	5800	SWC 15a		7.4%	3.5%	10%	50%	24%	4.9%		284		95%	1.1%	4%	285
14	1801.4	5910	SWC 14a	0.4%	8.1%	7.3%	7.7%	53%	23%	0.4%	0.4%	248		92%		8%	268
15	1859.3	6100	SWC 12a		8.8%	5.5%	9.9%	55%	21%		0.4%	273		84%		16%	322
16	1889.8	6200	SWC 30	0.7%	5.6%	4.5%	11%	60%	16%	3.0%		267		98%		2%	264
17	1935.5	6350	SWC 6a		6.0%	0.7%	6.3%	47%	38%	1.9%		268		99%		0.8%	265
18	1953.8	6410	Core 1	0.5%	12%	1.5%	13%	29%	43%	1.5%		195		98%		2%	195
19	1958.9	6427	Core 1		1.5%	3.6%	4.6%	28%	54%	8.8%		194		72%	2%	26%	247
20	1988.8	6525	SWC 4a		3.8%	1.5%	9.6%	51%	31%	3.1%		260		99%		0.8%	254
21	2009-18	6590-620	Coal cts		1.9%		13%	50%	35%			266		100%			266
22	2011.7	6600	SWC 26	0.4%	12%	1.1%	22%	21%	42%	2.5%		285		100%			278
23	2047.6	6718	SWC 25	0.4%	9.7%	5.8%	22%	32%	29%	1.2%		259		100%		0.4%	257
24	2072.6	6800	SWC 24														
25	2091-97	6860-80	Coal cts		1.2%	0.8%	9.6%	50%	38%	0.4%		260		100%			259
26	2134.8	7004	SWC 22		4.3%	2.4%	16%	27%	20%	29%	0.4%	255		100%			180
27	2169.6	7118	SWC 21	0.8%	10%		29%	17%	43%			259		100%			259
28	2194.6	7200	SWC 20	0.8%	5.1%	1.6%	29%	31%	23%	7.9%	1.2%	253		99%	1.3%		233
29	2225.0	7300	SWC 19	0.7%	1.8%	1.1%	9.6%	14%	59%	13%	0.4%	271		100%	0.4%		235
30	2237.2	7340	SWC 18		12%	2.3%	9.5%	18%	54%	4.6%		263		100%		0.4%	252
31	2257.3	7406	SWC 17	0.4%	5.7%	1.9%	4.2%	21%	65%	1.5%		261		100%	0.4%		258
32	2287.2	7504	SWC 16	0.9%	6.3%	0.9%	3.6%	5.4%	73%	9.8%		112		100%			101
33	2317.1	7602	SWC 15		3.0%	3.3%	3.3%	22%	51%	17%	0.7%	269		100%	0.5%		221
34	2362-74	7750-90	Cuttings		8.9%	1.5%	12%	5.2%	34%	39%		269		96%		4%	172
35	2377.4	7800	SWC 13	0.4%	3.9%	1.8%	8.9%	17%	68%		0.4%	281		99%		1.1%	283
36	2408-17	7900-30	Cuttings	0.3%	2.6%	3.8%	11%	6.2%	34%	41%		340		93%		7%	214
37	2426.2	7960	SWC 11	0.4%	7.2%	11%	8.8%	29%	43%	0.4%	0.4%	251		93%	4%	3%	267
38	2438.4	8000	SWC 10	3.8%	8.7%	15%	11%	8.7%	42%	9.9%	0.4%	263		100%	0.4%		237

Table 3. Poonboon-1 — abundances of major palynomorph groups.

No.	Depth metres	Depth feet	Sample Type	Gleicheniidites & Clavifera spores	ALL OTHER Spores	Dilwynites & Araucariacites pollen	ALL OTHER Gymnosperms	Nothofagidites species	ALL OTHER Angiosperms	FUNGAL microfossils	Reworked Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON Fresh & Brackish	MICROPLANKTON Marine	**SP + MP SUM**
39	2472.5	8112	Core 2	1.8%	12%	18%	3.6%	8.5%	50%	6.7%		165		59%		41%	259
40	2474.4	8118	Core 2														
41	2499-508	8200-30	Cuttings	0.3%	4.9%	8.2%	21%	16%	31%	18%		305		76%		24%	327
42	2499.4	8200	SWC 8														
43	2514.6	8250	SWC 7														
44	2529.8	8300	SWC 6	5.2%	6.4%	12%	12%	18%	46%	1.9%		267		96%	0.7%	3%	273
45	2560.3	8400	SWC 5														
46	2590.8	8500	SWC 4														
47	2624.3	8610	SWC 3	3.6%	4.4%	13%	35%	15%	28%	0.4%	0.8%	250		100%	0.4%		248
48	2651.8	8700	SWC 2	5.8%	14%	23%	26%	2.4%	28%		1.0%	206		95%		5%	215
49	2678.6	8788	SWC 1	17%	17%	19%	20%	10%	15%	1.5%	0.4%	264		96%	0.4%	4%	271
50	2688.0	8819	Core 3	13%	7.7%	19%	21%	18%	20%	0.7%	0.7%	272		99%	0.7%		270
51	2689.3	8823	Core 3	7.3%	13%	16%	27%	13%	23%	0.8%		262		99%	0.8%	0.4%	263
52	2713-25	8900-40	Cuttings	0.9%	12%	6.9%	28%	7.5%	17%	29%		319		98%		2%	233
53	2737-40	8980-90	Coal Cts	0.8%	9.0%	0.4%	47%	20%	22%	0.8%		244		100%			242
54	2758-61	9050-60	Coal Cts	2.8%	24%	0.8%	39%	23%	10%	0.4%		253		100%			252
55	2795-801	9170-90	Cuttings	1.4%	17%	14%	41%	7.8%	19%	0.7%		281		93%		7%	266
56	2838-44	9310-30	Cuttings	3.7%	24%	9.5%	47%	3.3%	12%	0.8%		241		95%	0.4%	5%	244
57	2847-50	9340-50	Coal Cts		1.6%		91%	3.2%	4.3%			253		100%			253
58	2877-80	9440-50	Coal Cts	2.8%	7.9%	1.6%	66%	7.5%	14%			253		99%	0.8%		255
59	2896-902	9500-20	Cuttings	3.4%	18%	9.7%	42%	6.9%	5.0%	15%		319		98%		2%	278
60	2951-57	9680-700	Cuttings	0.3%	13%	6.9%	43%	5.5%	6.9%	24%		290		99%		0.9%	222
61	2975-84	9760-90	Cuttings	0.5%	5.3%	1.3%	68%	3.7%	4.0%	17%		375		99%		0.6%	313
62	2995.6	9828	SWC 28	4.4%	8.8%	11%	33%	16%	7.0%	1.8%	18%	114		99%		1.1%	93
63	2997.4	9834	SWC 27	1.7%	1.7%		85%	3.4%	7.8%			232		100%			232
64	3042.2	9981	Core-4	1.6%	7.1%	6.3%	40%	5.1%	28%	13%		254		99%	0.9%		224
65	3066-69	10060-70	Cuttings	1.0%	6.5%		64%	1.6%	8.1%	19%		308		98%		2.3%	256
66	3116.9	10226	SWC 22	0.7%	15%	23%	29%	2.8%	27%	1.4%	0.7%	281		99%	0.7%	0.7%	279
67	3154.7	10350	SWC 18	1.6%	9.1%	12%	36%	8.7%	32%		0.8%	253		99%	1.2%		254
68	3183.6	10445	SWC 12	2.0%	3.5%	1.6%	67%	9.4%	16%			256		100%			256
69	3223.9	10577	SWC 33	0.5%	21%	22%	21%	4.2%	31%			189		86%	12%	1.4%	219
70	3231-40	10600-30	Cuttings	0.3%	6.1%	5.8%	58%	2.3%	8.7%	19%		309		99%	0.8%		252
71	3233.3	10608	SWC 5	0.4%	15%	44%	14%	2.4%	23%	0.8%		247		95%	5%	0.4%	258
72	3247.3	10654	SWC 34	0.4%	3.6%	29%	42%	0.7%	23%	0.7%	0.4%	277		100%			274
73	3262.3	10703	Core 5	4.0%	17%	44%	8.8%		26%			251		98%	2%		255

Table 4. Poonboon-1 — spore-pollen distribution. spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	SPORE SPECIES	Baculatisporites spp.	Camarozonosporites bullatus	Camarozonosporites heskermensis	Clavifera triplex	Conbaculatisporites apiculatus ms	Crassoretitriletes vanraadshooveni	Cyatheacidites annulatus	Cyathidites splendens	Cyathidites subtilis	Cyathidites spp. small <40µm	Densoisporites pellis ms	Dictyophyllidites spp.	Echinosporis echinatus	Foraminisporis ozotus ms	Foveotriletes balteus	Foveotriletes crater	Foveotriletes palaequetrus	Gleicheniidites circinidites	Grapnelispora evansii	Herkosporites elliotii	Ischyosporites spp.
1	1233.2	4046	SWC 27a		1.4%						0.5%		X	7.8%								0.9%			
2	1325.9	4350	SWC 26a											9.6%		3.2%		X				2.7%			
3	1505.7	4940	SWC 24a		0.5%						0.5%			6.5%					X	X	X				0.5%
4	1551-70	5090-150	Cuttings		X		X				X	0.7%	X	14%		0.7%		X				0.7%		X	0.7%
5	1600.2	5250	SWC 23a		X							0.5%		4.5%		X				X		0.5%		X	X
6	1652-70	5420-80	Cuttings		0.5%						X			2.3%		0.9%					X	0.5%			0.5%
7	1691.6	5550	SWC 22a																					X	X
8	1706.9	5600	SWC 21a		X							0.9%		1.3%		X						2.1%			0.4%
9	1722.1	5650	SWC 20a											X								X			X
10	1737.4	5700	SWC 19a		0.4%							0.4%		5.5%						X		1.6%		X	0.8%
11	1749.6	5740	SWC 18a		0.5%							0.5%		1.8%								0.5%			0.9%
12	1763.0	5784	SWC 16a		1.6%									8.1%	X							0.4%		X	2.4%
13	1767.8	5800	SWC 15a		0.7%							0.4%		3.3%					X		X			X	1.9%
14	1801.4	5910	SWC 14a		0.4%									5.3%								0.4%			0.4%
15	1859.3	6100	SWC 12a									X		6.3%											1.1%
16	1889.8	6200	SWC 30		1.2%					X				1.5%								0.8%			0.4%
17	1935.5	6350	SWC 6a											1.5%											0.8%
18	1953.8	6410	Core 1		1.6%							0.5%		1.0%			1.0%					0.5%			X
19	1958.9	6427	Core 1									0.6%													
20	1988.8	6525	SWC 4a		0.4%							X		0.8%											X
21	2009-18	6590-620	Coal cts											0.4%											
22	2011.7	6600	SWC 26		0.4%							0.7%		2.9%								0.4%			X
23	2047.6	6718	SWC 25		1.2%							1.6%		0.8%								0.4%			
24	2072.6	6800	SWC 24																						
25	2091-97	6860-80	Coal cts																						
26	2134.8	7004	SWC 22		0.6%							0.6%		2.8%			X								1.1%
27	2169.6	7118	SWC 21									1.5%		1.2%					X			0.8%			0.4%
28	2194.6	7200	SWC 20		0.4%							0.4%		1.7%	X							0.9%			0.4%
29	2225.0	7300	SWC 19				X		X					0.4%								0.9%			
30	2237.2	7340	SWC 18		0.4%				0.4%			0.4%		5.2%											
31	2257.3	7406	SWC 17						1.2%			X		1.2%					X			0.4%			X
32	2287.2	7504	SWC 16									1.0%		2.0%								1.0%			2.0%
33	2317.1	7602	SWC 15		0.5%				X					0.9%											
34	2362-74	7750-90	Cuttings		0.6%							4.2%		3.0%											
35	2377.4	7800	SWC 13		0.4%							X		0.7%								0.4%			
36	2408-17	7900-30	Cuttings		0.5%							1.0%		1.5%								0.5%			
37	2426.2	7960	SWC 11		2.0%							0.4%		2.4%			0.4%					0.4%			
38	2438.4	8000	SWC 10		2.1%			0.4%				2.5%		3.0%								3.8%			0.4%
39	2472.5	8112	Core 2		0.6%			0.6%				1.9%		3.9%					X			1.3%			
40	2474.4	8118	Core 2		X					X		X													X
41	2499-508	8200-30	Cuttings									0.4%		2.4%								0.4%			
42	2499.4	8200	SWC 8																						
43	2514.6	8250	SWC 7		X							X					X								
44	2529.8	8300	SWC 6		0.4%							X		2.3%								5.3%			

No.	Depth metres	Depth feet	Sample Type	Kuylisporites waterbolkii	Laevigatosporites major	Laevigatosporites ovatus	Latrobosporites amplus	Latrobosporites crassus	Latrobosporites ohaiensis	Marattisporites scabratus	Matonisporites gigantis	Matonisporites ornamentalis	Monolites alveolatus	Oramentifera sentosa	Peromonolites densus	Peromonolites vellosus	Perotriletes spp.	Polypodiaceoisporites varus ms	Polypodiidites/Verrucatosporites spp.	Retitriletes spp.	Ricciaesporites boxatus ms	Rotverrusporites stellatus ms	Rugulatisporites mallatus	Rugulatisporites trophus
1	1233.2	4046	SWC 27a		0.5%	1.8%		X																
2	1325.9	4350	SWC 26a			1.1%						X											X	
3	1505.7	4940	SWC 24a		X	0.5%						X									X		X	
4	1551-70	5090-150	Cuttings		X	2.2%													X					
5	1600.2	5250	SWC 23a	X				X				X				X			X		X			
6	1652-70	5420-80	Cuttings		X	X													X					X
7	1691.6	5550	SWC 22a									X				X							X	
8	1706.9	5600	SWC 21a	X		X		X				X					X		X	0.4%				
9	1722.1	5650	SWC 20a									X								X			X	
10	1737.4	5700	SWC 19a			1.2%				0.4%					X			X		0.4%				
11	1749.6	5740	SWC 18a	X	X	0.5%						X							X	X				
12	1763.0	5784	SWC 16a		X	0.4%		X				X								0.4%	X			
13	1767.8	5800	SWC 15a							0.4%		X								X	X		X	X
14	1801.4	5910	SWC 14a		X	0.8%				0.4%						0.4%							X	
15	1859.3	6100	SWC 12a		0.4%	0.7%													0.4%				X	
16	1889.8	6200	SWC 30		0.4%	1.5%															X		X	
17	1935.5	6350	SWC 6a		0.4%	1.9%										0.4%					X			
18	1953.8	6410	Core 1			4.2%		X				X							1.0%					
19	1958.9	6427	Core 1										X											
20	1988.8	6525	SWC 4a			0.8%		X				X				0.4%			0.8%				X	
21	2009-18	6590-620	Coal cts			0.8%													0.4%					
22	2011.7	6600	SWC 26		0.7%	5.4%										0.4%			0.4%				X	
23	2047.6	6718	SWC 25		0.4%	2.3%		X				X			0.8%								X	X
24	2072.6	6800	SWC 24					X																
25	2091-97	6860-80	Coal cts			0.8%																		
26	2134.8	7004	SWC 22			0.6%		X																
27	2169.6	7118	SWC 21			6.6%						X								0.4%				
28	2194.6	7200	SWC 20	X		1.3%		X				X			X				0.9%	0.4%				
29	2225.0	7300	SWC 19	X		0.4%																		
30	2237.2	7340	SWC 18	0.8%	0.4%	4.0%		X															X	
31	2257.3	7406	SWC 17			3.5%							X											
32	2287.2	7504	SWC 16		X	1.0%														1.0%				
33	2317.1	7602	SWC 15	X		1.4%																	X	
34	2362-74	7750-90	Cuttings			3.0%													0.6%					
35	2377.4	7800	SWC 13	0.4%		1.8%		0.4%		0.4%														
36	2408-17	7900-30	Cuttings													0.5%								
37	2426.2	7960	SWC 11			1.2%		0.4%															X	
38	2438.4	8000	SWC 10			1.7%																		
39	2472.5	8112	Core 2			1.9%												0.6%						
40	2474.4	8118	Core 2					X										X					X	
41	2499-508	8200-30	Cuttings			0.4%													0.4%					
42	2499.4	8200	SWC 8																					
43	2514.6	8250	SWC 7																				X	
44	2529.8	8300	SWC 6			0.4%					X												X	

Table 4. Poonboon-1 — spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Stereisporites antiquisporites	Stereisporites regium	Striamonoletes digitatoides	Trilete spores undiff.	Tripunctisporis maastrichtiensis	Verrucatosporites attinatus ms	Verrucosisporites cristatus	Verrucosisporites kopukuensis	**TOTAL Spores**	**GYMNOSPERM SPECIES**	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites balmei	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites mawsonii	Phyllocladidites reticulosaccatus	Phyllocladidites verrucosus	Podocarpidites spp.	Podocarpidites exiguus	Trichotomosulcites subgranulatus	**TOTAL Gymnosperms**
1	1233.2	4046	SWC 27a	3.7%			1.4%					18%		2.3%	2.8%		10%			0.5%			0.5%			1.8%			18%
2	1325.9	4350	SWC 26a	0.5%			1.1%					18%		1.6%	2.7%	0.5%	3.2%			2.1%			1.6%			7.4%			19%
3	1505.7	4940	SWC 24a	X				X		X		9%		3.8%	1.6%	0.5%	9.2%	0.5%		1.1%	0.5%		1.1%			2.7%			21%
4	1551-70	5090-150	Cuttings	1.5%								21%		4.4%	1.5%	X	7.4%			1.5%			1.5%			5.9%			22%
5	1600.2	5250	SWC 23a						X	X	X	6%			1.0%	X	1.5%	0.5%		3.0%			4.0%			4.0%		0.5%	15%
6	1652-70	5420-80	Cuttings	0.9%			0.5%				0.5%	6%		2.3%	1.4%		4.6%			1.8%			1.8%			3.2%		0.9%	16%
7	1691.6	5550	SWC 22a					X	X	X	X												X			X			
8	1706.9	5600	SWC 21a	1.3%			0.9%				X	7%		0.4%	0.9%	X	1.3%			1.7%	0.4%		1.7%			0.9%			7%
9	1722.1	5650	SWC 20a								X			X			X			X		X				X			
10	1737.4	5700	SWC 19a				2.0%			X	X	13%		1.6%	0.8%		0.4%			1.6%			2.8%			4.3%		0.8%	12%
11	1749.6	5740	SWC 18a	X				X		X	X	5%		0.9%	0.5%		1.4%		RW	1.8%		0.9%	2.3%			3.2%		0.9%	12%
12	1763.0	5784	SWC 16a	0.4%			0.8%	X			X	15%		0.4%	1.2%		1.2%			1.2%			5.7%			4.5%		0.4%	15%
13	1767.8	5800	SWC 15a					X		X	3	8%		1.9%	3.0%	0.4%	1.9%			0.7%	0.7%	0.4%	1.9%			3.7%			14%
14	1801.4	5910	SWC 14a				0.4%		X		X	9%		3.7%			3.7%			2.4%		0.4%	2.4%			2.4%			15%
15	1859.3	6100	SWC 12a						X		X	9%		0.4%			5.1%			2.2%	0.4%	0.7%	2.9%			3.3%		0.4%	15%
16	1889.8	6200	SWC 30	0.4%			0.4%	X	X		X	7%		1.5%	0.4%		2.3%	0.8%		1.5%	0.8%	0.4%	1.5%			6.6%			16%
17	1935.5	6350	SWC 6a								1.1%	6%		0.4%			0.4%			4.2%			0.8%			1.5%			7%
18	1953.8	6410	Core 1				0.5%				2.1%	13%			0.5%		1.6%			2.6%		1.0%	4.7%			3.6%		0.5%	15%
19	1958.9	6427	Core 1								1.1%	2%		1.1%	0.6%		2.3%	0.6%		0.6%			1.7%			2.3%			9%
20	1988.8	6525	SWC 4a	0.4%				X			0.4%	4%		0.8%	0.4%		0.8%			1.2%			3.2%			4.8%		0.4%	12%
21	2009-18	6590-620	Coal cts								0.4%	2%								1.5%	3.4%		3.8%			2.3%		2.3%	13%
22	2011.7	6600	SWC 26				0.4%	0.4%	X		0.4%	12%		0.4%	0.7%		0.7%			1.4%		0.7%	12%			7.2%		1.1%	24%
23	2047.6	6718	SWC 25				0.8%	0.4%			1.6%	10%		0.4%	0.4%		4.7%	0.8%		2.0%		0.8%	15%			3.5%			28%
24	2072.6	6800	SWC 24								X															X			
25	2091-97	6860-80	Coal cts								0.4%	1%		0.4%			0.4%			2.3%	0.8%		3.9%			2.3%		0.4%	10%
26	2134.8	7004	SWC 22	0.6%				X			X	6%		0.6%	0.6%		2.2%	0.6%			0.6%	0.6%	4.4%			16%		0.6%	26%
27	2169.6	7118	SWC 21									11%											19%			8.5%		2.3%	29%
28	2194.6	7200	SWC 20					X			X	7%		0.9%	0.4%	0.9%	0.9%			0.9%	1.3%	1.7%	5.7%			18%		3.5%	34%
29	2225.0	7300	SWC 19				0.4%				0.9%	3%					0.9%	0.4%		0.9%	0.9%	1.3%	3.0%			5.1%			12%
30	2237.2	7340	SWC 18				0.4%				0.4%	12%			0.4%		1.6%	0.8%		1.2%	0.8%	0.4%	0.8%			5.2%		1.2%	12%
31	2257.3	7406	SWC 17								X	6%		0.4%	0.4%		1.2%	0.4%					1.6%			2.3%			6%
32	2287.2	7504	SWC 16									8%		1.0%						1.0%			1.0%			2.0%			5%
33	2317.1	7602	SWC 15				0.5%				0.5%	4%		0.9%			2.3%	0.9%		1.4%						2.7%			8%
34	2362-74	7750-90	Cuttings	0.6%			2.4%					15%		2.4%		0.6%						1.2%	4.2%			9.1%		4.2%	22%
35	2377.4	7800	SWC 13									4%		0.4%			1.4%			1.1%	0.4%		0.4%			5.7%		1.4%	11%
36	2408-17	7900-30	Cuttings				1.0%					5%		1.0%	0.5%		4.5%	1.0%		0.5%			1.5%			13%		4.0%	26%
37	2426.2	7960	SWC 11				0.4%	X			X	8%		2.4%	0.4%		7.6%	1.2%		1.2%			1.6%			4.8%		0.8%	20%
38	2438.4	8000	SWC 10								X	14%		0.8%			15%	0.4%		0.8%		0.4%				9.7%		1.7%	29%
39	2472.5	8112	Core 2	2.6%			1.3%					15%		4.5%			14%	0.6%		0.6%		0.6%				1.9%		0.6%	23%
40	2474.4	8118	Core 2			X		X			X								RW				X			X			
41	2499-508	8200-30	Cuttings				2.4%					6%		2.0%			6.8%	1.2%		2.8%		0.8%	4.4%			17%		1.2%	36%
42	2499.4	8200	SWC 8																RW							X			
43	2514.6	8250	SWC 7								X								RW							X			
44	2529.8	8300	SWC 6	2.7%			0.4%	0.4%			X	12%		1.1%	0.8%		10%	0.8%		0.8%		1.1%	0.8%			6.1%		2.3%	24%

No.	**ANGIOSPERM SPECIES**	Angiosperm pollen undiff.	Aglaoreidia qualumis	Anacolosidites luteoides	Anacolosidites sectus	Anisocolporites triplex	Australopollis obscurus	Banksieaeidites arcuatus	Banksieaeidites elongatus	Battenipollis sectilis	Beaupreaidites elegansiformis	Beaupreaidites verrucosus	Clavatipollenites glarius	Concolpites leptos	Cupanieidites orthoteichus	Cyperaceaepollis neogenicus
1		0.5%									0.5%					
2		1.6%														
3		1.1%	X					X								
4		1.5%	X						X							
5		2.5%	1.0%													
6		1.8%	0.9%											0.5%		
7			X												X	
8		1.3%	0.9%						X		X				X	
9																
10			X						X						X	
11		1.8%	0.9%													
12		0.8%	0.4%								X	X		0.4%	X	
13											X				0.4%	
14		0.8%	0.4%		X						X					0.4%
15		1.1%			X			0.4%			X				X	
16		0.4%			X			X	X						X	
17		2.3%			X			0.8%						0.4%	1.5%	
18		1.0%				X		2.1%				X		1.0%	X	
19		1.1%						0.6%					1.7%		0.6%	
20		1.2%						1.6%				X		0.4%		
21		0.4%														
22		0.7%						X							0.4%	
23								0.4%							0.4%	
24																
25		0.8%										0.8%			1.2%	
26		0.6%													0.6%	
27		0.4%						1.5%								
28		0.4%						0.4%						0.4%		
29		1.7%						2.1%							0.9%	
30		0.4%						0.4%	X						0.4%	
31		1.9%						X				X			1.6%	
32		1.0%						1.0%							2.0%	
33		0.9%						X							X	
34		12%													1.2%	X
35		0.4%		X				X	X						1.8%	
36		6.5%														
37				X											X	
38		1.3%							X						0.8%	
39		1.9%													1.3%	
40				X											X	
41		8.0%														
42																
43															X	
44								X								

Table 4. Poonboon-1 — spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Dicotetradites clavatus	Dryadopollenites retequetrus	Dryptopollenites semilunatus	Elphedripites notensis	Ericipites crassiexinus/scabratus	Gambierina edwardsii	Gambierina rudata	Granodiporites nebulosus	Gothanipollis bassensis	Haloragacidites harrisii	Ilexpollenites spp.	Intratriporopollenites notabilis	Liliacidites spp.	Malvacipollis diversus	Malvacipollis grandis ms	Malvacipollis robustus ms	Malvacipollis subtilis
1	1233.2	4046	SWC 27a					0.5%					6.5%							0.5%
2	1325.9	4350	SWC 26a										8.5%							0.5%
3	1505.7	4940	SWC 24a									X	3.3%	0.5%					X	X
4	1551-70	5090-150	Cuttings										4.4%	X						
5	1600.2	5250	SWC 23a					X					5.0%	0.5%		X	RW	X		
6	1652-70	5420-80	Cuttings	0.5%									6.5%	X		2				
7	1691.6	5550	SWC 22a		X	X		X					X							X
8	1706.9	5600	SWC 21a					X					7.3%	0.9%		X				0.9%
9	1722.1	5650	SWC 20a										X							
10	1737.4	5700	SWC 19a									X	6.7%	X		X			X	X
11	1749.6	5740	SWC 18a	0.5%				X					1.8%	0.9%		0.5%			X	X
12	1763.0	5784	SWC 16a	X			X	X					5.7%	0.8%						X
13	1767.8	5800	SWC 15a					0.7%			X		7.0%			X			X	1.1%
14	1801.4	5910	SWC 14a										8.5%	0.8%					X	2.0%
15	1859.3	6100	SWC 12a					X					6.3%	0.4%						3.7%
16	1889.8	6200	SWC 30										6.2%	0.4%						1.2%
17	1935.5	6350	SWC 6a	X									9.5%			X	0.4%			2.3%
18	1953.8	6410	Core 1	1.0%			0.5%						11%	2.1%						2.1%
19	1958.9	6427	Core 1	0.6%				0.6%					10%							0.6%
20	1988.8	6525	SWC 4a	0.4%				X					4.8%	1.2%						1.2%
21	2009-18	6590-620	Coal cts	0.4%				0.8%					7.9%	0.8%		0.4%				0.4%
22	2011.7	6600	SWC 26	5.8%		0.7%						X	8.3%	0.4%			X		X	1.8%
23	2047.6	6718	SWC 25	0.8%									9.0%	0.4%					X	2.3%
24	2072.6	6800	SWC 24										X				X			
25	2091-97	6860-80	Coal cts										12%			0.8%				
26	2134.8	7004	SWC 22	1.1%		0.6%							2.2%	X						0.6%
27	2169.6	7118	SWC 21	3.9%				X					0.8%							X
28	2194.6	7200	SWC 20	0.9%		0.4%							1.7%	0.4%						1.3%
29	2225.0	7300	SWC 19	1.3%		0.4%	X	X					4.7%	0.4%						0.9%
30	2237.2	7340	SWC 18	2.4%			X	X					9.6%	0.4%	0.4%				X	1.2%
31	2257.3	7406	SWC 17	0.4%		1.2%						0.8%	8.2%	X		X	X		X	1.2%
32	2287.2	7504	SWC 16	2.0%									28%							X
33	2317.1	7602	SWC 15	0.5%		0.5%							13%	0.9%	0.5%		X		X	1.8%
34	2362-74	7750-90	Cuttings										8.5%	0.6%		1.8%				1.8%
35	2377.4	7800	SWC 13	0.7%		0.7%							5.0%	X	0.4%		X		X	1.8%
36	2408-17	7900-30	Cuttings	2.0%									8.5%				0.5%			4.0%
37	2426.2	7960	SWC 11	0.8%									8.0%		X	0.8%	2.4%			1.6%
38	2438.4	8000	SWC 10	1.7%		0.8%							3.8%		0.4%		2.1%		X	3.0%
39	2472.5	8112	Core 2										19%				4.5%		X	7.8%
40	2474.4	8118	Core 2	X									X		X		X			X
41	2499-508	8200-30	Cuttings	0.4%									6.0%		0.4%	0.4%				1.6%
42	2499.4	8200	SWC 8										X				X			
43	2514.6	8250	SWC 7	X									X		X		X			
44	2529.8	8300	SWC 6	0.8%			0.4%						5.3%	1.9%			0.8%			2.7%

No.	Milfordia incerta	Milfordia homeopunctatus	Monosulcites uvatus ms	Myrtaceidites parvus/mesonesus	Myrtaceidites tenuis	Myrtaceidites verrucosus	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites endurus	Nothofagidites falcatus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites senectus	Nothofagidites vansteenisii	Paripollis ochesis	Peninsulapollis gillii	Periporopollenites demarcatus	Periporopollenites polyoratus	Periporopollenites vesicus	Polycolporopollenites esobalteus	Polycolpites langstonii	Polyorificites oblatus	Proteacidites spp.	Proteacidites adenanthoides
1		0.5%		12%			0.9%		1.4%	29%		1.8%				1.4%									1.8%	
2		0.5%		12%					0.5%	26%		0.5%	2.7%												2.7%	
3		0.5%		4.9%		X	0.5%	0.5%	6.0%	40%		0.5%	0.5%	0.5%		0.5%			X						2.2%	
4				2.2%				0.7%	0.7%	37%		1.5%	1.5%			0.7%									1.5%	
5	X	X		7.0%			0.5%		6.5%	43%		0.5%	0.5%	0.5%		0.5%			0.5%	0.5%					2.5%	
6				2.3%		X	0.9%	0.5%	2.8%	49%		2.8%	0.9%			3.7%				X					0.5%	
7		X		X		X	X	X	X	X		X	X	X		X									X	
8				7.7%		X	0.9%	0.4%	13%	42%		0.4%	0.4%	0.4%		0.4%			X		X				1.7%	
9							X		X	X						X									X	
10		X		0.4%		X	0.4%	0.4%	3.5%	46%		2.0%	2.4%	0.4%		12%			0.4%						0.4%	RW
11				1.8%			0.5%	0.5%	22%	45%		0.5%	0.5%	0.5%		0.5%									1.4%	
12				6.9%		X	0.8%	2.0%	4.5%	35%		0.4%	3.6%	0.8%		0.4%					X				1.2%	
13				11%		X	0.7%	2.2%	2.2%	37%		2.2%	3.3%	1.5%		3.0%			0.4%						0.4%	X
14				1.6%			0.4%		3.3%	41%		1.2%	1.2%	0.4%		5.3%									2.8%	X
15				0.7%		X	1.8%		3.3%	43%		1.8%	0.4%			4.8%			1.1%						3.3%	X
16	0.4%			2.3%			1.2%	0.4%	5.0%	50%		3.1%	0.4%	0.4%		1.2%			X						1.9%	
17			X	6.5%				1.5%	3.0%	39%		0.8%	2.7%	0.4%		0.8%			0.8%	0.4%					6.8%	
18		0.5%		5.2%				0.5%	3.6%	20%			1.6%	0.5%		3.1%			X						7.3%	X
19				16%		X			2.8%	22%						5.6%									7.3%	
20	0.4%		X	4.4%		X	0.4%	2.8%	4.4%	40%			2.0%	0.4%		2.8%			0.8%	0.4%					7.1%	X
21			0.8%	0.8%					0.8%	47%			2.3%						1.5%						4.9%	
22	0.4%							0.7%	1.8%	15%			2.2%	0.4%		0.7%			1.1%	0.4%		0.7%			8.3%	X
23				0.8%			0.4%	0.4%	2.3%	25%			2.7%	0.4%		1.2%			0.8%	0.4%		X			7.0%	X
24								X		X																
25				0.4%			0.4%		1.5%	47%			1.9%						1.2%			0.4%			5.8%	
26				1.1%				2.2%	2.8%	24%			8.9%	1.1%					1.1%			X			13%	
27							0.4%	0.4%		12%			3.9%						0.4%						31%	X
28				0.9%			2.2%	0.9%	0.4%	20%			9.6%	0.9%					0.4%	0.4%					13%	X
29				21%	X			0.4%		15%			0.9%						0.9%			1.3%			7.3%	X
30		0.4%		3.6%	X			3.6%	1.6%	12%			2.0%						1.6%			X			10%	X
31		0.4%		10%	X			0.8%		21%									3.5%			X			8.9%	X
32				1.0%	X			1.0%	2.0%	3.0%															37%	
33		0.9%		4.1%	1.8%	X		1.4%	0.5%	24%			0.5%	0.5%					2.3%			0.9%		X	10%	X
34		0.6%		3.6%	X				8.5%										2.4%						12%	
35				19%		X			5.0%	11%			0.4%						1.4%	0.4%					8.6%	X
36				5.5%	0.5%			0.5%	8.0%	2.0%									2.5%						9.5%	
37				5.6%				0.4%	0.4%	26%			2.0%	0.4%					0.4%	X					7.2%	X
38		0.4%		11%				1.7%	0.4%	6.4%			1.3%						0.8%	0.4%					7.6%	
39				X				0.6%		7.1%			1.3%						0.6%						7.8%	X
40				X				X		X			X	X					X	X		X			X	X
41				2.8%				1.2%	16%	0.4%			0.8%	0.8%					0.8%	0.8%		0.4%			7.2%	
42																										
43				X				X		X			X												X	X
44				6.5%				0.4%		11%			6.1%	0.4%				0.4%	1.1%						10%	

Table 4. Poonboon-1 — spore-pollen distribution. spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Proteacidites alveolatus	Proteacidites angulatus	Proteacidites annularis	Proteacidites asperopolus	Proteacidites biporus	Proteacidites carobelindiae	Proteacidites clinei ms	Proteacidites confragosus	Proteacidites crassus	Proteacidites grandis	Proteacidites incurvatus	Proteacidites kopiensis	Proteacidites latrobensis	Proteacidites leightonii	Proteacidites nasus	Proteacidites obesolabrus ms	Proteacidites obscurus	Proteacidites ornatus	Proteacidites otwayensis ms	Proteacidites parvus	Proteacidites pachypolus	Proteacidites pallisadus	Proteacidites prodigus ms	Proteacidites pseudomoides	Proteacidites recavus	Proteacidites rectomarginis	Proteacidites reflexus	Proteacidites reticulatus	Proteacidites reticuloconcavus ms	Proteacidites reticuloscabratus	Proteacidites rugulatus	Proteacidites stipplatus	Proteacidites tenuiexinus	Proteacidites tuberculatus	Proteacidites tuberculiformis	Proteacidites truncatus	Proteacidites xestiformis ms	Pseudowinterapollis couperi	Quadraplanus brossus	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Schizocolpus marlinensis	Schizocolpus rarus ms
1	1233.2	4046	SWC 27a			0.5%																																								
2	1325.9	4350	SWC 26a			0.5%																																								
3	1505.7	4940	SWC 24a			X																					X		X						X		X							X		
4	1551-70	5090-150	Cuttings			X																							0.7%																	
5	1600.2	5250	SWC 23a			0.5%														X							X		0.5%						X		X							X	X	
6	1652-70	5420-80	Cuttings			0.9%																																								
7	1691.6	5550	SWC 22a														RW										X		X												X			X		
8	1706.9	5600	SWC 21a			0.4%											RW			0.4%									X						X		X									
9	1722.1	5650	SWC 20a																										X																	
10	1737.4	5700	SWC 19a											RW						X								RW	X								X									
11	1749.6	5740	SWC 18a			X	RW											RW		X							X		X					RW	X											
12	1763.0	5784	SWC 16a			X														X									X		X												0.4%			
13	1767.8	5800	SWC 15a											RW						0.4%									X		X				X				X							
14	1801.4	5910	SWC 14a			0.4%										X	0.4%			0.4%				1.2%				X	X																	
15	1859.3	6100	SWC 12a			0.7%								X		X	X							X					X		X												X			
16	1889.8	6200	SWC 30					X				X		X										X			X																			X
17	1935.5	6350	SWC 6a								X	X			X					0.4%				X										X											X	
18	1953.8	6410	Core 1				0.5%					X			X					0.5%				X			X	X															0.5%			
19	1958.9	6427	Core 1			1.1%																		0.6%																						
20	1988.8	6525	SWC 4a			0.8%						X		0.4%	X	X	X			0.4%				0.4%			X	X						X		X				X			0.4%			
21	2009-18	6590-620	Coal cts			1.1%											0.4%			0.4%														X							0.4%		1.1%			
22	2011.7	6600	SWC 26			2.2%	1.1%		X			X		X	X	X		X		0.4%			X	X		X	X	X															0.4%	0.4%		
23	2047.6	6718	SWC 25			0.4%	X										X							X		X	X			X	X			X		X							0.8%			
24	2072.6	6800	SWC 24														X																													
25	2091-97	6860-80	Coal cts			1.5%														0.8%							X																0.4%			0.8%
26	2134.8	7004	SWC 22			X		X						X			0.6%		X														X										0.6%			
27	2169.6	7118	SWC 21												X		0.8%	X					X			X	X									X							X			
28	2194.6	7200	SWC 20				X							X	X		X	X		0.4%																X							X			
29	2225.0	7300	SWC 19			0.4%	0.4%					X			X		0.4%			0.9%				0.4%									X					X					1.7%	0.4%	X	X
30	2237.2	7340	SWC 18			0.4%	X					X	X		X		0.4%		X	0.8%	X		X	0.4%			X						X			X							1.2%	0.4%		
31	2257.3	7406	SWC 17	X		X	0.4%					X	X				0.4%		X	0.8%			X	0.4%		X										X							0.4%			
32	2287.2	7504	SWC 16			1.0%	1.0%																	1.0%									X													
33	2317.1	7602	SWC 15			1.4%	X						X				0.5%		X	1.8%				0.5%			X																			
34	2362-74	7750-90	Cuttings																					0.6%																						
35	2377.4	7800	SWC 13														X	X						2.5%												X							0.4%			X
36	2408-17	7900-30	Cuttings										0.5%							0.5%																										
37	2426.2	7960	SWC 11			0.8%							2.0%				X			0.8%																		X								
38	2438.4	8000	SWC 10	X									0.4%					X								X	X									X									X	
39	2472.5	8112	Core 2			0.6%							0.6%							0.6%																										
40	2474.4	8118	Core 2										X	X						X	X																	X		X						X
41	2499-508	8200-30	Cuttings										1.6%							0.4%																										
42	2499.4	8200	SWC 8																																											
43	2514.6	8250	SWC 7										X																																	X
44	2529.8	8300	SWC 6			0.8%							0.4%							0.8%																X										

Table 4. Poonboon-1 —

No.	Depth metres	Depth feet	Sample Type	Spinizonocolpites prominatus	Tetracolporites multistrixus ms	Tetracolporites textus ms	Tetracolporites verrucosus	Tetradopollis securus ms	Tricolp(or)ates spp.	Tricolpites confessus	Tricolpites incisus	Tricolpites phillipsii	Tricolpites simatus	Tricolpites waiparaensis	Tricolporites (Cunoniaceae?)	Tricolporites adelaidensis	Tricolporites leuros	Tricolporites lilliei	Tricolporites marginatus ms	Tricolporites paenestriatus	Tricolporites scabratus	Triorites magnificus	Triporopollenites ambiguus	Triporopollenites chnosus	Triporopollenites helosus ms	Triporopollenites simplis	Triporopollenites spp.	TOTAL Angiosperms	TOTAL SP COUNT
1	1233.2	4046	SWC 27a						5.5%											0.9%								64%	217
2	1325.9	4350	SWC 26a						4.8%											2.1%								63%	188
3	1505.7	4940	SWC 24a						8.2%			X	X							0.5%						X	X	70%	184
4	1551-70	5090-150	Cuttings						3.7%											0.7%								57%	135
5	1600.2	5250	SWC 23a						7.5%								X			0.5%							X	80%	200
6	1652-70	5420-80	Cuttings						1.8%											0.5%								77%	217
7	1691.6	5550	SWC 22a						X				X			X	X						X			X			
8	1706.9	5600	SWC 21a						5.2%							X	X											85%	233
9	1722.1	5650	SWC 20a						X							X													
10	1737.4	5700	SWC 19a						0.4%							X	X				X							75%	254
11	1749.6	5740	SWC 18a						3.2%							X										0.5%		83%	217
12	1763.0	5784	SWC 16a						4.9%							X										1.6%		71%	247
13	1767.8	5800	SWC 15a						3.3%							X	X			0.4%						0.4%	0.4%	78%	270
14	1801.4	5910	SWC 14a						2.4%											0.4%		X	X			0.4%		76%	246
15	1859.3	6100	SWC 12a						2.9%				0.4%			X	X					X						76%	272
16	1889.8	6200	SWC 30						3.5%			X				X												78%	259
17	1935.5	6350	SWC 6a						5.7%			X	X			X				0.4%							0.4%	87%	263
18	1953.8	6410	Core 1						6.8%												X	X	X				1.0%	73%	192
19	1958.9	6427	Core 1						18%											0.6%								89%	177
20	1988.8	6525	SWC 4a						6.0%			X	X									X	X					85%	252
21	2009-18	6590-620	Coal cts						9.4%							0.8%				1.9%						0.8%	0.4%	85%	266
22	2011.7	6600	SWC 26						9.0%				X			0.7%					X		X	X				64%	278
23	2047.6	6718	SWC 25						5.5%							X				0.4%			0.4%					62%	256
24	2072.6	6800	SWC 24																				X						
25	2091-97	6860-80	Coal cts						4.6%						3.1%	0.4%				2.3%							1.2%	88%	259
26	2134.8	7004	SWC 22						6.7%			X				X												68%	180
27	2169.6	7118	SWC 21						4.6%							X										0.4%		60%	259
28	2194.6	7200	SWC 20						3.5%							X											0.9%	60%	230
29	2225.0	7300	SWC 19						18%							X				3.8%							X	85%	234
30	2237.2	7340	SWC 18	X					16%		0.4%					0.4%	0.4%			2.0%			0.4%				2.4%	75%	251
31	2257.3	7406	SWC 17						21%							X				1.6%			X		X	2.3%	X	88%	257
32	2287.2	7504	SWC 16						6.9%																			87%	101
33	2317.1	7602	SWC 15						14%		X				3.2%	X				0.5%			X				1.8%	88%	220
34	2362-74	7750-90	Cuttings						9.7%											0.6%								64%	165
35	2377.4	7800	SWC 13						20%							0.4%				1.8%					X		3.2%	85%	280
36	2408-17	7900-30	Cuttings						18%																			69%	200
37	2426.2	7960	SWC 11	0.8%					8.8%							0.4%				0.4%						X	2.0%	72%	249
38	2438.4	8000	SWC 10						6.8%						3.8%					0.4%			X			X	1.3%	57%	236
39	2472.5	8112	Core 2						5.8%											1.3%							0.6%	62%	154
40	2474.4	8118	Core 2	X												X				X									
41	2499-508	8200-30	Cuttings						7.2%											0.4%								58%	250
42	2499.4	8200	SWC 8																										
43	2514.6	8250	SWC 7																										
44	2529.8	8300	SWC 6						9.9%						2.3%					0.4%							1.9%	65%	262

Table 4. Poonboon-1 — spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	SPORE SPECIES	Baculatisporites spp.	Camarozonosporites bullatus	Camarozonosporites heskermensis	Clavifera triplex	Conbaculatisporites apiculatus ms	Crassoretitriletes vanraadshooveni	Cyatheacidites annulatus	Cyathidites splendens	Cyathidites subtilis	Cyathidites spp. small <40µm	Densoisporites pellis ms	Dictyophyllidites spp.	Echinosporis echinatus	Foraminisporis ozotus ms	Foveotriletes balteus	Foveotriletes crater	Foveotriletes palaequetrus
45	2560.3	8400	SWC 5																		
46	2590.8	8500	SWC 4																		
47	2624.3	8610	SWC 3		0.4%									2.4%							
48	2651.8	8700	SWC 2		1.5%			0.5%		X		2.0%		5.9%			X				
49	2678.6	8788	SWC 1		0.4%			1.5%				1.2%		1.9%		0.4%			0.4%		
50	2688.0	8819	Core 3		1.5%			0.7%				X		0.7%							
51	2689.3	8823	Core 3		1.2%			0.8%				0.8%		2.3%					0.4%		
52	2713-25	8900-40	Cuttings					1.3%				2.6%		4.8%		0.4%					
53	2737-40	8980-90	Coal Cts		2.1%			0.4%						0.8%							
54	2758-61	9050-60	Coal Cts		2.4%	X		0.4%				1.6%		1.2%							
55	2795-801	9170-90	Cuttings		1.6%		0.4%	0.4%				4.4%		2.4%							
56	2838-44	9310-30	Cuttings		2.6%							5.2%		6.1%		0.4%					
57	2847-50	9340-50	Coal Cts		0.8%									0.8%							
58	2877-80	9440-50	Coal Cts		0.4%			0.8%				0.4%		3.2%		0.4%					
59	2896-902	9500-20	Cuttings		1.5%							2.9%		1.8%					X		
60	2951-57	9680-700	Cuttings		1.4%							1.4%		2.3%							
61	2975-84	9760-90	Cuttings		0.6%							1.0%		0.3%							
62	2995.6	9828	SWC 28		1.1%			1.1%						3.3%							
63	2997.4	9834	SWC 27																		
64	3042.2	9981	Core-4		0.5%							X		1.4%		0.5%					
65	3066-69	10060-70	Cuttings		0.8%							1.2%		0.8%							
66	3116.9	10226	SWC 22		0.4%							0.7%		1.8%							
67	3154.7	10350	SWC 18		1.6%							0.4%		0.4%							
68	3183.6	10445	SWC 12				X					0.4%				X					
69	3223.9	10577	SWC 33		2.6%		X					1.6%		3.2%		0.5%					
70	3231-40	10600-30	Cuttings		0.4%																
71	3233.3	10608	SWC 5		1.2%									1.6%							
72	3247.3	10654	SWC 34		0.4%							0.4%		0.4%							
73	3262.3	10703	Core 5		2.4%			0.4%				0.8%		3.2%		0.4%					

spore-pollen distribution.

No.	Gleicheniidites circinidites	Grapnelispora evansii	Herkosporites elliotii	Ischyosporites spp.	Kuylisporites waterbolkii	Laevigatosporites major	Laevigatosporites ovatus	Latrobosporites amplus	Latrobosporites crassus	Latrobosporites ohaiensis	Marattisporites scabratus	Matonisporites gigantis	Matonisporites ornamentalis	Monolites alveolatus	Oramentifera sentosa	Peromonolites densus	Peromonolites vellosus	Perotriletes spp.	Polypodiaceoisporites varus ms	Polypodiidites/Verrucatosporites spp.	Retitriletes spp.	Ricciaesporites boxatus ms	Rotverrusporites stellatus ms	Rugulatisporites mallatus	Rugulatisporites trophus
45																									
46																									
47	3.6%			0.4%																0.4%					
48	5.4%			1.0%			1.5%		0.5%								0.5%						X	X	
49	16%		0.4%	0.4%			6.9%			X		0.4%				0.4%				0.4%	0.4%				
50	12%		0.4%	X			2.6%	X	X			X								0.4%	0.4%				
51	6.5%		0.4%				3.1%					0.4%								1.5%					
52							0.9%					0.4%								0.9%					
53	0.4%						6.2%	X	X																
54	2.4%					0.4%	15%				X														
55	1.2%						2.4%																		
56	3.9%						0.9%		0.4%																
57																X									
58	2.0%						2.8%		0.4%											0.4%				X	
59	4.0%						1.8%														0.7%				
60	0.5%						2.3%																		
61	0.6%		0.3%				0.6%																		
62	4.3%						1.1%									1.1%									
63	1.7%						1.3%																		
64	1.8%		1.4%				0.5%														0.5%				
65	1.2%						2.0%																		
66	0.7%		5.1%				3.3%			X								0.4%			1.1%				
67	1.6%		0.8%				1.2%											0.8%							
68	2.0%		1.6%				0.8%	X		X											X		X		
69	0.5%		3.2%				X	0.5%		X											0.5%				
70	0.4%						3.2%																		
71	0.4%		1.6%				1.6%	0.4%		0.4%											0.8%				
72	0.4%	X	0.4%				1.1%	X		X											0.4%				
73	3.6%		0.8%				1.6%	X		X					X						1.6%			X	

ABBREVIATIONS: X = Present % = Percentage RW = Reworked

ABBREVIATIONS: X = Present

Table 4. Poonboon-1 — spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Stereisporites antiquisporites	Stereisporites regium	Striamonoletes digitatoides	Trilete spores undiff.	Tripunctisporis maastrichtiensis	Verrucatosporites attinatus ms	Verrucosisporites cristatus	Verrucosisporites kopukuensis	TOTAL Spores
45	2560.3	8400	SWC 5									
46	2590.8	8500	SWC 4									
47	2624.3	8610	SWC 3				0.4%	0.4%			X	8%
48	2651.8	8700	SWC 2	0.5%	X		1.0%				X	20%
49	2678.6	8788	SWC 1	2.7%	X			0.4%			0.4%	34%
50	2688.0	8819	Core 3	1.9%	X			X			X	21%
51	2689.3	8823	Core 3	2.7%							0.4%	20%
52	2713-25	8900-40	Cuttings	0.4%			5.7%					18%
53	2737-40	8980-90	Coal Cts								X	10%
54	2758-61	9050-60	Coal Cts	3.6%								27%
55	2795-801	9170-90	Cuttings	0.4%			7.7%					21%
56	2838-44	9310-30	Cuttings	1.3%			8.2%					29%
57	2847-50	9340-50	Coal Cts									2%
58	2877-80	9440-50	Coal Cts									11%
59	2896-902	9500-20	Cuttings	3.7%			8.8%					25%
60	2951-57	9680-700	Cuttings	2.7%			7.3%	0.5%				18%
61	2975-84	9760-90	Cuttings	1.3%			2.3%					7%
62	2995.6	9828	SWC 28	3.3%			1.1%					16%
63	2997.4	9834	SWC 27	0.4%								3%
64	3042.2	9981	Core-4	2.3%				1.4%				10%
65	3066-69	10060-70	Cuttings	1.2%			2.0%					9%
66	3116.9	10226	SWC 22	1.5%	X		0.7%	0.7%				16%
67	3154.7	10350	SWC 18	3.2%			0.8%					11%
68	3183.6	10445	SWC 12	0.8%				X				5%
69	3223.9	10577	SWC 33	6.9%	X		1.6%	X				21%
70	3231-40	10600-30	Cuttings	1.6%			2.4%					8%
71	3233.3	10608	SWC 5	3.7%			1.6%	1.6%				15%
72	3247.3	10654	SWC 34	0.4%			0.4%	X				4%
73	3262.3	10703	Core 5	5.2%	X		0.4%	0.8%				21%

No.	GYMNOSPERM SPECIES	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites balmei	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites mawsonii	Phyllocladidites reticulosaccatus	Phyllocladidites verrucosus	Podocarpidites spp.	Podocarpidites exiguus	Trichotomosulcites subgranulatus	TOTAL Gymnosperms
45														X			
46														X			
47		2.8%	0.8%		10%	0.8%		0.8%	0.8%	0.4%	4.9%			26%	X	2.0%	49%
48		4.4%			13%	5.4%	0.5%	1.5%		1.5%	0.5%			17%		5.4%	50%
49		2.7%	2.3%		15%	1.5%	0.4%			0.8%	1.5%		0.8%	12%	1.2%	1.9%	40%
50		3.4%	0.4%		16%		2.6%	0.4%		2.2%	4.1%			10%		1.5%	41%
51		1.5%	4.2%		14%	0.8%	2.3%	1.9%	0.4%		3.1%			12%	1.5%	1.9%	44%
52		3.9%			5.7%			1.3%		1.3%	3.5%			25%		7.9%	49%
53					0.4%		0.4%	2.5%	0.4%	1.7%	4.5%			25%		13%	48%
54					0.4%	0.4%	0.8%	6.3%		1.2%	4.0%			23%		3.6%	40%
55		5.2%	0.4%		10%		2.8%			1.2%	2.0%		1.2%	32%		6.5%	62%
56		3.5%	0.4%		6.5%		0.4%	1.3%		1.3%	2.2%		0.4%	35%		7.8%	59%
57							0.8%	0.8%		7.1%	46%		2.8%	22%		11%	91%
58					1.2%	0.4%	0.4%	2.0%	0.4%	3.2%	34%	0.4%	1.2%	11%		15%	68%
59		2.2%			8.8%	0.4%	0.4%	0.4%			4.4%		1.5%	35%		7.7%	61%
60		2.3%			6.8%		0.5%	0.5%		0.5%	2.7%		0.9%	45%		6.4%	65%
61		0.3%	0.3%		1.3%		0.3%			0.6%	14%		3.2%	44%		20%	84%
62		5.4%			8.7%		1.1%				11%			23%		6.5%	55%
63							0.9%	2.2%		1.7%	69%	0.4%	0.4%	7.3%		3.4%	85%
64		4.1%	0.5%		3.2%		0.5%		0.5%	1.4%	10%	1.4%	0.9%	30%		0.5%	53%
65		1.2%	0.8%		5.6%			0.4%		0.4%	14%		0.4%	37%		18%	79%
66		2.9%	4.4%		20%	0.7%	X	1.1%	0.4%	0.7%	7.3%	0.4%		14%		1.1%	53%
67		2.0%	3.2%		10%			0.8%	0.4%	2.4%	4.8%	1.2%	0.4%	20%		3.6%	49%
68		0.4%	X		1.2%				1.6%	1.2%	25%	0.8%	2.0%	34%		2.3%	69%
69		6.9%	1.6%		15%					X	5.8%			14%			43%
70		1.2%	0.4%		6.0%			0.4%		0.4%	4.8%		0.4%	39%		26%	78%
71		6.1%			38%					0.4%	1.2%			11%		1.2%	59%
72		7.3%	1.8%		22%		X	0.7%		0.7%	19%		1.1%	15%		4.7%	72%
73		18%	0.4%		25%	0.4%	X			X	2.0%			5.6%		0.8%	53%

No.	ANGIOSPERM SPECIES	Angiosperm pollen undiff.	Aglaoreidia qualumis	Anacolosidites luteoides	Anacolosidites sectus	Anisocolporites triplex	Australopollis obscurus	Banksieaeidites arcuatus	Banksieaeidites elongatus	Battenipollis sectilis	Beaupreaidites elegansiformis	Beaupreaidites verrucosus	Clavatipollenites glarius	Concolpites leptos	Cupanieidites orthoteichus	Cyperaceaepollis neogenicus
45																
46																
47		0.8%														
48		2.5%					RW								0.5%	
49							4.6%									
50							0.7%								0.4%	
51		1.2%														
52		5.3%					1.3%									
53																
54							0.4%									
55		1.2%					1.2%									
56		0.9%														
57																
58																
59		2.6%					0.4%									
60		1.8%					0.9%									
61		0.6%														
62																
63																
64		0.5%														
65		1.6%					0.4%									
66		1.8%														
67																
68																
69																
70		0.4%														
71																
72										X						
73																

% = Percentage RW = Reworked

ABBREVIATIONS: X = Present % = Percentage RW = Reworked

Table 4. Poonboon-1 — spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Dicotetradites clavatus	Dryadopollenites retequetrus	Dryptopollenites semilunatus	Elphedripites notensis	Ericipites crassiexinus/scabratus	Gambierina edwardsii	Gambierina rudata	Granodiporites nebulosus	Gothanipollis bassensis	Haloragacidites harrisii	Ilexpollenites spp.	Intratriporopollenites notabilis	Liliacidites spp.	Malvacipollis diversus	Malvacipollis grandis ms	Malvacipollis robustus ms	Malvacipollis subtilis
45	2560.3	8400	SWC 5										X							
46	2590.8	8500	SWC 4										X							
47	2624.3	8610	SWC 3										1.6%	0.4%						
48	2651.8	8700	SWC 2	X		X							2.5%				2.0%			1.0%
49	2678.6	8788	SWC 1	0.4%						0.4%			1.2%							X
50	2688.0	8819	Core 3	0.7%					X	0.4%			1.1%	0.4%						0.4%
51	2689.3	8823	Core 3							1.9%										
52	2713-25	8900-40	Cuttings										0.9%							0.4%
53	2737-40	8980-90	Coal Cts	0.8%		0.4%							3.7%	0.4%			X			1.7%
54	2758-61	9050-60	Coal Cts	0.8%					X				0.8%	0.4%						
55	2795-801	9170-90	Cuttings							1.2%										
56	2838-44	9310-30	Cuttings							0.9%			1.3%							
57	2847-50	9340-50	Coal Cts																	
58	2877-80	9440-50	Coal Cts	X			0.4%			0.4%			1.2%	0.4%						
59	2896-902	9500-20	Cuttings	0.4%					X	0.4%										
60	2951-57	9680-700	Cuttings							X										
61	2975-84	9760-90	Cuttings							0.3%										
62	2995.6	9828	SWC 28							2.2%										
63	2997.4	9834	SWC 27					1.7%	X	1.3%			0.4%							
64	3042.2	9981	Core-4							14%			X							
65	3066-69	10060-70	Cuttings				0.4%			0.4%										
66	3116.9	10226	SWC 22	0.7%					X	5.1%										
67	3154.7	10350	SWC 18							6.8%										
68	3183.6	10445	SWC 12							3.5%										
69	3223.9	10577	SWC 33							2.6%										
70	3231-40	10600-30	Cuttings							1.2%				0.4%						
71	3233.3	10608	SWC 5							2.4%										
72	3247.3	10654	SWC 34							3.6%										
73	3262.3	10703	Core 5				0.8%			5.2%						0.4%				

No.	Milfordia incerta	Milfordia homeopunctatus	Monosulcites uvatus ms	Myrtaceidites parvus/mesonesus	Myrtaceidites tenuis	Myrtaceidites verrucosus	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites endurus	Nothofagidites falcatus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites senectus	Nothofagidites vansteenisii	Paripollis ochesis	Peninsulapollis gillii	Periporopollenites demarcatus	Periporopollenites polyoratus	Periporopollenites vesicus	Polycolporopollenites esobalteus	Polycolpites langstonii	Polyorificites oblatus	Proteacidites spp.	Proteacidites adenanthoides
45																										
46																										
47				0.4%				6.5%		7.7%			0.4%	0.4%				0.4%	0.4%	2.0%					7.7%	
48				0.5%				0.5%		1.5%			0.5%												8.8%	X
49							0.4%	3.1%		4.2%	1.2%		1.5%					0.8%		0.4%					3.5%	
50							0.4%	3.0%		5.2%	9.3%		0.7%					0.4%		0.4%			0.4%		9.0%	X
51				1.2%				0.8%		2.3%	9.2%		0.4%					3.1%		0.4%					10%	
52				4.4%				0.4%		0.4%	8.8%		0.9%												6.1%	
53								0.8%		2.9%	16%		0.4%						0.4%	0.4%					2.5%	
54								0.4%		0.8%	21%		0.4%				0.8%			0.4%					0.4%	
55				0.8%				0.8%		0.4%	7.3%		0.4%												2.8%	
56											3.5%							0.4%							3.0%	
57								0.4%			2.8%						0.4%			0.4%						
58										0.4%	7.1%									0.4%					2.0%	
59				0.4%							6.6%		1.5%												1.5%	
60											7.3%							0.5%							0.9%	
61								0.3%			4.2%														1.6%	
62											20%							2.2%		1.1%						
63											3.4%									0.4%					3.0%	
64							0.5%	0.5%		0.9%	4.1%							2.7%							9.9%	
65											2.0%														1.2%	
66								1.5%			1.5%							5.5%		0.4%					8.0%	
67											8.8%							10%							7.2%	
68											9.4%							6.3%							5.9%	
69											3.7%				0.5%			4.8%							17%	
70											2.8%							0.4%							2.0%	
71											2.4%							6.5%							11%	
72								0.4%							0.4%			7.7%							6.9%	
73																		4.0%							11%	

ABBREVIATIONS: X = Present % = Percentage RW = Reworked

Table 4. Poonboon-1 — spore-pollen distribution. spore-pollen distribution.

No.	Depth metres	Depth feet	Sample Type	Proteacidites alveolatus	Proteacidites angulatus	Proteacidites annularis	Proteacidites asperopolus	Proteacidites biporus	Proteacidites carobelindiae	Proteacidites clinei ms	Proteacidites confragosus	Proteacidites crassus	Proteacidites grandis	Proteacidites incurvatus	Proteacidites kopiensis	Proteacidites latrobensis	Proteacidites leightonii	Proteacidites nasus	Proteacidites obesolabrus ms	Proteacidites obscurus	Proteacidites ornatus	Proteacidites otwayensis ms	Proteacidites parvus	Proteacidites pachypolus	Proteacidites pallisadus	Proteacidites prodigus ms	Proteacidites pseudomoides	Proteacidites recavus	Proteacidites rectomarginis	Proteacidites reflexus	Proteacidites reticulatus	Proteacidites reticuloconcavus ms	Proteacidites reticuloscabratus	Proteacidites rugulatus	Proteacidites stipplatus	Proteacidites tenuiexinus	Proteacidites tuberculatus	Proteacidites tuberculiformis	Proteacidites truncatus	Proteacidites xestiformis ms	Pseudowinterapollis couperi	Quadraplanus brossus	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Schizocolpus marlinensis	Schizocolpus rarus ms
45	2560.3	8400	SWC 5																																											
46	2590.8	8500	SWC 4																	X																										
47	2624.3	8610	SWC 3										0.4%							0.8%																										
48	2651.8	8700	SWC 2										0.5%	X												X										X										
49	2678.6	8788	SWC 1										0.8%	0.4%												X																				
50	2688.0	8819	Core 3										0.4%	X												X							X													
51	2689.3	8823	Core 3										0.4%																															
52	2713-25	8900-40	Cuttings																																											
53	2737-40	8980-90	Coal Cts			0.8%							0.4%											0.8%																						
54	2758-61	9050-60	Coal Cts																																											
55	2795-801	9170-90	Cuttings																																											
56	2838-44	9310-30	Cuttings																																											
57	2847-50	9340-50	Coal Cts																																											
58	2877-80	9440-50	Coal Cts																																	X										
59	2896-902	9500-20	Cuttings																																											
60	2951-57	9680-700	Cuttings																																											
61	2975-84	9760-90	Cuttings																																											
62	2995.6	9828	SWC 28																																											
63	2997.4	9834	SWC 27																																											
64	3042.2	9981	Core-4							0.5%																																				
65	3066-69	10060-70	Cuttings																																											
66	3116.9	10226	SWC 22		1.1%					X																																				
67	3154.7	10350	SWC 18																																											
68	3183.6	10445	SWC 12																																											
69	3223.9	10577	SWC 33																															X				X										
70	3231-40	10600-30	Cuttings																																											
71	3233.3	10608	SWC 5																															0.4%														
72	3247.3	10654	SWC 34							0.4%																																				
73	3262.3	10703	Core 5							X												X			X																	0.4%				

ABBREVIATIONS: X = Present % = Percentage RW = Reworked

ABBREVIATIONS: X = P

Table 4. Poonboon-1 —

No.	Depth metres	Depth feet	Sample Type	Spinizonocolpites prominatus	Tetracolporites multistrixus ms	Tetracolporites textus ms	Tetracolporites verrucosus	Tetradopollis securus ms	Tricolp(or)ates spp.	Tricolpites confessus	Tricolpites incisus	Tricolpites phillipsii	Tricolpites simatus	Tricolpites waiparaensis	Tricolporites (Cunoniaceae?)	Tricolporites adelaidensis	Tricolporites leuros	Tricolporites lilliei	Tricolporites marginatus ms	Tricolporites paenestriatus	Tricolporites scabratus	Triorites magnificus	Triporopollenites ambiguus	Triporopollenites chnosus	Triporopollenites helosus ms	Triporopollenites simplis	Triporopollenites spp.	**TOTAL Angiosperms**	**TOTAL SP COUNT**
45	2560.3	8400	SWC 5																										
46	2590.8	8500	SWC 4																										
47	2624.3	8610	SWC 3						11%																		2.0%	43%	247
48	2651.8	8700	SWC 2	X					9.8%																			30%	204
49	2678.6	8788	SWC 1						2.3%			X															0.4%	25%	259
50	2688.0	8819	Core 3						3.7%			0.4%															1.5%	39%	268
51	2689.3	8823	Core 3						2.3%																		1.9%	35%	260
52	2713-25	8900-40	Cuttings						4.4%																		0.4%	34%	228
53	2737-40	8980-90	Coal Cts			0.8%	0.8%		7.4%														0.4%				0.4%	43%	242
54	2758-61	9050-60	Coal Cts			0.4%			5.6%																		0.4%	33%	252
55	2795-801	9170-90	Cuttings						0.8%																		0.4%	17%	248
56	2838-44	9310-30	Cuttings						2.2%																			12%	231
57	2847-50	9340-50	Coal Cts			2.0%			1.6%																			8%	253
58	2877-80	9440-50	Coal Cts						8.7%																		0.4%	21%	253
59	2896-902	9500-20	Cuttings						0.4%																			14%	272
60	2951-57	9680-700	Cuttings						5.0%																			16%	220
61	2975-84	9760-90	Cuttings				X		2.3%																			9%	311
62	2995.6	9828	SWC 28		X				2.2%																		1.1%	28%	92
63	2997.4	9834	SWC 27						0.9%																			11%	232
64	3042.2	9981	Core-4						1.4%					0.9%													1.8%	37%	222
65	3066-69	10060-70	Cuttings				X		5.6%																		0.4%	12%	250
66	3116.9	10226	SWC 22						4.0%										X								1.5%	31%	275
67	3154.7	10350	SWC 18				X		4.8%																		2.8%	41%	251
68	3183.6	10445	SWC 12		X		0.4%		0.4%																		X	26%	256
69	3223.9	10577	SWC 33				1.1%		3.7%																		2.1%	35%	189
70	3231-40	10600-30	Cuttings						5.6%																		0.8%	14%	250
71	3233.3	10608	SWC 5				0.8%		1.6%																		0.4%	26%	245
72	3247.3	10654	SWC 34				X	X	4.4%																			24%	274
73	3262.3	10703	Core 5				0.8%		2.8%	X				0.4%				X									0.8%	26%	251

resent % = Percentage RW = Reworked

Table 5. Poonboon-1 - microplankton distribution.

No.	Depth metres	Depth feet	Sample Type	ACRITARCHS & ALGAE	Acritarchs & Algae undiff.	Cymatisphaera sp. (polygonal)	Horologinella incurvata	Micrhystridium spp.	Amosopollis cruciformis	Botryococcus braunii	Crassosphaera concinnia	Pediastum sp.	Pseudoschizaea spp.	NON-MARINE DINOCYSTS	Cobricosphaeridium spp.	Morkallacysta spp.	Saeptodinium spp.	MARINE DINOCYSTS	Dinocysts undiff.	Apteodinium australicum	Apectodinium homomorphum	Apectodinium hyperacanthum	Apectodinium reburrus ms	Batiacasphaera spp.	Cannosphaeropsis sp.	Cleistosphaeridium spp.	Cooksonidium capricornum	Cordosphaeridium spp.	Cyclopsiella vieta	Dapsilidinium pseudocolligerum	Deflandrea heterophlycta	Deflandrea leptodermata	Deflandrea phosphoritica	Deflandrea spp.
1	1233.2	4046	SWC 27a							17%									11%										6%					
2	1325.9	4350	SWC 26a							26%									16%					X						6%				
3	1505.7	4940	SWC 24a				6%	X		4%									51%						X									
4	1551-70	5090-150	Cuttings					26%		1%									12%	3%										3%				
5	1600.2	5250	SWC 23a			X		7%		7%	7%								36%															
6	1652-70	5420-80	Cuttings				5%	35%											10%	5%										3%				
7	1691.6	5550	SWC 22a																															
8	1706.9	5600	SWC 21a			X													21%															3%
9	1722.1	5650	SWC 20a			X																												
10	1737.4	5700	SWC 19a																100%															
11	1749.6	5740	SWC 18a			X													100%															
12	1763.0	5784	SWC 16a																20%									1%			11%	1%	1%	1%
13	1767.8	5800	SWC 15a							9%		5%							14%															
14	1801.4	5910	SWC 14a																18%								4%	4%					4%	7%
15	1859.3	6100	SWC 12a																18%									40%						
16	1889.8	6200	SWC 30																60%															
17	1935.5	6350	SWC 6a																															
18	1953.8	6410	Core 1																100%															
19	1958.9	6427	Core 1					6%		1%									13%							4%		4%						
20	1988.8	6525	SWC 4a																															
21	2009-18	6590-620	Coal cts																															
22	2011.7	6600	SWC 26																															
23	2047.6	6718	SWC 25																100%															
24	2072.6	6800	SWC 24																															
25	2091-97	6860-80	Coal cts																															
26	2134.8	7004	SWC 22																															
27	2169.6	7118	SWC 21																															
28	2194.6	7200	SWC 20										33%				67%																	
29	2225.0	7300	SWC 19														100%																	
30	2237.2	7340	SWC 18																100%															
31	2257.3	7406	SWC 17							100%																								
32	2287.2	7504	SWC 16																															
33	2317.1	7602	SWC 15					100%																										
34	2362-74	7750-90	Cuttings																71%															
35	2377.4	7800	SWC 13																		67%													
36	2408-17	7900-30	Cuttings																43%															
37	2426.2	7960	SWC 11					6%								56%			28%															

Table 5. Poonboon-1 - microplankton distribution.

No.	Depth metres	Depth feet	Sample Type	Diphyes colligerum	Distatodinium ellipticum	Enneadocysta spp.	Fibrocysta bipolaris	Fromea blysma ms	Fromea leos ms	Fromea neochytra ms	Glaphrocysta spp.	Heteraulacacysta spp.	Homotryblium tasmaniense	Hystrichokolpoma rigaudiae	Impagidinium spp.	Kenleyia spp.	Lingulodinium machaerophorum	Operculodinium centrocarpum	Palaeocystodinium golzowensis	Paralecaniella indentata	Pentadinium laticinctum	Phthanoperidinium comatum	Phthanoperidinium spp.	Protoellipsodinium simplex ms	Protoellipsodinium spp.	Pyxidinopsis pontus ms	Reticulatosphaera stellata	Samlandia reticulifera	Spinidinium spp.	Spiniferites spp.	Systematophora placanthum	Tectatodinium sp.	Turbiosphaera filosa	TOTAL MICROPLANKTON COUNT
1	1233.2	4046	SWC 27a												3%		3%	6%						13%		1%				34%		7%		71
2	1325.9	4350	SWC 26a											19%				9%									4%			19%	1%			139
3	1505.7	4940	SWC 24a						X	21%							X													9%	9%			53
4	1551-70	5090-150	Cuttings							1%				X	X		X	6%	X	X	X			2%	X		X			45%		1%		121
5	1600.2	5250	SWC 23a							29%							7%													7%				14
6	1652-70	5420-80	Cuttings						15%	10%								3%							8%					8%				40
7	1691.6	5550	SWC 22a																															
8	1706.9	5600	SWC 21a															3%				15%	41%							18%				34
9	1722.1	5650	SWC 20a																															
10	1737.4	5700	SWC 19a																															1
11	1749.6	5740	SWC 18a					X										X												X	X	X		1
12	1763.0	5784	SWC 16a					1%									1%	4%				39%	1%							16%				74
13	1767.8	5800	SWC 15a		5%										5%			9%					32%		5%			5%		14%				22
14	1801.4	5910	SWC 14a			4%		7%						7%	4%		7%	4%												29%	4%			28
15	1859.3	6100	SWC 12a	2%				8%										8%		12%										12%				50
16	1889.8	6200	SWC 30																	20%										20%				5
17	1935.5	6350	SWC 6a																											100%				2
18	1953.8	6410	Core 1																															3
19	1958.9	6427	Core 1			46%						3%		1%									1%							20%				70
20	1988.8	6525	SWC 4a																											100%				2
21	2009-18	6590-620	Coal cts																															
22	2011.7	6600	SWC 26																															
23	2047.6	6718	SWC 25																															1
24	2072.6	6800	SWC 24																															
25	2091-97	6860-80	Coal cts																															
26	2134.8	7004	SWC 22																															
27	2169.6	7118	SWC 21																															
28	2194.6	7200	SWC 20																															3
29	2225.0	7300	SWC 19																															1
30	2237.2	7340	SWC 18																															1
31	2257.3	7406	SWC 17																															1
32	2287.2	7504	SWC 16																															
33	2317.1	7602	SWC 15																															1
34	2362-74	7750-90	Cuttings										14%			14%																		7
35	2377.4	7800	SWC 13																											33%				3
36	2408-17	7900-30	Cuttings										50%			7%																		14
37	2426.2	7960	SWC 11																	6%										6%				18

Table 5. Poonboon-1 - microplankton distribution.

No.	Depth metres	Depth feet	Sample Type	ACRITARCHS & ALGAE	Acritarchs & Algae undiff.	Cymatisphaera sp. (polygonal)	Horologinella incurvata	Micrhystridium spp.	Amosopollis cruciformis	Botryococcus braunii	Crassosphaera concinnia	Pediastum sp.	Pseudoschizaea spp.	NON-MARINE DINOCYSTS	Cobricosphaeridium spp.	Morkallacysta spp.	Saeptodinium spp.	MARINE DINOCYSTS	Dinocysts undiff.	Apteodinium australicum	Apectodinium homomorphum	Apectodinium hyperacanthum	Apectodinium reburrus ms	Batiacasphaera spp.	Cannosphaeropsis sp.	Cleistosphaeridium spp.	Cooksonidium capricornum	Cordosphaeridium spp.	Cyclopsiella vieta	Dapsilidinium pseudocolligerum	Deflandrea heterophlycta	Deflandrea leptodermata	Deflandrea phosphoritica	Deflandrea spp.
38	2438.4	8000	SWC 10					100%																										
39	2472.5	8112	Core 2																9%		58%					3%								
40	2474.4	8118	Core 2																															
41	2499-508	8200-30	Cuttings																94%		4%													
42	2499.4	8200	SWC 8																															
43	2514.6	8250	SWC 7																															
44	2529.8	8300	SWC 6					9%		9%									9%		9%					27%								
45	2560.3	8400	SWC 5																															
46	2590.8	8500	SWC 4																															
47	2624.3	8610	SWC 3					100%																										
48	2651.8	8700	SWC 2																36%			64%												
49	2678.6	8788	SWC 1							8%									8%				50%					8%						8%
50	2688.0	8819	Core 3					50%								50%																		
51	2689.3	8823	Core 3					33%								33%			33%															
52	2713-25	8900-40	Cuttings																100%															
53	2737-40	8980-90	Coal Cts																															
54	2758-61	9050-60	Coal Cts																															
55	2795-801	9170-90	Cuttings																100%															
56	2838-44	9310-30	Cuttings						8%										92%															
57	2847-50	9340-50	Coal Cts																															
58	2877-80	9440-50	Coal Cts							50%						50%																		
59	2896-902	9500-20	Cuttings																100%															
60	2951-57	9680-700	Cuttings																100%															
61	2975-84	9760-90	Cuttings																100%															
62	2995.6	9828	SWC 28					100%																										
63	2997.4	9834	SWC 27																															
64	3042.2	9981	Core-4										50%			50%																		
65	3066-69	10060-70	Cuttings													100%																		
66	3116.9	10226	SWC 22													50%			25%															
67	3154.7	10350	SWC 18													100%																		
68	3183.6	10445	SWC 12																															
69	3223.9	10577	SWC 33		3%					3%						83%			10%															
70	3231-40	10600-30	Cuttings													100%																		
71	3233.3	10608	SWC 5						8%	23%					8%	54%			8%															
72	3247.3	10654	SWC 34																															
73	3262.3	10703	Core 5		25%										50%	25%																		

ABBREVIATIONS: X = Present % = Percentage

Table 5. Poonboon-1 - microplankton distribution.

No.	Depth metres	Depth feet	Sample Type	Diphyes colligerum	Distatodinium ellipticum	Enneadocysta spp.	Fibrocysta bipolaris	Fromea blysma ms	Fromea leos ms	Fromea neochytra ms	Glaphrocysta spp.	Heteraulacacysta spp.	Homotryblium tasmaniense	Hystrichokolpoma rigaudiae	Impagidinium spp.	Kenleyia spp.	Lingulodinium machaerophorum	Operculodinium centrocarpum	Palaeocystodinium golzowensis	Paralecaniella indentata	Pentadinium laticinctum	Phthanoperidinium comatum	Phthanoperidinium spp.	Protoellipsodinium simplex ms	Protoellipsodinium spp.	Pyxidinopsis pontus ms	Reticulatosphaera stellata	Samlandia reticulifera	Spinidinium spp.	Spiniferites spp.	Systematophora placanthum	Tectatodinium sp.	Turbiosphaera filosa	TOTAL MICROPLANKTON COUNT
38	2438.4	8000	SWC 10																															1
39	2472.5	8112	Core 2	1%			1%				2%					16%				3%										7%			1%	117
40	2474.4	8118	Core 2																															
41	2499-508	8200-30	Cuttings																											3%				77
42	2499.4	8200	SWC 8																															
43	2514.6	8250	SWC 7																															
44	2529.8	8300	SWC 6	18%																										18%				11
45	2560.3	8400	SWC 5																															
46	2590.8	8500	SWC 4																															
47	2624.3	8610	SWC 3																															1
48	2651.8	8700	SWC 2																															11
49	2678.6	8788	SWC 1																	8%										8%				12
50	2688.0	8819	Core 3																															2
51	2689.3	8823	Core 3																															3
52	2713-25	8900-40	Cuttings																															5
53	2737-40	8980-90	Coal Cts																															
54	2758-61	9050-60	Coal Cts																															
55	2795-801	9170-90	Cuttings																															18
56	2838-44	9310-30	Cuttings																															13
57	2847-50	9340-50	Coal Cts																															
58	2877-80	9440-50	Coal Cts																															2
59	2896-902	9500-20	Cuttings																															6
60	2951-57	9680-700	Cuttings																															2
61	2975-84	9760-90	Cuttings																															2
62	2995.6	9828	SWC 28																															1
63	2997.4	9834	SWC 27																															
64	3042.2	9981	Core-4																															2
65	3066-69	10060-70	Cuttings																															6
66	3116.9	10226	SWC 22																												25%				4
67	3154.7	10350	SWC 18																															3
68	3183.6	10445	SWC 12																															
69	3223.9	10577	SWC 33																															30
70	3231-40	10600-30	Cuttings																															2
71	3233.3	10608	SWC 5																															13
72	3247.3	10654	SWC 34																															
73	3262.3	10703	Core 5																															4

ABBREVIATIONS: X = Present % = Percentage

APPENDIX C7.

Palynological analysis of Oligocene sandstones in Squid-1, Bass Basin.

by

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Biostrata Report 2002/12

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Palynological analysis of Oligocene sandstones in Squid-1, Bass Basin.

by Alan D. Partridge

Introduction

This palynological study of the Oligocene sandstones intersected in Squid-1 is a component of the Bass Basin Palynological Project coordinated by Geoscience Australia as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics to investigate aspects of the hydrocarbon prospectivity of the Bass and Sorell Basins.

The interval under investigation in Squid-1 is the 360 metre thick sandstone unit between 1425 and 1785m which overlies the Anglesea Formation. The age of this unit was not adequately determined in the original palynological reports on Squid-1, and further it was desirable to know whether the sandstone could be interpreted as filling a large channel entrenched into the top of the Anglesea Formation, or alternatively represented a lateral facies (ie. proximal strandline) of the shaly sediments overlying the Anglesea Formation in other wells. Analysis of both bulk and picked cuttings in Squid-1 and comparison with the sequence above the Anglesea Formation in Poonboon-1 are found to favour the second interpretation.

Materials and Methods

Unfortunately no conventional cores were cut and no sidewall cores were shot in the Squid-1 well so the new palynological analyses needed to rely solely on cuttings. Initially six bulk cuttings were analysed, but once these were discovered to be confused by both caved and reworked palynomorphs an additional four cuttings were collected and given alternative processing. The latter consisted of a pre-treatment with dilute HCl followed by sieving to breakdown and remove any of the calcareous shales and marls caved from between the 13-3/8" casing shoe at 1240m and top of the sand at 1425m. The assemblages extracted from this second batch of samples referred to as the ìpicked cuttingsî provided significant help in understanding the section.

The palynological zones assigned to the samples, zone Confidence Ratings, key defining species and interpreted palaeoenvironments are provided in Table 1. Basic palynological data on organic residue yields, palynomorph concentrations in the residues, palynomorph preservation and species diversity in the samples are provided in Table 2. Species abundance and range data are provided in Tables 3 to 5. Author citation for spore-pollen species can be principally sourced for published species from Stover & Partridge (1973, 1982), and for manuscript species from Partridge (1973). Author citation for dinocysts can be sourced from Williams *et al.* (1998), and for acritarchs, algal cysts and other microplankton from Fensome *et al.* (1990).

The nine cuttings analysed all gave moderate to high organic residue yields, which contained moderate to high concentration of generally well-preserved palynomorphs. Recorded spore-pollen diversity was a high 44 species per sample, but this does include a significant number of reworked species. Microplankton diversity was a moderate 15 species per sample, but would likely double if a thorough systematic study of the assemblages was undertaken.

Geological Discussion

The geological problem under investigation in Squid-1 was the age and correlation of the 360 metre thick sandstone unit between 1425 and 1785m, which is herein informally referred to as the Squid sandstone. The unit was presumed to have an Oligocene age as it overlies the Late Eocene Anglesea Formation, the regional seal to the Eastern View Group. However, no samples had been analysed from the Squid sandstone in the original palynological reports by Martin (1985) and Morgan (1986), nor were any studies made of the foraminiferal faunas from either this unit or the overlying Torquay Group. Two alternative lithological correlations of the sandstones also seemed possible. The Squid sandstone could represent a thicker development of the thin sands occurring immed-iately above the Anglesea Formation in other wells (eg. Cormorant-1 and King-1), or alternatively could wholly or partly represent a lateral facies of marine shales and marls in the other wells.

In anticipation that the palynological assemblages recovered from the Squid sandstone could give poor or equivocal results, samples were also analysed from the overlying marls assigned to the Torquay Group, and from the top of the underlying Anglesea Formation. A Late Eocene Middle *N. asperus* Zone age could be assigned to the latter formation based on slightly deeper cuttings samples that had previously been analysed by Martin (1985) and Morgan (1986). A fortuitous occurrence that assisted in the analysis was the presence of the 13-3/8" casing shoe at 1240m. The presence of this casing point meant that there was only 185 metres of open-hole section of the Torquay Group above the top of the Squid sandstone. Notwithstanding this limited exposure the soft marls of latter group caved extensively into the underlying sand section and confused the interpretation on the initial five bulk samples analysed (Table 1). This problem was partly overcome by a selective resampling and pre-treating the cuttings to remove or reduce the contamination from the caved marls.

From the Torquay Group samples were collected and analysed from a short distance below the casing point at 1275-80m, and from near the base of the marls at 1395-1400m. Within the Squid sandstone samples were collected a short distance below the top of the sandstone at 1445-70m, from an interval where thin coaly or carbonaceous beds were interbedded with the sandstone (samples at 1500-20m, 1530-50m), from immediately below the thin shale at 1586 to 1588m (samples at 1585-1600m, 1595-1600m), and from the middle of the lower massive sandstone section at 1670-85m. Finally the deepest sample at 1790-1800m is representative of the lithological change at the top of the Anglesea Formation.

Results of the new palynological study of Squid-1 indicate that the basal Torquay Group is Late Oligocene (Middle? *P. tuberculatus* Zone), the Squid sandstone Early Oligocene (Upper *N. asperus* to Lower? *P. tuberculatus* Zones), while the top of the Anglesea Formation is considered to be no younger than Late

Eocene (Middle *N. asperus* Zone). The palynomorph assemblages recovered from the Torquay Group are dominated by chorate dinocysts (principally *Spiniferites* spp.) which are recorded as caved to a greater or lesser extent in all the deeper cuttings. The other samples are dominated by angiosperm pollen (principally *Nothofagidites* spp.), as is typical of the broad *N. asperus* Zone. Finally, the top of the Anglesea Formation is characterised by a increased abundance of spores and the incoming of a significant number of typical Eocene dinocysts.

Because confidence in the identification of the spore-pollen zones is biased to FADs (First Appearance Datums) of species there is always some residual uncertainty in the spore-pollen zone assignments derived from cuttings. Fortunately, the associated microplankton assemblages contain species with important LADs (Last Appearance Datums) that provide additional age control.

Most critical to the age dating of the Squid sandstone in this report is the identification of the *Fromea leos* microplankton Zone from the cuttings between 1585 and 1600m that sample the interval at and just below the distinctive gamma ray shale spike at 1586 to 1588m. The as yet unpublished *F. leos* Zone has only previously been documented from the Gippsland Basin (eg. Partridge, 1994), where it is generally represented by less than 20 metres of open-marine marl at the base of the Seaspray Group, and forms part of the enigmatic ìEarly Oligocene Wedgeî that is irregularly distributed across the distal offshore portion of that basin (Bernecker & Partridge, 2001; appendix). The *F. leos* Zone in Squid-1 probably extends to the near the top of the Squid sandstone based on the occurrence of related species of *Fromea* in the cuttings at 1445-70m.

Age dating of the three cuttings samples between 1445 and 1550m from the upper part of the Squid sandstone is complicated by both cavings and significant reworking. Cuttings examined between the top of sandstone at 1425m and about 1550m where observed to be dominated by light to medium grey marl (interpreted as caved), with secondary loose quartz sand, and minor (<10%) black carbonaceous shale or coal. The last is interpreted to come from the ìcoalyî spikes on the sonic log between 1441 and 1535m, and is believed to be the principal source of *in situ* palynomorphs. The bulk of the recorded spore-pollen assemblages from the three cutting samples analysed between 1445 and 1550m were composed of long ranging species, but there was a conspicuous component, perhaps as high as 20% of spore-pollen assemblages, that is interpreted as reworked, based on well-established species ranges throughout southeast Australia. The most conspicuous reworked species recorded are *Proteacidites leightonii*, *P. asperopolus*, *P. pachypolus* and *Dicotetradites clavatus*. In combination these species indicate the source of the reworking was from sediments belonging to an interval extending from the *P. asperopolus* to basal Lower *N. asperus* Zones, implying an age range of late Early to early Middle Eocene. Although similar reworking has been recorded in other wells in the Bass Basin, at about the equivalent stratigraphic horizon above the Anglesea Formation, the numbers of reworked specimens is much lower (est. <1%). The postulated provenance of the reworking is to the south-east where the appropriate age sediments are at shallower depths (eg. Chat-1), or are suspected to have been eroded (eg. Durroon-1). Unfortunately the microplankton recorded from the three samples between 1445 and 1550m are not particularly diagnostic as most are interpreted as caved from the overlying Torquay Group.

The only cuttings from the sandstone interval below the shale spike with the *F. leos* Zone is also interpreted as badly contaminated and therefore not diagnostic. The next older *Phthanoperidinium comatum* microplankton Acme Zone could be anticipated to occur in this part of the sandstone based on electric log correlation to Poonboon-1 (Partridge 2002a-b), but except for the questionable identification of an endocyst of *Deflandrea heterophlycta* nothing new was recorded in the assemblage.

The next change in the spore-pollen and microplankton assemblages occurs in the deepest sample examined, which was collected from the top of the Anglesea Formation. The assemblage recorded contains common *Phthanoperidinium comatum* and mixed with key Eocene dinocysts and is assigned to the next older *Stoveracysta kakanuiensis* microplankton Zone. Although the eponymous species of the zone is purported to have a basal Oligocene age in New Zealand (Clowes & Morgan, 1984), data from the adjacent Gippsland Basin favours placing the zone in the latest Eocene (Partridge, 1999). The associated spore-pollen which are considered diagnostic of the Middle *N. asperus* Zone support this age assignment.

The palynological results from Squid-1, and a new palynological study of the equivalent interval in Poonboon-1 (Partridge, 2002a), when integrated with electric log correlation between the two wells (Partridge, 2002b; fig.11) refutes the interpretation that the thick Squid sandstone is filling a large channel entrenched into the top of the Anglesea Formation. Rather, the Squid sandstone represents a lateral sandy facies of the more shaly sediments overlying the Anglesea Formation in other wells. Reviewing the electric logs and limited palynological data in the wells across the basin from the Pelican field wells in the SW, through Poonboon-1 and Nangkero-1 in the middle of the basin, to Dondu-1, Yourongi-1 and Bass-2 in the NE, reveals that the equivalent sections in these wells all belong to the more shaly facies found in Poonboon-1. However, similar but thinner sands have been found to overlie the distinctive Anglesea Formation directly to the east in the Chat-1 well (1072-1132m), and to the SE in the Durroon-1 well (458-540m). Unfortunately, there is no reliable age dating of the sands in the latter two wells, but as the base of these sands are significantly shallower (650m in Chat-1 and 1245m in Durroon-1) they potentially could be much younger.

Based on the above well control and analogy to palaeoshorelines identified in other parts of Bass Strait (eg. Partridge, 1999; Holdgate *et al.*, 2002) the Squid sandstone is interpreted to be a barrier sandstone body with a probably SSW to NNE orientation that was largely deposited in a shoreface environment. The shale spike at 1586 to 1588m in Squid-1 representing a flooding horizon and the overlying thin coaly beds representing regressive back-barrier marsh environments.

Biostratigraphy

***Proteacidites tuberculatus* spore-pollen Zone and**
***Operculodinium* microplankton Superzone**
Interval: 1275 to 1400 metres.
Age: Early? to Late Oligocene.

Following the original zone definition of Stover & Partridge (1973) the two samples from the Torquay Group are confidently assigned to the *P. tuberculatus* Zone based on the presence of multiple specimens of the spore *Cyatheacidites annulatus*. In addition the presence of the spore *Cyathidites subtilis* in the next deepest cuttings at 1445-70m (where it is interpreted as caved), suggests that the marls below the 13-3/8" casing shoe at 1240m extend into the Middle *P. tuberculatus* Subzone and are therefore partly or mostly Late Oligocene in age. The associated microplankton assemblages are dominated by chorate dinocysts and conform to the *Operculodinium* Superzone of Partridge (1999). *Spiniferites* spp. dominates the assemblages (average 58%), with *Operculodinium centrocarpum* (average 10%) the next most abundant species. The presence of both the manuscript species *Protoellipsodinium simplex* and *Tuberculodinium vancampoae* in the cuttings suggest that the two informal zones based on these species are present in the section below the casing point.

Upper *Nothofagidites asperus* spore-pollen Zone and
***Fromea leos* microplankton Zone**
Interval: ?1445 to 1600 metres
Age: Early Oligocene.

A confident identification of the Upper *N. asperus* Zone cannot be made in Squid-1 because of the nature of the zone definition, and instead age dating of these cuttings samples is largely dependant on the identification of the unpublished *F. leos* microplankton Zone. The problem with the spore-pollen zone definition is that it is based on negative criteria of the absence of index species for the immediately underlying and overlying zones (Stover & Partridge, 1973). Further, the abundance of the gymnosperm pollen *Phyllocladidites mawsonii* originally cited as secondary characteristic of zone in the Gippsland Basin is now recognised to be facies dependant and is not applicable beyond the coal measures sequences deposited in the onshore Gippsland Basin. Support for the zone assignment does however come from the presence of a number of rare species in the samples. These include *Proteacidites stipplatus, P. rectomarginis, Psilodiporites pertritus* ms and *Malvacipollis grandis* ms.

The *F. leos* Zone is identified on the total range of the eponymous species. In the Gippsland Basin the species has a first occurrence after the LAD of *Phthanoperidinium comatum*, and although it is the basal zone of the *Operculodinium* Superzone it generally occurs before the oldest super-abundant occurrence of *Spiniferites* spp. The FAD of the spore *Cyatheacidites annulatus* which defines the base of the *P. tuberculatus* Zone is documented in a few sections to occur within the *F. leos* Zone. Such subtleties unfortunately cannot be confirmed in the contaminated cuttings analysed in Squid-1.

Middle *Nothofagidites asperus* spore-pollen Zone and
***Stoveracysta kakanuiensis* microplankton Zone**
Sample at: 1790-1800 metres
Age: Late Eocene.

The deepest cuttings sample analysed is assigned to the Middle *N. asperus* Zone based on the LADs of the secondary index species *Proteacidites recavus* and *P. tuberculiformis.* Unfortunately, the primary index species for the zone *Triorites magnificus* was not found, but is recorded from the slightly deeper cuttings at 1820-25m by Morgan (1986). Confidence in the zone assignment is somewhat reduced by the presence of extensive reworking in the overlying Squid sandstone including a number of key Eocene index species that normally have their LADs at the top of the Middle *N. asperus* Zone (eg. *Proteacidites pachypolus* and *Santalumidites cainozoicus*). Fortunately, strong independent support for the zone and age assignment is provided by the associated microplankton assemblage which is assigned to the *S. kakanuiensis* Zone based on the occurrence of the eponymous species. Although the latter species is considered to range into the basal Oligocene in New Zealand (Clowes & Morgan, 1984) it is not recorded above the Middle *N. asperus* Zone (or the Eocene) in the adjacent Gippsland Basin (Partridge, 1999).

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Table 1. Interpretative Palynological Data from Squid-1

No.	Sample Type	Depth Metres	Sample Origin	Spore-Pollen Zone	CR*	Microplankton Zone	CR*	Key Index Species	Palaeoenvironment
1	Bulk Cuttings	1275-1280	GA-1	*P. tuberculatus*	D2	*Operculodinium* Sz	D4		Open Marine
2	Bulk Cuttings	1395-1400	GA-1	*P. tuberculatus*	D2	*Operculodinium* Sz	D4	FAD of *Cyatheacidites annulatus*	Open Marine
3	Picked Cuttings	1445-1470	GA-2	*P. tuberculatus* to Upper *N. asperus*	D2	*F. leos* mixed with caved *P. simplex*	D4	LAD of *Fromea neochytra* ms	Marginal Marine
4	Picked Cuttings	1500-1520	GA-2	Upper *N. asperus* mixed with Early-Mid Eocene	D4	Indeterminate		Assemblage confused by both cavings and reworking.	Nearshore marine
5	Bulk Cuttings	1530-1550	GA-1	Upper *N. asperus* mixed with Early-Mid Eocene	D4	Indeterminate		Assemblage confused by both cavings and reworking.	Nearshore marine
6	Picked Cuttings	1585-1600	GA-2	Upper *N. asperus*	D4	*F. leos*	D3	Common *Fromea leos* ms	Marginal Marine
7	Bulk Cuttings	1595-1600	GA-1	Upper *N. asperus*	D4	*F. leos*	D3	FAD of *Fromea leos* ms	Marginal Marine
8	Picked Cuttings	1670-1685	GA-2	Indeterminate		Indeterminate		Assemblage entirely caved.	Nearshore marine
9	Bulk Cuttings	1790-1800	GA-1	Middle *N. asperus*	D4	*S. kakanuiensis*	D2	LAD of *Stoveracysta kakanuiensis*	Bay - restricted marine

ABBREVIATIONS
*CR = Confidence Ratings
LAD = Last Appearance Datum
FAD = First Appearance Datum
GA-1 = Samples collected Stage-1 Work program
GA-2 = Samples collected Stage-2 Work program

CONFIDENCE RATINGS

Alpha Code Linked to Sample
A = Core
B = Sidewall core
C = Coal cuttings
D = Ditch cuttings
J = Junk basket

Numeric Code Linked to Palynomorph Assemblage
1 = Excellent confidence: High diversity assemblage **plus** key zone species.
2 = Good confidence: Moderately diverse assemblage **plus** key zone species.
3 = Fair confidence: Low diversity assemblage **plus** key zone species.
4 = Poor confidence: Moderate to high diversity **minus** key zone species.
5 = Very low confidence: Low diversity assemblage **minus** key zone species.

Table 2. Basic Palynological Data from Squid-1

No.	PalLab Spl.No.	Sample Type	Top Metres	Base Metres	Visual Yield	Palynomorph Concentration	Palynomorph Preservation	No. SP Species	No. MP Species	Marine MP%	Other MP%	NED	Noth%
1	6405905	Bulk Cuttings	1275	1280	Moderate	Moderate to High	Fair-poor	25	17	66%		14%	17%
2	6405906	Bulk Cuttings	1395	1400	High	High	Poor-good	51	22	29%	<1%	17%	41%
3	6406909	Picked Cuttings	1445	1470	Moderate	Moderate	Poor	31	10	23%		4%	49%
4	6406910	Picked Cuttings	1500	1520	Moderate	Moderate	Poor-good	53	7	4%		2%	32%
5	6405907	Bulk Cuttings	1530	1550	High	High	Poor-good	55	7	6%		5%	44%
6	6406911	Picked Cuttings	1585	1600	High	High	Poor-good	36	14	22%	<1%	8%	57%
7	6405908	Bulk Cuttings	1595	1600	High	High	Poor-good	54	26	26%		14%	45%
8	6406912	Picked Cuttings	1670	1685	Moderate	Moderate	Fair	36	11	12%	<1%	10%	44%
9	6405909	Bulk Cuttings	1790	1800	High	Moderate	Poor-fair	53	24	12%		11%	29%

ABBREVIATIONS

MP = Microplankton

SP = Spore-Pollen

NED = Neves Effect based on *Dilwynites/Araucariacites* Percentage

Noth% = Percentage of *Nothofagidites* in SP count.

Table 3. Squid-1 — Abundances of major palynomorph groups.

No.	Top Metres	Base Metres	Sample Type	Gleicheniidites spores	ALL OTHER spores	Dilwynites and Araucariacites pollen	ALL OTHER gymnosperm pollen	Nothofagidites pollen	ALL OTHER angiosperm pollen	FUNGAL microfossils	Pre-Tertiary Spore-Pollen	**Total Terrestrial SUM**		SPORE-POLLEN TOTAL	MICROPLANKTON fresh to brackish	MICROPLANKTON marine	Microforaminiferal liners	Scolecodonts	**SP + Marine SUM**
1	1275	1280	Bulk Cuttings		39%	14%	17%	17%	11%	3%		109		33%		64%	3.1%	0.3%	325
2	1395	1400	Bulk Cuttings	2%	15%	16%	11%	40%	13%	5%	1.0%	200		71%	0.7%	28%	0.4%	0.4%	267
3	1445	1470	Picked Cutts		8%	4%	7%	44%	27%	9%	0.9%	224		77%		22%	0.8%		263
4	1500	1520	Picked Cutts		6%	2%	8%	29%	45%	9%		255		96%		4%			240
5	1530	1550	Bulk Cuttings	0.3%	6%	5%	6%	39%	34%	9%		295		93%		6%	1.0%		289
6	1585	1600	Picked Cutts		6%	7%	3%	51%	21%	11%		207		77%	0.4%	22%		0.4%	238
7	1595	1600	Bulk Cuttings	2%	10%	14%	10%	43%	18%	4%		197		71%	0.4%	25%	3.0%	0.4%	266
8	1670	1685	Picked Cutts	1%	7%	8%	4%	38%	28%	12%	0.4%	250		87%	0.4%	12%	0.4%		251
9	1790	1800	Bulk Cuttings		23%	10%	24%	28%	12%	1.4%	0.5%	222		88%	0.8%	12%			249

Table 4. Squid-1 well – spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	SPORE SPECIES	Baculatisporites spp.	Camarozonosporites heskermensis	Conbaculites apiculatus ms	Cyatheacidites annulatus	Cyathidites spp. large >40µm	Cyathidites spp. small <40µm	Cyathidites splendens	Cyathidites subtilis	Dictyophyllidites arcuatus	Echinosporis echinatus	Foveotriletes balteus	Foveotriletes palaequetrus	Gleicheniidites circinidites	Herkosporites elliottii	Ischyosporites spp.	Laevigatosporites major	Laevigatosporites ovatus	Matonisporites ornamentalis	Peromonolites spp.	Polypodiaceoisporites varus ms	Polypodiidites/Verrucatosporites spp.	Retitriletes spp.
1	1275	1280	Bulk Cuttings		1.9%			0.9%	6.6%	16%								1.9%	X	X	1.9%				0.9%	X
2	1395	1400	Bulk Cuttings		2.6%	X		0.5%		5.8%			X		X	X	1.6%	X	X		1.6%	X	X		0.5%	X
3	1445	1470	Picked Cutts							4.5%		0.5%		0.5%							3.0%					
4	1500	1520	Picked Cutts		0.9%	X	RW		0.9%	1.7%				X					X		3.0%			RW		
5	1530	1550	Bulk Cuttings		X				1.5%	3.0%					X		0.4%		X	X	1.5%				0.4%	
6	1585	1600	Picked Cutts		1.1%	X	RW			1.1%								0.5%	X		1.1%					
7	1595	1600	Bulk Cuttings		1.1%			CV	0.5%	2.1%			X				1.6%		X	X	3.2%		X		X	
8	1670	1685	Picked Cutts		0.5%				0.5%	3.2%							0.9%				0.9%					0.5%
9	1790	1800	Bulk Cuttings		0.5%				0.5%	14%	X		X		X			X	5.0%	X	0.9%	X	X		X	

ABBREVIATIONS
% = Percentage
X = Present
CV = Caved
RW = Reworked

Table 4. Squid-1 well – spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Ricciaesporites boxatus ms	Rugulatisporites mallatus	Stereisporites antiquisporites	Trilete spores undiff.	Tripunctisporis maastrichtiensis	Verrucosisporites kopukuensis	TOTAL Spores		GYMNOSPERM SPECIES	Araucariacites australis	Cupressacites sp.	Dacrycarpites australiensis	Dilwynites granulatus	Dilwynites tuberculatus	Lygistepollenites florinii	Microalatidites paleogenicus	Microcachryidites antarcticus	Phyllocladidites mawsonii	Podocarpidites spp.	Trichotomosulcites subgranulatus	TOTAL Gymnosperm Pollen		ANGIOSPERM SPECIES	Angiosperm pollen undiff.
1	1275	1280	Bulk Cuttings			2.8%	6.6%			40%			6.6%		2.8%	6.6%	0.9%			2.8%	1.9%	9.4%	0.9%	32%			
2	1395	1400	Bulk Cuttings	X		3.2%	1.1%		X	17%			6.3%	0.5%	X	9.5%	0.5%	0.5%		0.5%	1.1%	9.0%		28%			
3	1445	1470	Picked Cutts			0.5%	0.5%			9%			3.0%			1.0%		1.0%			2.0%	4.0%	0.5%	11%			2.0%
4	1500	1520	Picked Cutts			0.4%			X	7%			0.9%			0.9%		0.9%	0.4%	1.3%	2.6%	3.9%		11%			0.9%
5	1530	1550	Bulk Cuttings		X	0.4%			X	7%			1.5%			3.0%	0.7%	0.4%			2.6%	3.4%	0.4%	12%			
6	1585	1600	Picked Cutts			2.2%	1.1%		X	7%			2.2%	X		6.0%		1.1%		X	1.6%	1.1%		12%			2.2%
7	1595	1600	Bulk Cuttings		X	1.1%	2.1%		X	12%			3.2%	X	0.5%	10%	1.1%	0.5%		0.5%	1.1%	7.4%	0.5%	25%			
8	1670	1685	Picked Cutts			0.5%	2.3%			9%			1.8%	X		6.8%	0.9%	0.5%			1.4%	3.2%		15%			2.3%
9	1790	1800	Bulk Cuttings		X	1.4%	1.8%	X	X	24%			5.5%		X	4.1%	0.9%	3.2%		0.5%	7.8%	12%	0.5%	35%			0.9%

ABBREVIATIONS
% = Percentage
X = Present
CV = Caved
RW = Reworked

Table 4. Squid-1 well – spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Aglaoreidia qualumis	Arecipites sp.	Banksieaeidites arcuatus	Banksieaeidites elongatus	Beaupreaidites elegansiformis	Beaupreaidites trigonalis ms	Cupanieidites orthoteichus	Cyperaceaepollis neogenicus	Dicotetradites clavatus	Dryadopollis retequetrus	Dryptopollenites semilunatus	Ericipites crassiexinus/scabratus	Gothanipollis bassensis	Haloragacidites harrisii	Ilexpollenites spp.	Intratriporopollenites notabilis	Liliacidites spp.	Limingtonia sp.	Malvacipollis grandis ms	Malvacipollis robustus	Malvacipollis subtilis	Margocolporites vanwijhei	Milfordia spp.
1	1275	1280	Bulk Cuttings														8.5%									
2	1395	1400	Bulk Cuttings	0.5%			X		X				X			X	19	X		X		X				
3	1445	1470	Picked Cutts	1.5%	1.5%							0.5%					17									0.5%
4	1500	1520	Picked Cutts							1.3%		2.2%		0.4%	0.4%	X	28	0.4%		0.9%		X	X	1.3%		X
5	1530	1550	Bulk Cuttings	0.7%		0.4%				0.7%	0.4%	0.7%			X		28	0.4%		1.1%	X		X	0.7%		
6	1585	1600	Picked Cutts	1.1%						0.5%	0.5%						15			X				0.5%		
7	1595	1600	Bulk Cuttings	1.1%						X							18	1.1%	RW					1.1%	X	
8	1670	1685	Picked Cutts	0.9%						0.5%		1.4%					14	0.5%		0.9%				1.4%		
9	1790	1800	Bulk Cuttings	0.9%				X			X	0.5%			X		6.0%							0.9%		0.5%

ABBREVIATIONS
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Table 4. Squid-1 well – spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Myrtaceidites parvus/mesonesus	Myrtaceidites tenuis	Nothofagidites asperus	Nothofagidites brachyspinulosus	Nothofagidites deminutus	Nothofagidites emarcidus/heterus	Nothofagidites falcatus	Nothofagidites flemingii	Nothofagidites goniatus	Nothofagidites vansteenisii	Periporopollenites spp.	Polycolpites langstonii	Proteacidites spp.	Proteacidites adenanthoides	Proteacidites annularis	Proteacidites asperopolus	Proteacidites biporus	Proteacidites grandis	Proteacidites incurvatus	Proteacidites kopiensis	Proteacidites leightonii	Proteacidites nasus	Proteacidites obesolabrus ms
1	1275	1280	Bulk Cuttings			0.9%		0.9%	14%	0.9%						0.9%										
2	1395	1400	Bulk Cuttings			0.5%		4.8%	34%	0.5%	0.5%	0.5%	0.5%	X	RW	0.5%		X			RW					
3	1445	1470	Picked Cutts	2.5%		0.5%	2.5%	5.0%	38%	1.0%	1.5%		0.5%			4.5%								2.0%		
4	1500	1520	Picked Cutts	3.5%		0.4%	0.4%	3.0%	25%	0.4%	2.6%		0.4%			12%	RW	X	0.9%	RW			X	0.4%		
5	1530	1550	Bulk Cuttings	1.1%		3.7%		2.2%	36%	0.4%	0.4%		0.4%	1.9%		10%	RW	0.4%	2.2%				X	1.5%		RW
6	1585	1600	Picked Cutts	3.3%	0.5%	0.5%		4.3%	50%	2.2%	0.5%					2.7%		0.5%	0.5%					0.5%		
7	1595	1600	Bulk Cuttings	X		1.1%	0.5%	2.6%	35%	1.1%	2.1%	0.5%	1.6%			3.7%		0.5%	RW					RW	RW	
8	1670	1685	Picked Cutts	3.7%			1.4%	3.7%	36%	0.9%	1.4%		0.5%			4.6%		X						0.5%		
9	1790	1800	Bulk Cuttings			0.9%		0.9%	22%	0.5%	4.1%	0.5%				0.5%						X				

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Table 4. Squid-1 well – spore-pollen distribution.

No.	Top Metres	Base Metres	Sample Type	Proteacidites obscurus	Proteacidites pachypolus	Proteacidites recavus	Proteacidites rectomarginis	Proteacidites reticuloscabratus	Proteacidites stipplatus	Proteacidites tuberculatus	Proteacidites tuberculiformis	Psilodiporites pertritus ms	Santalumidites cainozoicus	Sapotaceoidaepollenites rotundus	Schizocolpus marlinensis	Tetrapollis campbellbrownii	Tricolp(or)ates spp.	Tricolpites thomasii	Tricolporites adelaidensis	Tricolporites paenestriatus	Tricolporites scabratus	Triporopollenites simplis	Triporopollenites spp.	TOTAL Angiosperm Pollen	TOTAL SP COUNT
1	1275	1280	Bulk Cuttings														1.9%			X				28%	106
2	1395	1400	Bulk Cuttings				0.5%			X				X		X	1.6%		X		X			55%	189
3	1445	1470	Picked Cutts	0.5%	0.5%								0.5%				4.5%			1.0%			X	79%	202
4	1500	1520	Picked Cutts	X	0.4%		X						0.4%				8.7%		0.9%	2.2%		0.9%		82%	231
5	1530	1550	Bulk Cuttings		0.7%	RW	X						0.4%				3.0%	0.4%	X					81%	268
6	1585	1600	Picked Cutts	X				X				X					2.2%			X				81%	184
7	1595	1600	Bulk Cuttings		RW				X	X				X			1.6%		X	X				63%	189
8	1670	1685	Picked Cutts	0.9%	0.5%												7.8%			0.5%				76%	219
9	1790	1800	Bulk Cuttings	X		X	X				X				X		2.3%		X					41%	218

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Table 5. Squid-1 – microplankton distribution.

No.	Top Metres	Base Metres	Sample Type	ACRITARCHS and ALGAE	Cymatisphaera sp. (polygonal)	Cymatisphaera sp. (zigzag)	Horologinella incurvata	Micrhystridium spp.	Botryococcus braunii	Crassosphaera concinnia	Lecaniella sp.	Pediastum sp.	DINOCYST SPECIES	Dinocysts undiff.	Achomosphaera spp.	Apectodinium australiense	Arachnodinium antarcticum	Batiacasphaera spp.	Chiropteridium dispersum	Cooksonites spp.	Cordosphaeridium spp.	Dapsilidinium pseudocolligerum	Deflandrea heterophlycta	Deflandrea phosphoritica	Enneadocysta pectiniformis	Eocladopyxis peniculata	Fromea leos ms	Fromea neochytra ms
1	1275	1280	Bulk Cuttings			0.5%		6%						12%		1%			X	0.5%								
2	1395	1400	Bulk Cuttings				X		1%		1%			17%	X	X				X		1%						1%
3	1445	1470	Picked Cuttings		3%			51%						8%														2%
4	1500	1520	Picked Cuttings					22%						11%				11%				X						
5	1530	1550	Bulk Cuttings											17%								6%						
6	1585	1600	Picked Cuttings				2%	23%	2%	X				15%								X					28%	4%
7	1595	1600	Bulk Cuttings							X		1%		13%		1%			CV	X		3%		X		X	1%	X
8	1670	1685	Picked Cuttings				3%	32%	3%					6%								X	X				10%	
9	1790	1800	Bulk Cuttings						3%			3%		10%	X		X			X	X		3%	X	X			

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Table 5. Squid-1 – microplankton distribution.

No.	Top Metres	Base Metres	Sample Type	Homotryblium plectilum	Hystrichokolpoma rigaudiae	Impagidinium spp.	Impletosphaeridium severinii	Lingulodinium machaerophorum	Lingulodinium solarum	Operculodinium centrocarpum	Palaeocystodinium golzowense	Paralecaniella indentata	Phenidinium sp.	Phthanoperidinium comatum	Protoellipsodinium simplex ms	Protoellipsodinium spp.	Pyxidinopsis pontus ms	Reticulatosphaera stellata	Samlandia reticulifera	Selenophemphix spp.	Spiniferites spp.	Stephanodinium spiniferum	Stoveracysta kakaniensis	Systematophora placacanthum	Tectatodinium spp.	Thalassiphora pelagica	Tuberculodinium vancampoae	TOTAL MP COUNT
1	1275	1280	Bulk Cuttings		1%	0.5%	X	0.5%		7%					1%	1%				X	67%			1%	X			208
2	1395	1400	Bulk Cuttings	X	3%	X		4%		13%	X	X			X	1%		4%		X	50%	X		3%			X	76
3	1445	1470	Picked Cuttings		3%			2%		7%								2%			20%			2%				59
4	1500	1520	Picked Cuttings							11%											44%							9
5	1530	1550	Bulk Cuttings		X			6%		17%					X						56%			X			X	18
6	1585	1600	Picked Cuttings		4%					4%					X	X					19%			X		X		53
7	1595	1600	Bulk Cuttings		X			X		13%		X			1%	X	1%	X		X	62%	X		1%		X		68
8	1670	1685	Picked Cuttings		X					16%					3%			X			26%							31
9	1790	1800	Bulk Cuttings		X			3%	X	13%	X		X	23%	X				X		39%		3%	X		X		31

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APPENDIX C8.

BASS BASIN PALYNOLOGICAL PROJECT
Unravelling a Late Cretaceous to Eocene geological history of large palaeolakes, coastal lagoons and marine bays.

by

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BASS BASIN PALYNOLOGICAL PROJECT
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by Alan D. Partridge

Summary

Until the establishment of the marine seaway through the Bass Strait in the latest Oligocene or early Miocene the Bass Basin has essentially been an intracratonic or landlocked sedimentary basin. During the Late Cretaceous and early Paleocene the palaeogeography of the basin is typified by large fresh-water palaeolakes surrounded by deltaic environments, although periodically this facies pattern was interrupted by episodes of more fluvial deposition. Marine waters appear to have first entered the basin from the north-west in the Paleocene at the time of the late Paleocene thermal maximum (LPTM). The then existing Palaeolake Koorkah and subsequent Early and Middle Eocene palaeolakes are interpreted as large coastal lagoons comparable in size to Lake Maracaibo the largest modern coastal lagoon. The thickest and most extensive coal seams, and highest percentage of coal, in the stratigraphic succession correlate to this episode of coastal lagoons, and both coal deposition and the coastal lagoon environments were terminated in the latest Middle Eocene by the widespread deposition of the sands of the Boonah Formation and subsequent finer-grained facies of the overlying Anglesea Formation. The consistent occurrence of diverse cosmopolitan dinocysts through these latter two units suggest deposition in estuarine to restricted marine bay environments, analogous to the modern Port Phillip, albeit at a much grander scale.

The palynological studies have focussed on improving the age framework and providing supporting evidence for the identification of lacustrine, lagoonal and marine environments. Distinguishing between these environments is derived from the study of abundance and diversity of organic-walled microplankton, and identification of Neves effects within the terrestrial spore-pollen component of the palynological assemblages. Microplankton identified include marine and non-marine dinocysts, acritarchs, and colonial and single-celled algae. The Neves effects are the tendency for certain pollen types to be dominant in more distal depositional environments and their presence and distribution in the Bass Basin is supportive of the presence of large and often deep palaeolakes in the basin.

New palynological analyses from the 360 metre sandstone section overlying the Anglesea Formation in Squid-1 confirm both an Early Oligocene age and correlation of the unit to marine shales in the central basin that are assigned to the Addiscot and Angahook Formations. This Squid sandstone is interpreted to have been deposited in a shoreface environment adjacent to a palaeoshoreline oriented SSW to NNE.

Introduction

Biostratigraphic analysis of the most prospective Late Cretaceous to Eocene section in the Bass Basin is entirely dependant on palynology as this part of the succession is largely depauperate in biogenic calcium carbonate making the search for and use of calcareous microfossil unproductive. Most of the 32 wells drilled in the offshore Bass Basin were also spudded prior to the mid-1980s, and although the palynological reports are typical of their vintage there has been little revision of the palynological data since then. In general, the older reports lack detailed range charts, comprehensive recording of dinocysts assemblages and quantitative assemblage counts required for modern sequence and facies analysis. In contrast to the early reports, the five most recent exploration wells drilled in the past decade lack palynological studies or have very skimpy analyses of a limited number of cuttings samples.

In consideration of the above limitations on the available biostratigraphy a Bass Basin Palynological Project component was initiated as part of the Western Tasmania Regional Minerals Program Offshore Collaborative Project, between Mineral Resources Tasmania, Geoscience Australia and the National Centre for Petroleum Geology and Geophysics, which had the ultimate objective of improving the hydrocarbon prospectivity of the Bass and Sorell Basins. The palynological studies have been focussed on the Bass Basin and had the following principal objectives:

1. To establish a composite quantitative reference section for the palynological succession from Late Cretaceous to basal Oligocene.
2. To quantify the distribution, abundance and diversity of marine and non-marine dinocysts and other microplankton in the basin, to aid in the identification in time and space of lacustrine and marine palaeoenvironments in the basin.
3. To document presence and distribution of Neves effects within the terrestrial spore-pollen assemblages, as supporting palynological evidence for existence of large palaeolakes.
4. To resolve the age limits and distribution of the Oligocene sandstones observed to locally overlie the regional seal formed by the Anglesea Formation.

Selection of wells for review

The timetable and budget for the project restricted the palynological study to selected intervals in just seven of the 32 wells drilled in the basin. The early wells Poonboon-1 and Durroon-1, both spudded in 1972, were chosen to construct a composite quantitative reference section as they were known to contain well-preserved microfloras and some of the best sidewall core sampling of any wells in the basin. The interval reviewed in Durroon-1 was the Upper Cretaceous (*P. mawsonii* to *F. longus* Zones), while in Poonboon-1 an essentially complete sequence from the latest Maastrichtian to basal Miocene (Upper *F. longus* to *P. tuberculatus* Zones) was re-examined. Other factors contributing to the choice of these wells was that Durroon-1 is the only well in the basin penetrating an extended section of the middle Cretaceous (ie. *P. mawsonii* to *T. lilliei* Zones), while the section penetrated in Poonboon-1 was believed to be unaffected by any volcanic intrusion.

The latter have carbonised and degraded parts of the palynological succession in many of the other wells. Finally, relinquished palynological slides were known to be available from these two wells, in contrast to more recent wells drilled through the 1980s and 1990s where the original palynological slides and what remains of the sidewall cores are not generally available.

To investigate the timing of the commencement and the subsequent distribution of marine influence across the basin additional studies were made of Konkon-1 and the close together Cormorant-1 and King-1 wells. Konkon-1 was chosen as the original palynological report by Stover (1973) suggested this well contained some of the most abundant and diverse marine microplankton assemblages recorded in the basin. The well is also located in the northwest portion of the basin which all the available data suggested was the direction from which marine influence entered the basin. In the Cormorant-1 and King-1 wells only the latest Early Eocene and Middle Eocene section was analysed. This interval is much thicker than in Konkon-1, and was also known to contain the very rare occurrence of key dinocyst index species in Cormorant-1. It was hoped to recover additional dinocyst index species in Cormorant-1 and King-1 so as to be able to apply the more detailed microplankton zonation developed in the Gippsland Basin. Unfortunately, as discussed below this objective was not achieved.

To investigate the presence of large palaeolakes and lagoons interpreted to be present at different times through the Bass Basin succession, new palynological studies were performed on thick shale units identified on the gamma ray logs in a number of wells. The oldest palaeolake identified, the Turonian Durroon Formation in Durroon-1, has always been regarded as a lacustrine unit based on the occurrence of non-marine algae and dinocysts (Partridge, 1973, 1996; Smith 1986). The issue was whether any lacustrine character could be identified in younger palynological assemblages in other wells. Identified as possible candidates were thick latest Cretaceous to Paleocene or Early Eocene shales in wells in the north-western portion of the basin (eg. Koorkah unit) , and a distinctive unit on the gamma log at the top of the Eastern View Group (eg. Toolka unit). The older shales were investigated as part of the studies of Konkon-1 and Poonboon-1, and by collection and analysis of fresh cuttings samples in Koorkah-1. Unfortunately, neither the original palynological slides, nor any of the sidewall cores from Koorkah-1 were available for this study. The younger unit was investigated as part of the reviews of Konkon-1 and Cormorant-1.

Study of the Oligocene sandstones was centred on the 360 metre thick sandstone found overlying the Anglesea Formation in Squid-1. The age of this unit was not adequately determined in the original palynological reports on Squid-1 and it was desirable to know whether the sandstone could be interpreted as filling a large channel entrenched into the top of the Anglesea Formation, or represented a lateral facies (ie. proximal strandline) of the shaly sediments overlying the Anglesea Formation in other wells. Analysis of both bulk and ìpickedî cuttings in Squid-1 and comparison with the sequence above the Anglesea Formation in Poonboon-1 were found to favour the second interpretation.

Palaeoenvironments

In the Bass Basin the analysis of stratigraphic units and palaeoenvironments at a broad scale is largely dependant on the distribution and proportion of the principal lithologies, shales, sandstones and coals. In general, the succession lacks either diagnostic mineral (eg. glauconite) or environmentally explicit lithologies (except of course for coal). As the stratigraphic succession being studied is entirely subsurface the basic lithological data comes from the cuttings descriptions, supplemented by a moderate density of sidewall cores and a relatively limited number of conventional cores. The electric logs provide additional information on the relative proportions of the principal lithologies, their distribution across the basin, and changes in the bedding thickness and stacking patterns. When this data is combined with knowledge of modern sedimentary environments, and modern analogues various facies associations and palaeoenvironments can be postulated.

Interpreting the palaeoenvironments in the Bass Basin also draws extensively on the more densely drilled and intensively studied Gippsland Basin. In the latter basin mapping the maximum seaward extent of coals in successive palynological zones has allowed the identification of the approximate positions of palaeoshorelines through time (Partridge, 1999a). When combined with palaeogeographic mapping the resulting improved understanding the distribution of both sedimentary parameters (lithologies, bed thickness etc) and fossils (dinocysts, mangrove pollen, Neves effects) with respect to these palaeoshorelines can be applied to the interpretation of palaeoenvironments in the Bass Basin. An empirical matrix for variety of environments identified and the parameters on which they are based is summarised in Figure 1.

In terms of the fossil content, generally all that is available are palynomorphs. As previously stated calcareous microfossils are absent from the Eastern View and Furneaux Groups, and generally rare and sporadic through the lower part of the Demons Bluff Group. The most important information that can be gleaned from the palynology are the abundances of microplankton and the identification of Neves effects amongst the spore-pollen.

Microplankton. The palynological assemblages in the Bass Basin contain a mixture of organic-walled microplankton including dinocysts, acritarchs and single-celled and colonial algae. The dinocysts can be divided between cosmopolitan marine forms (eg. *Apectodinium*, *Spiniferites*), and widely accepted non-marine forms (eg. *Morkallacysta, Saeptodinium*). Classification the latter as non-marine genera was first proposed by Harris (1974), notwithstanding the caveat that they can always be washed down-stream into marine environments. Also interpreted as non-marine are the suite of endemic single-celled algae (eg. *Rimosicysta, Wuroia*), originally described from the Kipper Shale in the Gippsland Basin by Marshall (1989), and also recorded from the Durroon Formation in Durroon-1. Colonial algae, represented by *Botryococcus* and *Pediastrum,* are mostly rare throughout the succession but their occurrences are consistent with the postulated environments of the sediments in which they are found. Acritarchs are mostly rare and only occasionally common in the succession, and because their modern affinities are unknown they are spilt between marine and non-marine types based solely on the environmental assignments of the associated microplankton.

Figure 1. Matrix of Palaeoenvironmental Indicators in Bass Basin and examples of their application to wells studied.

ENVIRONMENTS & FACIES versus LITHOLOGICAL & PALYNOLOGICAL CRITERIA

	Alluvial-Fluvial	Upper Coastal Plain	Lower Coastal Plain	Proximal or Shallow Water	Distal or Deep Water
Lithological Characteristics	No coals Sand >> Shale Conglomerates	Coals thin & infrequent Sand > Shale	Coals thickest & common Shale > Sand	Shale >> Sand Bedding thin Coals rare	Shale >>> Sand Bedding thick
Terrestrical Spore-pollen	SP diversity lowest often with notable species absences	SP moderate diversity Assemblages skewed by local abundances	SP diversity high Assemblages skewed or homogeneous	SP diversity high homogeneous assemblages + mangrove pollen	SP diversity often low assemblages skewed by Neves effects
Non-marine Microplankton (algae + dinocysts)	Rare and atypical eg. *Pseudoschizaea Circulisporites parvus*	Very sporadic and unusual if common eg. *Saeptodinium*	Uncommon with low diversity & abundnace eg. *Saeptodinium*	Low diversity <3 species but often abundant eg. *Morkallacysta*	Moderate diversity 3 to 10 species mostly abundant eg. *Rimosicysta* and *Wuroia*
Marine Microplankton (mainly dinocysts)	Absent	Absent	Often monospecific with high abundance ie. "dinocyst blooms" eg. *Apectodinium Paralecaniella*	Diversity moderate 5-10+ species MP abundance >5% to <20% eg. *Homotryblium*	Diversity high 10-30+ species MP abundance >20% Common *Spiniferites*

EXAMPLES FROM MAJOR UNITS AND WELLS STUDIED

Torquay Group **Open Marine Carbonates**	Facies not intersected	Facies not intersected	Facies not intersected	Facies not intersected	Abundant + diverse dinocysts in carbonates + weak Neves effect eg. Poonboon-1
Demons Bluff Group **Marine Clastics Bay/Estuarine**	Facies not intersected	Facies not intersected	Diverse SP + low MP assemblages from coaly shales in Squid sandstone	Diverse SP + variably abundant MP from Boonah Fm. Konkon-1, Poonboon-1	Some MP assemblages in Anglesea Fm in Poonboon-1 but Neves effect weak
Upper Eastern View Group **Lagoonal – Brackish to Restricted Marine**	This age facies not analysed in study	Moderately diverse SP assemblages, no MP, few coals, Poonboon unit in Poonboon-1	Diverse SP, infrequent MP abundances Narimba & Cormorant units in Poonboon-1	Diverse SP with mangrove pollen, MP diversity high Cormorant unit in King-1 & Cormorant-1	Possibly low diversity MP assemblages in Toolka unit but Neves effect weak
Lower Eastern View and Furneaux Groups **Lacustrine to Fresh-water**	Low diversity SP from conglomerates in Boobyalla Subbasin	Low diversity SP assemblages, no MP, few coals, Narimba in Pelican field wells	Moderate diversity SP rare non-marine MP, coaly lower Narimba unit in Poonboon-1	Weak Neves effect mostly rare MP in Palaeolake Koorkah tongue in Poonboon-1	Strong Neves effect rare to abundant MP assemblages in Palaeolakes Koorkah & Durroon

Neves Effect. Amongst the spore-pollen assemblages unusual high abundance of gymnosperm pollen belonging to the fossil genera *Dilwynites* and *Araucariacites* are interpreted as Neves effects (Traverse, 1988), and the sediments in which they found are interpreted to have been deposited in distal marine and lacustrine environments. The modern affinity of *Dilwynites* pollen is with the recently discovered Wollemi pine, a member of the family Araucariaceae.

The concept of the Neves effect (Figure 2), is derived from empirical observation of spore-pollen abundances in modern sedimentary environments, and is defined as the tendency for certain more buoyant spores or pollen to have greater relative abundances in sediments deposited in more distal marine or lacustrine environments. Typical of a Neves effect is for pine pollen from trees growing in the hinterland to have high relative abundance in the most distal offshore environments (Line 4). In contrast pollen and spores from coastal plain and shoreline vegetation tends to have greater absolute and relative abundance in deltaic and nearshore environments (Lines 1 & 2). Part of the reason for the effect is the relative differences in surface areas. Proximal sediments are generally dominated by spores and pollen from the local area which often represents a limited geographic area. In contrast, distal sediments provide a more regional spore-pollen spectrum and therefore tend to be dominated by spore-pollen derived from the geographically much larger hinterland.

Stratigraphic Framework

A summary of a new stratigraphic framework for the Bass Basin is provided in Figure 3. The scheme is a mixture of established formation names that can be applied to the Bass Basin (eg. Durroon, Boonah, Anglesea, Addiscot formations) and informal names proposed to facilitate discussion of the relationships of the major lithological and facies units identified. Additional testing and discussions of the utility of this stratigraphic framework is required before the formal description of the units as either formations or sequences can be made.

At the highest rank the succession is divided into four groups, the Turonian to early Maastrichtian Furneaux Group, the late Maastrichtian to Middle Eocene Eastern View Group, the Late Eocene to Early Oligocene Demons Bluff Group and Late Oligocene to Recent Torquay Group. The Eastern View Group is distinguished from the underlying and overlying groups by the presence of extensive coals, while the Torquay Group represents the commencement of carbonated deposition in the basin.

The currently informal Furneaux Group (name proposed by Peter Baillie *pers comm*.), is comprised of sandstones and shales deposited in lacustrine, deltaic and fluvial environments. The succession is only fully penetrated in Durroon-1 where it is subdivided into an unnamed basal volcanic and sandstone unit, the Durroon Formation defined by Smith (1986), and the informal Boobyalla unit. A significant time gap occur between the latter two units which is correlated to the Longtom Unconformity identified in the Gippsland

Figure 2. Illustration of Neves effect adapted from Traverse (1988).

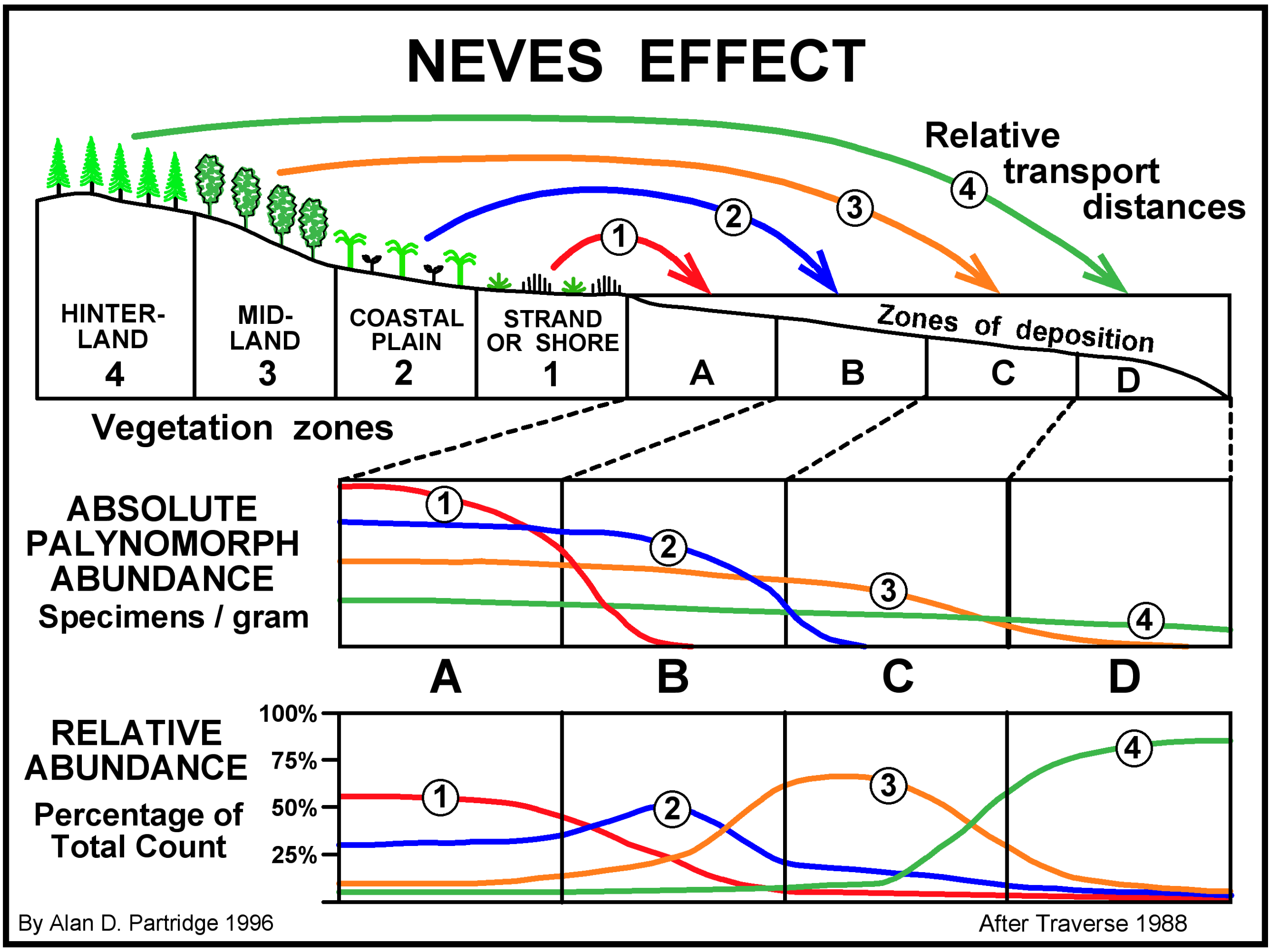
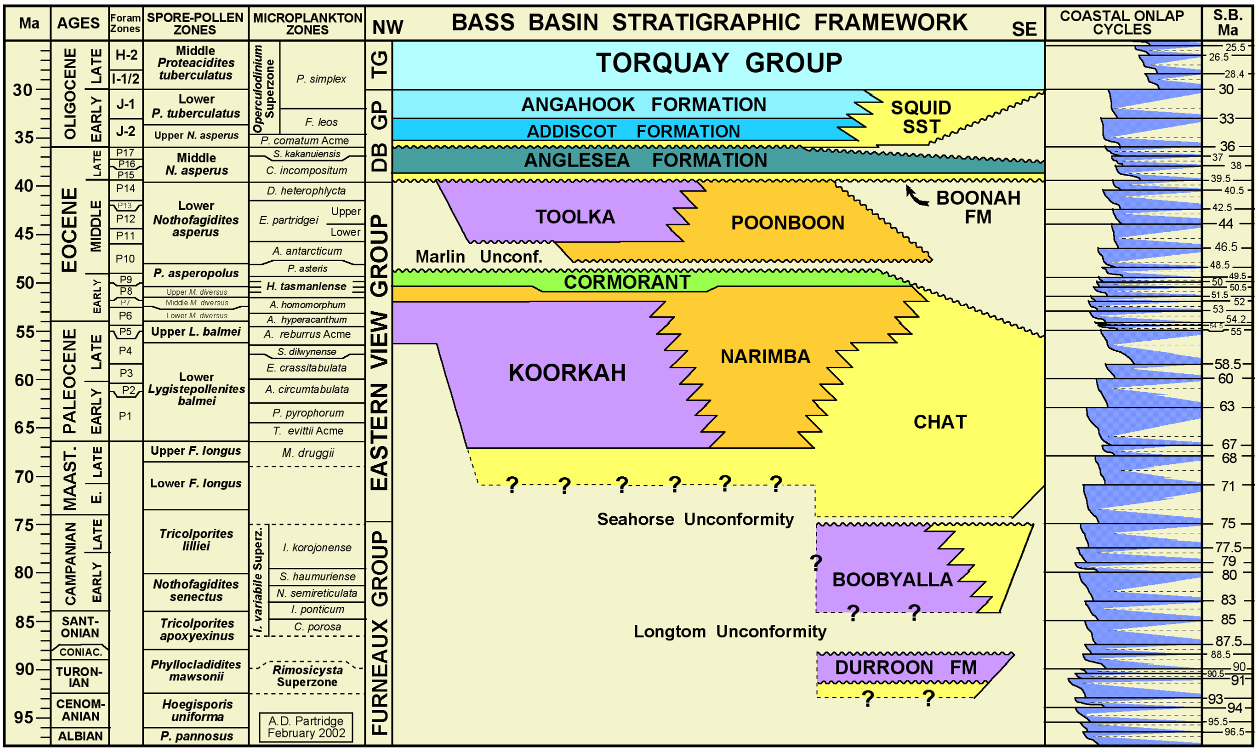


Figure 3. Proposed stratigraphic framework for the Bass Basin. Palynological zones and correlation to timescale of Haw et al. (1987) adapted from Partridge (1999a). Demons Bluff Group abbreviated to DB GP, and Torquay Group to TG. Except for those labelledas formations, new unit names are informal as is Furneaux Group.



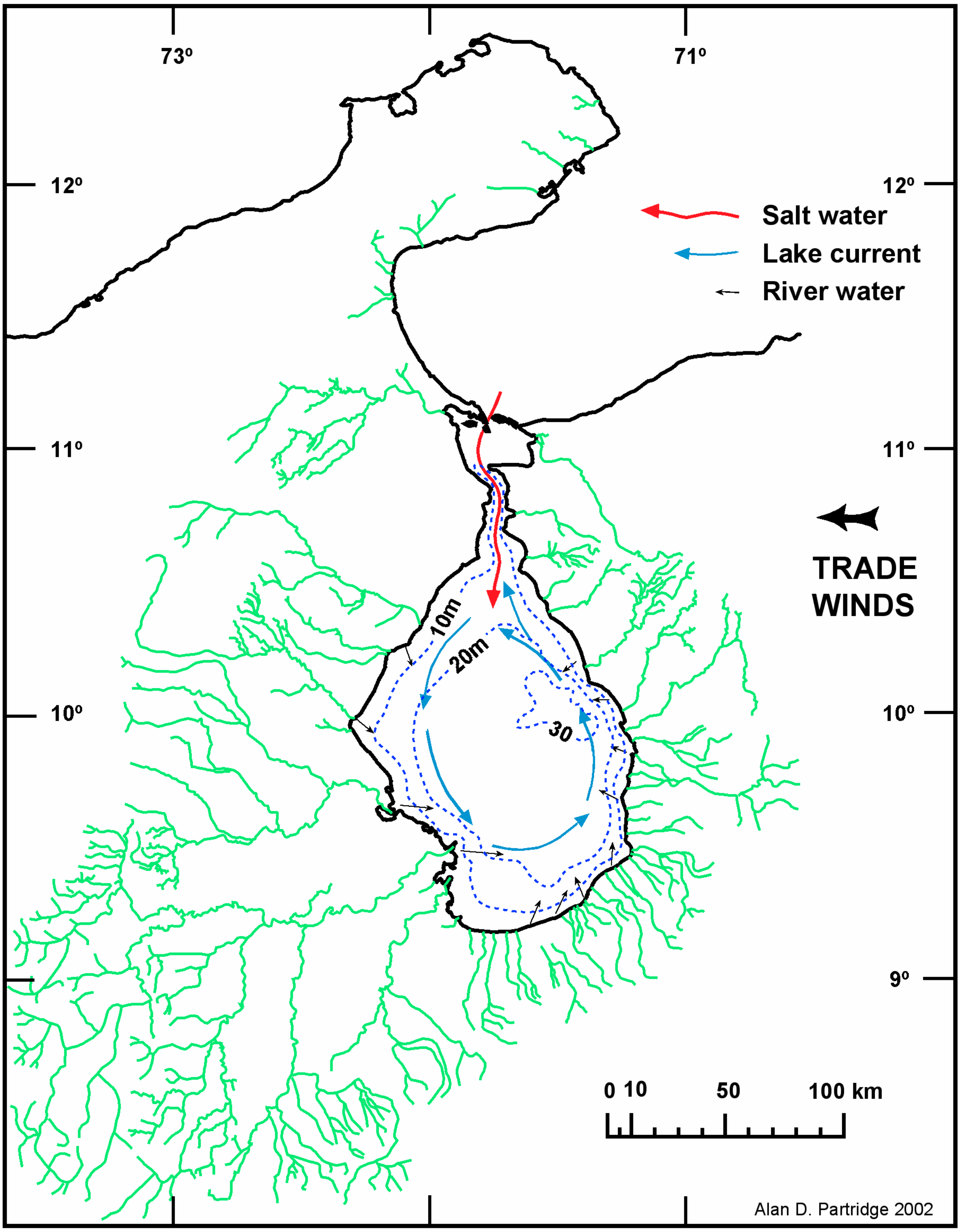
Basin by Bernecker & Partridge (2001). An unconformity also separates the Furneaux Group from the overlying Eastern View Group, but its precise age and stratigraphic position is uncertain. It is place between the *T. lilliei* and Lower *F. longus* Zones in Durroon-1 but may be lie within the Chat unit in other wells (eg. Koorkah-1). This unconformity is tentatively correlated with the Seahorse Unconformity identified in the Gippsland Basin by Bernecker & Partridge (2001), and with one or more unconformities identified within the Timboon Sandstone in the Otway Basin by Partridge (2001). The Eastern View Group, a contraction of the Eastern View Coal Measures, currently lacks a formal lithological subdivision of named formations. Seven informally named units are therefore proposed to facilitate the discussion of the facies relationships identified within the group (Figure 3). The subdivision is based largely on a NW to SE cross-section through the wells Konkon-1, Toolka-1, Cormorant-1, Koorkah-1, Poonoon-1, Squid-1, Chat-1 and Durroon-1. Key to the subdivision is the recognition of two thickly bedded shaly lacustrine facies referred to as the Koorkah and Toolka units, which are largely restricted to wells in the northwest portion of the basin (ie. Konkon-1, Seal-1, Toolka-1, Cormorant-1, Koorkah-1, and Aroo-1).

Laterally age equivalent to these lake or lagoonal facies are coastal plain to deltaic facies containing coals that are assigned to the Narimba and Poonboon units. These latter units are typified by the sequence in the Poonboon-1 well, and have been identified in the surrounding a circle of wells in the middle of the basin (ie. Tarook-1, Narimba-1, Pelican-1 to 5, Squid-1, Yurongi-1 and Tilana-1). The coaly coastal plain facies of the Narimba unit grades laterally into more sandy fluvial/alluvial sediments lacking coal in the most southeasterly Chat-1 and Durroon-1 wells. These non-marine sediments are referred to the Chat unit, and the name is also applied to sediments underlying the Koorkah and Narimba units, which also lack coal. It is surmised that coal deposition only started in the Bass Basin upon the initiation of Palaeolake Koorkah in the northwest portion of the basin. The younger Poonboon unit is still represent by coal measures in Chat-1, but is eroded or was never deposited in Durroon-1.

Between the major lacustrine facies of the Koorkah and Toolka units lies the Cormorant unit and parts of the Narimba and Poonboon units. The Cormorant unit is typically thinly bedded with a higher density of thin coal seams interbedded with restricted marine shales, and generally only rare sands. The thin bedding throughout the Cormorant unit suggests frequent and extensive changes in the environment of deposition as is likely to have occurred in a very shallow water lagoon, like modern Lake Maracaibo (Figure 4). In contrast, the thicker and more thickly bedded shales in the Koorkah and Toolka are interpreted to be more distal, and thus deeper water lacustrine or lagoonal facies. The intervening Narimba unit is considered to be transitional between the Koorkah and Cormorant units.

Correlation of the spore-pollen succession between the Bass and Gippsland Basins suggests the Cormorant unit is separated from the overlying Poonboon unit by missing Middle Eocene section correlated with the Marlin Unconformity of Partridge (1999a). This unconformity is based on missing dinocyst zones in the Gippsland Basin microplankton succession compared to more complete microplankton sequences in New

Figure 4. Locality map for Lake Maracaibo, Venezuela South America.



Zealand (Partridge, 1999a). Although identification in the Bass Basin of section equivalent to the Marlin Unconformity in the Gippsland Basin was a secondary objective of the palynological project, this correlation problem could not be solved in the wells analysed and additional palynological studies are still required.
The next major subdivision of the Bass Basin succession is assigned to the revised Demons Bluff Group of Holdgate *et al.* (2001), described from the Torquay Basin. This group represents the interval from the end of coal deposition to and commencement of widespread carbonate deposition.

Based on Holdgate *et al.* (2001) the main seal unit in the Bass Basin is now known as the Anglesea Formation. This unit was previously referred to as either the Upper Eocene Shale (Robinson, 1974) or Demons Bluff Formation (Baillie & Bacon, 1989). Also, the local name Konkon Sandstone of Baillie & Bacon (1989) is now recognised as a junior synonym of the Boonah Formation. Palynological data also confirms the correlation of the slightly calcareous marine sediments overlying the Anglesea Formation to the type sections of the Addiscot and Angahook Formations in the Torquay Basin. But as there is no clear electric log break, and little apparent change in lithology, between these formations in the Bass Basin a single name may be more appropriate. Further analysis of this interval is required. The widespread occurrence of cosmopolitan marine dinocysts, and absence of coal (except perhaps in Squid-1), in the formations of the Demons Bluff Group indicates deposition in marginal to restricted marine environments ranging from estuarine to bay facies.

The youngest major subdivision comprises the carbonate-rich sediments that are assigned to the Torquay Group, originally established in the Torquay Basin (Raggatt & Crespin, 1955). The group contains calcareous shales, marls, calcarenites and local volcanic piles, which have not yet been subdivided into formations or informal units. Torquay Group deposition commences in the Late Oligocene when the Bass Basin finally became an open-marine strait between the Otway and Gippsland Basins and extends through to the Pleistocene when the Bass Basin was again temporarily a large bay during the glacial periods.

Palaeolakes and Lagoons

Identification of palaeolakes and lagoons is integral to the interpretation of the stratigraphy and palynology of the Bass Basin presented in this report. According to the *Glossary of Geology* (Bates & Jackson, 1980; p.366) a lake is defined as any inland body of open standing water, that is sufficiently large and deep enough to sustain waves capable of producing somewhere on its periphery a barren wave swept shore. The term lagoon is restricted to shallow bodies of seawater separated from the adjacent sea by a low, narrow and elongate strip of land. Lagoons generally extend parallel to the coast, have irregular communication with the sea and may be little affected by tides (Bates & Jackson, 1987; p.365). The palaeolakes and lagoons postulated in the Bass Basin are identified from a combination of palynological, lithological and palaeogeographic evidence, and conform to definition of large lakes given by Herdendorf (1982) in having surface areas greater than 500 km^2. There are only 253 modern large lakes conforming to this definition (Herdendorf, 1982).

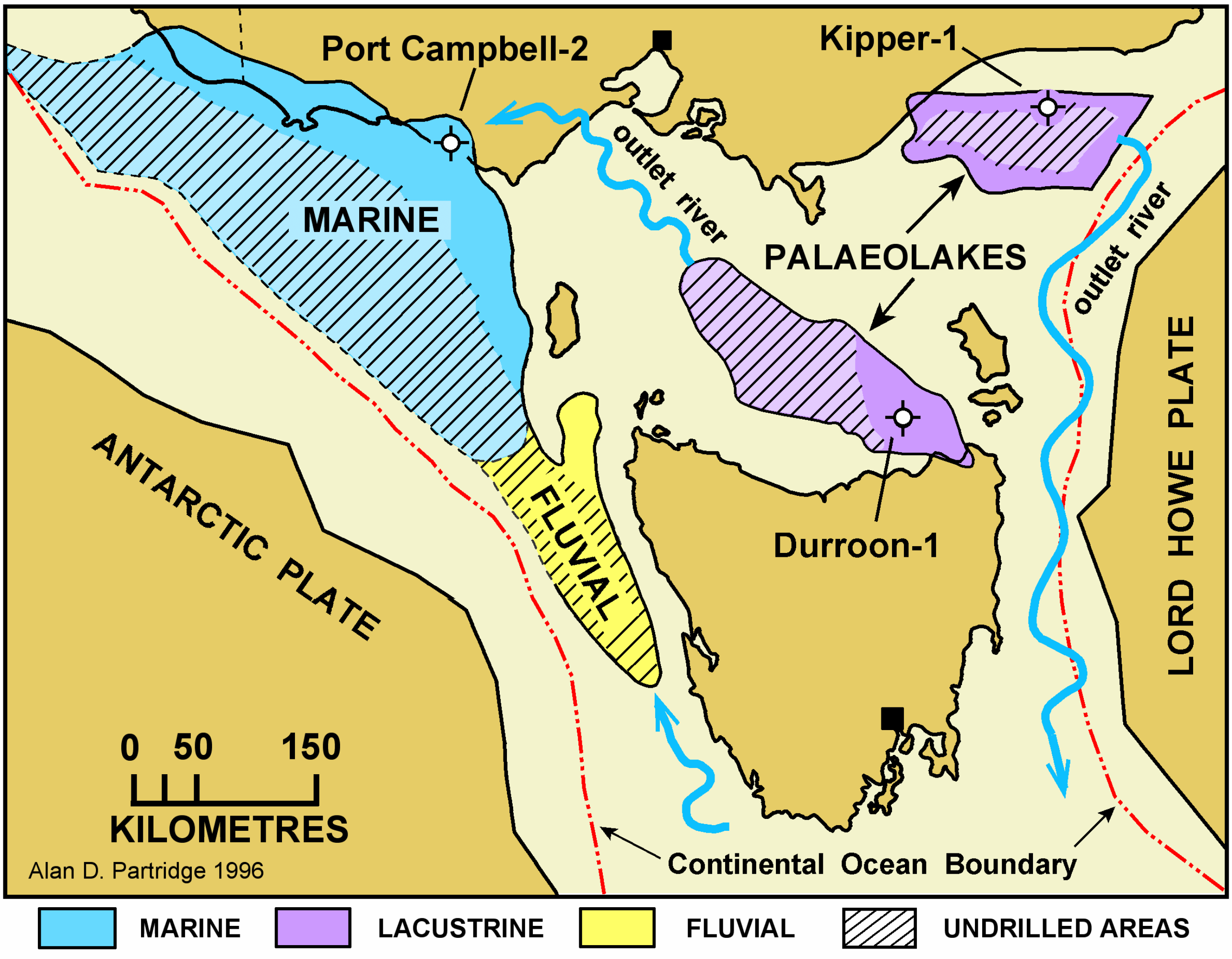
Palaeolake Durroon, even though only intersected in a single well, is the oldest acknowledged and perhaps best accepted palaeolake in the Bass Basin, because of the occurrence of an equivalent Turonian palaeolake in the adjacent Gippsland Basin (Partridge, 1973, 1996, 1999a; Bernecker & Partridge, 2001). The latter Palaeolake Kipper represented by the Kipper Shale is recognised on the basis of thick sequences of homogenous fine-grained clastics, the common occurrence of endemic non-marine microplankton and presence of Neves effects amongst the spore-pollen, the same criteria used to identify the Durroon Formation as a lacustrine facies. The features observed in Palaeolakes Kipper and Durroon also compare favourably with the general model of rift-valley lake sedimentation developed by Le Fournier (1980) and Johnson (1984) from studies of the great lakes along the East African Rift, and therefore these lakes are interpreted to have been relatively deep-water.

The palaeogeographic map for the Bass Strait region during the Turonian (Figure 5) shows the postulated extent of these two large lakes, as well as the extent of the marine transgression of the Otway Basin by the equivalent Waarre and Flaxman Formations. Also shown are the hypothetical overflow outlets for both lake systems. Because the Bass Strait region was at high palaeolatitudes during the Turonian based on continental reconstructions (eg. Veevers *et al.*, 1991; fig.6) there would have been a surfeit of precipitation over evaporation (Johnson, 1984; p.182) that would cause both lakes to fill their respective basins to capacity and overflow out to the ocean.

The latest Maastrichtian to Early Eocene Palaeolake Koorkah, the next major lacustrine facies that can be confidently identified in the Bass Basin, also displays most of the same characteristics as the older Turonian lakes. These include thick homogeneous shales, occurrence of known non-marine dinocysts and the same type of Neves effect. The similar high latitudinal position of the basin, and temperate rainforest vegetation indicated by the palynology, means that there was once again a surfeit of precipitation over evaporation, and the lake would have been filled to capacity and must have outflowed to the ocean. The influx of marine dinocysts from the northwest, documented in the Konkon-1 well, indicates that the outlet was in that direction.

Based on the surfeit of precipitation over evaporation and availability of plenty of geological time both Palaeolakes Durroon and Koorkah are likely to have had surface water levels close to the prevailing sea level. This conclusion is derived from the observation that with the exception of those tectonically formed lakes that are remote from the oceans (eg. East African Rift lakes, Lake Baikal) most modern perched lakes are Holocene glacial lakes and in the fullness of geological time their outlets will erode down to sea level. Under this model it should not be a surprise that the first major influx of marine dinocysts into the Bass Basin is found to correlate with high stands of sea level associated with the late Paleocene thermal maximum (LPTM).

Figure 5. Turonian palaeogeography of the Bass Strait.



Following the establishment of a permanent marine connection, in the Late Paleocene, the subsequent lacustrine facies in the Bass Basin are more analogous with modern Lake Maracaibo, situated at a latitude of 10°S in northern South America (Figure 4). This largest of all modern lagoons is comparable in size to the postulated Eocene lagoons (Cormorant and Toolka units), is relatively shallow (mean depth ~20 metres), and has a regular oval shape maintained by trade winds. Further, the modern Lake Maracaibo morphology can only have been established during the last 12,000 years, and considering the annual rainfall of >100 cm, and abundant rivers draining into the lagoon, it is easy to envisage the lagoon being quickly filled in course of geological time, so therefore its current morphology must also be partly controlled by the underlying geology.

With the cessation of coal deposition at the top of the Eastern View Group (top Middle Eocene) all the younger sediments of the Demons Bluff Group show a significantly greater marine character. The basin was nevertheless still mostly landlocked as there was no connection into the Gippsland Basin until Late Oligocene or Miocene at the earliest. A more appropriate model for deposition during this time is a large marine bay, analogous to modern Port Phillip only much larger. It needs to be remembered that all wells drilled to date in the Bass Basin are centrally located and coastal plain facies may have been deposited on the flanks of the basin as occurs in the Gippsland Basin at this time (Partridge, 1999a). The possibility of a thin succession of Early Oligocene coastal plain facies in the southeast portion of the basin is hinted at by the age of the Squid sandstone.

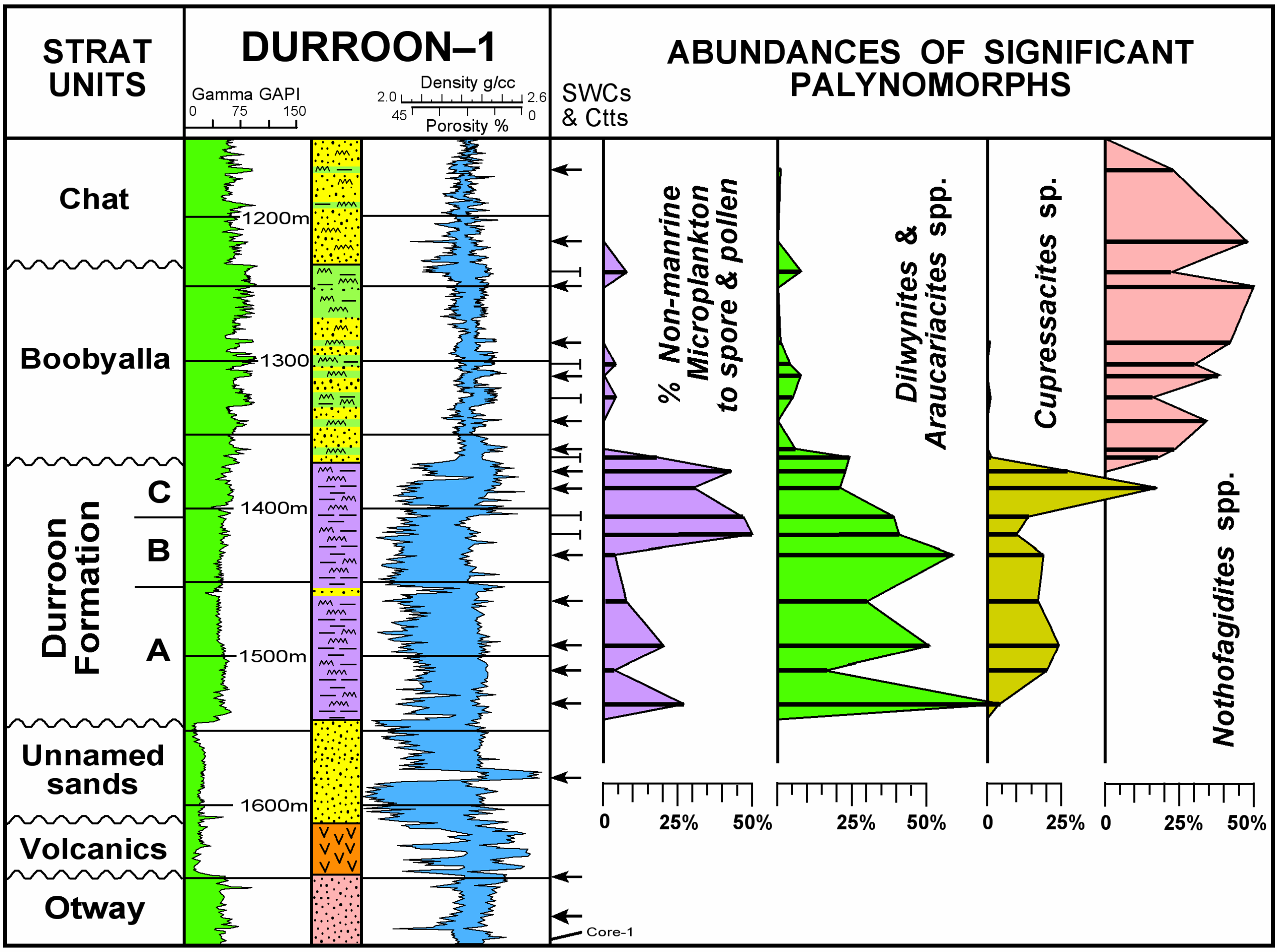
Geological Results of Palynological Studies.

Durroon-1.

Drilled in 1972, Durroon-1 is the only well in the basin that fully penetrates the upper Cretaceous Furneaux Group (Figure 3). Fortunately the well was sufficiently well-sampled by sidewall cores to serve as the quantitative palynological reference section over the interval Turonian to Maastrichtian (Figure 6; Partridge, 2002b). The interval investigated in the palynological study consists of the Turonian Durroon Formation, and the overlying informal Boobyalla and Chat units of Campanian to Maastrichtian age. The thick sequence of older Otway Group (1646-3024m), the unnamed sandstones and volcanics between 1545 and 1646m, and Tertiary sequence above 900m where not re-examined.

The Durroon Formation originally proposed by Smith (1986; p.264) for the interval 1374 to 1545m (here redefined as 1370 to 1544m) is of late Turonian age (*P. mawsonii* Zone), and is characterised by significant abundances of non-marine microplankton including dinocysts referred to *Morkallacysta* and algal cysts of the *Rimosicysta* Superzone recorded from the Kipper Shale in the adjacent Gippsland Basin (Partridge, 1999a; Bernecker & Partridge, 2001). The associated spore-pollen assemblages contain abundant *Dilwynites* pollen diagnostic of a Neves effect, and in the upper part of the formation (Unit C) a spike in the abundance of *Cupressacites* pollen is also present. This can be correlated with similar spike in *Cupressacites* pollen in

Figure 6. Abundances of significant palynomorphs in Upper Cretaceous in Durroon-1.



the Banoon Member at the top of the Flaxman Formation in the Otway Basin (Partridge, 2001). The 175 metre thick mudstone of the Durroon Formation is interpreted to have been deposited in distal fresh-water lacustrine facies (Palaeolake Durroon) which is coeval with the Flaxman Formation in the Otway basin and the youngest part of the Kipper Shale in the Gippsland Basin. The moderate to high abundance of non-marine microplankton, the abundant *Dilwynites* and *Araucariacites* pollen indicating a strong Neves effect, and overall homogeneous nature of the mudstone lithology evidenced by even gamma ray log and broad separation of the density and porosity logs, in combination are interpreted to mean that the Durroon Formation was deposited in a distal and probably deep fresh-water lacustrine environment.

The Durroon Formation is separated by a significant time break of between 5 and 9 million years from the overlying Boobyalla unit which is of Campanian age (*N. senectus* to *T. lilliei* Zones). Rare non-marine dinocysts and algae in this unit hint at the probable presence of more shaly lacustrine facies in the adjacent troughs. Equivalent age conglomerates and interbedded sandstones and mudstones are present in the onshore Boobyalla Subbasin (Moore *et al*., 1984), hence the derivation of the informal name for the unit. At the top of the diagram the informal Chat unit consists of non-marine fluvial sediments which lack any non-marine microplankton. Both these younger units represent much more fluvial to deltaic environments relative the unconformably underlying Durroon Formation. unfortunately, no reliable palynological dating has ever been obtained from the "Unnamed sands and volcanics" lying below the Durroon Formation. The original sidewall cores processed from this interval did not yield datable assemblages (Partridge, 1973), and subsequent studies of sidewall core material and cuttings by Morgan (1990) are here interpreted as unreliable due to contamination by material caved from higher in the well.

From the Chat unit new cuttings samples were collected and analysed over the interval 963 to 1008m in an attempt to more precisely define the position of the Cretaceous/Tertiary boundary. These analyses were unsuccessful as they gave a very low yield of palynomorphs which did not provide a reliable age.

Koorkah-1

The new palynological study of the Koorkah-1 well (drilled in 1985) was focussed on the thick shaly unit identified between 2250 and 2692m (Koorkah unit), and the underlying interbedded sands and shale section from 2692 to 3149mTD (Chat unit). A summary of the results obtained is provided in Figure 7. The interval was found to extends from the Early Maastrichtian Lower *F. longus* Zone to Late Paleocene Upper *L. balmei* Zone, with the latter identified in the sidewall cores at 2241m and 2266.5m previously analysed by Morgan (1986a). The thick shales were interpreted, from log character and the original palynological study, to represent probable lacustrine facies, and the objective was to provide additional supporting evidence from the palynology. As neither the original palynological slides, nor any of the remaining sidewall cores from Koorkah-1 were available for re-examination eleven new cuttings samples were collected and analysed (Partridge, 2002e).

Microplankton ranged from <1% to 27% of the combined spore-pollen and microplankton count in the cuttings samples, and although not particularly abundant are mainly represented by known non-marine dinocysts (eg. *Morkallacysta* Harris 1974). Marine dinocysts were only identified from the shallowest cuttings at 2266-75m and are most likely caved. The associated spore-pollen assemblages are characterised by abundant *Dilwynites* and *Araucariacites* pollen (average 29%) that are interpreted to be representative of a strong Neves effect. The combination of these palynological features is interpreted to indicate a fresh-water lacustrine environments of deposition. The more pronounced Neves effect in the thicker shales is taken as evidence that the depositional environments were more distal and probably also deeper water.

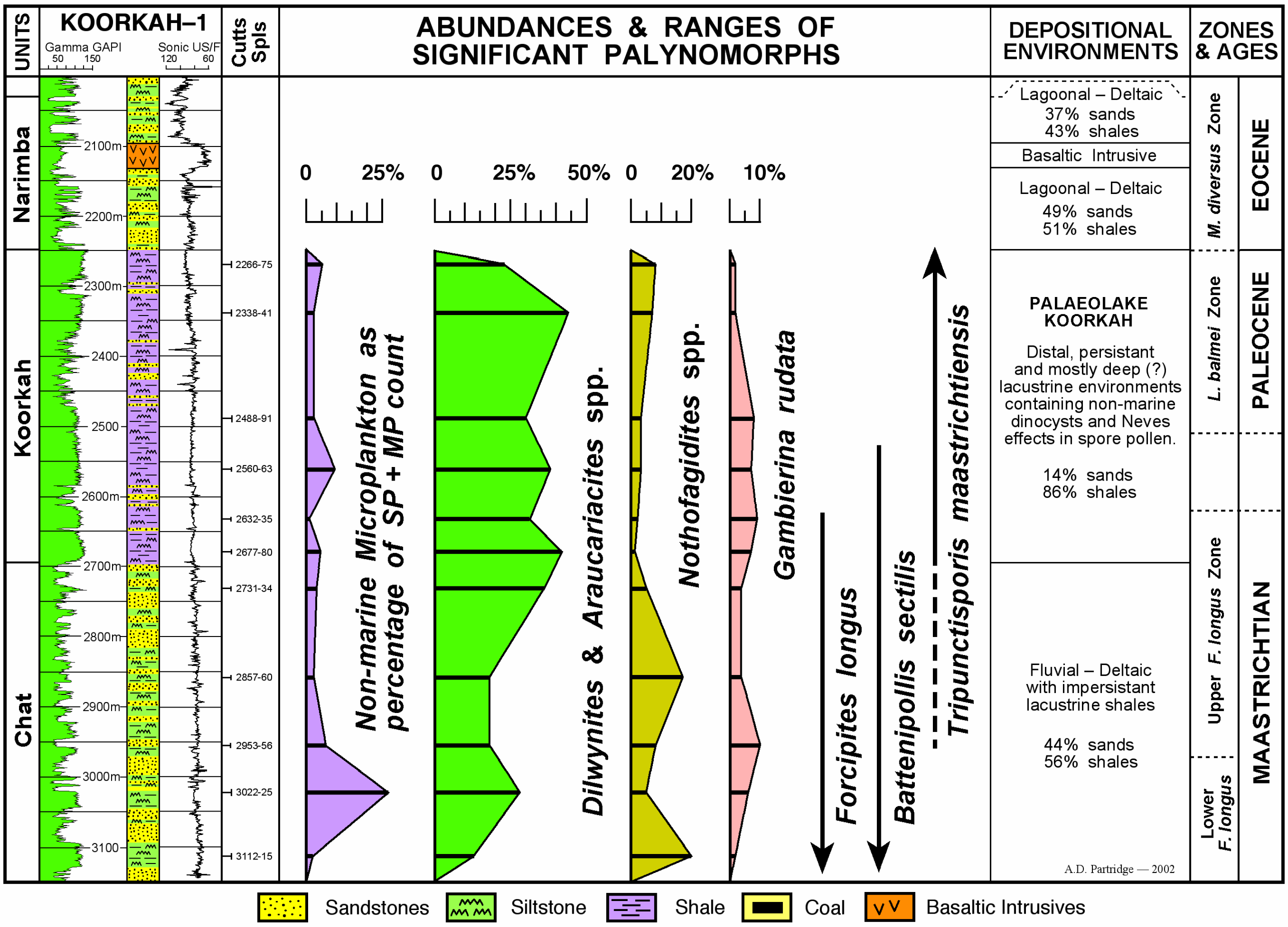
The Well Completion Report placed an "Intra Late Cretaceous Angular Unconformity" at 2690m at the base of the major shale section, and the presence of a major unconformity in the section is supported by the latest studies of the seismic data for the Bass Project. Although no obvious break can be identified in the palynology succession the most likely position would be between the Upper and Lower *F. longus* Zones and lie within the Chat unit rather than at the base of the Koorkah unit. The position of the zone boundary is based on the oldest occurrence of the spore *Tripunctisporis maastrichtiensis*, which is rare and inconsistent in the cuttings and only recorded by Morgan (1986a) from a single sidewall core at 2959m in the Chat unit. An unconformity at the equivalent stratigraphic level is identified within the Timboon Sandstone in the Otway Basin (Partridge, 2001).

The palynological data also indicates the Cretaceous/Tertiary boundary lies within the Koorkah unit but the precise position is equivocal. The boundary could lie above 2490m based on the youngest occurrence of *Battenipollis sectilis* and other secondary index species for the *F. longus* Zone, or alternatively deeper, just above youngest occurrence of the primary index species *Forcipites longus* at 2626m. The deeper pick is favour by the author based solely on the similarity of the log character over the interval 2470 to 2692m to the thicker sections of the Kate Shale in the Gippsland Basin (Partridge, 1999a-b). The anomalous shallower occurrences of the secondary index species in the Koorkah-1 well being interpreted as younger extensions of the species ranges or reworking.

Konkon-1

The new study of Konkon-1 was made to investigate the abundance of marine microplankton in the more shaly northwestern part of the Bass Basin, which available data suggested was the most likely source direction from which marine incursions entered the basin. The Konkon-1 well, drilled in 1973, was preferred to the later Seal-1 well, drilled in 1986, because it was better sampled by sidewall cores and the deep Paleocene section was less disturbed by igneous intrusions. The original palynological report by Stover (1973) also suggested this well contained some of the most abundant and diverse marine microplankton assemblages recorded in the basin. The original core and sidewall core samples between 1095.8 and 1494.7m were re-examined and six new samples collected and analysed by Partridge (2002d).

Figure 7. Abundances and ranges of significant palynomorphs through the Maastrichtian and Paleocene in Koorkah-1.



The distinctive feature of the section reviewed in Konkon-1 (Figure 8) is the thick shale unit from 1337 to 1474m (Koorkah unit) which is broken only by two distinctive coal seams at 1352-55m and 1402-03m. The palynological assemblages from the shale contains both microplankton and a strong Neves effect. The change in the microplankton assemblages from non-marine dinocysts below 1400m, to an increasing abundance and diversity of cosmopolitan marine dinocysts above 1400m, is interpreted to represent a change from a fresh-water lake to a marine coastal lagoon, and to represent the first major marine flooding of the Bass Basin. This change occurs in the Late Paleocene (Upper *L. balmei* Zone) and correlates with one or more major high sea level during the late Paleocene thermal maximum (LPTM). Sidewall core samples at 1354.8m and 1402.7m from the two coal seams are characterised by spore-pollen assemblages with very high abundances of *Gleicheniidites circinidites* and *Clavifera triplex* spores. These assemblages suggest the coals represent low stands of sea level when the lakes drained and this part of the basin was replaced by ìfern marshesî. The palaeolake and lagoon are referred to as Palaeolake Koorkah which is interpreted to have covered the northwestern half of the Bass Basin at its maximum extent (Figure 9). A modern analogue for the later lagoonal phase of Palaeolake Koorkah is Lake Maracaibo the largest modern coastal lagoon (Figure 4). In Konkon-1 the Palaeolake Koorkah is identified over the interval 1336 to 1474m and ranges in age from Early Paleocene to Early Eocene (Lower *L. balmei* to Middle *M. diversus* Zone).

No comparable abundances of microplankton or evidence of a Neves effect were recorded from either the older Chat unit or younger Narimba, Cormorant and Poonboon units, although this may largely reflect the limited number of palynological samples analysed, especially in the case of the Narimba unit. Marine dinocysts are next recorded in the succession from the Toolka unit between 1173 and 1213m. Although abundances are low (<1% to 5%) the presence of a low to moderate diversity of cosmopolitan dinocysts marks this as another lacustrine or lagoonal unit which has a similar distribution to the older Palaeolake Koorkah.

The approximately 320 metres of the Paleocene to Middle Eocene portion of the Eastern View Group penetrated in Konkon-1 is the most condensed section of the group so far encountered by any well drilled in the basin. It compares with an average thickness of over 1000 metres for the equivalent section in all other wells, and a maximum thickness of about 1800m penetrated in Tilana-1. The condensed nature and more basin margin location of the section in Konkon-1 would suggest the lacustrine sedimentation is representative of those intervals of time when the palaeolakes reached their maximum extent. In comparison to the lacustrine facies the other units in Konkon-1 are thinner and also more condensed, and when compared to the other wells they are also more incomplete. Thinnest are the Cormorant and Poonboon units which are more sandy and lack the coals found in these units in the rest of the basin (eg. Cormorant-1 and King-1). In addition, a major unconformity is postulated between the Early and Middle Eocene based on red and yellow weathered sandstones recorded in both the sidewall cores and cuttings. This unconformity is correlated to the Marlin Unconformity in the Gippsland Basin (Bernecker & Partridge, 2001; fig.2).

Figure 8. Abundances of significant Paleocene to Eocene palynomorphs in Konkon-1.

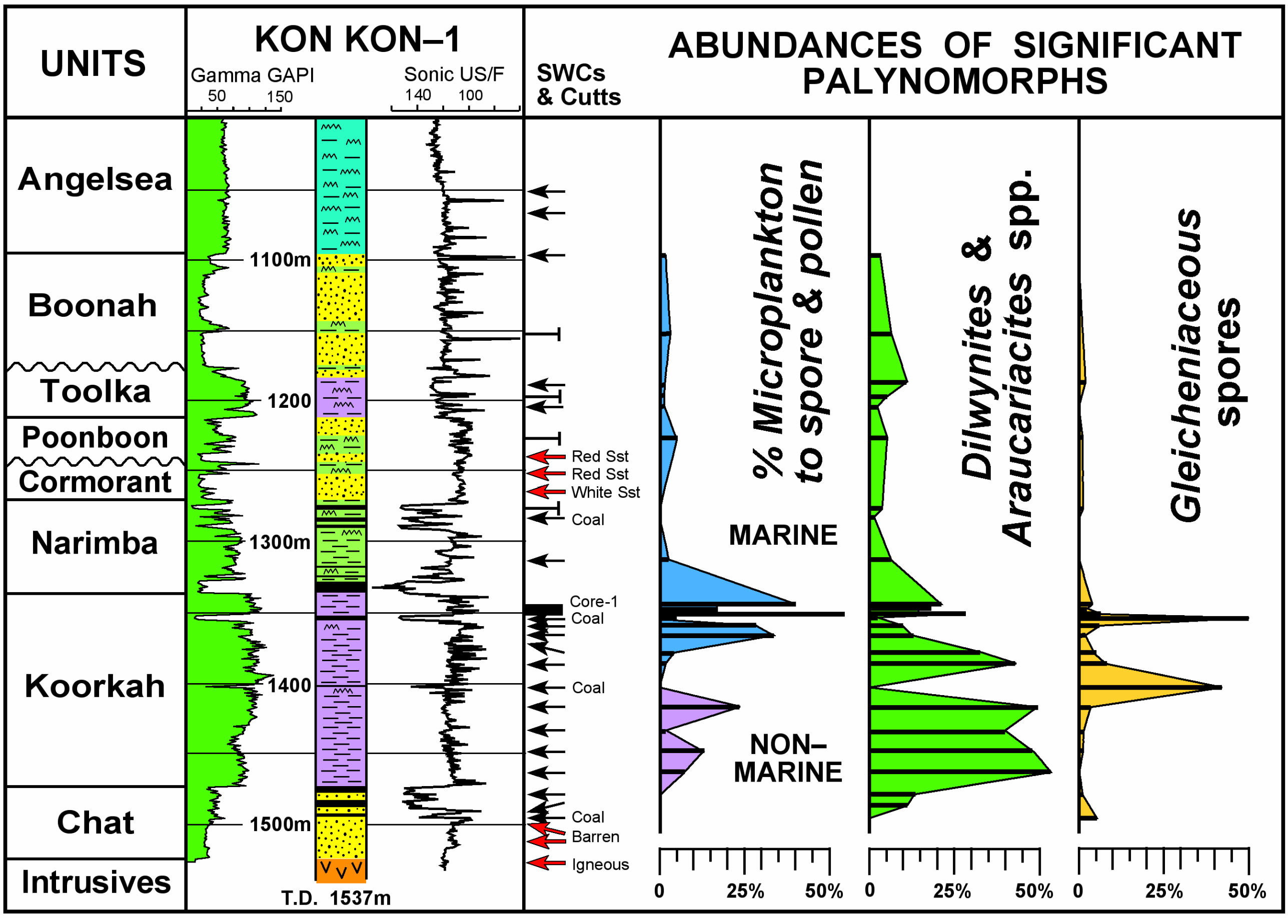
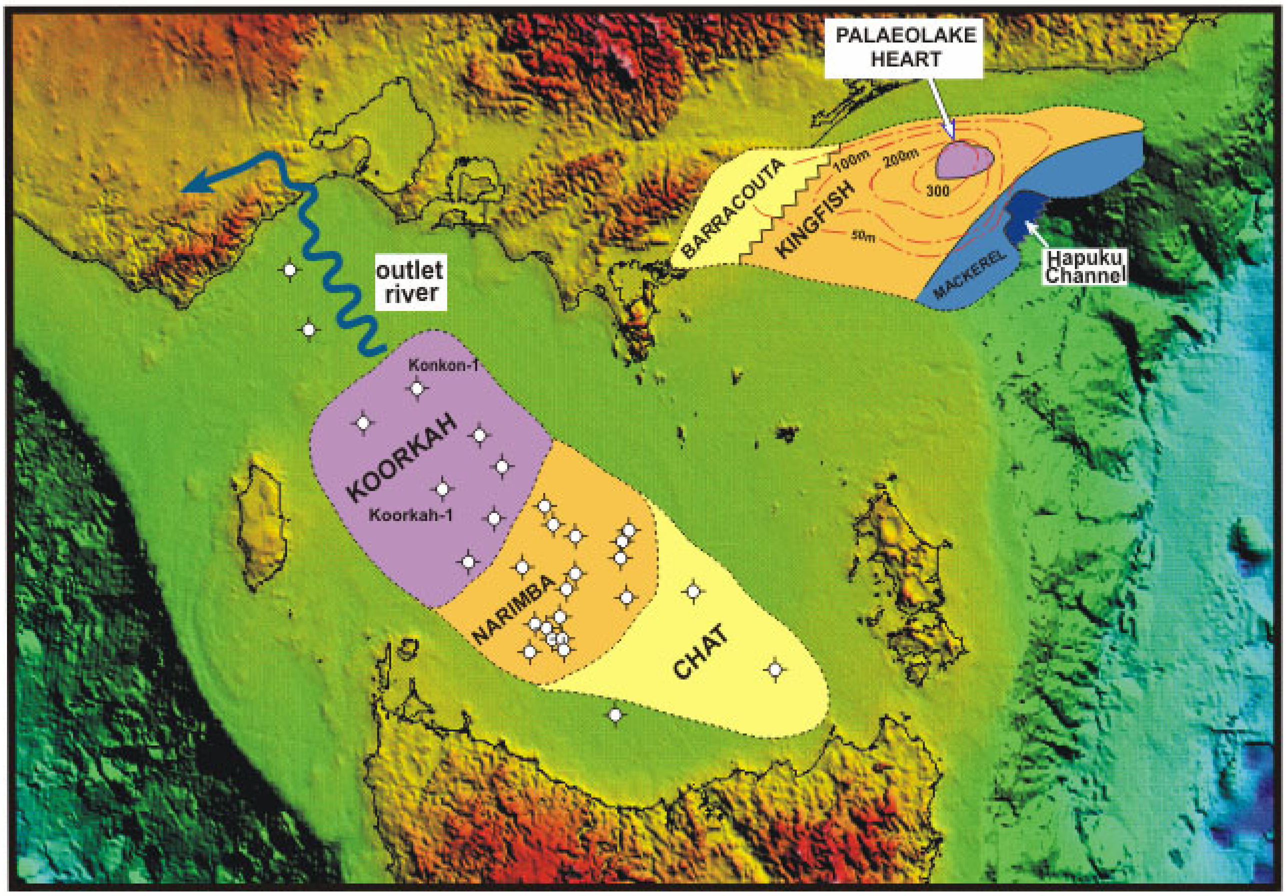


Figure 9. Late Paleocene palaeogeography of Bass Strait.



Palynological samples analysed from the younger Toolka unit and succeeding Boonah and Anglesea Formations, somewhat surprisingly only contained low abundances (<1% to 5%) of microplankton in the assemblage count. The assemblages also lack any obvious Neves effect. However, based on their low to moderate diversity of cosmopolitan dinocysts the assemblages are nevertheless interpreted as restricted marine. The Toolka unit is envisaged to have been deposited in a coastal lagoon, while the Boonah and Anglesea Formations are more likely deposited in estuarine or bay environments.

Poonboon-1

The early Poonboon-1 well, drilled in 1972, was chosen to be the principal quantitative reference section for the interval latest Maastrichtian to basal Miocene (Upper *F. longus* to *P. tuberculatus* Zones). The well is located near the centre of the basin, and contains the best sidewall core sampling through the Eastern View Group, and none of the palynological assemblages are obviously effected by igneous intrusions. Assemblage counts were made on 65 samples comprising 39 sidewall cores, 6 conventional core and 6 cuttings from the original palynological study by Partridge (1972), and a new collection of 13 cuttings and 1 core sample selected to increase the sample density through poorly sampled intervals. Data was recorded from an additional 8 samples which were not counted. Results of this new work is given in Partridge (2002f), and only a brief summary is provided here.

In Poonboon-1 significant abundances of marine dinocysts are only consistently recorded from Late Eocene and younger sediments above 1994m (ie. Boonah, Anglesea and younger formations), while a Neves effect is only identified from Maastrichtian age shale (*F. longus* Zone) intersected over the bottom 60 metres of the well (below 3204m). The latter is interpreted to represents the most southerly known extent of Palaeolake Koorkah. The intervening 1210 metres of Eastern View Group from 1994 to 3204m was predominantly deposited in lower coastal plain or deltaic environments as attested by the consistent presence of thin coal seams through the section. The sporadic occurrence of non-marine and marine dinocysts through this interval confirm short duration lacustrine or lagoonal palaeoenvironments (paralic facies) within the succession. The most significant of these events are:

1) Non-marine dinocysts referred to the genus *Morkallacysta* Harris 1974 recorded from the thicker shales (3107-3140m and 3205-3245m) near the bottom of the well that are associated with the most prominent Neves effects. These shales are interpreted to be tongues of the lacustrine Koorkah facies extending into the southeastern part of the basin during episodes of maximum lake level.
2) Marine dinocysts recorded from sidewall cores that are diagnostic of the *Apectodinium reburrus* Acme Zone (2678.6m) and the succeeding *Apectodinium hyperacanthum* Zone (at 2651.8m). These zones represent the first major marine incursion into the Bass Basin at the time of the late Paleocene thermal maximum (LPTM).
3) Sporadic occurrences of the *Apectodinium homomorphum* Zone in the Lower and Middle *M. diversus* Zones. The deeper from a sidewall core at 2529.8m has an microplankton (MP) abundance of 3% and

a low diversity of 5+ species. The shallower from core-2 at 2472.5m has an MP abundance of 43% with a moderate diversity of 11+ species. With more detailed study these horizons could potentially be linked to MP flooding events in the Dilwyn Formation in the Otway Basin.

4) Sporadic occurrences of dinocysts diagnostic of the *Homotryblium tasmaniense* Zones are found through the Upper *M. diversus* and *P. asperopolus* Zones. Although both abundance and diversity are low (<6% and <5 species per sample) they nevertheless confirm that a diluted marine influence has extended across most of the basin by the end of the Early Eocene.

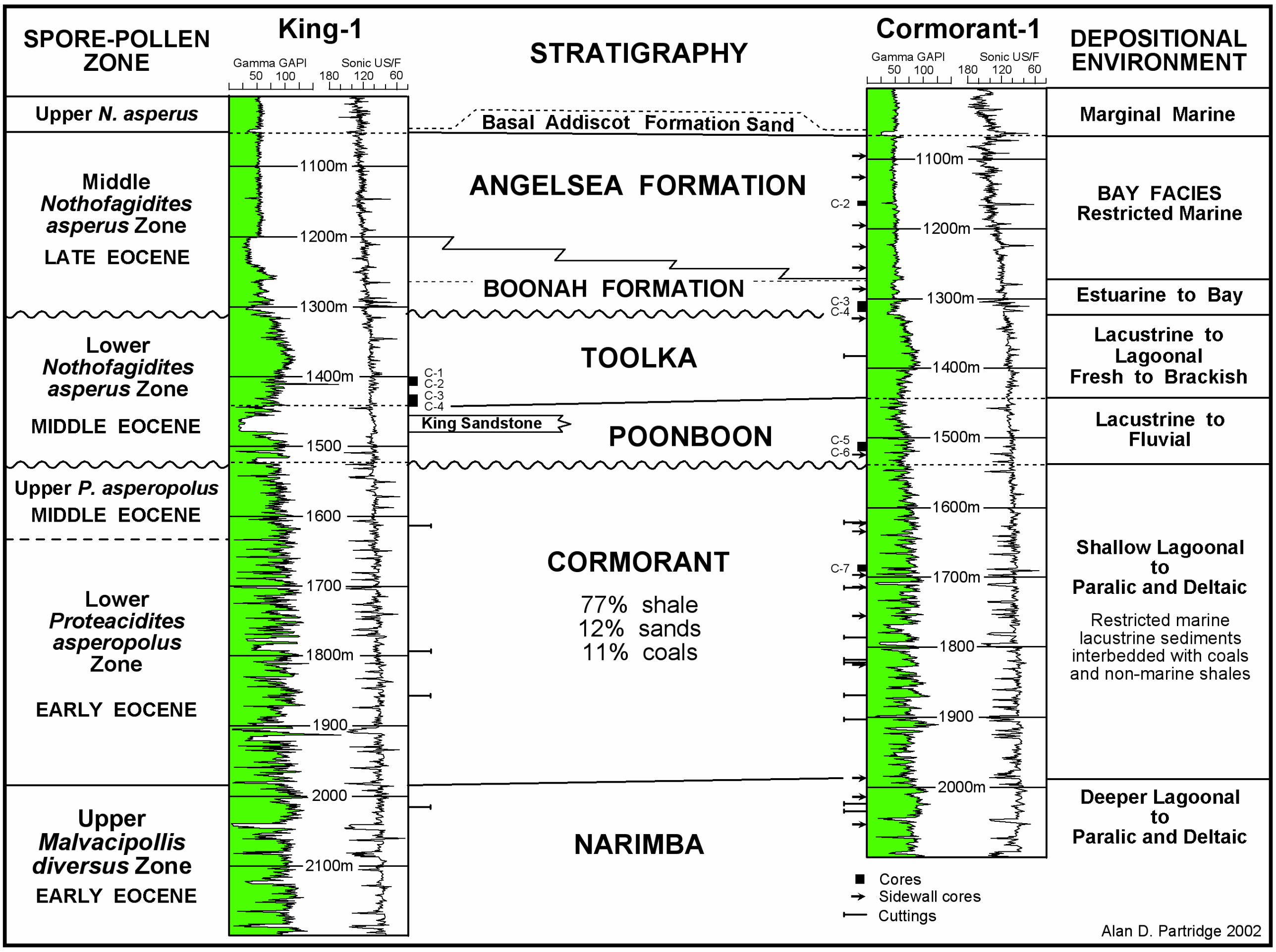
Cormorant-1 and King-1.

Palynological studies were conducted in Cormorant-1 and King-1 to investigate the expanded section from late Early Eocene through Middle Eocene (uppermost Upper *M. diversus* to Lower *N. asperus* Zones). The original palynological data indicated that this interval in Cormorant-1 contained marine dinocysts including the zone index *Charlesdowniea* (al. *Kisselovia*) *edwardsii* which had been reported from a sidewall core at 1825.8m. The objective of the study was to quantify the abundance and diversity of the microplankton present (both marine and non-marine), and determine whether other short ranging index species from the Subfamily Wetzelielloideae could be found in the section. Samples from the adjacent King-1 were analysed because this well had no previous palynological studies, and contained conventional cores at a stratigraphic level not previously sampled in Cormorant-1 (Figure 10).

Unfortunately the results of the search for microplankton were disappointing (Partridge, 2002a & c). Although overall composite species diversity through the intervals studied was high, in individual samples both abundance and species diversity was mostly low (abundance generally <10% and diversity <5 species per sample). Non-marine to brackish dinocysts were generally the most abundant species, but this group requires considerable taxonomic study before they will be of much stratigraphic use. The search for key index dinocysts was also unsuccessful. The presence of *Charlesdowniea edwardsii* in Cormorant-1 could not be confirmed, and *Wetzeliella articulata* was the only other species in this subfamily recorded. The original record of *C. edwardsii* must now be considered suspect, and perhaps can be interpreted as introduced into the sample as a laboratory contaminant. The study revealed that routine application of dinocyst for age dating and correlation within the upper Eastern View Group will be difficult. It requires an increase in both the density of sampling for palynology and much more intensive (and time consuming) searching of the palynological slides under the microscope to find the diagnostic index species.

The sections studied in Cormorant-1 and King-1 do help provide a better understanding of the stratigraphy and environment of deposition through the upper part of the Eastern View Group. In both wells the interval over which samples were examined extends from the upper part to the Narimba unit into the Toolka unit (Figure 10). Most of the samples analysed were from the Cormorant unit which is comprised of >75% shaly sediments on gross log character, with secondary sandstones and coals (each <15%). The section is characteristically thinly bedded (all beds <10 metres thick), with the shales consistently containing a

Figure 10. Palynological and log correlation between King-1 and Cormorant-1.



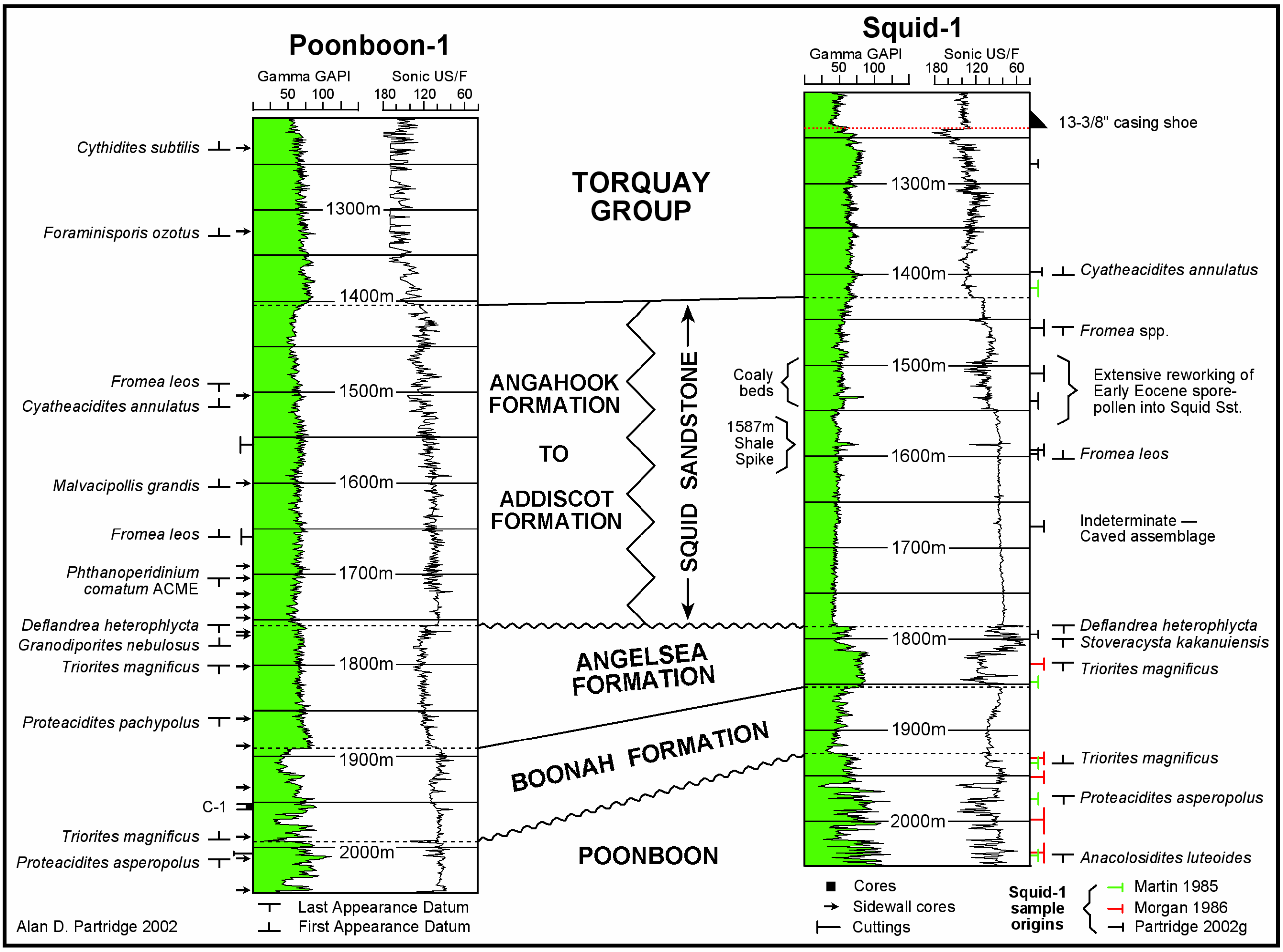
diversity of mainly marine dinocyst, but in low abundance (typically <1% to 5%). The associated spore-pollen assemblages contain rare specimens of the mangrove pollen *Spinizonocolpites prominatus* (= modern *Nypa* palm), but lack any significant development of a Neves effect. The environment of deposition is interpreted to be predominantly a shallow-water, restricted marine lagoon, which is periodically and frequently being replaced by coastal plain marshes. The presence of only minor sands through the unit suggests that the local Cormorant-1 and King-1 area is temporarily remote from any deltaic source or stabilised lake edge where strand-line sands could be developed. The suggested analogue for the Cormorant unit would be the modern Lake Maracaibo (Figure 4).

The underlying Narimba unit is distinguished from the Cormorant unit by containing thicker shales (typically >10 metres thick) and this is interpreted to mean that the lagoon or palaeolake facies was in general deeper. In the overlying Poonboon and Toolka units the palynological assemblages are distinguished by a decline in the overall diversity of cosmopolitan marine dinocysts and an increase in brackish or non-marine types including undescribed species that might be endemic. Non-marine genera include *Saeptodinium* Harris 1974, *Cubiculosphaera* Harris 1974, while the possible brackish-water species *Paralecaniella indentata* (Deflandre & Cookson 1955) is the dominant species in some samples. Diversity remains low in individual samples (1 to 5 species), while abundances are <1% except in samples dominated by non-marine dinocysts. The shaly sediments of the Poonboon and Toolka units are thus also interpreted to represent predominantly lacustrine to lagoonal environments, although more brackish to fresh-water than the preceding Cormorant unit. This subtle change in facies is suggested to be indicative of a unconformity at the top of the Cormorant unit that correlates with the Marlin Unconformity in the Gippsland Basin (Partridge, 1999a). The presumed fluvial King sandstone in King-1 (Figure 10) may be reflective of a more fluvial regime in the Bass Basin at the time of the Marlin Unconformity.

Squid-1.

Palynological studies of Squid-1 were focussed on the 360 metre thick Oligocene sand unit from 1425 to 1785m (Figure 11). This unit had not been analysed in the original palynological reports by Martin (1985) and Morgan (1986b), nor was there any foraminiferal analysis from the interval or in the well. The geological problem was the age of this sand and whether it correlated with just the thin sands seen in some wells immediately above the Anglesea Formation (eg. Cormorant-1 and King-1), or alternatively was wholly or partly a lateral facies of the overlying marine shales and marls. Unfortunately, no conventional cores or sidewall cores were cut in Squid-1 so the palynological analysis needed to rely solely on cuttings. Initially six bulk cuttings were analysed, but once these were discovered to be confused by both caved and reworked palynomorphs an additional four cuttings were collected and given alternative processing. The latter consisted of a pre-treatment with dilute HCl followed by sieving to breakdown and remove any of the calcareous shales and marls caved from between the 13-3/8" casing shoe at 1240m and top of the sand at 1425m. The second batch of samples clarified and complimented the initial results, and the palynological analysis of both batches of samples are documented in Partridge (2002g).

Figure 11. Palynological and log correlation between Poonboon-1 and Squid-1.



Results from the new palynological study indicate that the Squid sandstone section is entirely Early Oligocene in age (Upper *N. asperus* to Lower *P. tuberculatus* Zones), and is a lateral facies of more shaly facies in wells to the northwest as illustrate by the palynological and electric log correlation to Poonboon-1 (Figure 11). The correlation relies principally on the identification of the *Fromea leos* microplankton Zone originally documented from the base of the Seaspray Group in the Gippsland Basin (Partridge, 1994). The *F. leos* Zone is identified in both bulk and pre-treated cuttings covering the distinctive gamma ray shale spike at 1586 to 1588m in Squid-1, and from sidewall cores and cuttings over the interval 1505.7m to 1670m in Poonboon-1. The next older *Phthanoperidinium comatum* microplankton Acme Zone is recorded over the interval 1706.9 to 1763m in Poonboon-1. However, the equivalent interval at the base of the sandstone in Squid-1 was not sampled as none of the cuttings were deemed to be suitable for analysis. No change in lithology or new shaly material was observed in the Squid-1 cuttings between 1600m and the next obvious log break at 1785m. Below the latter break the microplankton assemblages from the top samples from the Anglesea Formation in both wells are characterised by the LAD of the dinocyst *Deflandrea heterophlycta*. In the marly sediments above the Squid sandstone the microplankton assemblages are dominated by the dinocysts *Spiniferites* spp. and *Operculodinium centrocarpum* which are diagnostic of the *Operculodinium* Superzone. This latter interval equates to the Torquay Group. The spore-pollen assemblages support these correlations but the differentiation of the zones is less clear because the First Appearance Datums (FADs) on which the zone definitions depend are much less reliable in cuttings. Note especially that the FAD of the spore *Cyatheacidites annulatus*, the marker species for the base of the *P. tuberculatus* Zone, is found to occur **within** the *F. leos* Zone in other sections sampled by sidewall cores (eg. Partridge, 1994).

Another distinct feature of the new palynological analysis of Squid-1 is the discovery of a substantial reworking event in the upper part of the Squid sandstone. Cuttings examined between 1430 and 1550m where observed to be dominated by light to medium grey marl (interpreted as caved), with secondary loose quartz sand, and minor (<10%) black carbonaceous shale or coal. The last is interpreted to come from the ì coalyî spikes on the sonic log between 1441 and 1535m, and is believed to be the principal source of *in situ* palynomorphs. The bulk of the recorded spore-pollen assemblages from the three cutting samples analysed between 1445 and 1550m were composed of long ranging species (Partridge, 2002g), but there was a conspicuous component, perhaps as high as 20% of spore-pollen assemblage, that is interpreted as reworked, based on well-established species ranges throughout southeast Australia. The most conspicuous reworked species recorded are *Proteacidites leightonii*, *P. asperopolus*, *P. pachypolus* and *Dicotetradites clavatus*. In combination these species indicate the source of the reworking was from sediments belonging to an interval extending from the *P. asperopolus* to basal Lower *N. asperus* Zone, implying an age range of late Early to early Middle Eocene. Although similar reworking has been recorded in other wells in the Bass Basin, at about the equivalent stratigraphic horizon above the Anglesea Formation, the numbers of reworked specimens is much lower (est. <1%). The postulated provenance of the reworking is to the south-east where the appropriate age sediments are at shallower depths (eg. Chat-1), or are suspected to have been eroded (eg. Durroon-1).

The palynological age dating obtained in Squid-1 and the palynological and log correlation established to Poonboon-1, refutes the interpretation that the thick Squid sandstone is filling a large channel entrenched into the top of the Anglesea Formation. Rather, the Squid sandstone represents a lateral sandy facies of the more shaly sediments overlying the Anglesea Formation in other wells. Reviewing the electric logs and limited palynological data in the wells across the basin from the Pelican field wells in the SW, through Poonboon-1 and Nangkero-1 in the middle of the basin, to Dondu-1, Yurongi-1 and Bass-2 in the NE, reveal that the equivalent section in these wells all belong to the more shaly facies found in Poonboon-1. However, similar but thinner sands are known to overlie the distinctive Anglesea Formation directly to the east in the Chat-1 well (1072-1132m), and to the SE in the Durroon-1 well (458-540m). Unfortunately, there is no reliable age dating of the sands in the latter two wells, but as the base of these sands are significantly shallower (650m in Chat-1 and 1245m in Durroon-1, compared to 1785m in Squid-1) they potentially could be much younger.

Based on the above well control and analogy to palaeoshorelines identified in other parts of Bass Strait (eg. Partridge, 1999a; Holdgate *et al.*, 2002) the Squid sandstone is interpreted to be a barrier sandstone body with a probably SSW to NNE orientation that was largely deposited in a shoreface environment. The shale spike at 1586 to 1588m in Squid-1 representing a flooding horizon and the overlying thin coaly beds representing regressive back-barrier marsh environments.
Also based on the new analyses the thin sandstones (typically <10 metres thick) immediately overlying the Anglesea Formation in some other wells (eg. Cormorant-1 and King-1; Figure 10) can only be age equivalent to oldest part of the Squid sandstone. However, since they directly overlie the unconformity and sequence boundary postulated at the top of the Anglesea Formation they still may be related to entrenchment at this surface.

The 360 metre thick Squid sandstone and the equivalent section in other wells in the Bass Basin is an **expanded** section of an interval that is both poorly represented and poorly understood in other basins in southeast Australia. Based on my own unpublished palynological studies the interval is equivalent to both the Addiscot and Angahook Formations of the Demons Bluff Group in the onshore Torquay Basin where it has a maximum thickness of about 50 metres (Holdgate *et al.*, 2001; fig.15). In the Gippsland Basin the equivalent section is involved with the enigmatic "Early Oligocene Wedge" and broader issues about the appropriate definition of the top of Latrobe Unconformity (Bernecker & Partridge, 2001; appendix). For example, in the distal offshore Gippsland Basin the time-interval is either missing or represented by less than 20 metres of open-marine marl at the base of the Seaspray Group (eg. Partridge, 1994), whereas in the onshore Gippsland Basin the time-interval is represented by up to 150 metres of coal measure facies of the Burong Formation overlain by about 10 metres of Cunningham Greensand (Bernecker & Partridge, 2001; Partridge, 1999a).

In the Otway Basin and more westerly St Vincent Basin the precise correlation is less clear largely because of a lack of detailed palynological studies of basal Oligocene strata. Correlations of the better known Late Eocene palynological sequences suggests that the distinctive log break mapped at the top of the Anglesea Formation in most wells in the Bass Basin is a sequence boundary unconformity that correlates to the commencement of the Chinaman Gully regression of McGowran *et al.* (1992). The succeeding, essentially non-marine Chinaman Gully Formation in the St Vincent Basin is correlated with part of the Squid sandstone, but exactly how much is uncertain. The problem revolves around how to correlate the succeeding ìtransgressive eventsî recognised by McGowran *et al.* (1992) into the Bass Basin. These are the Aldinga transgression (representing the restoration of neritic carbonate at the base of the Aldinga Member), the Ruwarung maximum flooding surface at the base of the Ruwarung Member, and the sequence boundary at Willungan/Janjukian Stage boundary. The current interpretation as shown in Figure 11 is that the Squid sandstone and laterally equivalent sediments assigned to the combined Addiscot and Angahook Formation in the more central parts of the basin are equivalent to the entire Early Oligocene. The overlying carbonate sediments are assigned to a currently undifferentiated Torquay Group and are Late Oligocene and younger in age.

Conclusions and Recommendations

The new palynological studies of selected intervals from only one-fifth of the wells drilled in the Bass Basin provide critical new information towards construction of a better stratigraphic framework and more comprehensive models for depositional processes in the basin. The core objective of providing a quantitative reference section for the palynological succession, although little discussed in this report, will ultimately prove its worth as the palynological data is upgraded in other wells to the same quality.

The principal immediate results from the project has been obtaining a quantitative picture of the distribution of marine and non-marine dinocysts and other microplankton in the basin, and the identification of Neves effects amongst the spore-pollen. This information has allowed better models to be formulated for the duration and geographic extent of palaeolakes and lagoons in the basin.

Notwithstanding these achievements more detailed palynological studies of wells in the Bass Basin are required as the density and quality of biostratigraphic data compares unfavourably with palynological techniques and approaches applied in other hydrocarbon bearing basin around Australia. Indeed lack of this type of data has probably contributed to perception that the Bass Basin has low productivity.

The following additional studies are recommended as a contribution to rectifying these perceptions:

1. Description and further study of the non-marine dinocysts to better understand the environmental controls on their distribution and potential source contribution.
2. Re-examination of Maastrichtian portion of Chat unit to better understand the boundary relationship between the Furneaux and Eastern View Groups.
3. Further study of sections crossing Early to Middle Eocene boundary to improve correlations with

adjacent basins and confirm or disprove the existence of a fluvial system in the basin corresponding to the Marlin Unconformity in the Gippsland Basin.

4. Review of existing data and new palynological analysis of sections in the Torquay Basin to identify position of palaeolake outlet from Bass Basin postulated to have been present as far back as the Cretaceous.

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APPENDIX D.

LIST OF CORE AND CUTTINGS FROM THE BASS BASIN ANALYSED FOR ORGANIC GEOCHEMISTRY

C. Boreham, Geoscience Australia

Geoscience Australia No.	Palynology Laboratory No.	Well	Sample Depth Top m	Sample Depth Base m	Sample Type	Lithology	VRF	Kinetics	SANS
20010060	6405386	Cormorant 1	910.30	910.45	Core	shale	yes		
20010061	6405387	Cormorant 1	1160.08	1160.24	Core	shale	yes		
20010062	6405388	Cormorant 1	1310.96	1311.11	Core	shale	yes		
20010346	6405910	Cormorant 1	1444.77	1450.87	Cutt	coal			yes
20010347	6405913	Cormorant 1	1478.30	1487.44	Cutt	coal			yes
20010063	6405389	Cormorant 1	1518.46	1518.47	Core	shale	yes		
20010064	6405390	Cormorant 1	1519.75	1519.90	Core	coal	yes	yes	
20010065	6405391	Cormorant 1	1520.31	1520.36	Core	shale	yes	yes	yes
20010348	6405914	Cormorant 1	1530.11	1536.21	Cutt	coal			yes
20010349	6405915	Cormorant 1	1633.75	1639.84	Cutt	coal			yes
20010350	6405916	Cormorant 1	1661.18	1667.28	Cutt	coal			yes
20010066	6405392	Cormorant 1	1685.31	1685.39	Core	shale	yes		
20010067	6405393	Cormorant 1	1685.56	1685.72	Core	coal	yes	yes	yes
20010068	6405394	Cormorant 1	1686.58	1686.63	Core	shale	yes		
20010351	6405917	Cormorant 1	1725.19	1728.24	Cutt	coal			yes
20010352	6405918	Cormorant 1	1777.01	1780.05	Cutt	coal			yes
20010344	6405919	Cormorant 1	1829.53	1829.58	Core	coal			yes
20010353	6405920	Cormorant 1	1877.59	1883.69	Cutt	coal			yes
20010069	6405395	Cormorant 1	1950.74	1959.89	Cutt		yes		yes
20010354	6405921	Cormorant 1	2005.61	2011.70	Cutt	coal			yes
20010355	6405922	Cormorant 1	2042.18	2048.28	Cutt	coal			yes
20010356	6405923	Cormorant 1	2090.95	2097.05	Cutt	coal			yes
20010070	6405396	Cormorant 1	2154.96	2167.15	Cutt	coal	yes		yes
20010357	6405924	Cormorant 1	2215.92	2222.02	Cutt	coal			yes

20010345	6405925	Cormorant 1	2232.38	2232.53	Core	coal			yes
20010358	6405926	Cormorant 1	2276.88	2279.93	Cutt	coal			yes
20010071	6405397	Cormorant 1	2340.89	2353.08	Cutt	coal	yes		yes
20010359	6405927	Cormorant 1	2377.47	2383.56	Cutt	coal			yes
20010360	6405928	Cormorant 1	2414.05	2420.14	Cutt	coal			yes
20010361	6405929	Cormorant 1	2444.53	2447.57	Cutt	coal			yes
20010362	6405930	Cormorant 1	2478.05	2484.15	Cutt	coal			yes
20010363	6405931	Cormorant 1	2539.01	2545.11	Cutt	coal			yes
20010364	6405932	Cormorant 1	2563.40	2569.50	Cutt	coal			yes
20010365	6405933	Cormorant 1	2593.88	2599.98	Cutt	coal			yes
20010366	6405934	Cormorant 1	2621.31	2627.41	Cutt	coal			yes
20010367	6405935	Cormorant 1	2651.79	2654.84	Cutt	coal			yes
20010368	6405936	Cormorant 1	2688.37	2691.42	Cutt	coal			yes
20010369	6405937	Cormorant 1	2715.80	2718.85	Cutt	coal			yes
20010072	6405398	Cormorant 1	2758.47	2770.67	Cutt	coal	yes		yes
20010370	6405938	Cormorant 1	2792.00	2798.10	Cutt	coal			yes
20010371	6405939	Cormorant 1	2819.43	2822.48	Cutt	coal			yes
20010372	6405940	Cormorant 1	2831.63	2837.72	Cutt	coal			yes
20010373	6405941	Cormorant 1	2843.82	2849.91	Cutt	coal			yes
20010374	6405942	Cormorant 1	2941.36	2944.40	Cutt	coal			yes
20010073	6405399	Cormorant 1	2990.12	2996.22	Cutt	shale	yes		
20010081	6405407	Konkon 1	1280.18	1286.27	Cutt	coal		yes	
20010082	6405408	Konkon 1	1341.14	1344.18	Cutt	coal		yes	
20010083	6405409	Konkon 1	1344.87	1344.89	Core	shale			
20010084	6405410	Konkon 1	1345.17	1345.28	Core	coal			
20010085	6405411	Konkon 1	1345.68	1345.73	Core	shale			
20010086	6405412	Konkon 1	1353.33	1356.38	Cutt	coal			
20010047	6405373	Pelican 5	1700	1705	Cutt	shale	yes		
20010375	6405943	Pelican 5	1899.00	1905.00	Cutt	coal			yes
20010048	6405374	Pelican 5	2028	2031	Cutt	shale	yes		
20010049	6405375	Pelican 5	2034.00	2037.00	Cutt	coal	yes	yes	yes
20010376	6405944	Pelican 5	2190.00	2193.00	Cutt	coal			yes
20010377	6405945	Pelican 5	2304.00	2307.00	Cutt	coal			yes
20010378	6405946	Pelican 5	2409.00	2412.00	Cutt	coal			yes
20010050	6405376	Pelican 5	2418.00	2424.00	Cutt	shale	yes	yes	

20010379	6405947	Pelican 5	2502.00	2505.00	Cutt	coal			yes
20010380	6405948	Pelican 5	2592.00	2595.00	Cutt	coal			yes
20010051	6405377	Pelican 5	2640.00	2643.00	Cutt	shale	yes		
20010381	6405949	Pelican 5	2721.00	2724.00	Cutt	coal			yes
20010052	6405378	Pelican 5	2791.87	2792.00	Core	coal	yes		yes
20010053	6405379	Pelican 5	2792.10	2792.20	Core	shale	yes		
20010382	6405950	Pelican 5	2799.00	2802.00	Cutt	coal			yes
20010383	6405951	Pelican 5	2958.00	2601.00	Cutt	coal			yes
20010054	6405380	Pelican 5	3015.00	3018.00	Cutt	shale	yes		
20010384	6405952	Pelican 5	3063.00	3066.00	Cutt	coal			yes
20010385	6405953	Pelican 5	3162.00	3165.00	Cutt	coal			yes
20010386	6405954	Pelican 5	3246.00	3249.00	Cutt	coal			yes
20010055	6405381	Pelican 5	3399.00	3405.00	Cutt	shale	yes		
20010387	6405955	Pelican 5	3414.00	3417.00	Cutt	coal			yes
20010388	6405956	Pelican 5	3567.00	3570.00	Cutt	coal			yes
20010056	6405382	Pelican 5	3630.00	3636.00	Cutt	shale	yes		
20010389	6405957	Pelican 5	3702.00	3705.00	Cutt	coal			yes
20010057	6405383	Pelican 5	3810.00	3816.00	Cutt	shale	yes		
20010390	6405958	Pelican 5	3822.00	3825.00	Cutt	coal			yes
20020024	6406736	Pelican 5	3891.00	3906.00	Cutt	coal			yes
20010391	6405959	Pelican 5	3960.00	3963.00	Cutt	coal			yes
20010058	6405384	Pelican 5	4044.00	4055.00	Cutt	shale	yes		
20020025	6406737	Pelican 5	4227.00	4257.00	Cutt	coal			yes
20010059	6405385	Pelican 5	4251.00	4257.00	Cutt	shale	yes		
20010392	6405960	Pelican 5	4257.00	4260.00	Cutt	coal			yes
20010074	6405400	Poonboon 1	2398.81	2407.95	Cutt	coal		yes	
20010075	6405401	Poonboon 1	2472.54	2472.57	Core	shale			
20010076	6405402	Poonboon 1	2473.10	2473.18	Core	coal			
20010077	6405403	Poonboon 1	2473.94	2474.04	Core	shale		yes	
20010078	6405404	Poonboon 1	3040.39	3040.54	Core	coal		yes	
20010079	6405405	Poonboon 1	3041.48	3041.56	Core	shale		yes	
20010080	6405406	Poonboon 1	3127.29	3133.38	Cutt	coal		yes	
20010087	6405413	Tilana 1	2319.00	2325.00	Cutt	coal			
20010088	6405414	Tilana 1	2346.00	2352.00	Cutt	coal			
20010089	6405415	Tilana 1	2376.00	2379.00	Cutt	coal			

APPENDIX E.

VITRINITE-INERTINITE REFLECTANCE AND FLUORESCENCE (VRF™ or VIRF) RESULTS FOR CORMORANT-1 AND PELICAN-5

Jane Newman, Newman Pty. Ltd.

Table E1. Summarised VIRF data for Cormorant-1. Ro (normal) is calculated from actual measurements on indigenous vitrinite of normal chemistry. Ro (inferred) describes the potential range of Ro (normal) values suggested by the overall VIRF profile of a sample, and is important when normal vitrinite is absent or biased. Shaded rows indicate paired coal/shale samples.

Depth (m)		Type	Ro (normal)			Hydrothermal features
top	base		Measured	std dev	inferred	
910.30	910.45	core	**0.34** (n=19)	0.063	0.25 - 0.40	
1160.08	1160.24	core	**0.35** (n=2)	0.016	0.25 - 0.45	
1310.96	1311.11	core	**0.36** (n=17)	0.043	0.30 - 0.45	
1518.45	1518.47	core	**0.46** (n=24)	0.044	0.40 - 0.55	
1519.75	1519.90	core	**0.48** (n=22)	0.036	0.40 - 0.55	
1520.31	1520.36	core	**0.51** (n=37)	0.043	0.40 - 0.55	
1685.31	1685.39	core	**0.51** (n=17)	0.025	0.40 - 0.55	
1685.56	1685.72	core	**0.49** (n=20)	0.037	0.40 - 0.55	
1686.58	1686.63	core	**0.50** (n=8)	0.051	0.40 - 0.55	
1950.74	1959.89	cuttings	**0.56** (n=21)	0.044	0.45 - 0.60	coal has shrinkage cracks
2154.96	2167.15	cuttings	**0.65** (n=14)	0.084	0.50 - 0.65	coal has shrinkage cracks, thermally altered
2340.89	2353.08	cuttings	**0.71** (n=13)	0.052	*	coke, baked zs, thermally altered coal
2758.47	2770.67	cuttings	**1.02** (n=13)	0.038	0.80 - 1.10	igneous material, coke, baked zs - ?caved
2990.12	2996.22	cuttings	**1.00** (n=12)	0.066	0.80 - 1.10	microbreccia, coke, hydrothermal minerals

** inferred value cannot be determined due to inadequate inertinite*

Figure E1. The reflectance profile for Cormorant-1, based on VIRF analysis.

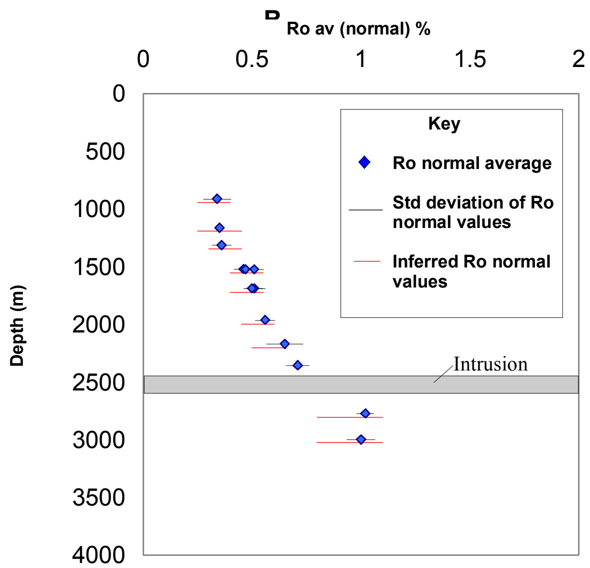
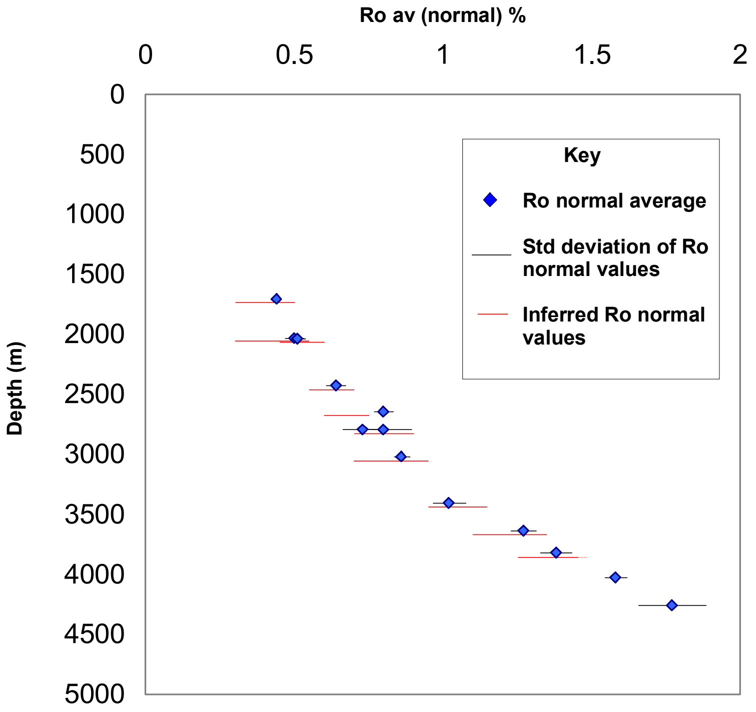


Table E2. Summarised VIRF data for Pelican-5. Ro (normal) is calculated from actual measurements on indigenous vitrinite of normal chemistry. Ro (inferred) describes the potential range of Ro (normal) values suggested by the overall VIRF profile of a sample, and is important when normal vitrinite is absent or biased. Shaded rows indicate paired coal/shale samples.

Depth		Type	Ro (normal)			Hydrothermal features
Top	**base**		*Measured*	*Std dev*	*Inferred*	
1700	1705	cuttings	**0.44** (n=15)	0.029	0.30 - 0.50	Rare, reworked
2028	2031	cuttings	**0.50** (n=50)	0.061	0.30 - 0.55	Abundant, indigenous
2034	2037	cuttings	**0.52** (n=39)	0.049	0.45 - 0.60	Very rare - coal sample
2418	2424	cuttings	**0.64** (n=19)	0.064	0.55 - 0.70	Rare; iron-stained carbonate
2640	2643	cuttings	**0.80** (n=24)	0.062	0.60 - 0.75	Rare
2791.87	2792	core	**0.73** (n=15)	0.138	0.70 - 0.90	Very rare - coal sample
2792.1	2792.2	core	**0.80** (n=2)	0.186	0.70 - 0.90	Rare, possibly reworked
3015	3018	cuttings	**0.86** (n=22)	0.056	0.70 - 0.95	Moderately abundant
3399	3405	cuttings	**1.02** (n=10)	0.112	0.95 - 1.15	Abundant, diverse
3630	3636	cuttings	**1.26** (n=9)	0.086	1.10 - 1.35	Abundant, diverse
3810	3816	cuttings	**1.38** (n=8)	0.107	1.25+	Abundant, diverse
4044	4050	cuttings	**1.58** (n=8)	0.074	-[1]	Very abundant, pervasive
4251	4257	cuttings	**1.77** (n=17)	0.227	-	Very abundant, pervasive

[1] inferred ranges cannot be determined above 1.30% Ro (normal)

Figure E2. The reflectance profile for Pelican-5, based on VIRF analysis.



APPENDIX F.

PALYNOLOGY OF COALS AND CLAYSTONES FROM THE CORMORANT-1 AND PELICAN-5 WELLS USED FOR OIL SOURCE CORRELATION

Mike Macphail , Australian National University

Appendix F. Palynology on coals and claystones from Cormorant-1 and Pelican-5 used for oil-source correlation.

AGE	WELL	DEPTH (m)		RAW COUNTS						
(from WCR)		top	base	gymnosperms	angiosperms	ferns/allies	fungi	marine dinos	f/w algae	recycled
Oligocene	Cormorant-1	910.3	910.45	82	177	16	15	23	3	0
Late Eocene	Cormorant-1	1160.08	1160.24	131	148	58	0	35	0	0
Late Eocene	Cormorant-1	1162.1	1162.12	96	375	13	33	0	1	0
Middle-Late Eocene	Cormorant-1	1310.96	1311.11	94	59	94	8	2	0	0
Middle Eocene	Cormorant-1	1381	1390	117	149	31	25	5	1	0
Middle Eocene	Cormorant-1	1444.77	1450.87	43	296	10	82	0	0	0
Middle Eocene	Cormorant-1	1478.3	1487.44	58	220	12	54	0	0	0
Middle Eocene	Cormorant-1	1510.9	1510.93	101	313	24	35	0	0	0
Middle Eocene	Cormorant-1	1518.46	1518.74	139	109	29	23	0	4	1
Middle Eocene	Cormorant-1	1519.75	1519.9	152	213	7	25	0	1	0
Middle Eocene	Cormorant-1	1520.31	1520.36	118	193	12	3	0	0	0
Middle Eocene	Cormorant-1	1530.11	1536.21	72	241	7	85	0	0	0
Late Early Eocene	Cormorant-1	1633.75	1639.84	26	274	3	174	0	0	0
Late Early Eocene	Cormorant-1	1661.18	1667.28	30	245	9	79	0	0	0
Late Early Eocene	Cormorant-1	1685.31	1685.39	81	152	60	40	6	0	2
Late Early Eocene	Cormorant-1	1685.56	1685.72	26	311	2	85	0	0	0
Late Early Eocene	Cormorant-1	1686.58	1686.63	72	138	78	75	0	0	10
Late Early Eocene	Cormorant-1	1725.19	1728.24	50	251	5	160	0	0	0
Late Early Eocene	Cormorant-1	1777.01	1780.05	54	234	3	116	0	0	0
Late Early Eocene	Cormorant-1	1820	1823	30	90	35	121	7	0	0
Late Early Eocene	Cormorant-1	1829.53	1829.58	1	0	0	0	0	0	0
Late Early Eocene	Cormorant-1	1877.59	1883.69	2	1	0	0	0	0	0
Late Early Eocene	Cormorant-1	1950.74	1959.89	26	149	1	39	0	0	0
Late Early Eocene	Cormorant-1	1999.3	1999.33	83	217	31	110	16	15	0
Late Early Eocene	Cormorant-1	2005.61	2011.7	2	1	2	8	0	0	0
Late Early Eocene	Cormorant-1	2024	2033	39	112	16	124	19	0	0
Late Early Eocene	Cormorant-1	2042.18	2048.28	0	2	0	3	0	0	0
Late Early Eocene	Cormorant-1	2090.95	2097.05	0	5	0	0	0	0	0
Late Early Eocene	Cormorant-1	2154.96	2167.15	58	229	8	434	0	0	1
Late Early Eocene	Cormorant-1	2215.92	222.02	0	1	0	0	0	0	0
Mid. Early Eocene	Cormorant-1	2232.38	2232.53	86	219	7	75	0	0	0
Mid. Early Eocene	Cormorant-1	2232.8	2232.83	20	316	12	405	0	0	0

AGE	WELL	DEPTH (m)		RAW COUNTS						
(from WCR)		top	base	gymnosperms	angiosperms	ferns/allies	fungi	marine dinos	f/w algae	recycled
Mid. Early Eocene	Cormorant-1	2276.88	2279.93	0	1	1	2	0	0	0
Mid? Early Eocene	Cormorant-1	2340.89	2353.08	20	151	4	147	1	0	0
Mid? Early Eocene	Cormorant-1	2377.47	2383.56	31	226	3	203	0	0	0
Mid? Early Eocene	Cormorant-1	2414.05	2420.14	29	194	1	64	0	0	1
Mid? Early Eocene	Cormorant-1	2444.53	2447.57	0	0	0	3	0	0	0
Mid? Early Eocene	Cormorant-1	2478.05	2484.15	0	16	0	22	0	0	0
Mid? Early Eocene	Cormorant-1	2539.01	2545.11	38	195	5	170	1	18	7
Mid? Early Eocene	Cormorant-1	2563.4	2569.5	0	0	0	1	0	0	0
Mid? Early Eocene	Cormorant-1	2593.88	2599.98	73	225	3	132	0	1	0
Mid? Early Eocene	Cormorant-1	2621.31	2627.41	29	243	0	400	1	0	0
Mid? Early Eocene	Cormorant-1	2648.1	2648.12	7	19	14	54	0	1	2
Mid? Early Eocene	Cormorant-1	2651.79	2654.84	16	162	32	460	0	0	0
Early Early Eocene	Cormorant-1	2688.37	2691.42	66	195	4	115	0	0	1
Early Early Eocene	Cormorant-1	2715.8	2718.5	1	1	0	0	0	0	0
Early Early Eocene	Cormorant-1	2758.47	2770.67	21	132	0	62	0	0	0
Early Early Eocene	Cormorant-1	2792	2798.1	0	0	0	3	0	0	0
Early Early Eocene	Cormorant-1	2819.43	2822.48	0	0	0	0	0	0	0
Early Early Eocene	Cormorant-1	2831.63	2837.72	6	20	1	43	0	0	0
Early Early Eocene	Cormorant-1	2843.82	2849.91	13	199	2	154	0	0	0
Early Early Eocene	Cormorant-1	2941.36	2944.4	0	0	0	0	0	0	0
Early Early Eocene	Cormorant-1	2990.12	2996.22	47	7	11	36	0	0	0
Middle-Late Eocene	Kon Kon-1	1152	1152	116	197	39	7	10	0	0
Late Early Eocene	Kon Kon-1	1225	1231	89	188	22	22	16	1	0
Late Early Eocene	Kon Kon-1	1247	1280	30	61	9	11	1	0	0
Late Early Eocene	Kon Kon-1	1280.18	1286.27	22	35	3	0	0	0	0
Late? Early Eocene	Kon Kon-1	1341.14	1344.18	81	133	3	56	0	1	0
Late? Early Eocene	Kon Kon-1	1344.87	1344.89	76	53	20	50	250	0	0
Late? Early Eocene	Kon Kon-1	1345.17	1345.28	89	130	2	31	0	0	0
Late? Early Eocene	Kon Kon-1	1345.68	1345.73	201	46	42	74	1	288	0
Late Early Eocene	Kon Kon-1	1347.5	1347.5	101	64	23	57	128	1	0
Late Early Eocene	Kon Kon-1	1351.5	1351.5	156	51	29	42	50	4	0
Late? Early Eocene	Kon Kon-1	1351.7	1351.72	162	180	9	115	2	0	0
Mid. Early Eocene	Kon Kon-1	1353.33	1356.38	125	143	86	16	0	0	0
Early Oligocene	Pelican-5	1700	1705	119	203	38	45	30	1	0

AGE	WELL	DEPTH (m)		RAW COUNTS						
(from WCR)		top	base	gymnosperms	angiosperms	ferns/allies	fungi	marine dinos	f/w algae	recycled
Middle Eocene	Pelican-5	1899	1905	1	5	0	2	0	0	0
Middle Eocene	Pelican-5	2028	2031	47	52	15	4	0	0	0
Middle Eocene	Pelican-5	2034	2037	268	164	8	131	0	0	0
Middle Eocene?	Pelican-5	2049	2412	0	0	0	0	0	0	0
Late Early Eocene	Pelican-5	2190	2193	2	1	0	4	0	0	0
Late Early Eocene	Pelican-5	2418	2424	7	25	4	16	0	0	0
Late Early Eocene	Pelican-5	2502	2505	5	42	0	1	0	4	0
Late? Early Eocene	Pelican-5	2592	2595	6	0	0	3	0	0	0
Mid. Early Eocene	Pelican-5	2640	2643	90	37	38	34	1	0	1
Mid. Early Eocene	Pelican-5	2721	2724	113	25	13	48	0	1	0
Mid. Early Eocene	Pelican-5	2791.7	2791.72	3	22	32	7	0	0	0
Mid. Early Eocene	Pelican-5	2791.87	2792	77	64	112	9	0	0	0
Mid. Early Eocene	Pelican-5	2792.1	2792.2	82	52	16	43	0	0	1
Mid. Early Eocene	Pelican-5	2799	2802	46	64	11	165	0	0	0
Early Early Eocene	Pelican-5	2806.6	2806.7	112	102	51	38	15	0	0
Early Early Eocene	Pelican-5	2890.8	2890.83	44	12	45	19	1	0	0
Early Early Eocene	Pelican-5	2958	2601	15	7	8	28	0	0	0
Early Early Eocene	Pelican-5	3015	3018	37	19	5	64	0	0	1
Early Early Eocene	Pelican-5	3063	3066	84	22	147	20	0	0	0
Late? Paleocene	Pelican-5	3162	3163	78	22	114	27	0	0	0
Late? Paleocene	Pelican-5	3246	3249	45	4	26	13	0	0	0
Late? Paleocene	Pelican-5	3399	3405	90	31	48	34	0	0	1
Late? Paleocene	Pelican-5	3414	3417	11	1	6	4	0	0	0
Maastrichtian	Pelican-5	3567	3570	13	2	3	6	0	0	0
Maastrichtian	Pelican-5	3630	3636	50	13	42	29	0	0	0
Maastrichtian	Pelican-5	3702	3705	2	39	14	11	0	0	0
Maastrichtian	Pelican-5	3891	3906	8	75	22	35	0	2	0
Maastrichtian	Pelican-5	3960	3963	8	56	30	1	0	0	1
Campanian	Pelican-5	4227	4257	0	10	20	3	0	0	4
Late Early Eocene	Poonboon-1	2362	2374	36	105	24	105	7	0	0
Late? Early Eocene	Poonboon-1	2398.81	2407.95	92	271	15	38	0	0	0
Late? Early Eocene	Poonboon-1	2408	2417	52	138	10	140	14	0	0
Mid. Early Eocene	Poonboon-1	2472.54	2472.57	77	105	35	49	132	0	1
Mid. Early Eocene	Poonboon-1	2473.1	2473.18	41	85	202	125	0	0	0

AGE	WELL	DEPTH (m)		RAW COUNTS						
(from WCR)		**top**	**base**	gymnosperms	angiosperms	ferns/allies	fungi	marine dinos	f/w algae	recycled
Mid. Early Eocene	Poonboon-1	2473.94	2474.04	135	73	22	310	107	0	3
Mid Early Eocene	Poonboon-1	2499	2508	90	140	16	55	77	0	0
Late? Paleocene	Poonboon-1	2713	2725	111	77	41	91	5	0	0
Early Paleocene	Poonboon-1	2795	2801	153	43	52	52	18	0	0
Early Paleocene	Poonboon-1	2838	2844	134	31	66	28	12	1	2
Early Paleocene	Poonboon-1	2896	2902	165	38	69	47	6	0	0
Early Paleocene	Poonboon-1	2951	2957	144	36	40	70	2	0	0
Early Paleocene	Poonboon-1	2975	2984	260	29	22	64	2	0	0
Early Paleocene	Poonboon-1	3040.39	3040.54	12	1	11	174	0	0	0
Early Paleocene?	Poonboon-1	3041.48	3041.56	165	70	64	108	0	0	5
Early Paleocene?	Poonboon-1	3041.8	3041.81	193	97	50	72	0	1	0
Early Paleocene?	Poonboon-1	3066	3069	195	31	23	58	6	0	0
Early Paleocene?	Poonboon-1	3127.29	3133.38	268	11	44	11	0	1	0
Maastrichtian	Poonboon-1	3231	3240	195	34	18	59	2	0	0
Early? Eocene	Tilana-1	2319	2325	0	0	0	0	0	0	0
Early? Eocene	Tilana-1	2346	2352	2	30	3	33	0	0	0
Early? Eocene	Tilana-1	2376	2379	11	22	2	32	0	0	0

WELL	PREDICTED VEGETATION INPUT	DEPOSITIONAL ENVIRONMENT
Cormorant-1	Woody angiosperms + gymnopserms	Marginal marine
Cormorant-1	Gymnosperms + woody angiosperms	Marginal marine
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Gymnosperms + ferns	Peat swamp with minor marine influence?
Cormorant-1	Woody angiopserms + gymnopserms	Peat swamp with marine influence
Cormorant-1	Woody angiosperms + gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + gymnosperms	Freshwater peat swamp
Cormorant-1	Gymnosperms + woody angiosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Peat swamp with minor marine influence
Cormorant-1	Woody angiosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + ferns	Peat swamp with possible marine influence
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + ferns/gymnosperms	Peat swamp with possible marine influence
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Peat swamp with minor marine influence
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiopserms + minor gymnosperms	Peat swamp with marine influence
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperm + gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp

WELL	PREDICTED VEGETATION INPUT	DEPOSITIONAL ENVIRONMENT
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Peat swamp with possible marine influence
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms?	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Peat swamp with possible marine influence
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	Woody angiosperms?	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor ferns	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Woody angiosperms?	Freshwater peat swamp
Cormorant-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Cormorant-1	No prediction	(oxidative destruction of organic sediments)
Cormorant-1	Gymnosperms + minor ferns	Freshwater peat swamp
Kon Kon-1	Angiosperms + gymnosperms	Peat swamp with minor marine influence
Kon Kon-1	Angiosperms + gymnosperms	Peat swamp with minor marine influence?
Kon Kon-1	Angiosperms + gymnosperms	Freshwater peat swamp
Kon Kon-1	Woody angiosperms + gymnosperms?	Freshwater peat swamp?
Kon Kon-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Kon Kon-1	Dinocysts + minor gymnosperms and ferns	Marginal marine
Kon Kon-1	Woody angiosperms + gymnosperms	Freshwater peat swamp
Kon Kon-1	Freshwater dinocysts + gymnosperms	Freshwater lake
Kon Kon-1	Dinocysts + gymnosperms, angiosperms	Marginal marine (Neves Effect?)+Q20
Kon Kon-1	Gymnosperms + dinocysts, angiosperms	Marginal marine (Neves Effect?)
Kon Kon-1	Woody angiosperms + gymnosperms	Peat swamp with possible marine influence
Kon Kon-1	Woody angiosperms, gymnosperms, ferns	Freshwater peat swamp
Pelican-5	Woody angiosperms + gymnosperms	Marginal marine

WELL	PREDICTED VEGETATION INPUT	DEPOSITIONAL ENVIRONMENT
Pelican-5	No prediction	(oxidative destruction of organic sediment?)
Pelican-5	Woody angiosperms, gymnosperms, ferns	Freshwater peat swamp
Pelican-5	Gymnosperms + minor woody angiosperms	Freshwater peat swamp
Pelican-5	No prediction	(oxidative destruction of organic sediment)
Pelican-5	No prediction	(oxidative destruction of organic sediment)
Pelican-5	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Pelican-5	Woody angiosperms	Freshwater peat swamp?
Pelican-5	Gymnosperms?	(oxidative destruction of organic sediments)
Pelican-5	Gymnosperms + minor ferns	Peat swamp with minor marine influence?
Pelican-5	Gymnosperms + minor ferns	Freshwater peat swamp
Pelican-5	Ferns + woody angiosperms	Freshwater peat swamp
Pelican-5	Ferns + minor angiosperms, gymnosperms	Freshwater peat swamp
Pelican-5	Gymnosperms + woody angiosperms	Freshwater peat swamp
Pelican-5	Gymnosperms + woody Angiosperms	Freshwater peat swamp
Pelican-5	Woody angiosperms + gymnosperms	Peat swamp with marine influence
Pelican-5	Gymnosperms + ferns	Peat swamp with minor marine influence?
Pelican-5	Gymnosperms + ferns?	Freshwater peat swamp
Pelican-5	Gymnosperms + minor woody angiosperms	Freshwater peat swamp
Pelican-5	Ferns + minor gymnosperms	Freshwater peat swamp
Pelican-5	Ferns + minor gymnosperms	Freshwater peat swamp
Pelican-5	Gymnosperms + minor ferns	Freshwater peat swamp
Pelican-5	Gymnosperms + ferns	Freshwater peat swamp
Pelican-5	Gymnosperms + minor ferns?	(oxidative destruction of organic sediments)
Pelican-5	Gymnosperms + minor ferns?	(oxidative destruction of organic sediments)
Pelican-5	Ferns + gymnosperms	Freshwater peat swamp
Pelican-5	Woody angiosperms + minor ferns	Freshwater peat swamp?
Pelican-5	Woody angiosperms + minor ferns	Freshwater peat swamp?
Pelican-5	Woody? angiosperms + ferns	Freshwater peat swamp?
Pelican-5	Woody angiosperms + minor ferns	Freshwater peat swamp?
Poonboon-1	Angiosperms + minor gymnosperms	Peat swamp with minor marine influence
Poonboon-1	Woody angiosperms + minor gymnosperms	Freshwater peat swamp
Poonboon-1	Woody angiosperms + gymnosperms	Peat swamp with possible marine influence
Poonboon-1	Dinocysts + gymnosperms, angiosperms	Marginal marine
Poonboon-1	Ferns + minor angiosperms, gymnosperms	Freshwater peat swamp?

WELL	PREDICTED VEGETATION INPUT	DEPOSITIONAL ENVIRONMENT
Poonboon-1	Gymnosperms + dinocysts, angiosperms	Marginal marine
Poonboon-1	Gymnosperms + dinocysts, angiosperms	Marginal marine
Poonboon-1	Gymnosperms + minor ferns	Peat swamp (possible marine influence?)
Poonboon-1	Gymnosperms + minor ferns, dinocysts	Freshwater peat swamp
Poonboon-1	Gymnosperms + ferns	Freshwater peat swamp
Poonboon-1	Gymnosperms + ferns	Freshwater peat swamp
Poonboon-1	Gymnosperms + minor ferns, angiosperms	Freshwater peat swamp
Poonboon-1	Gymnosperms	Freshwater peat swamp
Poonboon-1	Gymnosperms + ferns?	Freshwater peat swamp?
Poonboon-1	Gymnosperms + minor angiosperms, ferns	Freshwater peat swamp
Poonboon-1	Gymnosperms + minor angiosperms, ferns	Freshwater peat swamp?
Poonboon-1	Gymnosperms + minor angiosperms, ferns	Freshwater peat swamp?
Poonboon-1	Gymnosperms + minor ferns	Freshwater peat swamp?
Poonboon-1	Gymnosperms + minor, angiosperms, ferns	Freshwater peat swamp?
Tilana-1	No prediction	(oxidative destruction of organic sediment)
Tilana-1	Woody angiosperms?	(thermal destruction of organic sediments)
Tilana-1	Woody angiosperms?	thermal destruction of organic sediments)

APPENDIX G.

LIST OF OIL AND GASES IN THE BASS BASIN ANALYSED IN THIS STUDY

Chris Boreham, Geoscience Australia

GA No.	Well	Top m	Test	Type
10037	Cormorant-1	1500.0	FIT 6	oil
19999150	Pelican-1	3161.4		oil
19999151	Pelican-2	2879.5	FIT 1	oil
10036	Yolla-1	1830.0	DST 2	oil
10035	Yolla-1	2824.0	DST 1	oil
20009241	White Ibis-1	2015.2		gas
20009247	White Ibis-1	2048.5		gas
20009248	Yolla-2	2802.0		gas
20009250	Yolla-2	2815.0		gas

APPENDIX H.

SMALL ANGLE NEUTRON SCATTERING (SANS) STUDY ON LOW-ASH COALS FROM CORMORANT-1 AND PELICAN-5, BASS BASIN

Andrzej Radlinski, Alan Hinde and Chris Boreham, Geoscience Australia

H1. SAMPLE SELECTION AND PREPARATION

Small Angle Neutron Scattering (SANS) analysis was performed on low ash coals obtained by the flotation of cuttings or, where available, sidewall core material (density less than 1.5 g/cm^3) from Cormorant-1 (30 samples) and Pelican-5 (12 samples). These cuttings were collected within the Eastern View Coal Measures (EVCM), at average intervals of about 50 m between the depths 1445 to 2945 m at Cormorant-1, and at average intervals of about 100 m between the depths 1899 to 3165 m at Pelican-5 (Table H1). The samples were prepared for SANS analysis by gentle crushing, sieving and then embedding the 0.355 - 0.475 mm particle size fraction in resin.

SANS data were acquired in December 2001 using the SAND instrument at IPNS, Argonne National Laboratory, USA. In some cases (4 Cormorant-1 samples, 2 Pelican-5 samples) there was only enough float material to prepare small diameter SANS samples (marked *small* in Table H1). SANS data collected from these samples proved to be unreliable under the experimental conditions used and are not included in this report.

H2. RESULTS AND INTERPRETATION – PELICAN-5

Figure H1 shows the SANS data for 20 coal samples from Pelican-5. The results are presented in a standard manner: scattering intensity, I(Q) in absolute units, versus the scattering vector Q. Scattering curves comprise a (1) broad feature monotonically increasing towards small Q-values, approximately linear on the log-log scale, (2) a broad band peaked at about Q = 0.2 Å^{-1} whose amplitude increases with coal rank, and (3) a small flat background of about 0.2 to 0.3 cm^{-1}. These three features correspond to (1) a broad distribution of the pore sizes, (2) the formation of polyaromatic sheets as the thermal maturity of kerogen increases, and (3) the incoherent scattering on hydrogen atoms and coherent scattering on small-scale (nearly molecular-size) inhomogeneities in the coal matrix, respectively.

The scattering data at each sample depth are used to derive (i) the pore size distribution, (ii) specific surface area (Radlinski, et al., 2001), and (iii) the repeat distance of the polyaromatic sheets in the coal matrix. The data are then used to quantify the evolution of the pore space geometry with depth (maturity) in the pore size range 80 Å to 1000 Å (0.008 μm to 0.1 μm) and to infer the onset of hydrocarbon generation from kerogen.

The results shows there is a significant and systematic variation of the scattering intensity with depth. This is illustrated in Figure H2 for scattering intensity measured at Q=0.01 $Å^{-1}$, which corresponds to the pore size 2.5/Q = 0.025μm +/-50%. The SANS intensity at Q=0.01$Å^{-1}$ decreases by a factor of 4.5 within the depth range 1899 to 2792 m, and then increases by a factor of 2 at depth 2998 m and remains unchanged down to depth 3165m.

The pore size distributions, f(r), calculated for various depths from the full SANS curves (Figure H3) indicate there is a significant change of the micro-geometry of the pore space between depths from 2410 to 2593 m. For depths shallower than 2410 m the f(r) values (blue symbols) fall on a common curve with a characteristic kink at pore size of about 120 Å. For depths below 2593 m the f(r) values (red symbols) fall on a common curve (a power law distribution, linear on the log-log scale), which has no kink and lies above the distribution curves for shallower depths. The f(r) curve for depth 2499.5 m (black full circles) coincides with the "shallow" curve for small pore sizes and with the "deep" curve for large pore sizes. This trend indicates that re-arrangement of the pore space as depth increases first occurs for larger pores and gradually progresses towards the smaller ones.

A close analysis of the variation of the number density of pores (proportional to the pore size distribution f(r)) with depth indicates a significant and nearly stepwise increase of micro-porosity within the depth interval 2400 - 2600 m (Figure H4). This transition occurs within the vitrinite reflectance interval 0.55% to 0.65%.

The specific surface area (SSA) versus the probe size, calculated for various depths in Pelican-5 (in the units of cm^2/cm^3), is presented in Figure H5. (Note that 1 cm^2/cm^3 is equivalent to $0.714x10^{-4}$ m^2/g, assuming coal density of 1.4 g/cm^3). The extrapolated SSA in Pelican-5 for the probe size of several Å (*i.e.* , the linear size of methane or CO_2 molecule) varies from about 10,000 to 100,000 cm^2/cm^3, which corresponds to about 0.71 to 7.1 m^2/g. Figure H6 illustrates the variation of SSA with depth for the smallest measured probe size of 100 Å. The specific surface area systematically decreases with depth down to about 2800 m, then slightly increases at depths below 3000 m and stays relatively unchanged down to about 3150 m.

SANS curves in Figure H1 exhibit a weak broad band centered at the Q-value of about Q_o=0.2 $Å^{-1}$, whose intensity increases with the coal rank. This band corresponds to the scattering on the stacked poly-aromatic sheets within the coal matrix. The concentration of these sheets increases as the coal rank increases from sub-bituminous to anthracite (Radlinski and Radlinska, 1999). The position of the maximum of the peak corresponds to the mean stacking repeat distance of $2\pi/Q_o \approx 30$ Å.

Significance for hydrocarbon generation and expulsion: Pelican-5.

The intensity of SANS signal in coals is proportional to the specific surface area of the pore/matrix interface and to the scattering contrast between the coal matrix and the pore content. It is known that in the vitrinite reflectance range 0.3 -1.0%, the porosity (King and Wilkins, 1944) and the internal surface roughness of coals (Radlinski and Radlinska, 1999) decrease with rank, which results in a "structural" decrease of SANS intensity with rank. The process of internal restructuring of coals can be particularly active in a narrow range of rank variation.

Superimposed on this "structural" decrease there is a variation of SANS signal caused by the onset of hydrocarbon generation, which results in the micropores being increasingly filled with bitumen. The scattering contrast between the bitumen and the coal macerals is low, which further decreases the "structural" scattering signal from a coal that has generated bitumen. In such coal, the bitumen partially filling the pore space is perceived by neutrons as part of the coal matrix. However, this "generation" decrease is limited to depths at which the bitumen is actually present in the pore space. Brine or gas have large SANS contrast with the coal matrix, which results in an increased scattering signal at depths directly above and below the generation window, where coal macerals have either not yet generated or the bitumen (or its components) has been expelled and/or cracked.

The pore size distribution (Figures H3 and H4) indicates that a significant re-distribution of the pore space takes place inside the coals of the Eastern View Coal Measures within the depth range 2400m to 2600 m, corresponding to the Ro range 0.55% to 0.65%. In particular, there is a significant increase of coal porosity within this depth interval, especially for pores larger than 100 Å in diameter. For pores of diameter 100 Å the change of porosity is much less pronounced (Figure H4). These changes are not reflected in the scattering intensity (Figure H2), which monotonically decreases down to the depth of 2800 m. This indicates that the rearrangement of the microstructure of the coal matrix does not affect the internal specific area beyond the usual decrease with rank.

Below depth 2800 m the scattering intensity increases stepwise by a factor of 2 at depth 2942 m and remains constant down to the maximum tested depth of 3162 m (Figure H2). There is no significant difference in pore size distribution in the depth range 2600 to 3126 m (Figures H3 and H4).

These results are used to interpret SANS data for Pelican-5 as graphically represented in Figure H7. Hydrocarbons are generated at depths around 2800 m and expelled upwards and sideways, but there is a permeability barrier located between depths 2800 and 2942 m. Data indicate that there is good communication at depths below 2942 m, and that the onset of hydrocarbon generation coincides with the region of structural re-arrangement in the depth range 2400 m to 2600 m.

Integration of the SANS results with independent geochemical data from Rock Eval analysis reveals much synergy. Figure H8 shows the depth plot of Hydrogen Index (HI) and Bitumen Index (BI). The HI parameter is a measure of the TOC-normalised residual hydrocarbon potential while the latter reflects the TOC-normalised yield of free hydrocarbons. The depth trend of increasing HI, reaching a maximum followed by a HI decrease is in response to increasing maturity. Sykes (2001) has seen the same maturity-driven HI trend in New Zealand coals of similar age and has used this feature to understand the key hydrocarbon generation and expulsion events. In Pelican-5, the onset of hydrocarbon (oil) generation corresponds to the rapid increase in HI at approximately 2450 m (Ro = 0.6%), consistent with the region of structural re-arrangement seen in SANS. The onset of oil expulsion is identified at 2850 m (Ro = 0.74%) by the rapid decrease in HI immediately after the HI maximum. Over this range the BI shows a continual increase. The region in which the BI shows no further increase and remains fairly constant (SANS scattering intensity data is also constant; Figure H7), due to the maintenance of maximum saturation of the pore space with oil, occurs from 2850 to 3600 m (Ro = 0.74 – 1.13%) is defined as the oil window (Figure H8). This is in good agreement with the chemical maturity of the Bass Basin reservoired oils (Yolla-1 and Pelican-1 and -2) which indicates that the effective source rocks expelled oil over the Ro range from 0.75 to 0.95 % (main phase of oil generation). At depths > 3600 m, the BI begins to fall corresponding to removal (loss) of oil due either to increasing generation of primary gas resulting in more efficient expulsion of residual oil or the beginning of oil-to-gas cracking. This is consistent with maturity data on reservoired gases which suggests that gas was generated from source rocks at Ro > 1.3%.

H3. RESULTS AND INTERPRETATION – CORMORANT-1

Figure H9 shows SANS data for 20 coal samples (selected out of 30 coals analysed) in Cormorant-1 presented in the standard manner: scattering intensity, I(Q) in absolute units, versus the scattering vector Q. Scattering curves comprise of a (1) broad feature monotonically increasing towards small Q-values, approximately linear on the log-log scale, (2) a broad band peaked at about Q = 0.2 $Å^{-1}$ whose amplitude increases with coal rank, and (3) a small flat background of about 0.2 cm^{-1}. These three features correspond to (1) a broad distribution of the pore sizes, (2) formation of polyaromatic sheets as the thermal maturity of kerogen increases, and (3) incoherent scattering on hydrogen atoms and coherent scattering on small-scale (nearly molecular size) inhomogeneities in the coal matrix, respectively.

The scattering data have been used to derive for every depth (i) the pore size distribution, (ii) specific surface area (Radlinski et al., 2001), and (iii) the repeat distance of the polyaromatic sheets in the coal matrix. These data are used to quantify the evolution of the pore space geometry with depth (maturity) in the pore size range from 80 to 1000 Å (0.008 to 0.1 μm) and infer about the onset of hydrocarbon generation in the Eastern View Coal Measures.

There is a systematic decrease of the scattering intensity with depth. This is illustrated in Figure H10 for scattering intensity measured at Q=0.01 $Å^{-1}$, which corresponds to the pore size 2.5/Q = 0.025 μm +/-50%. For Cormorant-1 coals, SANS intensity decreases by a factor of 6 within the depth range 1445 to 2941.4 m.

The pore size distributions, f(r), calculated for various depths (Figure H11) indicate that there may be an onset of change of the micro-geometry of the pore space at depths below 2821 m. For depths shallower than 2821 m the f(r) curves (blue and red symbols) fall within a broad band with little apparent systematic variation with depth, apart from the general decrease of amplitude indicating a decrease of the porosity with depth. However, the pore size distribution curve for the deepest sample (2942.9 m) clearly lies outside of the band and indicates closing off (or clogging with bitumen) of pores smaller than about 100 Å across.

A close analysis of the variation of number density of pores (proportional to the pore size distribution f(r)) with depth indicates a significant increase of porosity for pores larger than about 100 Å across at depths below 2800 m (Figure H12). The transition occurs at the vitrinite reflectance value of about 0.80-0.85%.

The specific surface area versus the probe size, calculated for various depths in well Cormorant-1 (in the units of cm^2/cm^3), is presented in Figure H13. (Note that 1 cm^2/cm^3 is equivalent to $0.714x10^{-4}$ m^2/g, assuming coal density of 1.4 g/cm^3). The extrapolated specific surface area in Cormorant-1 for the probe size of several Å (*i.e.* , the linear size of the methane or CO_2 molecule) varies from about 10^3 to $4x10^5$ cm^2/cm^3, depending on coal rank, which corresponds to about 0.07 to 28 m^2/g. Figure H13 illustrates the variation of SSA with depth for the smallest measured probe size of 100 Å. The specific surface area systematically decreases with depth down to the maximum depth of about 2942.9 m.

SANS curves in Figure H9 exhibit a weak broad band centered at the Q-value of about Q_o=0.2 $Å^{-1}$, whose intensity increases with the coal rank. This band corresponds to the scattering on the stacked poly-aromatic sheets within the coal matrix. The concentration of these sheets increases as the coal rank increases from sub-bituminous to anthracite (Radlinski and Radlinska, 1999). The position of the maximum of the peak corresponds to the mean stacking repeat distance of $2\pi/Q_o \approx 30$ Å.

Significance for hydrocarbon generation at Cormorant-1

The intensity of SANS signal in coals is proportional to the specific surface area of the pore/matrix interface and to the scattering contrast between the coal matrix and the pore content. It is well known that in the vitrinite reflectance range 0.3 to 1.0%, the porosity (King and Wilkins, 1944) and the internal surface roughness of coals (Radlinski and Radlinska, 1999) decreases with rank, which is a "structural" decrease of SANS intensity with rank. The process of internal restructuring of coals can be particularly active in a narrow range of rank variation.

Superimposed on this "structural" decrease there is a variation of SANS signal caused by the onset of hydrocarbon generation, which results in the micropores being increasingly filled with bitumen. The scattering contrast between the bitumen and the coal macerals is very low, which further decreases the "structural" scattering signal from a coal that has generated bitumen. In such coal the bitumen partially filling the pore space is perceived by neutrons as part of the coal matrix. However, this "generation" decrease is limited to depths at which the bitumen is actually present in the pore space. Brine or gas have large SANS contrast with the coal matrix, which results in an increased scattering signal at depths directly above and below the generation window, where coal macerals have either not yet generated or the bitumen (or its components) has been expelled and/or cracked.

The pore size distribution (Figures H11 and H12) indicates that the onset of re-distribution of the pore space takes place inside the coals of the Eastern View Coal Measures below depth 2800 m, corresponding to Ro values larger than 0.85%. It is important to note that pores of diameter smaller than 100 Å practically disappear at these depths, which strongly indicates a possibility of clogging of these pores with liquid bitumen. However, there is a significant increase of coal porosity for pores larger than 100 Å across at depths below 2800 m. These changes are not reflected in the scattering intensity (Figure H11), which monotonically decreases down to the maximum depth of 2943 m. This indicates that the rearrangement of the microstructure of the coal matrix does not affect the internal specific area beyond the usual decrease with rank.

These results are used to interpret SANS data for Cormorant-1 as graphically represented in Figure H15. Hydrocarbons are generated at depths around 2940 m and expelled upwards and sideways. Data indicate that there is good communication at all depths above 2942 m, and that the onset of hydrocarbon generation coincides with the region of structural re-arrangement in the depth range 2800 to 2940 m.

H4. VARIATION OF VITRINITE REFLECTANCE WITH DEPTH IN PELICAN-5 AND CORMORANT-1

Figure H16 shows the plot of vitrinite reflectance versus depth for wells Cormorant-1 and Pelican-5. Generally, the Ro data were measured on samples collected at different depths than these used for SANS measurements. Because of the scatter, it is convenient to fit a smooth curve to Ro data and use it to calculate the Ro-value at any depth rather than rely on the interpolation between the data points nearest to the depth of interest.

For Cormorant-1, the vitrinite reflectance versus depth in the interval 600 – 3000 m is well represented by the following second order polynomial:

$$Ro = 0.3403 - 7.5467 \times 10^{-5}\, D + 9.0932 \times 10^{-8}\, D^2 \qquad (1)$$

where D is depth in metres. The correlation coefficient is R = 0.992.
For Pelican-5, the corresponding polynomial, valid in the depth interval 1800 to 4300 m is:

$$Ro = 0.6914 - 3.8912 \times 10^{-4}\, D + 1.425 \times 10^{-7}\, D^2 \qquad (2)$$

and the correlation coefficient is R = 0.984.

It is possible to represent the vitrinite reflectance versus depth for both wells with one universal equation (Figure H17), using a third order polynomial:

$$Ro = 0.23371 + 9.798 \times 10^{-5}\, \Delta - 2.52 \times 10^{-8}\, \Delta^2 + 1.863 \times 10^{-11}\, \Delta^3 \qquad (3)$$

where Δ = D for Pelican-5 and Δ = D + 300m for Cormorant-1, and D is depth in metres.
The correlation coefficient is 0.989.

This result could be interpreted that the maturity for Eastern View Coal Measures coals in Cormorant-1 is the same as for the Pelican-5 coals located 300m deeper. This could be caused either by different thermal history of the two wells or a different thermal transformation kinetics for the organic matter in each well, or a combination of the above. Formula 3 has been used to calculate the Ro values for SANS samples presented in Table H1.

H5. REFERENCES

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Table H1. Basic data for low ash preparations used in the SANS analyses.

AGSO No.	*SANS sample*	*Well*	*Top mRT*	*base mRT*	*Interval m*	*Ro% calc*	*Type*	*Lithology*
20010346	normal	Cormorant-1	1444.77	1450.87		0.428	Cut	coaly
20010347	normal	Cormorant-1	1478.30	1487.44	35	0.435	Cut	coaly
20010064	normal	Cormorant-1	1519.75	1519.90	37	0.441	CORE 6	coal
20010348	normal	Cormorant-1	1530.12	1536.21	13	0.444	Cut	coaly
20010349	normal	Cormorant-1	1633.74	1639.84	3.6	0.465	Cut	coaly
20010350	normal	Cormorant-1	1661.18	1667.28	27	0.471	Cut	coaly
20010067	normal	Cormorant-1	1685.56	1685.72	21	0.475	CORE 7	coal
20010351	normal	Cormorant-1	1725.19	1728.24	41	0.484	Cut	coaly
20010352	normal	Cormorant-1	1777.01	1780.06	52	0.496	Cut	coaly
20010344	normal	Cormorant-1	1829.53	1829.59	51	0.508	CORE 8	coal
20010353	normal	Cormorant-1	1877.59	1883.69	51	0.521	Cut	coaly
20010069	normal	Cormorant-1	1950.74	1959.89	75	0.541	Cut	coal
20010354	normal	Cormorant-1	2005.61	2011.70	53	0.556	Cut	coaly
20010355	normal	Cormorant-1	2042.19	2048.28	37	0.566	Cut	coaly
20010356	normal	Cormorant-1	2090.95	2097.05	49	0.580	Cut	coaly
20010070	normal	Cormorant-1	2154.96	2167.15	67	0.602	Cut	coal
20010357	normal	Cormorant-1	2215.92	2222.02	58	0.619	Cut	coaly
20010345	normal	Cormorant-1	2232.38	2232.54	13	0.623	CORE 10	coal
20010358	normal	Cormorant-1	2276.88	2279.93	46	0.639	Cut	coaly
20010071	normal	Cormorant-1	2340.89	2353.09	69	0.664	Cut	coal
20010359	small	Cormorant-1	2377.47	2383.57	34	0.675	Cut	coaly
20010360	normal	Cormorant-1	2414.05	2420.14	37	0.689	Cut	coaly
20010361	normal	Cormorant-1	2444.53	2447.57	29	0.700	Cut	coaly
20010362	*none*	Cormorant-1	2478.05	2484.15		0.713	Cut	coaly
20010363	*none*	Cormorant-1	2539.02	2545.11		0.738	Cut	coaly
20010364	small	Cormorant-1	2563.40	2569.50	20	0.748	Cut	coaly
20010365	*none*	Cormorant-1	2593.88	2599.98		0.760	Cut	coaly
20010366	small	Cormorant-1	2621.31	2627.41	58	0.772	Cut	coaly
20010367	small	Cormorant-1	2651.79	2654.84	29	0.784	Cut	coaly
20010368	*none*	Cormorant-1	2688.37	2691.42		0.800	Cut	coaly
20010369	normal	Cormorant-1	2715.80	2718.85	64	0.812	Cut	coaly
20010072	normal	Cormorant-1	2758.47	2770.67	47	0.836	Cut	coal
20010370	*none*	Cormorant-1	2792.00	2798.10		0.849	Cut	coaly
20010371	normal	Cormorant-1	2819.43	2822.48	57	0.861	Cut	coaly
20010372	*none*	Cormorant-1	2831.63	2837.72		0.869	Cut	coaly
20010373	*none*	Cormorant-1	2843.82	2849.92		0.875	Cut	coaly
20010374	normal	Cormorant-1	2941.36	2944.40	123	0.923	Cut	coaly
20010375	normal	Pelican-5	1899	1905		0.458	Cut	coaly
20010049	normal	Pelican-5	2034	2037	135	0.486	Cut	coal
20010376	normal	Pelican-5	2190	2193	156	0.524	Cut	coaly
20010377	normal	Pelican-5	2304	2307	114	0.554	Cut	coaly
20010378	normal	Pelican-5	2409	2412	105	0.585	Cut	coaly
20010379	normal	Pelican-5	2502	2505	93	0.614	Cut	coaly
20010380	normal	Pelican-5	2592	2595	90	0.644	Cut	coaly
20010381	normal	Pelican-5	2721	2724	129	0.690	Cut	coaly
20010052	normal	Pelican-5	2791.87	2792	70	0.716	CORE 1	coal
20010382	small	Pelican-5	2799	2802	8	0.720	Cut	coaly
20010383	normal	Pelican-5	2958	2601	159	0.646	Cut	coaly
20010384	normal	Pelican-5	3063	3066	105	0.834	Cut	coaly
20010385	normal	Pelican-5	3162	3165	99	0.882	Cut	coaly
20010386	*none*	Pelican-5	3246	3249		0.925	Cut	coaly
20010387	*none*	Pelican-5	3414	3417		1.017	Cut	coaly
20010388	*none*	Pelican-5	3567	3570		1.110	Cut	coaly
20010389	small	Pelican-5	3702	3705	540	1.198	Cut	coaly
20010390	*none*	Pelican-5	3822	3825		1.282	Cut	coaly
20010391	*none*	Pelican-5	3960	3963		1.386	Cut	coaly
20010392	*none*	Pelican-5	4257	4260		1.634	Cut	coaly

Figure H1. SANS scattering intensity versus Z for 15 low ash coal samples from Pelican-5 within the Eastern View Coal Measures succession. Legend shows depth for each sample. Small diamtere samples are marked "sd".

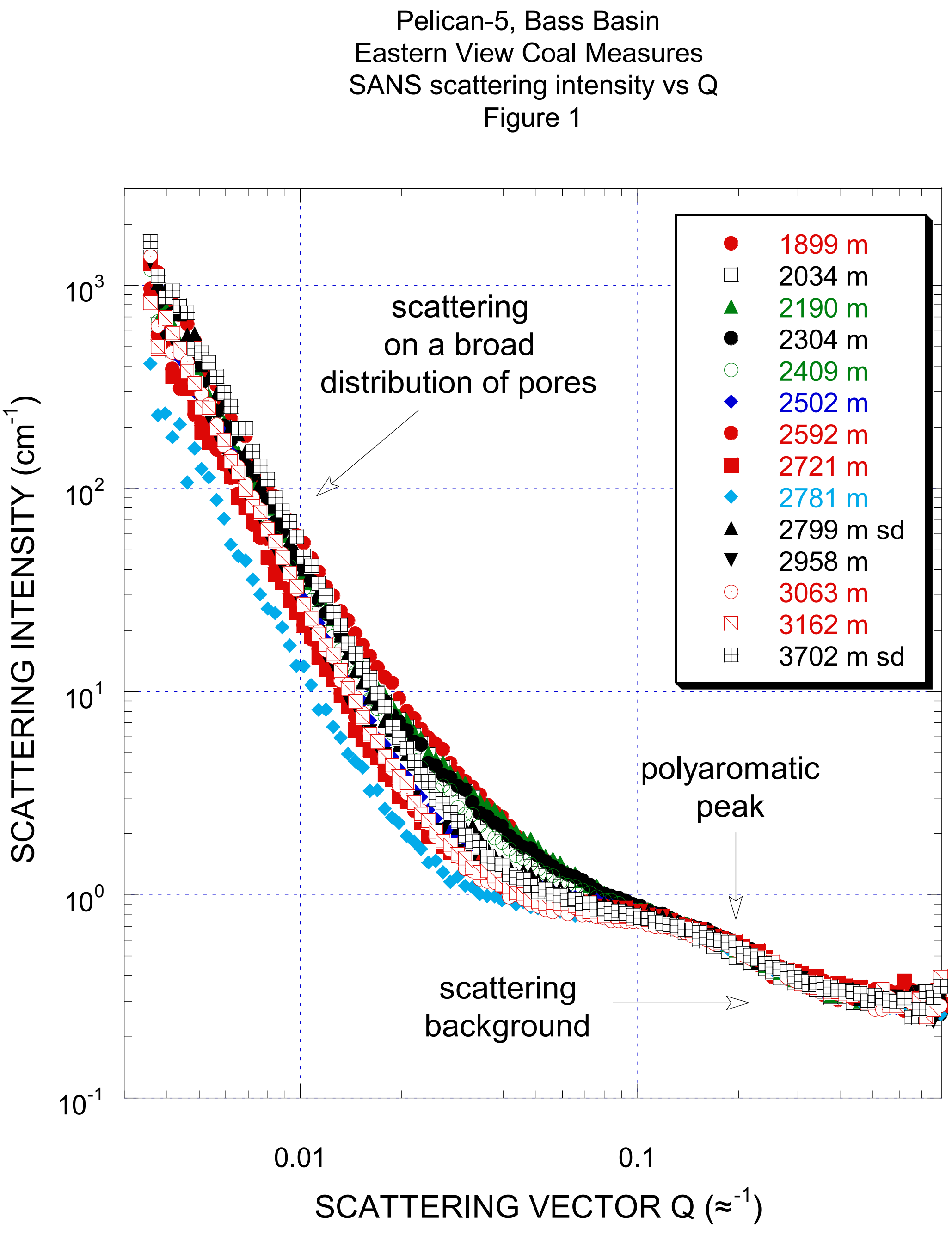


Figure H2. SANS intensity at Q=0.01 Å^{-1} versus depth for 12 low ash coal samples from Pelican-5.

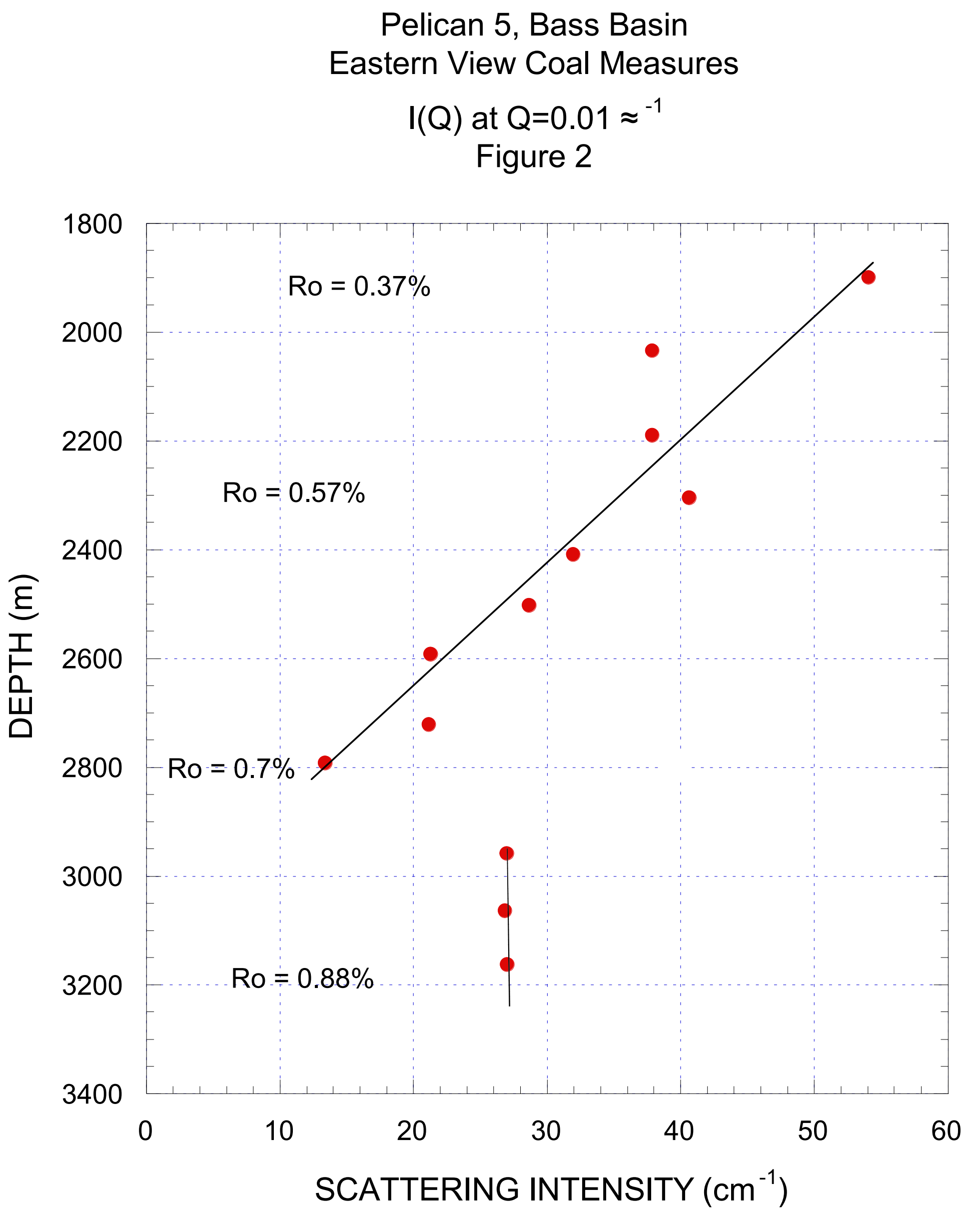


Figure H3. Variation of the pore size distribution with depth for low ash coal samples from Pelican-5. Only pores of diameter in the range of 80 – 800 Å are included.

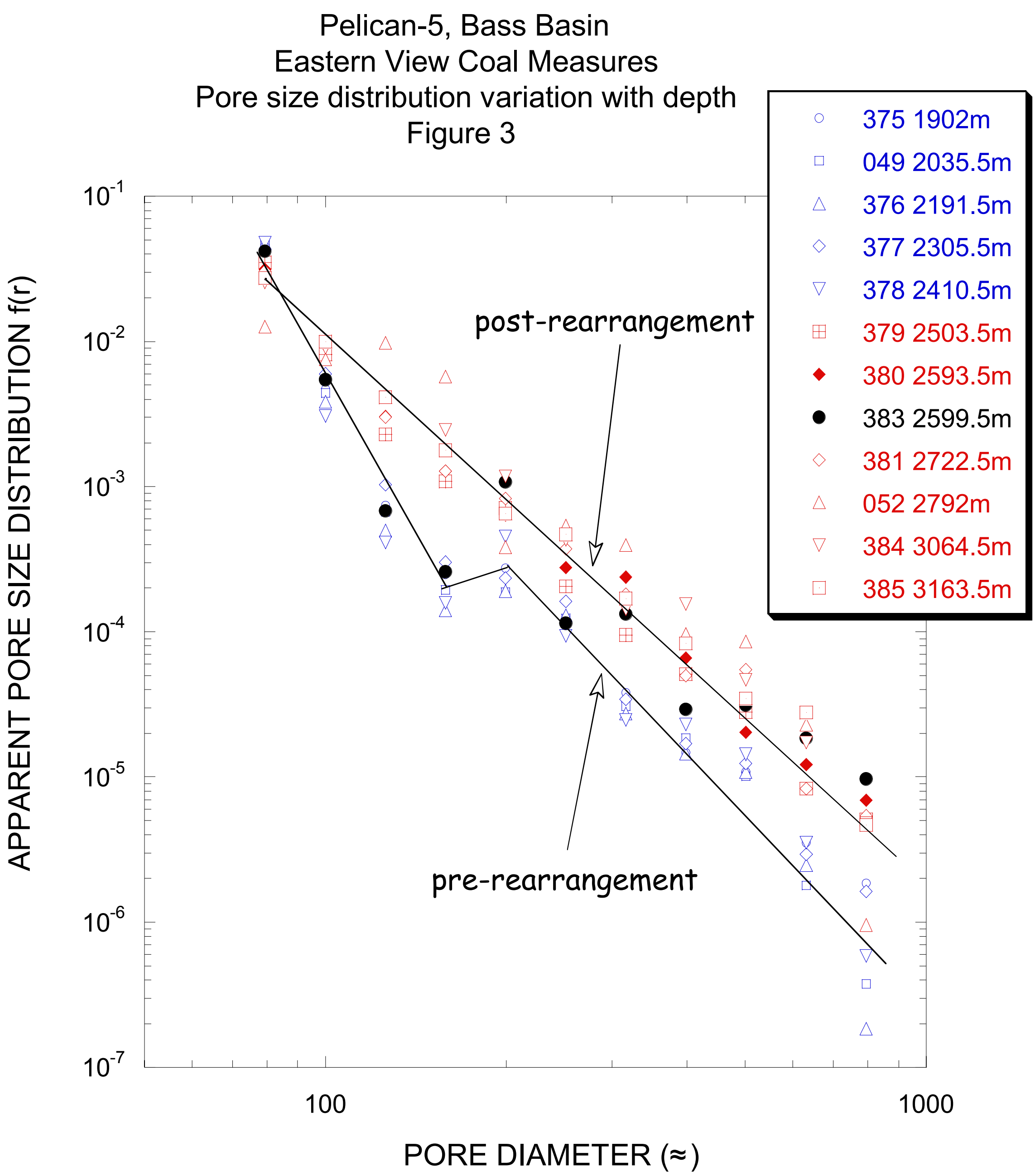


Figure H4. Variation of pore number density with depoth for three pore sizes: 100 A, 316 Å and 630 Å in Pelican-5, Eastern View Coal Measures, low ash preparations.

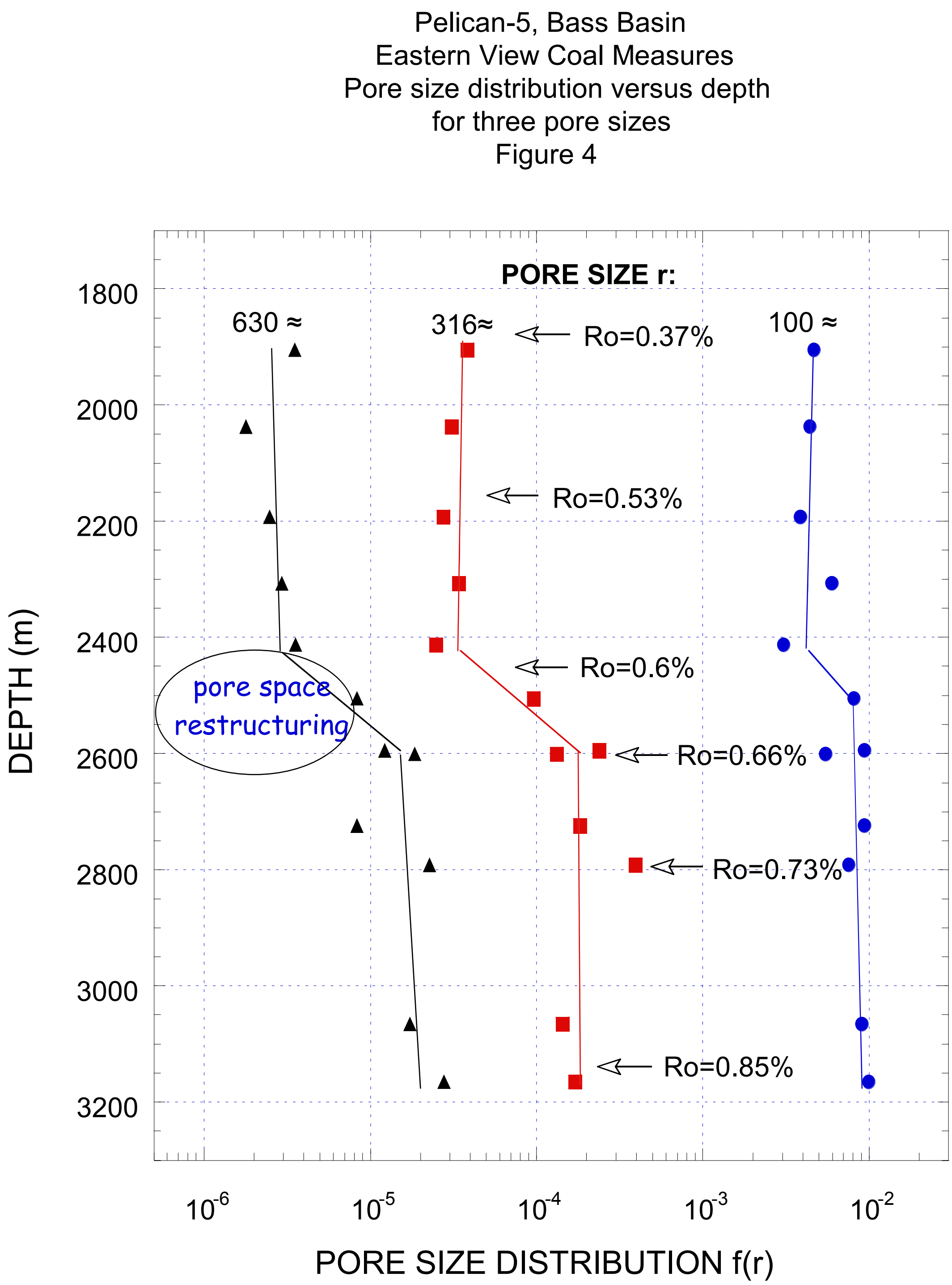


Figure H5. Specific internal surface area versus probe diameter calculated for 12 low ash coals from Pelican-5.

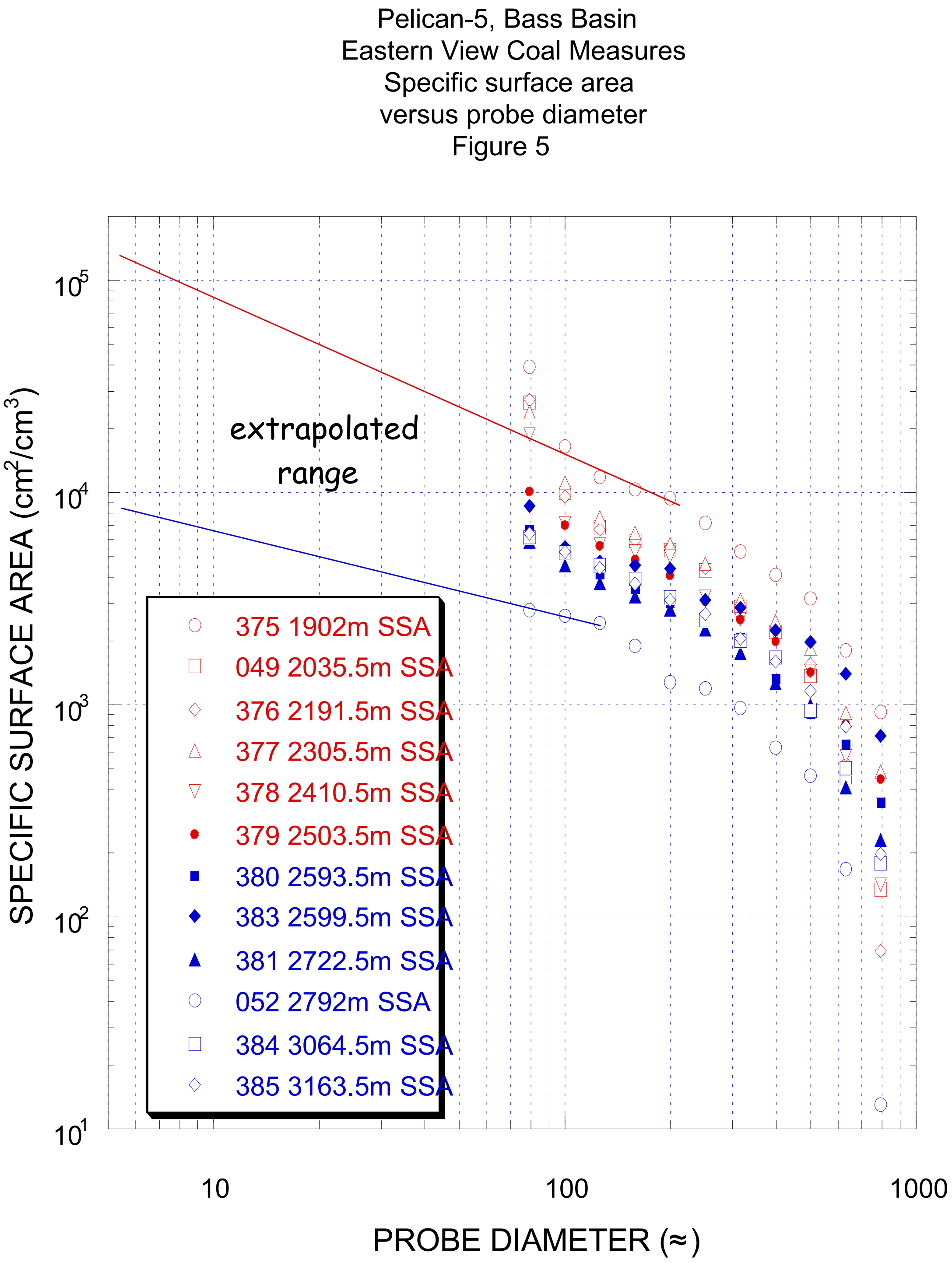


Figure H6. The variation of the specific surface area with depth for probe size 100 Å, Pelican -5, low ash preparations, Eastern View coals Measures.

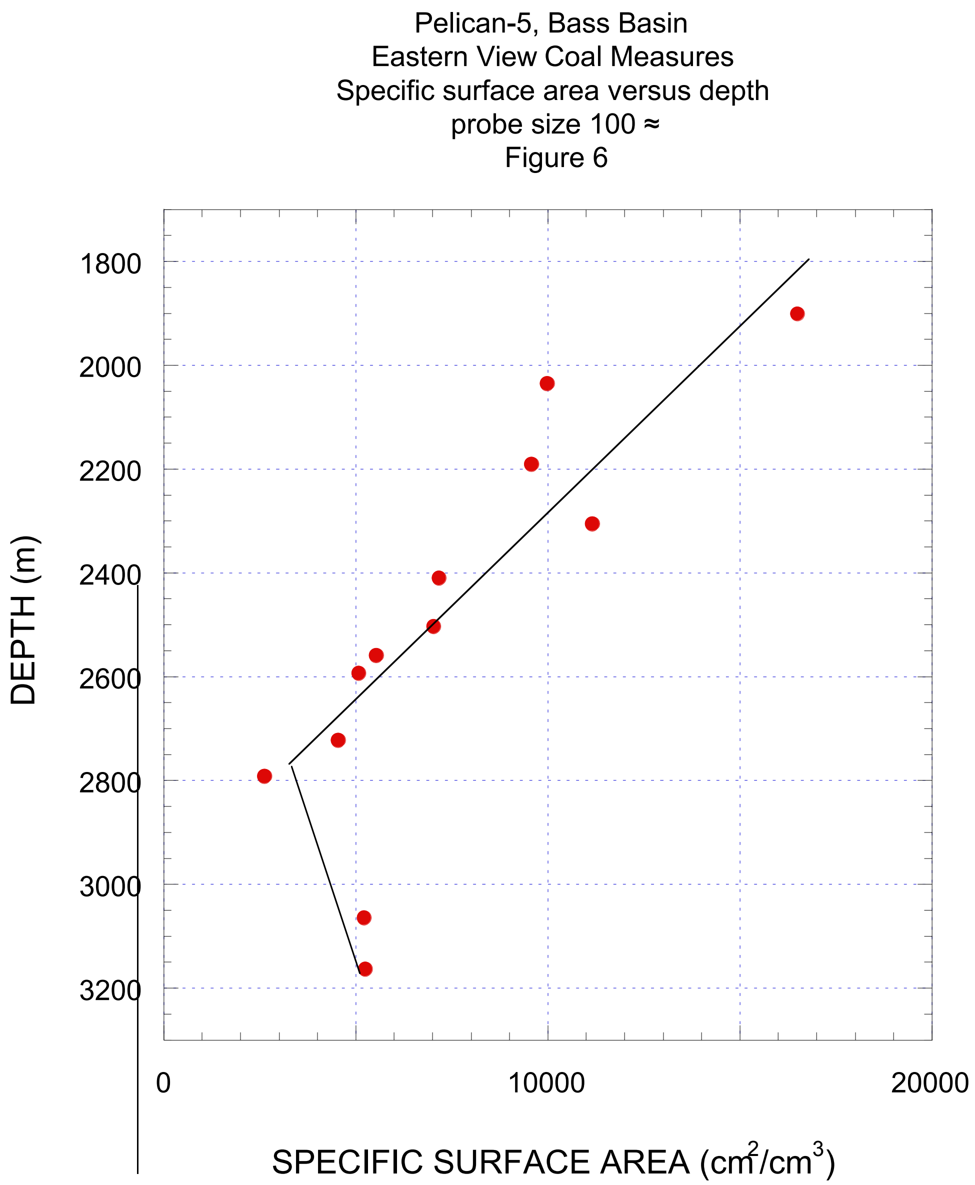


Figure H7. Interpretation of SANS data for Pelican-5, micro-structural events, hydrocarbon generation and expulsion.

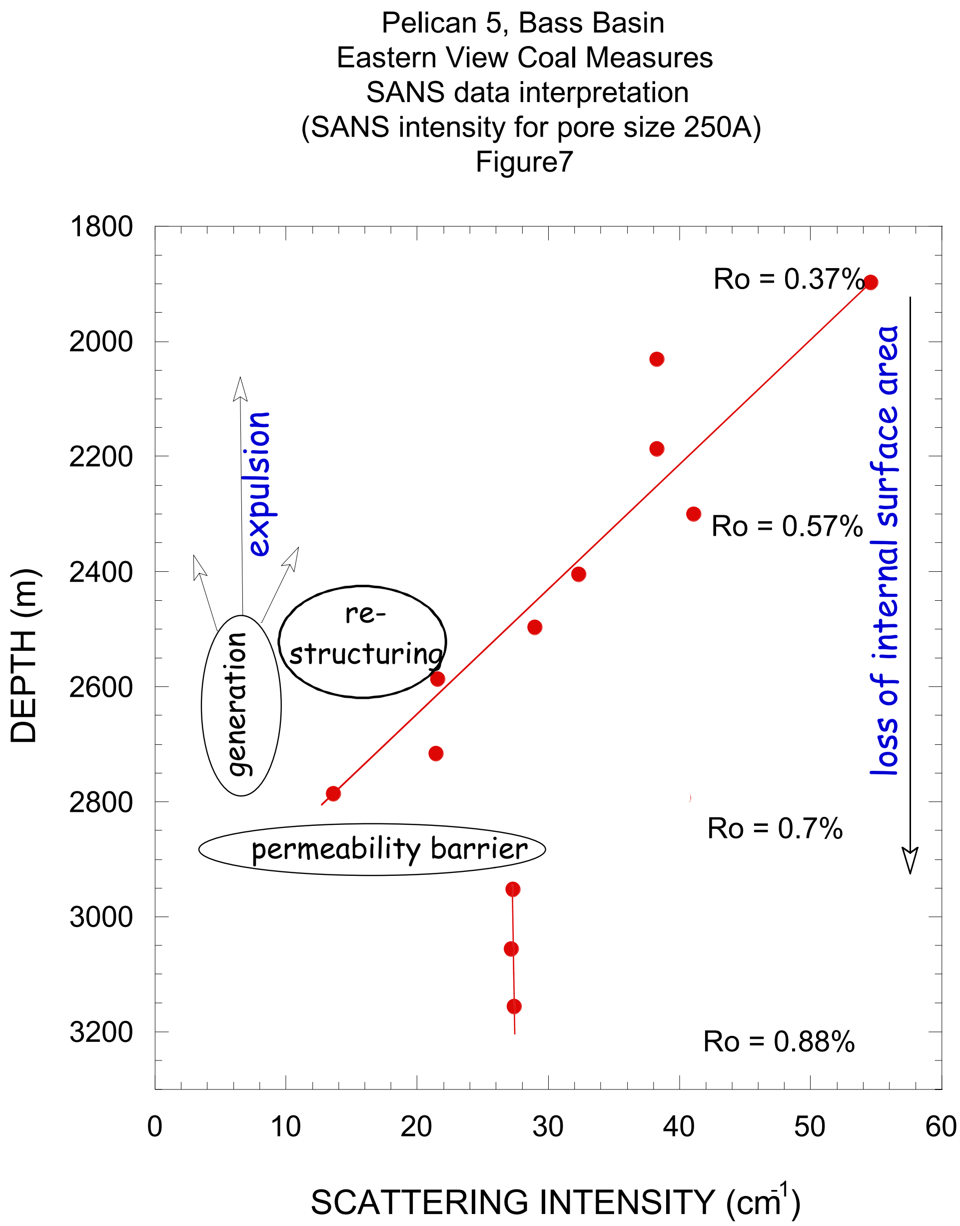


Figure H8. Depth plot of Hydrocarbon Index and Bitumen Index for low-ash coals from Pelican-5.

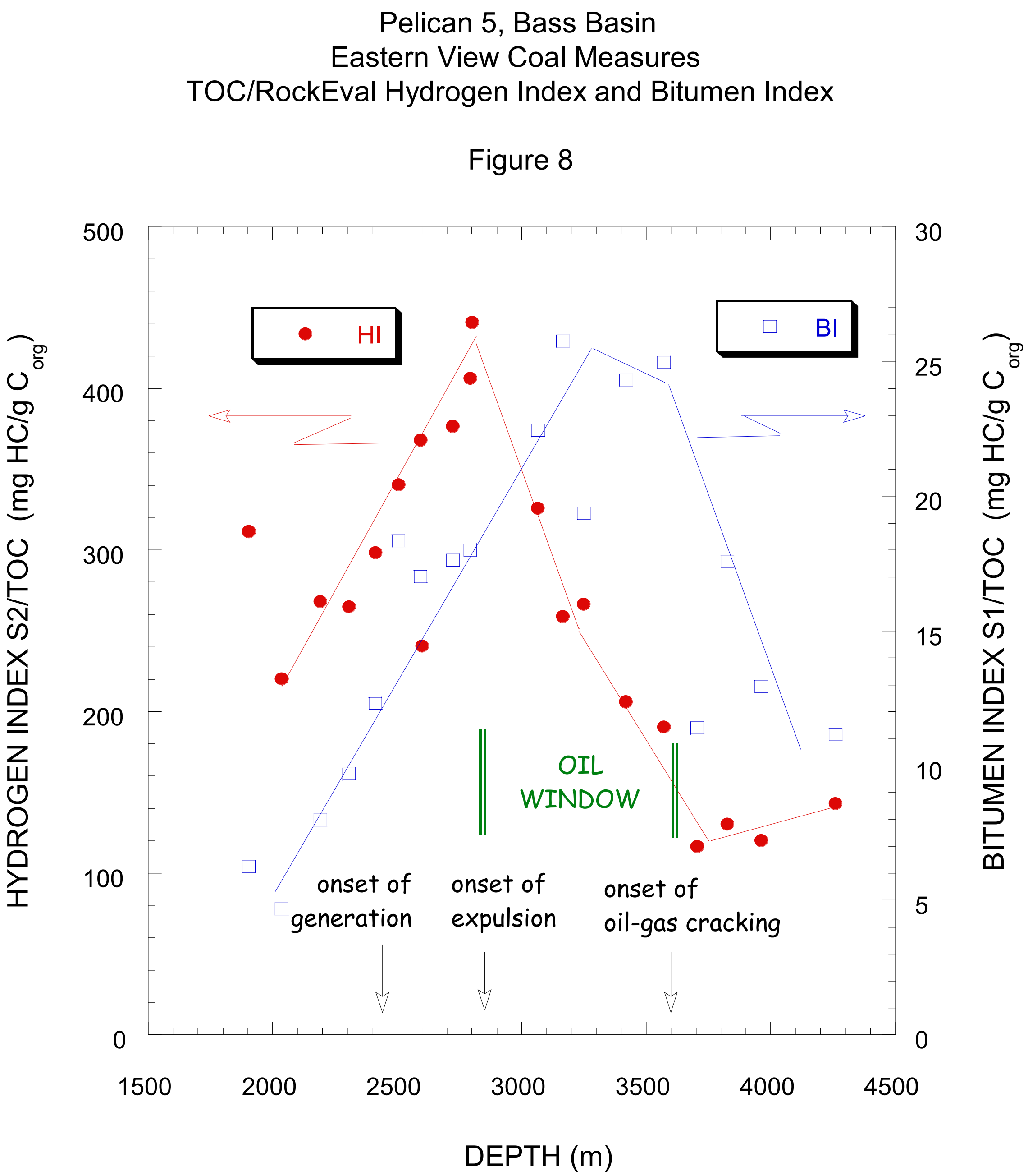


Figure H9. SANS scattering intensity versus Z for 20 low ash coal samples from Eastern View coal Measures, Cormorant-1. The legend shows depth of each sample.

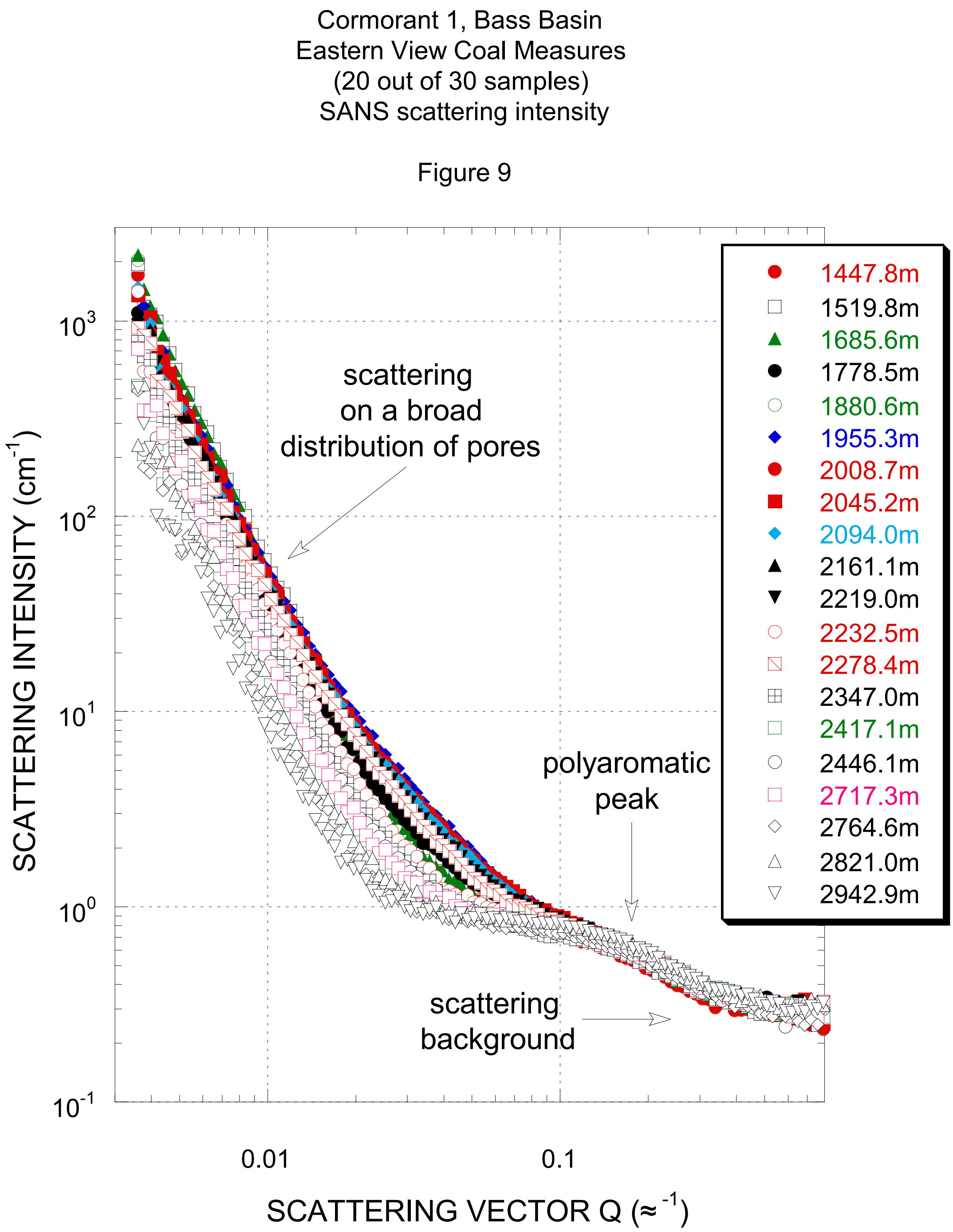


Figure H10. SANS ontensity at Q=0.01 Å^{-1} versus depth for 26 low ash coal samples from Cormorant-1. Data points for sidewall samples are marked "C".

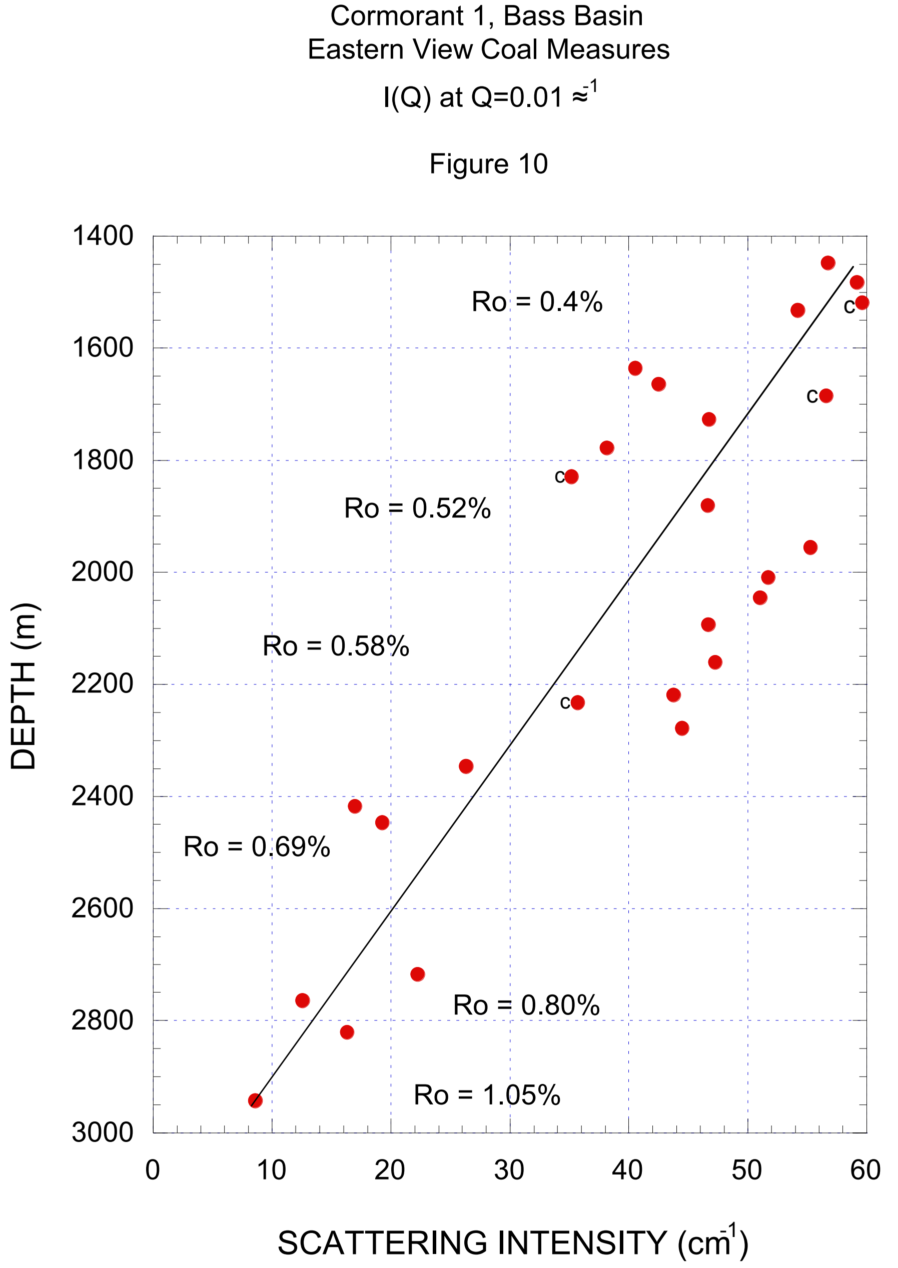


Figure H11. Variation of the pore size distribution with depth for low ash coal samples from Cormorant-1. Only pores of diameter in the range 80 – 800 Å are included.

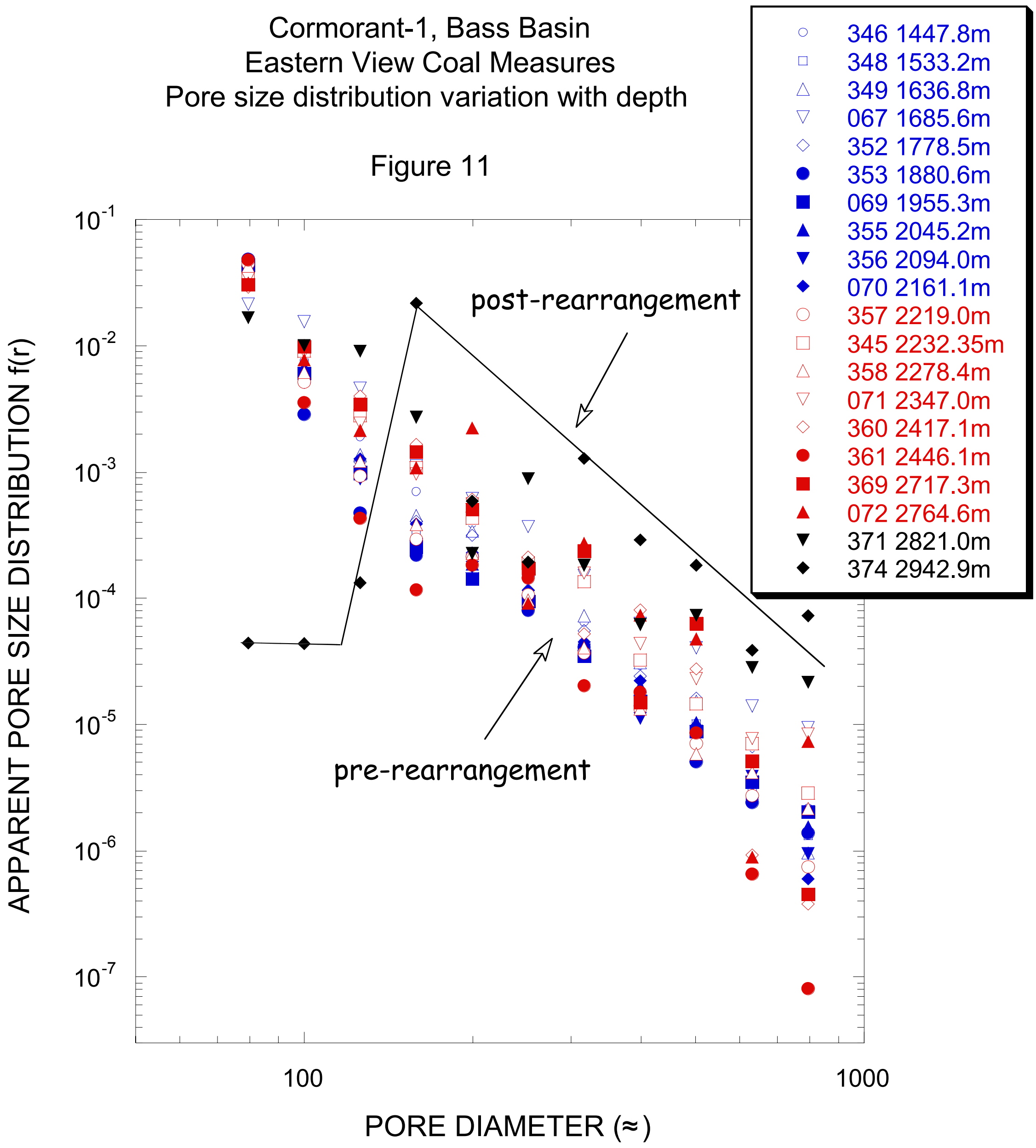


Figure H12. Variation of pore number density with depth for three pore sizes: 100 Å, 316 Å, and 630 Å, in Cormorant-1, Eastern View Coal Measures, low ash preparations.

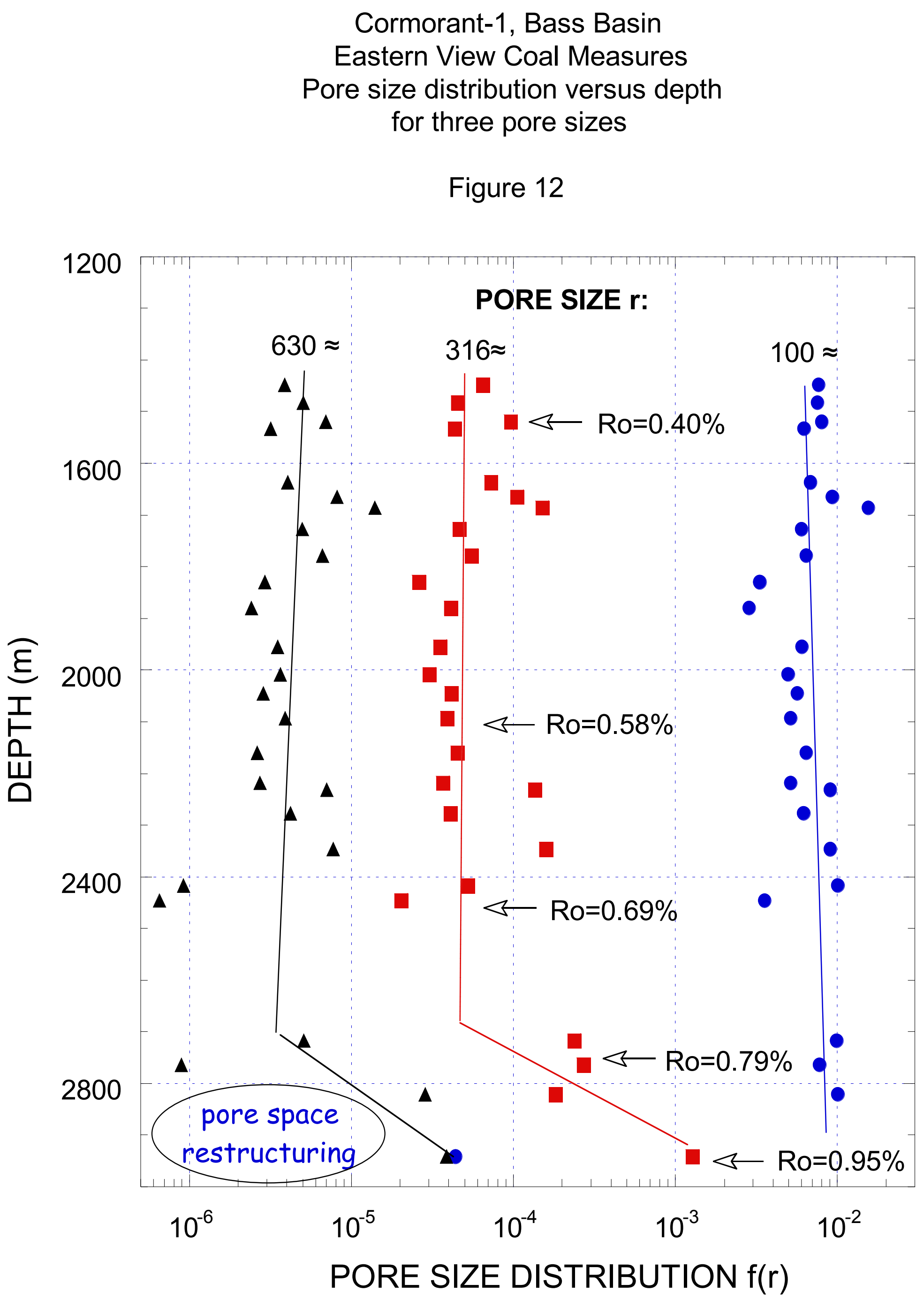


Figure H13. Specific internal surface area versus probe diameter calculated for 12 low ash coals from Cormorant-1.

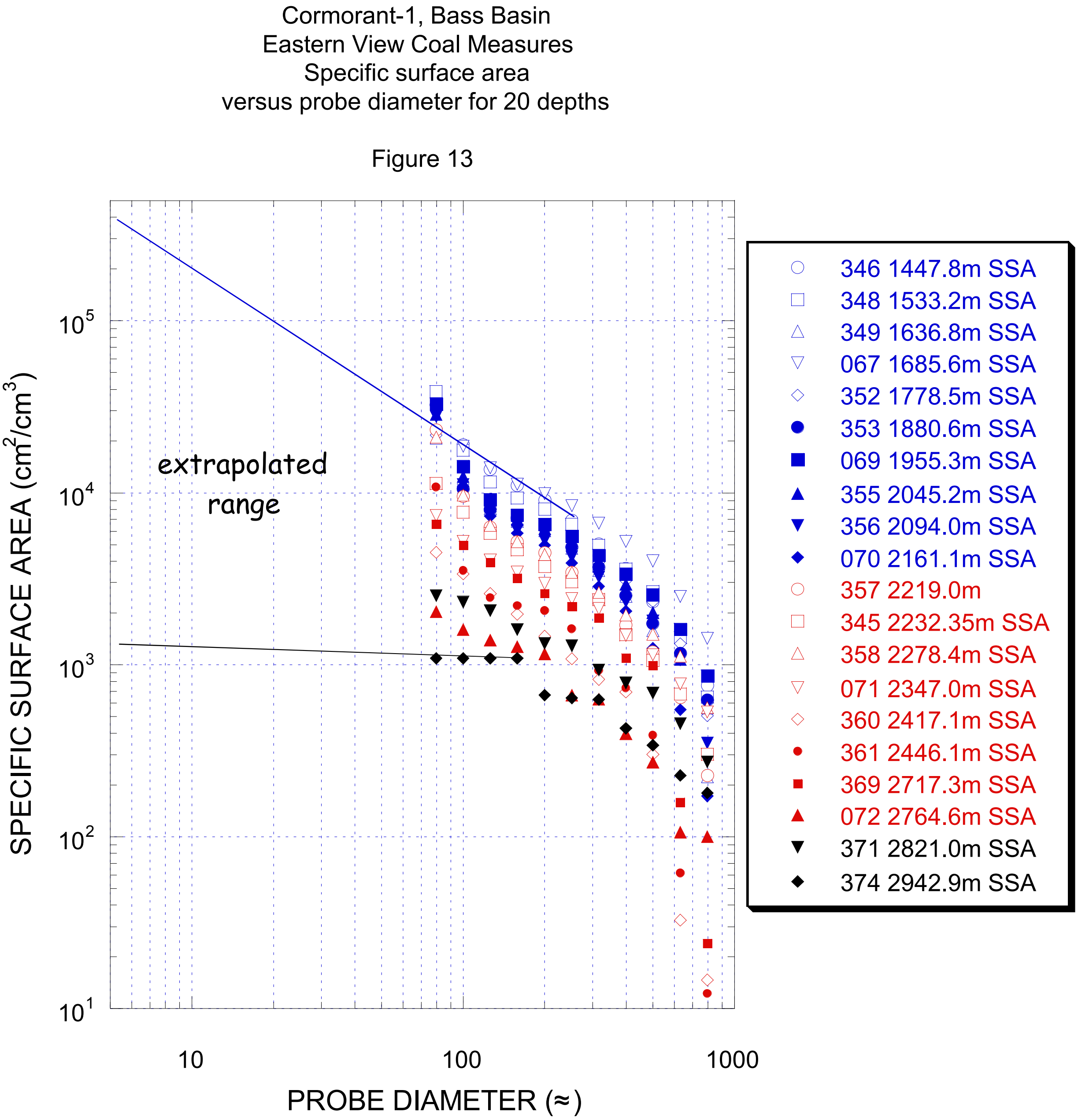


Figure H14. The variation of the specific surface area with depth for probe size 100 Å, low ash preparations, Eastern View Coal Measures, Cormorant-1.

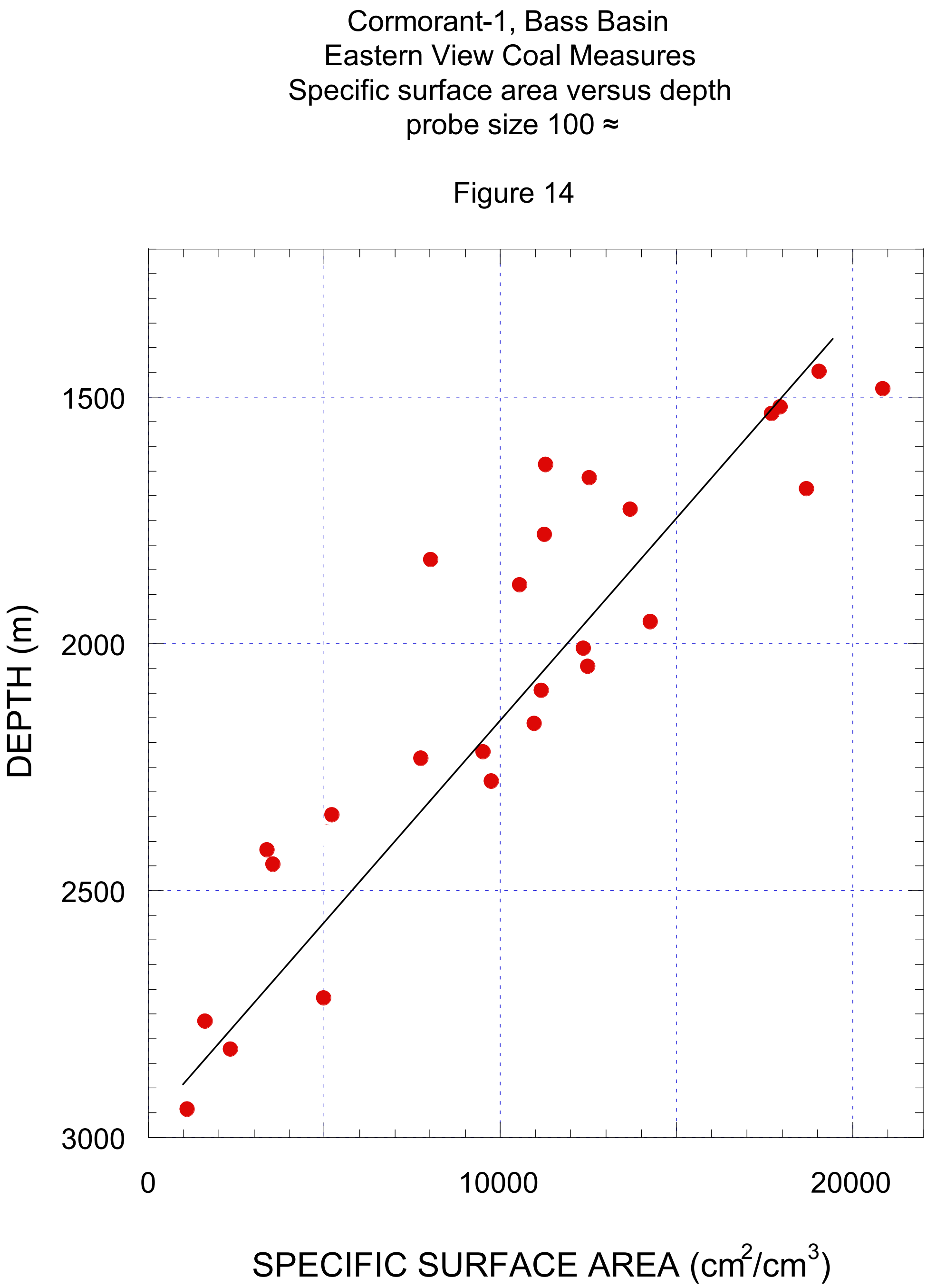


Figure H15. Interpretation of SANS data for Cormorant-1, micro-structural events, hydrocarbon generation and expulsion.

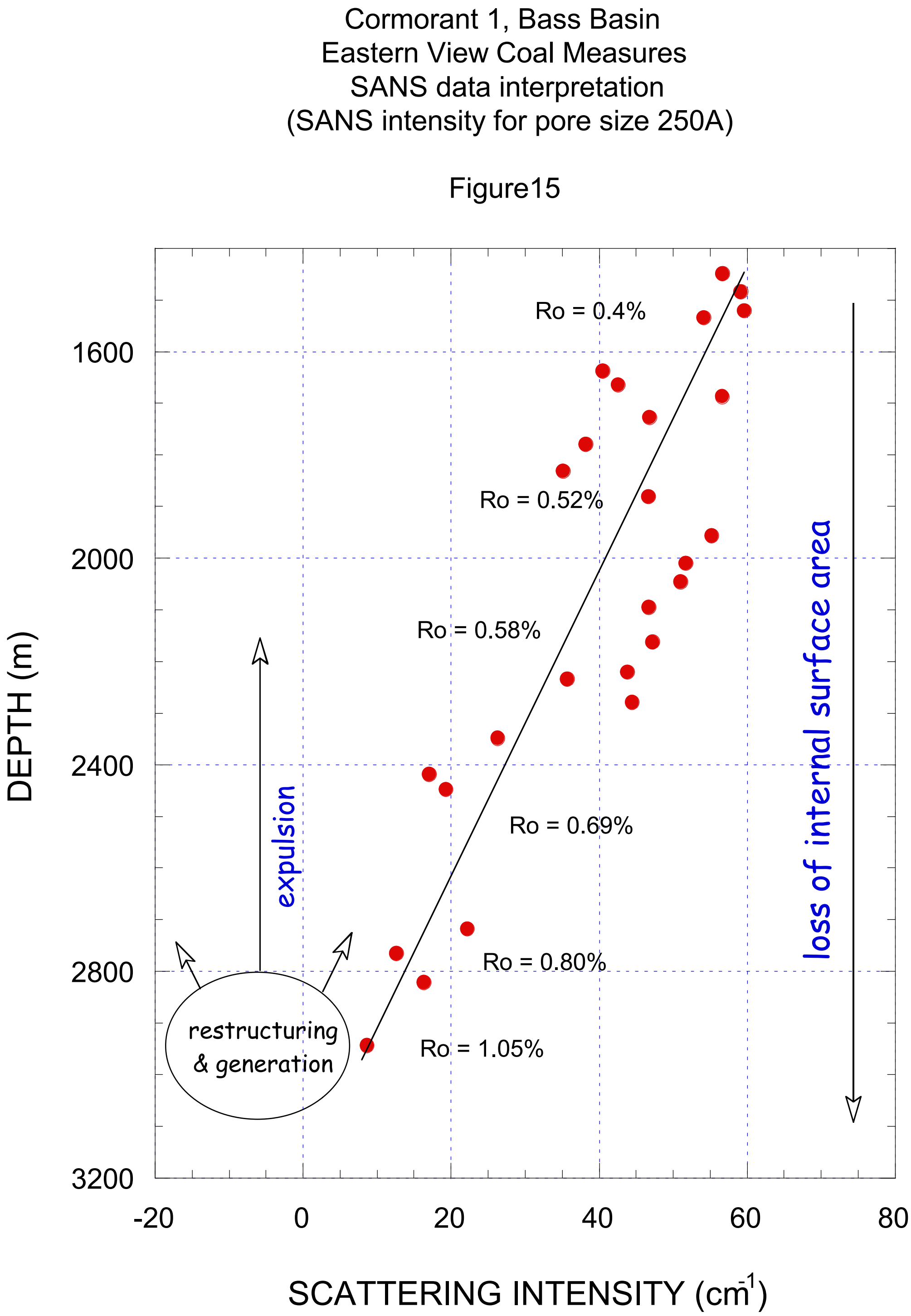


Figure H16. Vitrinite reflectance versus depth for Cormorant-1 and Pelican-5. The legends show parameters for second order polynomial fits.

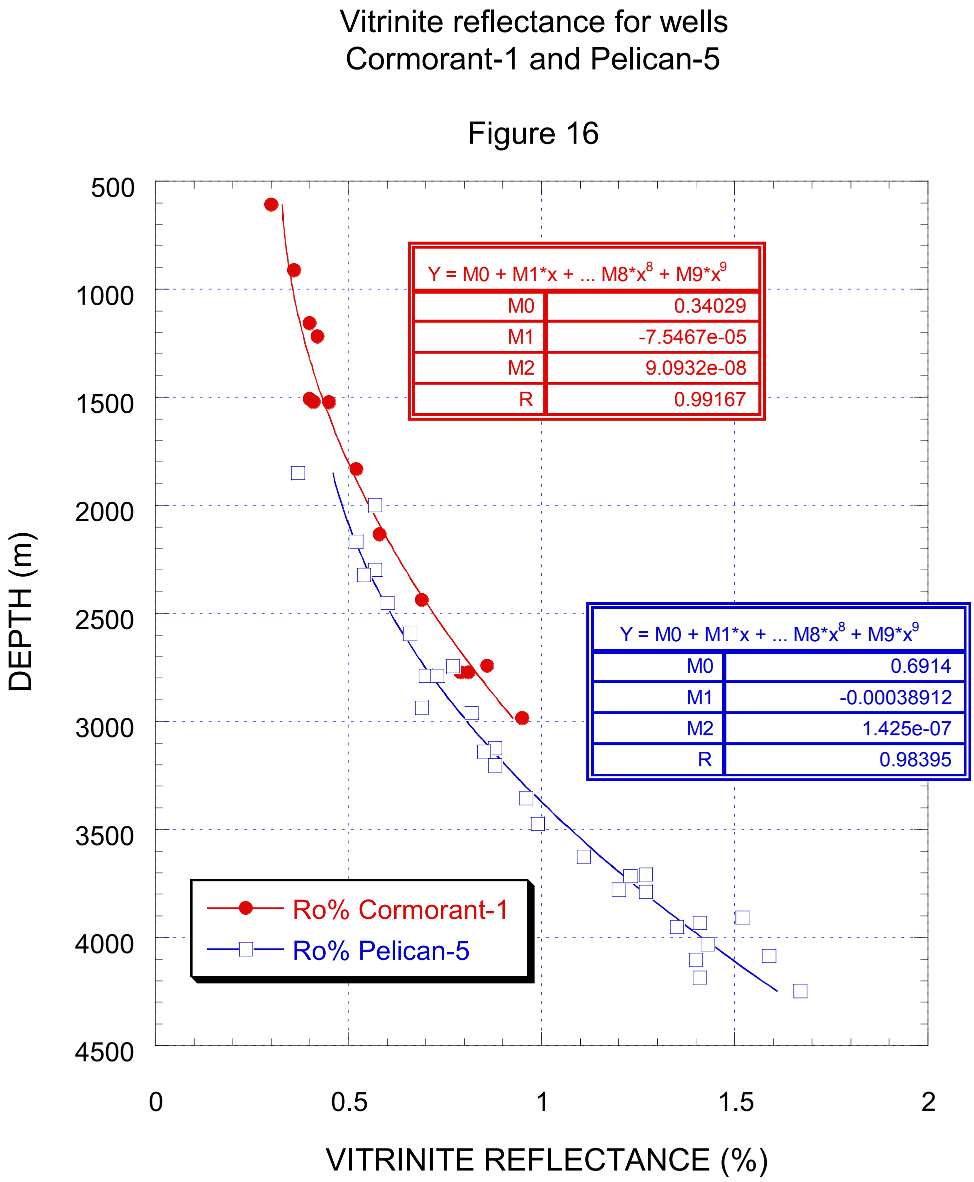
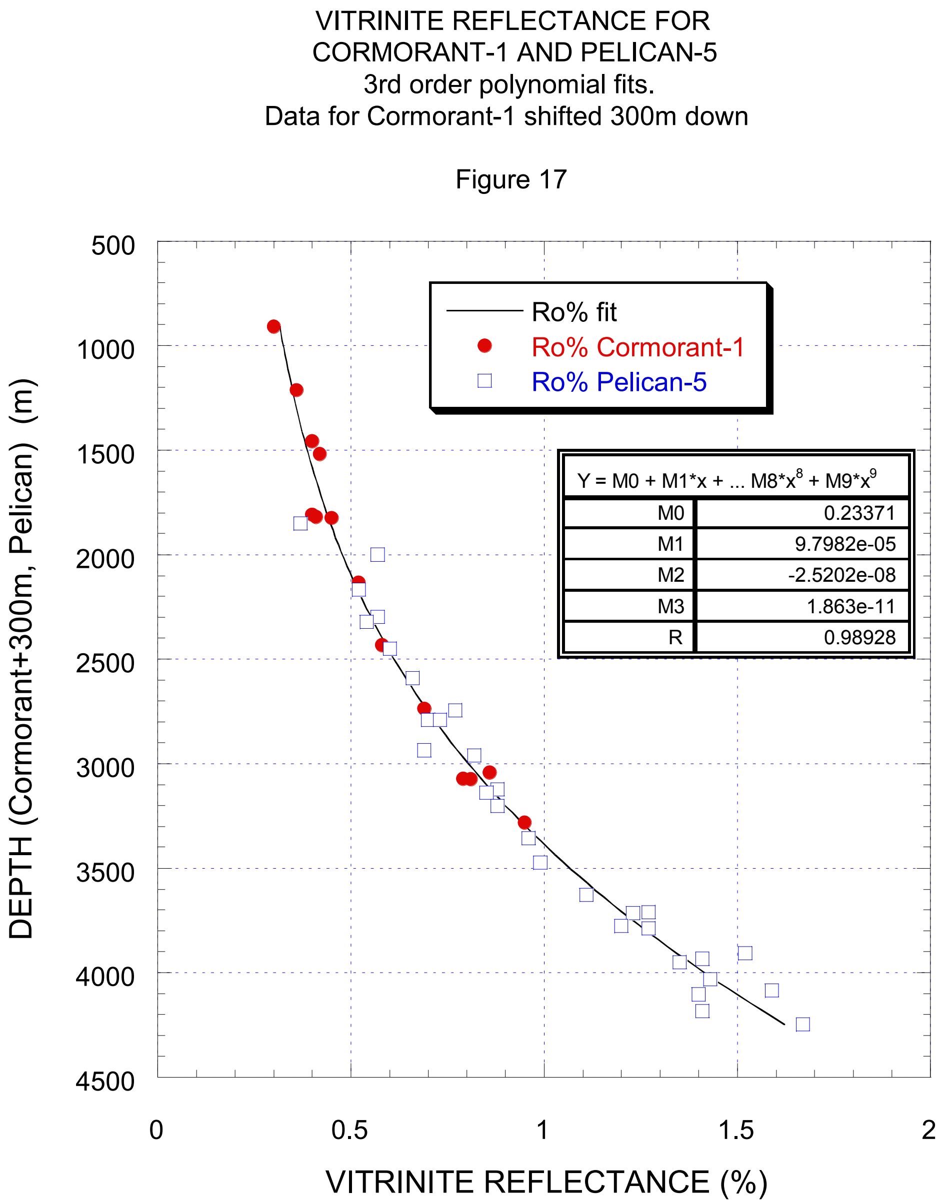


Figure H17. Universal representation for vitrinite reflectance versus effective depth for Cormorant-1 and Pelican-5. The legend shows parameters for a universal third order polynomial fit.



APPENDIX I.

ORGANIC PETROLOGY OF SUITES FROM A NUMBER OF PETROLEUM EXPLORATION BOREHOLES DRILLED IN THE BASS BASIN (MARCH 2002)

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Note: The format of this report has been altered. The contents are unchanged.

AROO-1, p 1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Lower Torquay Group (Early / Late Oligocene)
T8310	5740-5770	0.48	0.40-0.58	28	Rare lamalginite and liptodetrinite yellow to orange. (Siltstone> carbonate. Dom sparse, V>L>L. Vitrinite sparse, inertinite and liptinite rare. Fossil fragments sparse. Mineral fluorescence patchy weak orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	0.74	0.62-1.00	5	
					Upper Eastern View Coal Measures (Mid / Late Eocene)
T8311	6860-6880	0.56	0.47-0.65	28	Rare resinite and sporinite orange, rare *Botryococcus*-related telalginite yellow. (Siltstone>carbonate. Dom abundant, I>V>L. Inertinite and vitrinite abundant, liptinite rare. Mineral fluorescence patchy weak orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	0.96	0.75-1.24	17	
					Upper Eastern View Coal Measures (Mid Eocene)
T8312	7370-7380	0.55	0.50-0.65	27	Sparse cutinite orange to weak brown, sparse resinite greenish yellow, sparse sporinite orange to dull orange, rare lamalginite, orange rare suberinite dull orange to weak brown, rare liptodetrinite orange to dull orange, rare exsudatinite, orange. (Siltstone>carbonate>coal. Coal abundant, duroclarite>vitrite> vitrinertite, V>>L>I. Maceral group composition of coal (mf):: vitrinite-95.0%, inertinite-1.0%, liptinite-4.0%. Dom common, V>L>I. Vitrinite common, liptinite and inertinite sparse. Mineral fluorescence patchy weak dull orange to absent. Iron oxides common. Pyrite sparse.)
Ctgs	$\bar{R}_I$max	0.83	0.77-0.91	6	
					Upper Eastern View Coal Measures (Early / Mid Eocene)
T8313	7910-7920	0.64	0.53-0.72	28	Sparse cutinite orange to weak brown, sparse resinite greenish yellow to orange, sparse sporinite yellow to dull orange, rare lamalginite orange, rare suberinite dull orange to weak brown, rare liptodetrinite yellow to dull orange. (Siltstone>carbonate> coal. Coal abundant, vitrite>clarite, V>>L>I. Maceral group composition of coal (mf): vitrinite-97.0%, inertinite-0.2%, liptinite-2.8%. Dom common, V>L>I. Vitrinite and liptinite sparse, inertinite rare. Coals belong to the Upper Eastern View facies with most of the inertinite being sclerotinite rather than inertodetrinite and semifusinite. Mineral fluorescence patchy dull orange to absent. 'Frypanned' rims on coal rare but some strong alteration noted. Iron oxides abundant. Pyrite sparse.)
Ctgs	$\bar{R}_I$max	0.99	0.81-1.38	5	

					Mid/Upper Eastern View Coal Measures (Early Eocene)
T8314 Ctgs	8880-8890 $\bar{R}_I$max	0.67 1.23	0.57-0.77 0.90-1.67	33 10	Sparse sporinite orange, rare cutinite, resinite and lamalginite orange, rare liptodetrinite yellow to dull orange. (Siltstone> carbonate>coal. Coal sparse, duroclarite>vitrinertite. V>I>L. Maceral group composition of coal (mf): vitrinite-59.0%, inertinite-40.0%, liptinite-1.0%. Dom common, V>I>L. All three maceral groups sparse. The coal shows a change in organic facies to the Lower Eastern View B facies. Mineral fluorescence patchy dull orange to absent. 'Fry panned' rims on coal rare and relatively weak. Iron oxides abundant. Pyrite common.)
					Mid Eastern View Coal Measures (Upper Cretaceous)
T8315 Ctgs	11690-11700	-	-	-	Fluorescing liptinite absent. (Igneous rock fragments, doleritic. textures, but some grains strongly altered and with rosette structures. Dom absent, all maceral groups absent. Mineral fluorescence absent. Iron oxides major. Pyrite sparse.)

The Torquay Group sample is immature to marginally mature and contains sparse vitrinite. The next four samples are from the Eastern View Coal Measures and are early mature to mid-mature. T8311 to T8313 contain coals that belong to the Upper Eastern View organic facies of Smith and Cook (1984). T8314 belongs to the Lower Eastern View organic facies of Smith and Cook (1984). The deepest sample represents an igneous rock that is interpreted as being an intrusion although some strongly altered grains were noted that may be more consistent with a volcanic origin. No evidence of contact alteration was found in T8314 but it is nearly 3000' above the igneous horizon and effects would not normally be expected at this distance. Some frypanning effects were noted in coal grains. The rims of such grains and cracks within them, show higher reflectances, but the cores may show lower vitrinite reflectance values due probably to migration of tars into the coals. Some occurrences show relatively pervasive alteration rather than having the raised reflectances confined to rims and fractures. The presence of pervasive alteration and the lowering effects of heat alteration can make it difficult to assess the original reflectance of the vitrinite.

NOTE: "Frypanning" is the term given to a process where the sample has been raised during the initial drying process (usually at the rig site) to a temperature where the organic matter oxidizes. In coals it is apparent by the presence of high reflecting rims. In siliciclastic sediments, frypanning is generally seen either as zones where liptinite lack fluorescence or mineral fluorescence is weak or absent. The temperatures to cause heat alteration are variable but of the order of 300°C plus. Any temperatures over 400°C cause rapid heat alteration and may support continued combustion where the TOC is over about 30%. The exact temperatures at which alteration occurs depend in part on organic matter type and rank and in part on the duration of the heating. With coals, excessive heating produces an offensive odour that usually causes the process to be stopped. With other sediment types, the odour may not be as severe and heating effects are potentially more severe.

Frypanning has the effect of reducing TOC, raising reflectances (except where lower values are found within core zones) and lowering fluorescence intensity. The effects on Rock-Eval analyses are more difficult to predict. This is because the carbonaceous residue shows much higher Tmax and lower HI, but the tar devolatilization products driven into the grains ahead of the oxidation front are likely to show lower Tmax and higher HI values. Data from bulk analysis methods cannot readily be corrected for the effects of frypanning. Microscope analyses attempt to exclude the effects of the alteration that has occurred. Microscope methods are the normal method of detecting that samples have been affected by excessive temperatures during drying.

BASS-2

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Late Eocene)
T8317	3811.5	0.49	0.41-0.63	31	Rare cutinite, resinite and liptodetrinite yellow to dull orange, rare sporinite and lamalginite yellow to orange. (Siltstone. Dom sparse, V>I>L. Vitrinite sparse, inertinite and liptinite rare. Oil drops rare greenish yellow. Mineral fluorescence weak to absent. Iron oxides abundant. Pyrite abundant.)
Core	$\bar{R}_I$max	0.78	0.65-0.90	5	

BASS-3

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Late Eocene)
T8318	5300-5320	0.52	0.41-0.62	29	Rare lamalginite orange, rare sporinite orange. (Siltstone> carbonate. Dom sparse, V>I>L. Vitrinite sparse, inertinite and liptinite rare. Fossil fragments sparse. Mineral fluorescence patchy weak dull orange to absent. Iron oxides abundant. Pyrite abundant.)
Ctgs	$\bar{R}_I$max	0.85	0.68-1.47	10	

The Bass-2 and Bass-3 samples are marginally mature and contain sparse dom.

CHAT-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Late Eocene)
T8319	3966.5-4025.5	0.46	0.39-0.51	18	Fluorescing liptinite absent. (Carbonate>claystone>sandstone.. Dom rare, V>I. Vitrinite and inertinite rare, liptinite absent. Rare yellow oil inclusions within quartz grains. Mineral fluorescence absent. Iron oxides sparse. Pyrite common.)
Ctgs	$\bar{R}_I$max	0.68	0.60-0.77	4	
					Mid ECVM (Late Cretaceous/Maastrichtian)
T8320	7667.2-7677.1	0.49	0.39-0.62	31	Sparse cutinite yellow to dull orange, sparse lamalginite yellow to orange, sparse sporinite orange to dull orange, rare resinite greenish yellow to dull orange, rare liptodetrinite yellow to dull orange. Coal abundant, vitrite>duroclarite, V>I>>L. Maceral group composition of coal (mf): vitrinite-70.0%, inertinite-28.0%, liptinite-2.0%. Dom common, V>L>I. Vitrinite and liptinite sparse, inertinite rare. Lower Eastern View facies. Mineral fluorescence patchy orange to dull orange. Iron oxides sparse. Pyrite rare.)
Ctgs	$\bar{R}_I$max	1.28	1.01-1.54	5	

The Chat-1 samples are immature but rare oil inclusions were noted in some quartz grains. Frypanning was not a prominent feature of these samples.

NANGKERO-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Mid / Late Eocene)
T8321	6440-6460	0.52	0.45-0.62	28	Sparse cutinite orange dull orange to weak brown, sparse sporinite orange, sparse resinite yellow, sparse liptodetrinite orange to dull brown, rare suberinite dull orange to dull brown. (Carbonate>siltstone>coal. Coal abundant, clarite>vitrite. V>>L>I. Maceral group composition of coal (mf): vitrinite-93.0%, inertinite-1.0%, liptinite-6.0%. Dom common, V>L>I. All three maceral groups sparse. Mineral fluorescence patchy weak dull orange to absent. 'Frypanned' coal sparse. Iron oxides abundant. Pyrite sparse.)
Ctgs	$\bar{R}_I$max	0.80	0.74-0.92	6	
					Mid EVCM (Cretaceous / Paleocene Boundary)
T8322	8290-8300	0.57	0.48-0.66	32	Sparse resinite greenish yellow to orange, sparse sporinite yellow to orange, sparse cutinite dull orange to weak brown, rare liptodetrinite orange to dull orange, rare suberinite dull orange to dull brown. (Calcareous siltstone>coal. Coal abundant, clarite> vitrite. V>>L>I. Maceral group composition of coal (mf): vitrinite-91.0%, inertinite-1.0%, liptinite-8.0%. Dom sparse, V>I>L. Vitrinite and inertinite sparse, liptinite rare. 'Frypanned' coal common. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite sparse to common.)
Ctgs	$\bar{R}_I$max	0.85	0.82-0.89	5	

The two samples are early mature and both appear to belong to the Upper Eastern View Facies although the deeper sample may be transitional to the Lower Eastern View facies. Frypanning is present in both samples.

NARIMBA-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Mid Upper Eastern View Coal Measures (Early Eocene)
T8323	7810-7820	0.59	0.51-0.66	31	Sparse cutinite dull orange to weak brown, sparse sporinite orange to dull orange, sparse resinite greenish yellow to dull orange, rare lamalginite orange, rare liptodetrinite orange to dull orange. (Carbonate>siltstone>coal. Coal abundant, vitrite> clarite. V>>L>I. Maceral group composition of coal (mf): vitrinite-92.0%, inertinite-<0.1%, liptinite-8.0%. Dom common, V>L>I. Vitrinite common, liptinite sparse, inertinite rare. Upper Eastern View facies. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	1.55	1.19-1.83	3	

The sample is early mature and the coal belongs to the Upper Eastern View facies.

PELICAN-3

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Late Eocene)
T8324	5820-5880	0.51	0.41-0.59	27	Rare sporinite orange, rare lamalginite and liptodetrinite yellow to orange. (Claystone>carbonate. Dom sparse, V>I>L. Vitrinite sparse, inertinite and liptinite rare. Oil drops rare greenish yellow. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	0.73	0.70-0.78	4	
					Upper Eastern View Coal Measures (Mid / Late Eocene)
T8325	6210-6240	0.53	0.44-0.65	27	Common cutinite orange to weak brown, sparse resinite greenish yellow to dull orange, sparse suberinite dull orange to weak brown, sparse sporinite yellow to dull orange, rare liptodetrinite orange to dull orange. (Siltstone>>coal. Coal abundant, clarite> vitrite. V>>L>I. Maceral group composition of coal (mf): vitrinite-87.0%, inertinite-3.0%, liptinite-10.0%. Dom sparse, V>I>L. Vitrinite sparse, inertinite and liptinite rare. 'Frypanned' coal common. Mineral fluorescence absent. Iron oxides abundant. Pyrite abundant.)
Ctgs	$\bar{R}_I$max	0.88	0.75-1.10	6	
					Upper Eastern View Coal Measures (Early Eocene)
T8326	7190-7200	0.59	0.49-0.67	31	Abundant suberinite dull orange to weak brown, abundant resinite greenish yellow to dull orange, abundant sporinite yellow to dull orange, abundant cutinite orange to weak brown, common liptodetrinite orange to dull orange. (Coal>>claystone> carbonate. Coal dominant, clarite>vitrite>liptite. V>>L>I. Maceral group composition of coal (mf): vitrinite-83.0%, inertinite-1.0%, liptinite-16.0%. Dom sparse, V>L>I. Vitrinite sparse, liptinite and inertinite rare. 'Frypanned' coal rare. Mineral fluorescence absent. Iron oxides sparse. Pyrite rare.)
Ctgs	$\bar{R}_I$max	0.97	0.83-1.07	6	

The three sample are all early mature and the organic facies is the Upper Eastern View facies.

SEAL-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Base of Demons Bluff Formation
T8327	3280.8-3313.6	0.43	0.40-0.49	26	Rare cutinite orange to dull orange, rare resinite yellow to dull orange, rare sporinite orange, rare liptodetrinite yellow to dull orange. (Carbonate>siltstone>sandstone>coal. Coal sparse, duroclarite> clarite>vitrite. V>>L>I. Dom sparse, V>L>I. Vitrinite sparse, liptinite and inertinite rare. Higher plant inertinite prominent. Rare yellow oil inclusions within quartz grains. Glauconite rare. Mineral fluorescence patchy orange to absent. Iron oxides common. Major siderite. Pyrite common.)
Ctgs	$\bar{R}_I$max	1.03	0.70-1.40	6	

The section sampled is immature but rare oil inclusions were noted within quartz grains.

TAROOK-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Top Upper Eastern View Coal Measures (Late Eocene)
T8328	6100-6160	0.52	0.44-0.58	18	Rare cutinite dull orange, rare liptodetrinite orange to dull orange. (Siltstone>>carbonate. Dom sparse, I>V>L. Inertinite and vitrinite sparse, liptinite rare. Mineral fluorescence patchy dull orange to absent. Iron oxides common. Pyrite abundant.)
Ctgs	$\bar{R}_I$max	0.83	0.73-1.15	9	
					Upper Eastern View Coal Measures (Mid Eocene)
T8329	6860-6870	0.53	0.46-0.61	28	Sparse cutinite and suberinite dull orange weak brown, sparse resinite yellow to dull orange, rare sporinite yellow to dull orange, rare liptodetrinite orange to dull orange. (Calcareous siltstone>carbonate>siltstone>coal. Coal abundant, clarite> vitrite. V>>L>I. Maceral group composition of coal (mf): vitrinite-91.0%, inertinite-<0.1%, liptinite-9.0%. Dom sparse, V>I>L. Vitrinite and inertinite sparse, liptinite rare. Exsudatinite rare, yellow to orange. Mineral fluorescence patchy orange to absent. Iron oxides common. Pyrite abundant.)
Ctgs	$\bar{R}_I$max	0.86	0.75-1.00	5	
					Upper Eastern View Coal Measures (Early Eocene)
T8330	7400-7430	0.54	0.46-0.61	27	Sparse cutinite and suberinite dull orange to weak brown, sparse resinite greenish yellow to orange, sparse sporinite orange to dull orange, rare lamalginite and liptodetrinite orange to dull orange. (Siltstone>carbonate>coal. Coal abundant, duroclarite>clarite> vitrite. V>>I>L. Maceral group composition of coal (mf): vitrinite-88.6%, inertinite-1.4%, liptinite-10.0%. Dom common, V>L>I. All three maceral groups sparse. Oil drops rare, greenish yellow, some green oil haze developed on standing. 'Frypanned' coal sparse, effects widespread and penetrative. Mineral fluorescence patchy orange to absent. Iron oxides common. Pyrite abundant.)
Ctgs	$\bar{R}_I$max	0.96	0.90-1.06	5	
					Upper Eastern View Coal Measures (Early Eocene)
T8331	7820-7850	0.58	0.50-0.67	27	Sparse cutinite dull orange weak brown, sparse resinite greenish yellow to dull orange, sparse sporinite orange to dull orange, rare liptodetrinite orange to dull orange. (Siltstone>carbonate> coal. Coal abundant, clarite>vitrite. V>>I>L. Maceral group composition of coal (mf): vitrinite-95.8%, inertinite-0.2%, liptinite-4.0%. Dom common, V>L>I. All three maceral groups sparse. Fossil fragments rare. 'Frypanned' coal common and effects are penetrative. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	1.02	0.85-1.17	5	
					Upper Eastern View Coal Measures (Early Eocene)
T8332	8340-8380	0.61	0.50-0.67	29	Sparse cutinite orange to dull orange, sparse suberinite dull orange to dull brown, sparse resinite and sporinite yellow to dull orange, sparse lamalginite orange to dull orange, sparse *Botryococcus*-related telalginite orange, rare liptodetrinite orange to dull orange. (Siltstone>carbonate>coal. Coal abundant, clarite >vitrite>duroclarite. V>>I>L. Maceral group composition of coal (mf): vitrinite-91.9%, inertinite-0.1%, liptinite-8.0%. Dom abundant, V>L>I. Vitrinite abundant, liptinite common, inertinite rare. 'Frypanned' coal sparse. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite common.)
Ctgs	$\bar{R}_I$max	0.98	0.85-1.10	5	

Frypanning of samples has been extensive and although oxidized rims were excluded and care was taken to exclude grains where the whole grains had elevated reflectances, it is possible that the vitrinite reflectance values for T8330 and T8331 are too high, possibly by about 0.04%. The section sampled ranges from early to mid-mature and all belong to the Upper Eastern View facies.

TOOLKA-1a

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Late Eocene)
T8333 Ctgs	4880-4900	0.60	0.49-0.70	28	Sparse cutinite orange to weak brown, sparse suberinite dull orange to weak brown, rare resinite yellow to dull orange, rare sporinite and liptodetrinite yellow to dull orange, rare lamalginite dull orange. (Siltstone>carbonate>coal. Coal abundant, vitrite> clarite. V>>L>I. Maceral group composition of coal (mf): vitrinite-97.0%, inertinite-<0.1%, liptinite-3.0%. Dom common, V>I>L. Vitrinite common, inertinite and liptinite rare. 'Frypanned' coal abundant and effects are penetrative. Mineral fluorescence absent. Iron oxides abundant. Pyrite common.)
					Upper Eastern View Coal Measures (Early / Mid Eocene)
T8334 Ctgs	5580-5600 $\bar{R}_I$max	0.57 1.00	0.46-0.70 0.95-1.05	26 5	Sparse cutinite and resinite yellow to dull orange, sparse suberinite dull orange to weak brown, rare sporinite yellow to dull orange, rare liptodetrinite orange to dull orange. (Siltstone> calcareous siltstone>coal. Coal abundant, vitrite>clarite, V>>L>I. Maceral group composition of coal (mf): vitrinite-95.0%, inertinite-2.0%, liptinite-3.0%. Dom common, V>L>I. Vitrinite common, inertinite and liptinite sparse. Exsudatinite rare, yellow. 'Frypanned' coal common and effects are penetrative. Mineral fluorescence patchy orange to absent. Iron oxides abundant. Pyrite common.)
					Mid/Upper Eastern View Coal Measures (Early Eocene)
T8335 Ctgs	6090-6100 $\bar{R}_I$max	0.58 1.00	0.50-0.72 0.87-1.15	30 6	Sparse resinite greenish yellow to dull orange, sparse cutinite and suberinite dull orange to weak brown, sparse lamalginite orange to dull orange, rare sporinite yellow to dull orange, rare liptodetrinite orange to dull orange. (Siltstone>coal. Coal abundant, vitrite>clarite. V>>L>I. Maceral group composition of coal (mf): vitrinite-95.9%, inertinite-0.1%, liptinite-4.0%. Dom abundant, V>L>I. Vitrinite abundant, liptinite common, inertinite rare. Facies is generally Upper Eastern View but may be transitional to Lower Eastern View facies.. 'Frypanned' coal rare. Mineral fluorescence patchy dull orange to absent. Iron oxides abundant. Pyrite sparse.)

The value for the shallowest of the samples may be higher due to the effects of frypanning, but a corrected value is not less than 0.55%. T8335 is probably the least affected of the three. The section sampled is marginally mature.

YURONGI-1

KK # Ref #.	Depth (ft) /Type	$\bar{R}_v$max	Range	N	Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					Upper Eastern View Coal Measures (Mid / Late Eocene)
T8336 Ctgs	4710-4740	0.41	0.36-0.50	31	Abundant resinite yellow to dull orange, common cutinite dull orange, common suberinite dull orange to weak brown, sparse sporinite yellow to orange, sparse *Botryococcus*-related telalginite bright orange, sparse liptodetrinite yellow to dull orange. (Coal>siltstone>carbonate. Coal dominant, vitrite> clarite. V>>L>I. Maceral group composition of coal (mf): vitrinite-90.0%, inertinite-<0.1%, liptinite-10.0%. Dom sparse, V>L>I. Vitrinite and liptinite sparse, inertinite rare. Exsudatinite sparse, yellow. Mineral fluorescence absent. Iron oxides common. Pyrite sparse.)
					Upper Eastern View Coal Measures (Early Eocene)
T8337 Ctgs	5580-5600 $\bar{R}_I$max	0.60 0.97	0.46-0.70 0.90-1.05	30 6	Sparse suberinite and cutinite dull orange to weak brown, sparse resinite and sporinite yellow to dull orange, rare liptodetrinite orange to dull orange. (Carbonate>sandstone.coal. Coal major, duroclarite>vitrite. V>>I>L. Maceral group composition of coal (mf): vitrinite-85.0%, inertinite-11.0%, liptinite-4.0%. Dom rare, V>L>I. All three maceral groups rare. 'Frypanned' coal abundant and effects are extensive and intensive so that unaltered coal is difficult to find. It appears that the dom may be less affected. Mineral fluorescence patchy dull orange to absent. Iron oxides common. Pyrite sparse.)

The difference in vitrinite reflectance between the two samples may have been exaggerated by the effects of frypanning. T8336 is immature and T8337 is probably best interpreted as marginally mature.

Samples collected for vitrinite analyses, 23-25 October 2001, Petroleum Data Repositories, Geoscience Australia. Stratigraphic Codes: DB – Demons Bluff Formation, EVCM – Eastern View Coal Measures

Well	Sample	Inverval/s				Sample Type	Stratigraphic Location	Strat Tops m (KB)
		Depth (KB) m		Depth (KB) ft				
		Top	Base	Top				
Aroo-1	**1**	1749.6	1758.7	5740	5770	Cuttings	Lower Torquay Group (Early/Late Oligocene)	DB = 1814m
	2	2090.9	2097.0	6860	6880	Cuttings	Upper EVCM - Mid/Late Eocene	EVCM = 2052m
	3	2246.4	2249.4	7370	7380	Cuttings	Upper EVCM - Mid Eocene	
	4	2411.0	2414.0	7910	7920	Cuttings	Upper EVCM - Early/Mid Eocene	
	5	2706.6	2709.7	8880	8890	Cuttings	Mid/Upper EVCM - Early Eocene	
	6	3563.1	3566.2	11690	11700	Cuttings	Mid EVCM - Upper Cretaceous	
Bass-2	**1**	1161.7		3811.5		Core	Upper EVCM - Late Eocene	DB = 1103m EVCM = 1170m
Bass-3	**1**	1615.4	1618.5	5300	5310	Cuttings composite over two intervals	Upper EVCM - Late Eocene	DB = 1434m
		1618.5	1621.5	5310	5320			EVCM = 1170m
Chat-1	**1**	1209	1218	3966.5	3996.0	Cuttings composite over two intervals	Upper EVCM - Late Eocene	DB = 1071m
		1218	1227	3996.0	4025.5			EVCM = 1181m
	2	2337	2340	7667.2	7677.1		Mid EVCM - Late Cretaceous (Maastrictian)	
Nangkero-1	**1**	1962.9	1969.0	6440	6460	Cuttings	Upper EVCM - Mid/Late Eocene	DB = 1752m
	2	2526.8	2529.8	8290	8300	Cuttings	Mid EVCM - Cretaceous/Palaeoce Boundary	EVCM = 1881m
Narimba-1	**1**	2380.5	2383.5	7810	7820	Cuttings	Mid/Upper EVCM - Early Eocene	DB = 1654m EVCM = 1793m
Pelican-3	**1**	1773.9	1783.1	5820	5850	Cuttings composite over two intervals	Upper EVCM - Late Eocene	DB = 1665m
		1783.1	1792.2	5850	5880			EVCM = 1786m
	2	1892.8	1902.0	6210	6240	Cuttings	Upper EVCM - Mid/Late Eocene	
	3	2191.5	2194.6	7190	7200	Cuttings	Upper EVCM - Early Eocene	
Seal	**1**	1000	1010	3280.8	3313.6	Cuttings	Base of Demons Bluff Fm	DB = 885m EVCM = 1004m

Tarook-1	**1**	1859.3	1865.4	6100	6120	Cuttings composite over three intervals	Top Upper EVCM - Late Eocene	DB = 1726m
		1865.4	1871.5	6120	6140			EVCM = 1862m
		1871.5	1877.6	6140	6160			
	2	2090.9	2094.0	6860	6870	Cuttings composite over two intervals	Upper EVCM - Mid Eocene	
		2094.0	2097.0	6870	6880			
	3	2255.5	2258.6	7400	7410	Cuttings composite over three intervals	Upper EVCM - Early Eocene	
		2258.6	2261.6	7410	7420			
		2261.6	2264.7	7420	7430			
	4	2383.5	2386.6	7820	7830	Cuttings composite over three intervals	Upper EVCM - Early Eocene	
		2386.6	2389.6	7830	7840			
		2389.6	2392.7	7840	7850			
	5	2542.0	2545.1	8340	8350	Cuttings composite over four intervals	Upper EVCM - Early Eocene	
		2545.1	2548.1	8350	8360			
		2548.1	2551.2	8360	8370			
		2551.2	2554.2	8370	8380			
Toolka-1A	**1**	1487.4	1493.5	4880	4900	Cuttings	Upper EVCM - Late Eocene	DB = 1104m
	2	1700.8	1706.9	5580	5600	Cuttings	Upper EVCM - Earl/Mid Eocene	EVCM = 1330m
	3	1856.2	1859.3	6090	6100	Cuttings	Mid/Upper EVCM - Early Eocene	
Yurongi-1	**1**	1435.6	1444.8	4710	4740	Cuttings	Upper EVCM - Mid/Late Eocene	DB = 1302m
	2	1700.8	1706.9	5580	5600	Cuttings	Upper EVCM - Early Eocene	EVCM = 1379m

APPENDIX J.

UNCORRECTED BOTTOM HOLE TEMPERATURE DATA FOR BASS BASIN WELLS

Aaron Cummings and Peter Tingate, National Centre for Petroleum Geology and Geophysics

Well	Depth m	Temperature °C	Time Since Circulation (hrs)	Circulation Time (hrs)
Aroo-1	923.54	121.11	-	-
	2951.99	106.11	-	-
	3222.35	121.11	-	-
	3429.30	121.11	-	-
	3649.37	127.22	-	-
	3652.11	138.89	-	-
Bass-1	701.04	40.00	3	-
	1952.85	75.00	4	-
	2349.40	96.67	3	-
Bass-2	640.08	36.67	2	-
	640.08	36.67	4	-
	1687.37	68.33	4	-
	1800.45	72.22	4	-
Bass-3	853.74	46.11	3	-
	1900.43	83.33	2	-
	1900.43	86.11	3	-
	2411.27	96.11	2	-
	2433.83	97.78	3	-
Chat-1	3107.00	98.90	8	1.92
	3107.00	104.40	16.25	1.62
Cormorant-1	915.01	38.89	4	-
	915.01	40.00	6	-
	2640.48	80.00	5	-
	3000.76	92.22	5	-
	3000.76	71.11	9	-
	3000.76	114.44	19	-
Dondu-1	2577.08	115.56	7	-
	2577.08	108.89	7.5	-
	2695.96	111.11	11	-
	2926.99	92.22	3.5	-
	2926.99	116.67	4	-
	2926.99	119.44	6	-
	2926.99	126.67	11	-
Durroon - 1	933.60	35.56	7	-
	933.60	35.56	12	-
	1838.00	63.89	16	-
	1838.00	63.89	10.5	-
	1838.00	62.78	5	-
	3021.50	80.00	5	-
	3021.50	91.11	11	-

Flinders-1	1252.00	48.30	7.9	2.9
	2718.80	116.70	13.6	1.3
	2718.80	123.30	20.6	1.3
	2718.80	126.10	38.1	1.3
King-1	1239.20	56.70	10	2
	2225.20	83.30	10	3.5
	2225.20	88.30	14.1	3.5
	2225.20	92.20	26.4	3.5
	2225.20	100.00	34.1	3.5
	2225.20	102.20	38.4	3.5
	1486.00	63.70	14.5	2.5
	1436.25	62.00	16.8	2.5
	1460.00	64.30	21.2	2.5
	2122.00	88.30	26.7	2.5
Konkon-1	1537.11	76.11	4.5	-
	1537.11	65.56	5.5	-
	1537.11	68.89	7.5	-
Koorkah-1	1598.98	58.89	4	-
	3146.15	98.89	7.5	-
	3149.19	120.00	18	-
	3146.15	125.56	23.5	-
	3146.15	131.67	33	-
Nangkero-1	1005.84	44.44	3	-
	1005.84	44.44	6	-
	990.60	41.11	5	-
	2877.31	86.67	5	-
	2877.31	93.89	11	-
	2877.31	97.78	18	-
Narimba-1	2684.68	120.00	9	-
	2686.20	85.00	5	-
	2686.20	92.78	8	-
	2686.20	108.33	25	-
	2914.19	107.78	2.5	-
	2914.19	113.89	7	-
	3018.74	114.44	4	-
	3018.74	117.78	6	-
	3169.92	128.89	13	-
	3170.53	127.78	17	-
	3353.71	129.44	7.5	-
	3353.71	130.00	9.5	-
	3353.71	138.89	17	-
Pelican-1	2602.99	120.00	5	-
	2612.14	86.11	5	-
	2612.14	96.11	15	-
	2621.28	84.44	2.5	-
	2621.28	98.89	9	-
	3178.45	114.44	2.5	-
	3178.45	114.44	3	-
	3178.45	112.78	3.5	-
	3178.45	112.78	4	-

Pelican-2	2838.30	87.78	8	-
	2879.45	92.22	3	-
	2894.08	107.22	5	-
	2894.08	98.33	7	-
	2932.18	87.78	4.5	-
	3068.12	90.00	3	-
	3068.12	87.78	4	-
	3068.12	92.22	10	-
Pelican-3	2864.21	100.00	6.5	-
	2902.00	93.89	5	-
	2905.96	95.56	6	-
Pelican-4	872.95	37.78	3	-
	872.95	43.33	6	-
	2552.09	88.33	6	-
	2869.08	97.78	6	-
	2869.08	97.78	9	-
	2869.08	97.78	15	-
	2869.08	112.22	6	-
	2869.08	112.22	9	-
	2869.08	113.89	15	-
	3050.74	108.89	11	-
	3050.74	106.11	11.5	-
	3050.74	115.56	14	-
Pelican-5	1776.07	64.44	18	-
	3002.28	95.56	7.5	-
	3002.28	104.44	9.5	-
	3002.28	104.44	12	-
	3002.28	111.67	16.5	-
	3002.28	135.00	57	-
	3020.26	102.22	7.5	-
	3647.24	131.11	7.5	-
	3647.24	131.11	11	-
	3647.24	138.89	11	-
	3647.24	130.00	12	-
	3647.24	143.33	14.5	-
	3647.24	135.00	30.5	-
	3647.24	146.11	21	-
	4029.15	161.67	19.5	-
	4267.20	170.00	7	-
	4267.20	172.78	8.5	-
	4267.20	175.56	16.8	-
	4267.20	170.56	48	-
	4267.20	177.78	52	-
Pipipa-1	879.96	39.44	5.5	-
	2115.01	76.67	8.5	-
	2115.01	86.11	8.5	-
	2115.01	83.33	12.5	-
	2115.01	86.11	18	-

Poonboon-1	2690.47	98.89	8	-
	2690.47	100.00	18	-
	3198.27	106.67	6	-
	3198.27	113.33	12	-
	3258.31	108.89	2.5	-
	3258.31	120.00	12	-
	3259.23	112.78	12	-
	3267.46	115.56	3	-
Seal-1	1669.00	68.30	5.67	0.85
	1669.00	74.40	9.75	0.85
Squid-1	-	-	-	-
Tarook-1	2773.68	91.11	6	-
	2773.68	94.44	7	-
Tilana-1	1661.16	60.00	5	-
	3066.29	103.89	7.5	-
	3900.22	111.11	10	-
	3900.22	115.56	19.5	-
Toolka-1A	2714.85	101.11	6	-
	2714.85	104.44	7	-
	2714.85	106.67	18	-
	2714.85	106.67	23	-
Yolla-1	1759.00	75.00	10	-
	1982.11	72.22	5.5	-
	1982.11	78.89	9	-
	2022.96	78.89	14.5	-
	3347.01	121.11	9.5	-
	3347.01	132.22	18	-
	3347.01	140.00	18	-
	3347.01	143.33	24	-
	3347.01	137.78	31	-
Yurongi-1	2438.40	83.33	4.5	-
	2438.40	89.44	5.5	-
	2438.40	105.56	21	-

APPENDIX K.

KINETIC MODELLING OF PELICAN-5

Aaron Cummings, National Centre for Petroleum Geology and Geophysics

Kinetics calibration in Pelican-5

The interpreted depth to onset of oil expulsion in the previous chapter was modelled based upon source rock kinetic data described in Chapter 5 of this Record (Figure 5.17; Boreham et al., 2003). The range in source rock kinetic behaviour can be approximated by two end members that have been termed "Bass Resistive" and "Bass Labile" based upon coals analysed in Cormorant-1 (1686 m) and Konkon-1 (1280 m) respectively. A model was made for Pelican-5 where coals with end member kinetics were sited at different stratigraphic levels. Oil expulsion versus time plotted with maturity was carried out for a hypothetical coal at the base of the Paleocene (Middle EVCM) within Pelican-5. The saturation level of 0.8 gave the best fit to give expulsion at a vitrinite level of 0.75%. This value is high but coals typically need greater oil saturation levels prior to expulsion than shales.

Using a saturation value of 0.8 for oil and 0.1 for gas prior to expulsion, the base of Pelican-5 (*Upper T. longus*) was also plotted to display oil (Figure K1) and gas expulsion behaviour (Figure K2) over a wider maturity range. Mixed Type II/III kinetic parameters, based on BasinMod default values, give a reasonable approximation to the labile and resistive kinetic behaviour for oil expulsion. Kinetic parameters are given in Appendix III.

Figure K1. Plot of coal source rock oil expulsion and maturity versus time based upon kinetic descriptions of coal source rocks from the basal Paleocene horizon, Pelican-5 well. The end member kinetic behaviour brackets the range of coal expulsion behaviour for Bass Basin coals. A saturation of ~ 0.8 is required prior to expulsion for coals to expell oil at a vitrinite reflectance value of 0.75%. See Appendix K for kinetic parameters.

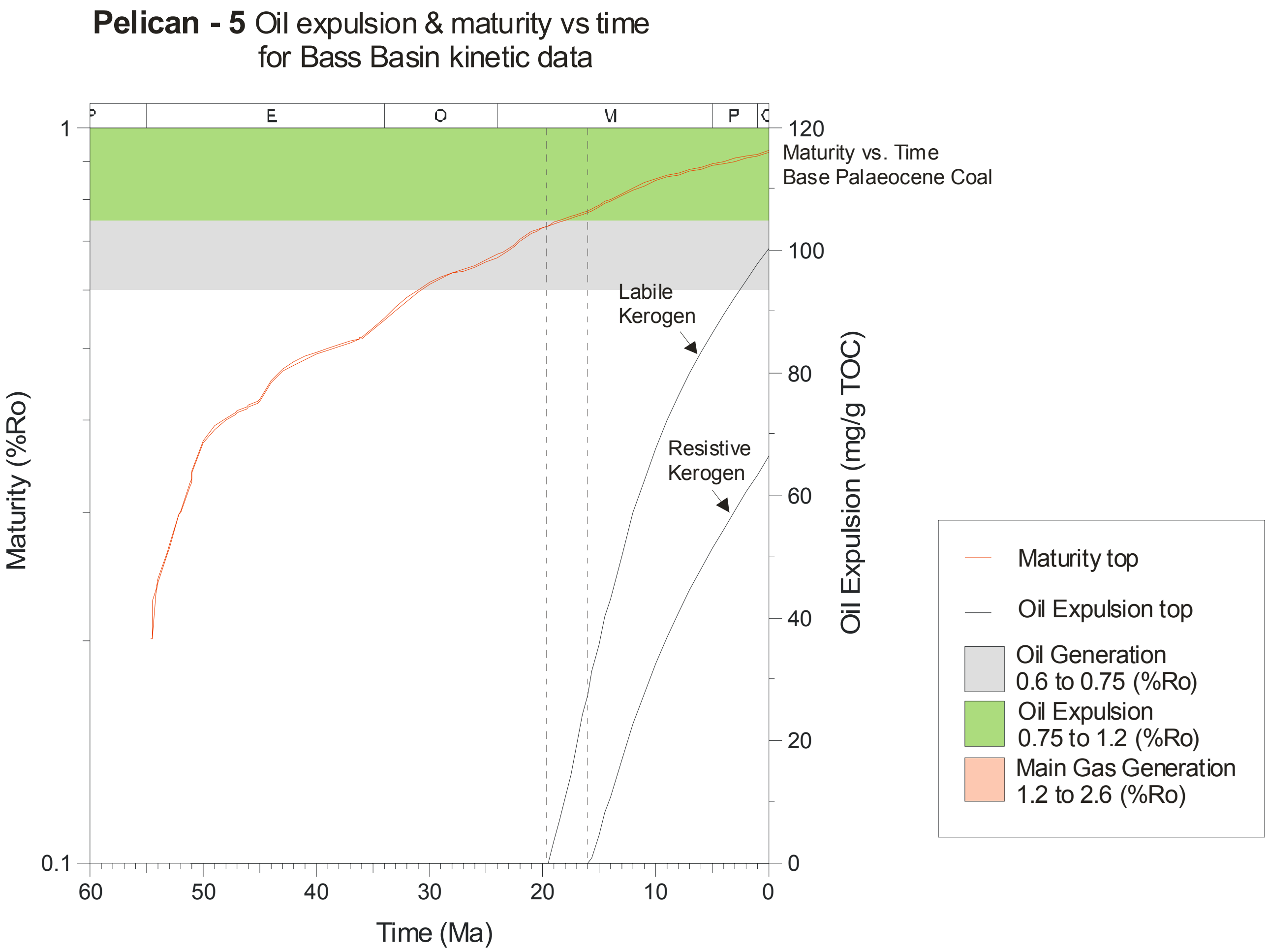
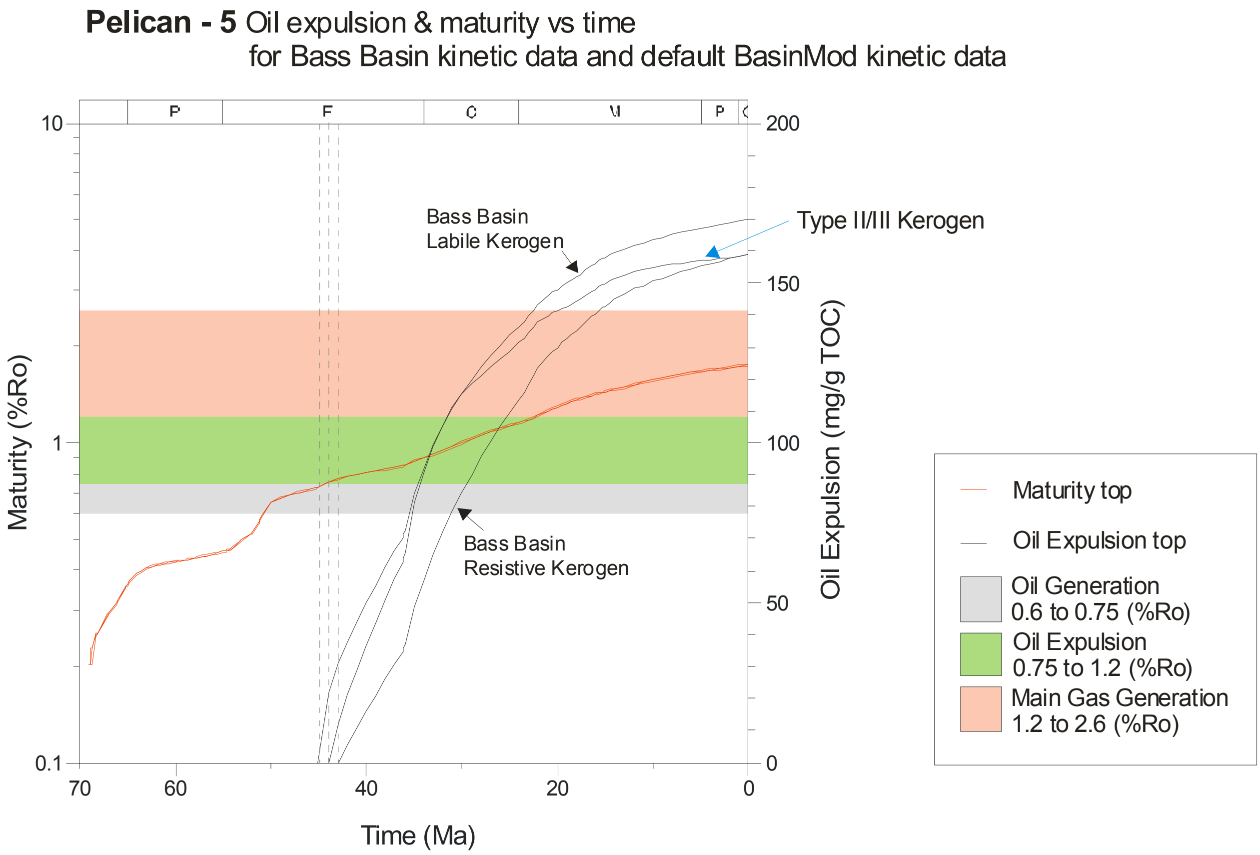


Figure K2. Comparison of oil expulsion versus time between end member coal kinetics and a mixture of BasinMod default Type II and Type III kinetics over a wider maturity range. The mixed Type II and Type III kinetic model approximates Bass Basin coal source rock behaviour reasonably well.



APPENDIX L

REPORT ON MERCURY INJECTION CAPILLARY PRESSURE TEST RESULTS

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This appendix contains the complete version of the "Hydrocarbon Seal Evaluation Study, Bass Basin, Tasmania" report as prepared for Mineral Resources Tasmania by the National Centre for Petroleum Geology and Geophysics (2002). This report has been formatted for inclusion in this appendix.

HYDROCARBON SEAL EVALUATION STUDY,

BASS BASIN,

TASMANIA

REPORT PREPARED FOR

MINERAL RESOURCES TASMANIA,

GEOSCIENCE AUSTRALIA,

NATIONAL CENTRE FOR PETROLEUM GEOLOGY AND GEOPHYSISCS

BY

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2002

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EXECUTIVE SUMMARY

This report details the results of a study to determine seal capacity of potential seal rocks in the Bass Basin, Offshore Tasmania. Samples from eight wells were analysed using mercury injection capillary pressure (MICP) techniques.

A correlation of depositional environments to seal capacities reveal that environments with significant sealing capacity include fine-grained rocks from the lower and upper shoreface, interdistributary bays, lagoon and stacked crevasse channels/flood plains. Sensitivities to variations in contact angle (θ, interfacial tension (IFT) and subsurface fluid densities were included in the analysis. Capillary pressure results were used to determine seal capacities (hydrocarbon height retention), as well as pore-throat size distributions and height above free water level (HAFWL) versus water saturation (Sw). Hydrocarbon column heights for oil and gas were calculated for each sample. The sensitivities, in turn, were averaged for both oil and gas. Average sealing capacity for all samples were determined. The average column height of oil (density 0.735g/cc) able to be sealed is 605 metres. A column height of 262 metres of gas (density 0.1 g/cc) can be held. The highest oil column (>1400m) is supported by muds from the lower shoreface in Dondu 1. Lagoonal muds from Cormorant 1 will support an ~1140m column of oil, while the fluvial channel fills from Durroon 1 and Tilana 1 support > 700m oil column. Coastal plain, fluvial overbank and back barrier berm deposits are the least significant sealing lithologies in this study, supporting <200m oil columns.

L1. INTRODUCTION

Mineral Resources Tasmania, Geoscience Australia, and the National Centre for Petroleum Geology and Geophysics (NCPGG), University of Adelaide, undertook a joint study on petroleum systems in the Bass Basin. The NCPGG conducted the seal evaluation component of the study. Eight wells from the Bass Basin, offshore Tasmania were examined, and samples were taken from conventional cores. The aim of this part of the study is to assess the sealing capacity of specific mudstone/ siltstones, which are potential seals within the Bass Basin. Samples were analysed by Mercury Injection Capillary Pressure (MICP) Porosimetry.

Details on the operation and quality control of the porosimeter are described in Section L4. Individual plot of wells results follow this discussion. The Excel spreadsheets containing the MICP analytical data are not inlcuded in this PDF file. These spreadsheets are available in the "Seal Analyses Results" folder on the CD-ROM and should be accessed using Windows Explorer.

Samples from Bass Basin wells analysed by MICP

Well Name	Depth, metres	Sample type	Rock type
Bass-2	1164.5	Core	Carbonaceous laminated siltstone/mudstone
Bass-2	1261.0	Core	Carbonaceous laminated siltstone
Cormorant-1	1687.0	Core	Laminated siltstone/mudstone
Cormorant-1	1999.3	Core	Laminated mudstone
Cormorant-1	2231.6	Core	Very-fine grained sandstone/siltstone
Cormorant-1	2685.3	Core	Very-fine grained sandstone, carbonaceous siltstone
Dondu-1	2342.0	Core	Carbonaceous mudstone/siltstone
Durroon-1	3021.9	Core	Mudstone, very-fine grained sandstone
Pelican-5	2805.2	Core	Mudstone cemented
Pelican-5	2863.8	Core	Siltstone/sandstone
Pelican-5	2890.8	Core	Laminated siltstone
Poonboon-1	1954.2	Core	Siltstone
Poonboon-1	2473.8	Core	Carbonaceous laminated siltstone
Poonboon-1	2689.6	Core	Very-fine grained sandstone
Poonboon-1	3035	Core	Siltstone
Poonboon-1	3259	Core	Mudstone
Tilana-1	1667	Core	Carbonaceous siltstone, very-fine grained sandstone
Tilana-1	2800	Core	Carbonaceous mudstone
Yolla-2	3039	Core	Siltstone, very-fine grained sandstone

L2. METHODOLOGY

Mercury Injection Capillary Pressure (MICP)

The theory of the mercury porosimeter is based on the physical principle that a non-reactive, non-wetting liquid will not penetrate pores until sufficient pressure is applied to force its entrance. The relationship between the applied pressure and the pore size into which mercury will intrude is given by the Washburn equation:

$$PD = -4 \gamma \cos \theta$$

Where P is the applied pressure, D is the diameter, γ is the surface tension of mercury (480 dyne cm^{-1}) and θ is the contact angle between mercury and the pore wall, usually near 140°. This equation assumes that all pores are right circular cylinders. As pressure increases, the instrument senses the intrusion volume of mercury by the change in capacitance between the mercury column and a metal sheath surrounding the stem of the penetrometer. As the mercury column shortens, the pressure and volume data are continuously acquired by an attached personal computer. Mercury porosimetry is a technique, which is rate limited, as predicted by the Darcy equation. This describes the general function of pressure drop vs. flowrate.

Where p_1 is the upstream pressure, p_2 is the downstream pressure, L is the pore length, $1/\alpha$ is the permeability coefficient, μ is the fluid viscosity, V is the superficial velocity of fluid and g_c is a dimensional constant. The velocity of flow in a viscous liquid such as mercury is proportional to the pressure drop and inversely proportional to the length and surface area of the pore. Hence, given a specific limited flow velocity, the complete filling of a porous network will be a function of time. The larger the volume of pores the more time is required to fill the total pore volume completely. Therefore mercury porosimetry is most accurate when mercury is allowed to fill all the available pores, at equilibration.

The mercury injection porosimetry analyses for this study were carried out using a Micromeritics Autopore 9410 instrument (Section L4). This is composed of two separate systems, one for low pressure runs and the second for the high pressure runs. The low pressure run must always be done first, followed quickly by the high pressure run, to preclude the possibility of extra mercury intrusion into the sample by capillary action while the sample is held at atmospheric pressure at the conclusion of the low pressure run.

The system operates using the equilibration by time method - after the required pressure for a reading is attained it is held for twenty seconds to allow the amount of mercury entering the pores to stabilise. This is done because the process of mercury filling the pores is not an instantaneous one. Mercury begins entering the pores as soon as the pressure exceeds the value required for the pore throats' diameter, but the time required to fill the pores depends on the volume and shape of the pores. The equilibration by time process allows the pores to fill. If equilibration is not allowed, then the filling may not be complete when the reading is taken, which leads to estimation of lower pore volumes and smaller pore sizes than is actually the case.

Readings of mercury intrusion are taken by measuring the electrical capacitance of the penetrometer. This varies as the mercury is intruded from the precision bore stem into the pore space of the sample by the increasing pressure.

Each sample is washed in alcohol and dried at $60^{o}C$ for 24 hours, weighed and placed into a penetrometer (a glass chamber attached to a precision bore nickel-plated glass tube) and the entire assembly weighed. This is placed in the low pressure port and evacuated to 0.05 torr. This vacuum is held for thirty minutes to ensure that no vapour remains in the sample. After this time the penetrometer is filled with mercury and the low pressure run is carried out. The pressure is increased incrementally from 2 psia to 28.94 psia, with a reading taken after 20 seconds of equilibration at each pressure. At the end of the low pressure run the penetrometer returns to atmospheric pressure. It is removed from the instrument and weighed to obtain its weight plus that of the mercury.

The penetrometer is then placed in the high pressure chamber, which uses hydraulic oil to take the pressure incrementally from 28.94 psia to 60,000 psia. Again readings are taken after a twenty second equilibration period. The pressure then decreases incrementally from 60,000 psia to 20 psia, with readings taken after the equilibration period. The sample is removed from the penetrometer and weighed.

Capillary Pressure

The samples were analysed using the Mercury Injection Capillary Pressure (MICP) techniques described in the above section on Methodology. MICP involves forcing a non-wetting fluid (mercury) into the pore system of a cleaned and dried core sample. The mercury displaces the wetting phase (air) that initially saturated the pores within the rock. Surface forces oppose the entrance of the mercury and pressure must be exerted to enable the mercury to enter the pores and thereby displace the air (Purcell, 1949). The smaller the pore throats, the greater the pressure required for the mercury enter the rock. Mercury saturation is commonly plotted as a function of mercury injection pressure.

Capillary pressure can be expressed as the relationship:

1) $Pc = 2\sigma \cos \tilde{\theta} r$

Where: Pc = Capillary Pressure (psi)

σ = interfacial tension (dynes/cm)

θ = contact angle (degrees)

r = radius of capillary (microns)

MICP Plots

MICP plots of the side wall cores and cuttings samples are presented in the first two graphs in each set of analyses. These display the data in a lognormal format from 0-60,000 psi against volume of mercury injected into the sample (the lognormal format is useful for differentiating data points in the low-pressure regime when analysing reservoir lithologies). The second graph displays plots of pressure against volume of mercury injected as a percentage (this is used for calculating the water saturation graphs).

Pore Throat Size

Using the following data for the air mercury system from (Vavra et al, 1992), capillary pressure data were converted to effective pore throat size:

Air/mercury contact angle (θa/m) = 140°, and
interfacial tension (σa/m) = 480 dynes/cm.
σ(a/m) cos θ(a/m)= 370
1 cm = 10,000 µm, (microns)
1 psi = 69035 dynes/cm2

Solving for r in equation results in the following relationship of capillary pressure to pore throat size:

1 psi = (approx.) 100 microns
10 psi = (approx.) 10 microns
100 psi = (approx.) 1 micron
1000 psi = (approx.) 0.1 micron

The cumulative pore-throat size distributions for the samples are presented in the third figure of the sample analysis set as lognormal size distribution.

Water Saturation

While MICP studies done solely for the purpose of determining pore throat radius and pore throat size distribution are valuable, there is, perhaps, even greater benefit in using these analyses to relate the rock types to saturations as a function of height above the FWL.

The mercury/air capillary pressure system is used to replicate static distribution of hydrocarbons in the subsurface. The initial pressure at which the mercury first displaces the air is referred to as "displacement pressure" (Pd). In the subsurface, buoyancy pressure drives hydrocarbon (the non-wetting phase) movement and forces it into the pore throats of a rock, displacing water (the wetting phase). Buoyancy is simply the density difference between hydrocarbon and brine multiplied by the column height and a constant (k) gravitational factor, which is 0.433. The greater the column thickness, the greater the buoyancy pressure driving the hydrocarbon.

Pd in the reservoir system is the pressure at which hydrocarbon first entered the pore system by displacing the water. Different rocks with different pore throat sizes will have different displacement pressures and different saturations as a function of height (h) above the free water level (FWL). Thus, in any given reservoir section, the lowest indication of live (vs residual) hydrocarbon in a particular rock type approximates the displacement pressure (Pd) for that rock. The Pd can thus be considered as the hydrocarbon – water contact *for that particular rock type*. It should be remembered that a reservoir may have several hydrocarbon water contacts (as a function of pore properties controlled by rock type), but will have only one FWL. It is therefore of significance to determine the FWL.

In order to do this, capillary pressure data must first be converted to height above free water level information by using the equation:

2. $Pcb/o = h(\rho b - \rho o) \times 0.433$

   Where: Pcb/o = Capillary Pressure (psi) reservoir brine/oil system
   h = height (in ft.)
   ρb = rine density (gm/cc)
   ρo = density (gm/cc)

In order to use the capillary pressure relationships to interpret real subsurface data in such a way, the data must first be converted from the air/mercury system used in the laboratory to the hydrocarbon/brine system in the reservoir. Laboratory analyses of fluid samples from well completion reports indicate the following reservoir fluid parameters for the wells:

Gas Density - 0.1 gm/cc
Oil Density – 0.735 to 0.797 gm/cc
Brine Density – 1.01- 1.05 gm/cc

No measurements for Contact Angle and Interfacial Tensions were available, so based on existing data from other samples in the region the following values were considered reasonable:

System	**Contact angle (θ)**	**Interfacial tension (σ)**
Brine/oil	5	15 dynes/cm
Brine/gas	0°	30 dynes/cm
Air/mercury	140°	485 dynes/cm

Once the capillary pressure values have been converted to h (height in metres), a plot of height versus mercury (non-wetting phase) saturations can be constructed. However, conversion of mercury (non-wetting phase) to hydrocarbon (non-wetting phase) will now result in a height versus hydrocarbon saturation plot. Since water (wetting phase) saturation is more commonly used in the oil and gas industry, the non-wetting phase saturation needs to be converted to water (wetting-phase) saturation (Schowalter, 1979). This is done using the simple conversion:

3) Sw = 1 – Snw

here: Sw = wetting phase (water) saturation

nw = non-wetting phase (hydrocarbon) saturation

Combining equations (2) and (3) results in a plot of height (above FWL) versus water saturation.

Saturation height functions were calculated using input parameters of the brine and hydrocarbon densities indicated in well completion reports (above). The conversion was run using a brine density value (1.01 to 1.05 gm/cc) and the oil density (0.735 to 0.797 gm/cc). and the Sw versus height functions were plotted on the fourth and fifth graph (linear and semi log formats, respectively) for each sample analysis. The column height versus water saturation curves for each well were also plotted on a single graph for comparison, both in linear and semi-log format (see combined colour plots below)

L3. SEAL CAPACITY

A summary of the water saturation curves for the samples from the Bass basin is presented in the following coloured composite graphs of normal (linear) and lognormal parameters. The average hydrocarbon height is highlighted on each graph. The lognormal graphs are more definitive as a result of larger scale values in the lower height range. Sensitivities determined for the study were determined from Bass Basin well completion reports and corroborated with data from adjacent areas. Tables and corresponding plots of the various sensitivities are presented, following the composite water saturation curves.

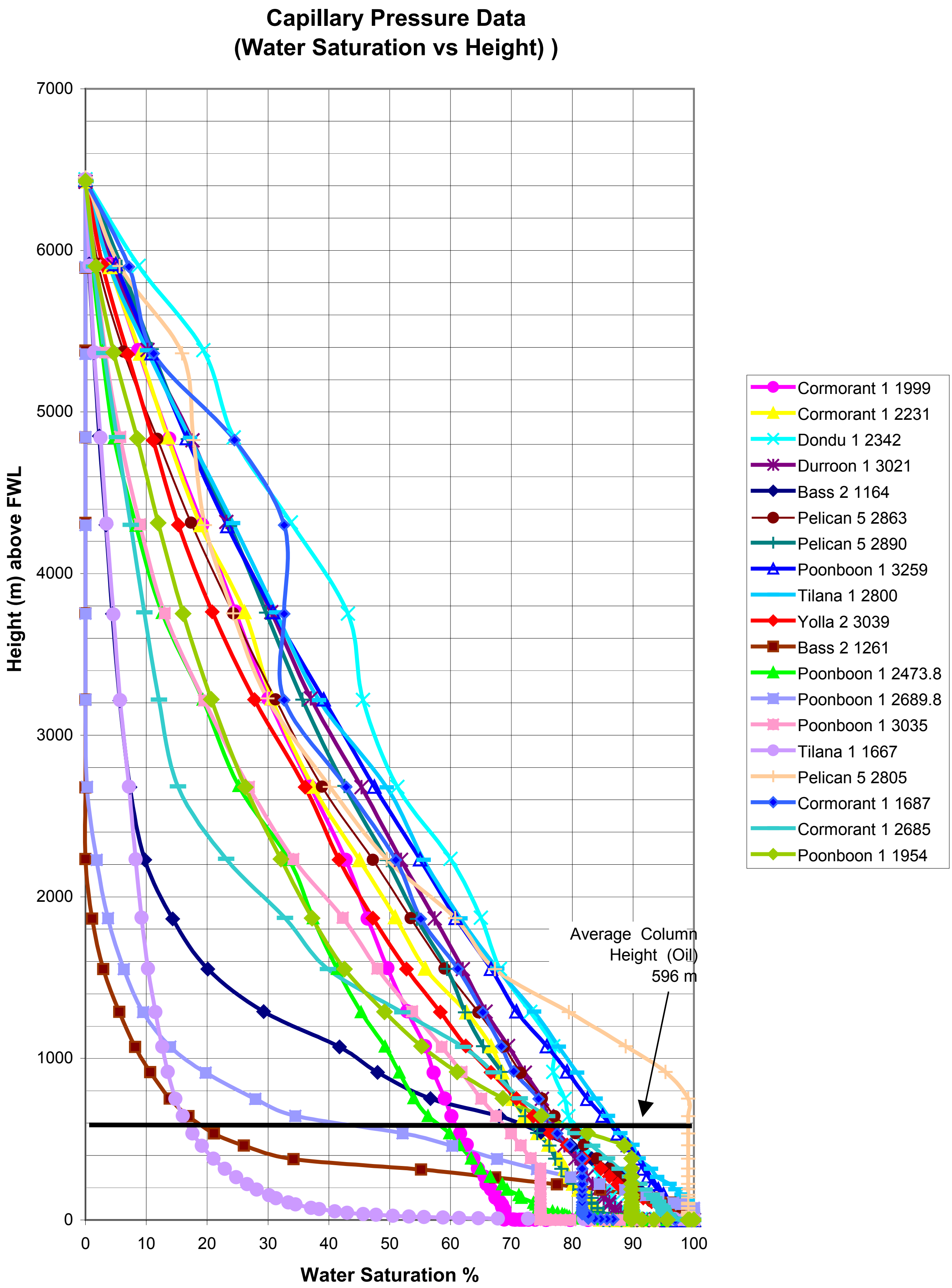
The threshold or displacement pressure of the samples from the Bass Basin, averages **5835 psia at 596** metres above free water level. This means that the average sealing lithology will support a **596 metre column of oil** with a density of ~ 0.735 gm/cc (or a **263 metre column of gas** with a density of 0.1 gm/cc).

The results and interpretation of the analyses on sediments from the these wells can be viewed in terms of minimum hydrocarbon heights that can be supported by the sealing lithologies. The seal lithological samples are derived from a variety of depositional environments, which are highlighted in the following graphs and are shown below. Plots of length versus width and area versus thickness of ancient and modern analogues of seal depositional environments (mudstone and siltstone lithologies) are presented. These highlight the spatial extent of the various depositional environments attributed to the potential sealing lithologies analysed in this study.

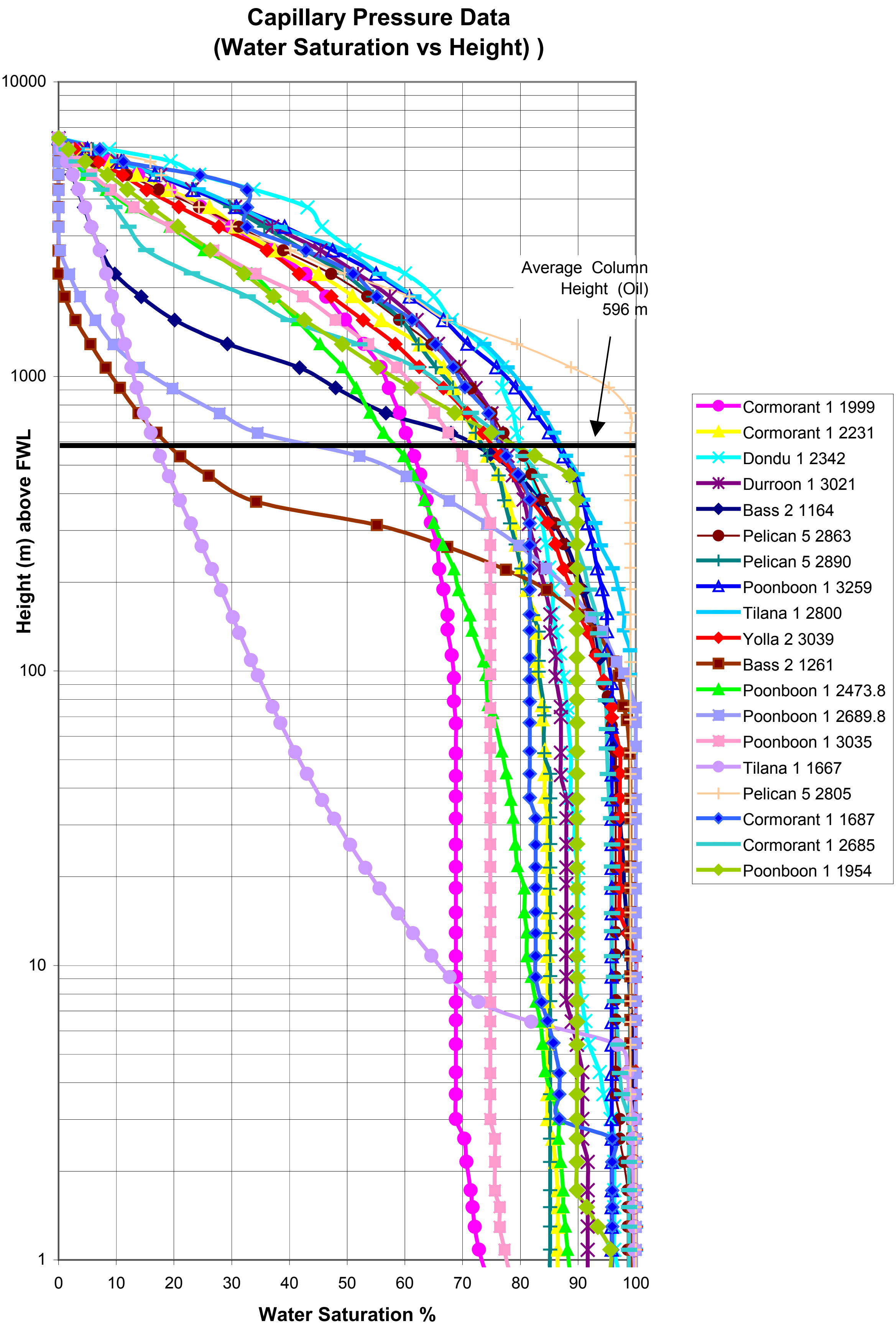
DEPOSITIONAL ENVIRONMENT
Shelf
Lower Shoreface
Foreshore - Upper Shoreface
Back Barrier Lagoon/Lake
Lacustrine or Marine (shelf)
Back Barrier Berm
Coastal Plain (?)
Interdistributary Bay/Lake
Interdistributary Swamp/Marsh
Fluvial Channel
Fluvial Overbank
Stacked Crevasse Channel
Fluvial Overbank; Crevasse Splays/Channels

Significant seal depositional environments determined from this study are the lower shore face (muds) lagoons (silty muds) and abandoned channel fill (silty muds). The areal distribution of these environments are >1,000 km^2, 10-1000 km^2 and 1 km^2, with thicknesses 1-30 m, 2-1-50 m and 5-10 m respectively.

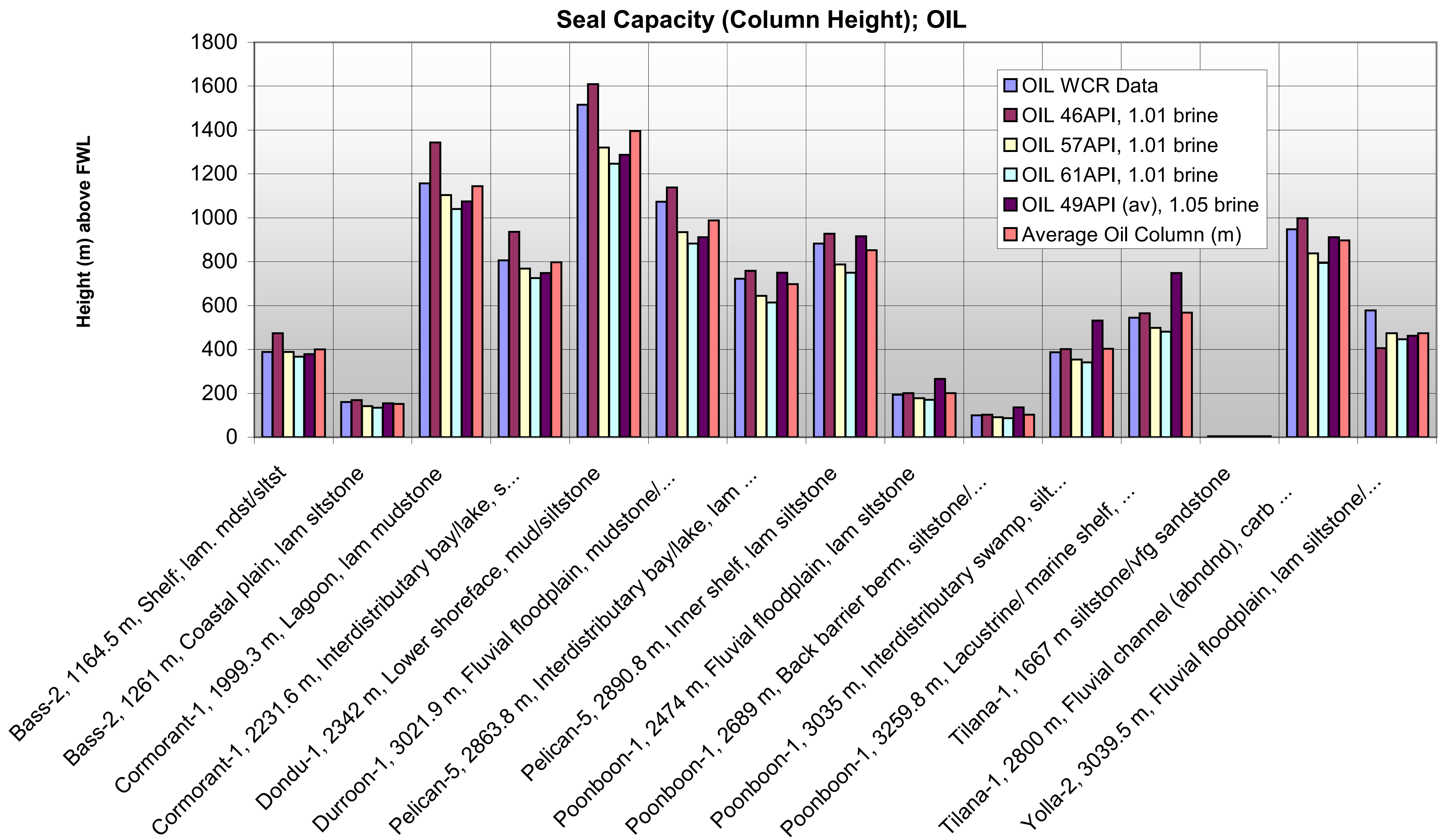
The highest oil column (>1400 m) is supported by mudsones from the lower shoreface in Dondu 1. Lagoonal mudstones from Cormorant 1 will support an ~1140 m column of oil, while the fluvial channel fill mudstones from Durroon 1 and Tilana 1 support > 700 m oil column. Coastal plain, fluvial overbank and back barrier berm deposits are the least significant sealing lithologies in this study (siltstones to very fine sandstones), supporting <200 m oil columns.

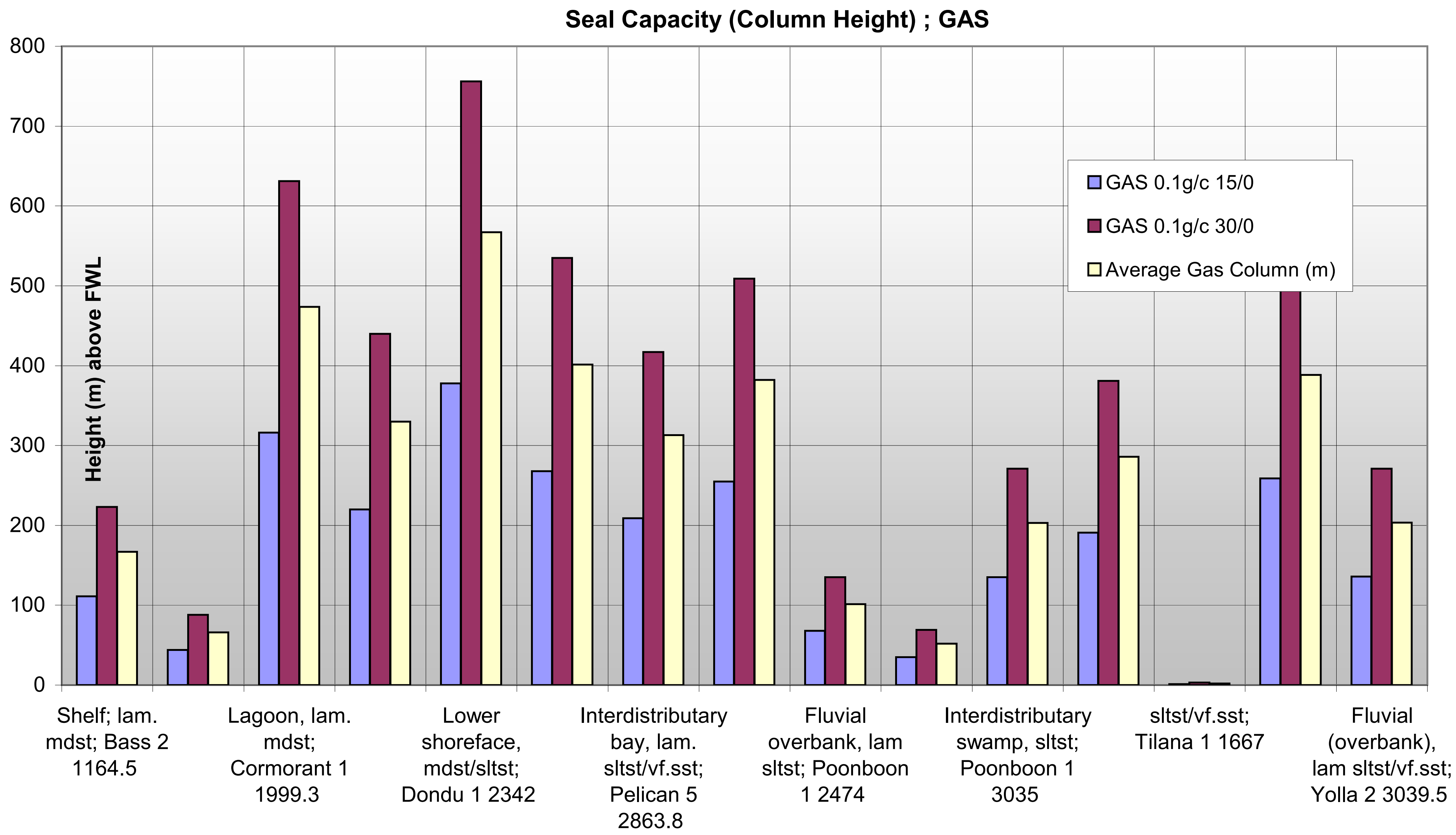


Capillary Pressure Data
(Water Saturation vs Height))
Height (m) above FWL
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Average Column Height (Oil) 596 m
Cormorant 1 1999
Cormorant 1 2231
Dondu 1 2342
Durroon 1 3021
Bass 2 1164
Pelican 5 2863
Pelican 5 2890
Poonboon 1 3259
Tilana 1 2800
Yolla 2 3039
Bass 2 1261
Poonboon 1 2473.8
Poonboon 1 2689.8
Poonboon 1 3035
Tilana 1 1667
Pelican 5 2805
Cormorant 1 1687
Cormorant 1 2685
Poonboon 1 1954

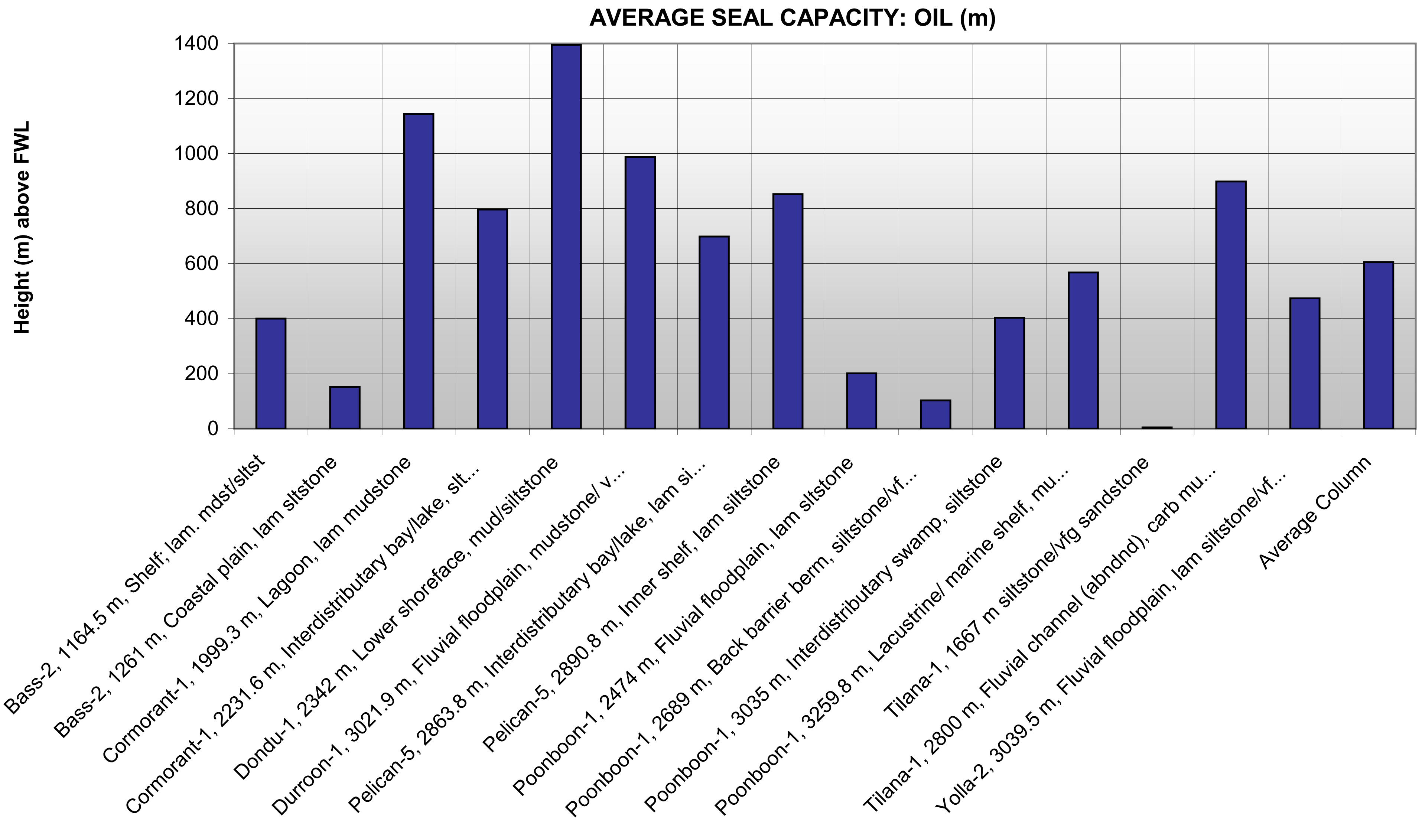


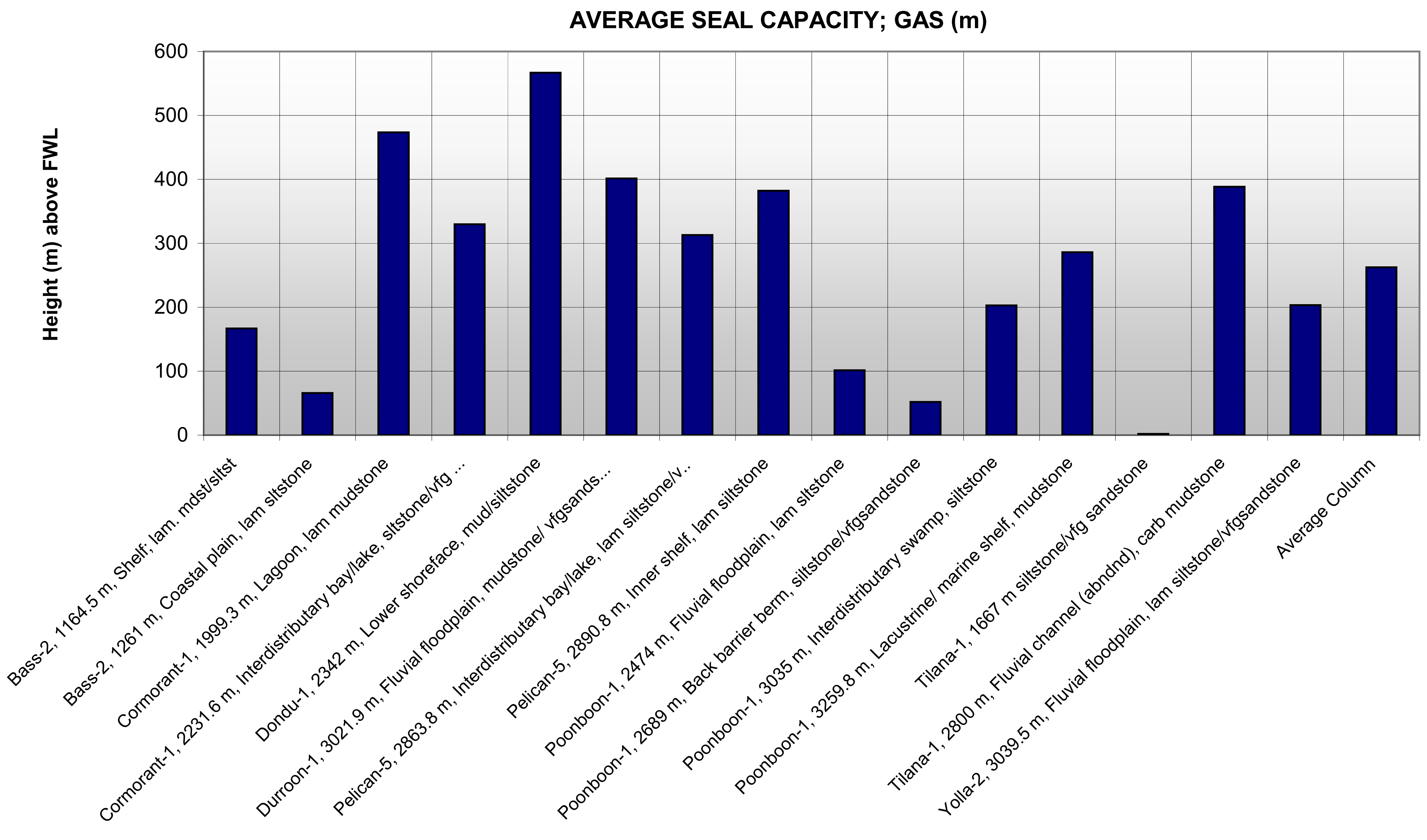
Capillary Pressure Data
(Water Saturation vs Height))
Height (m) above FWL
Water Saturation %
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Average Column
Height (Oil)
596 m
Cormorant 1 1999
Cormorant 1 2231
Dondu 1 2342
Durroon 1 3021
Bass 2 1164
Pelican 5 2863
Pelican 5 2890
Poonboon 1 3259
Tilana 1 2800
Yolla 2 3039
Bass 2 1261
Poonboon 1 2473.8
Poonboon 1 2689.8
Poonboon 1 3035
Tilana 1 1667
Pelican 5 2805
Cormorant 1 1687
Cormorant 1 2685
Poonboon 1 1954

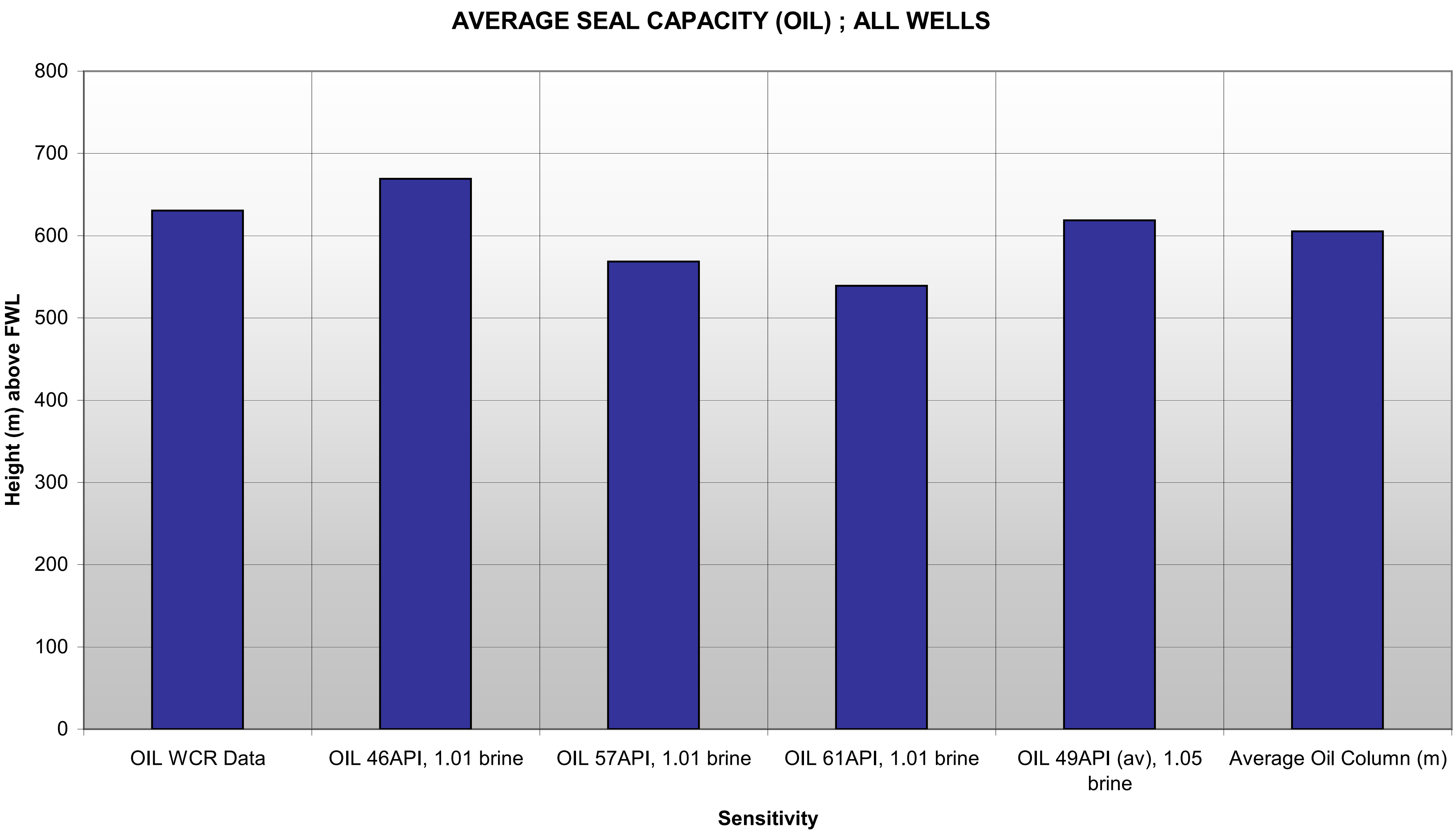

Seal Capacity (Column Height); OIL
Height (m) above FWL
1800
1600
1400
1200
1000
800
600
400
200
0
OIL WCR Data
OIL 46API, 1.01 brine
OIL 57API, 1.01 brine
OIL 61API, 1.01 brine
OIL 49API (av), 1.05 brine
Average Oil Column (m)
Bass-2, 1164.5 m, Shelf; lam. mdst/sltst
Bass-2, 1261 m, Coastal plain, lam sltstone
Cormorant-1, 1999.3 m, Lagoon, lam mudstone
Cormorant-1, 2231.6 m, Interdistributary bay/lake, s...
Dondu-1, 2342 m, Lower shoreface, mud/siltstone
Durroon-1, 3021.9 m, Fluvial floodplain, mudstone/...
Pelican-5, 2863.8 m, Interdistributary bay/lake, lam ...
Pelican-5, 2890.8 m, Inner shelf, lam siltstone
Poonboon-1, 2474 m, Fluvial floodplain, lam sltstone
Poonboon-1, 2689 m, Back barrier berm, siltstone/...
Poonboon-1, 3035 m, Interdistributary swamp, silt...
Poonboon-1, 3259.8 m, Lacustrine/ marine shelf, ...
Tilana-1, 1667 m siltstone/vfg sandstone
Tilana-1, 2800 m, Fluvial channel (abndnd), carb ...
Yolla-2, 3039.5 m, Fluvial floodplain, lam siltstone/...

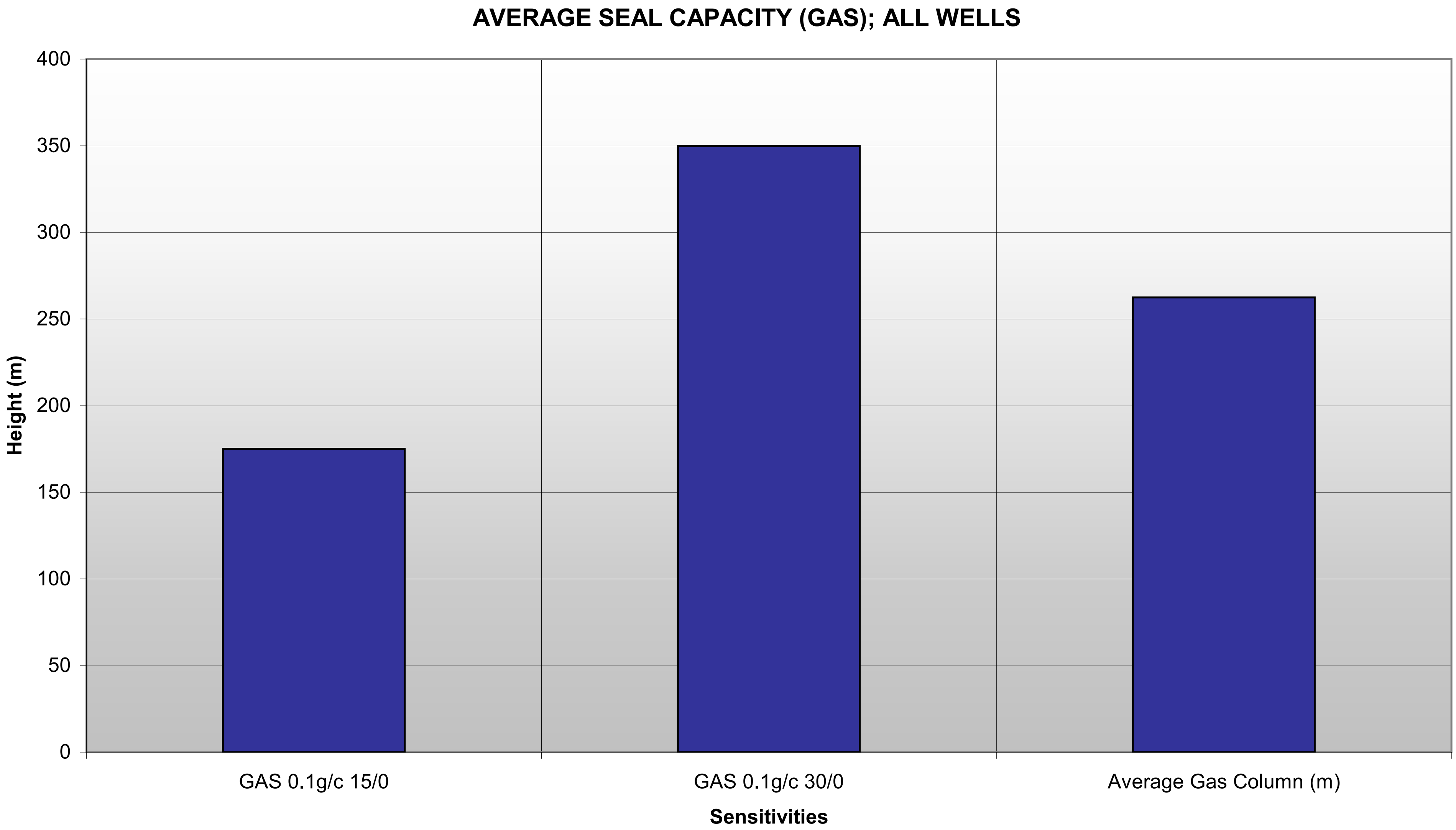


Seal Capacity (Column Height) ; GAS
Height (m) above FWL
800
700
600
500
400
300
200
100
0
GAS 0.1g/c 15/0
GAS 0.1g/c 30/0
Average Gas Column (m)
Shelf; lam. mdst; Bass 2 1164.5
Lagoon, lam. mdst; Cormorant 1 1999.3
Lower shoreface, mdst/sltst; Dondu 1 2342
Interdistributary bay, lam. sltst/vf.sst; Pelican 5 2863.8
Fluvial overbank, lam sltst; Poonboon 1 2474
Interdistributary swamp, sltst; Poonboon 1 3035
sltst/vf.sst; Tilana 1 1667
Fluvial (overbank), lam sltst/vf.sst; Yolla 2 3039.5


AVERAGE SEAL CAPACITY: OIL (m)
Height (m) above FWL
1400
1200
1000
800
600
400
200
0
Bass-2, 1164.5 m, Shelf; lam. mdst/sltst
Bass-2, 1261 m, Coastal plain, lam sltstone
Cormorant-1, 1999.3 m, Lagoon, lam mudstone
Cormorant-1, 2231.6 m, Interdistributary bay/lake, slt...
Dondu-1, 2342 m, Lower shoreface, mud/siltstone
Durroon-1, 3021.9 m, Fluvial floodplain, mudstone/ v...
Pelican-5, 2863.8 m, Interdistributary bay/lake, lam si...
Pelican-5, 2890.8 m, Inner shelf, lam siltstone
Poonboon-1, 2474 m, Fluvial floodplain, lam siltstone
Poonboon-1, 2689 m, Back barrier berm, siltstone/vf...
Poonboon-1, 3035 m, Interdistributary swamp, siltstone
Poonboon-1, 3259.8 m, Lacustrine/ marine shelf, mu...
Tilana-1, 1667 m siltstone/vfg sandstone
Tilana-1, 2800 m, Fluvial channel (abndnd), carb mu...
Yolla-2, 3039.5 m, Fluvial floodplain, lam siltstone/vf...
Average Column


AVERAGE SEAL CAPACITY; GAS (m)
Height (m) above FWL
600
500
400
300
200
100
0
Bass-2, 1164.5 m, Shelf; lam. mdst/sltst
Bass-2, 1261 m, Coastal plain, lam sltstone
Cormorant-1, 1999.3 m, Lagoon, lam mudstone
Cormorant-1, 2231.6 m, Interdistributary bay/lake, sltstone/vfg ...
Dondu-1, 2342 m, Lower shoreface, mud/siltstone
Durroon-1, 3021.9 m, Fluvial floodplain, mudstone/ vfgsands...
Pelican-5, 2863.8 m, Interdistributary bay/lake, lam siltstone/v..
Pelican-5, 2890.8 m, Inner shelf, lam siltstone
Poonboon-1, 2474 m, Fluvial floodplain, lam sltstone
Poonboon-1, 2689 m, Back barrier berm, siltstone/vfgsandstone
Poonboon-1, 3035 m, Interdistributary swamp, siltstone
Poonboon-1, 3259.8 m, Lacustrine/ marine shelf, mudstone
Tilana-1, 1667 m siltstone/vfg sandstone
Tilana-1, 2800 m, Fluvial channel (abndnd), carb mudstone
Yolla-2, 3039.5 m, Fluvial floodplain, lam siltstone/vfgsandstone
Average Column


AVERAGE SEAL CAPACITY (OIL) ; ALL WELLS
800
700
600
500
400
300
200
100
0
Height (m) above FWL
OIL WCR Data
OIL 46API, 1.01 brine
OIL 57API, 1.01 brine
OIL 61API, 1.01 brine
OIL 49API (av), 1.05 brine
Average Oil Column (m)
Sensitivity



AVERAGE SEAL CAPACITY (GAS); ALL WELLS
400
350
300
250
200
150
100
50
0
Height (m)
GAS 0.1g/c 15/0
GAS 0.1g/c 30/0
Average Gas Column (m)
Sensitivities

APPENDIX L. SENSITIVITIES, BASS BASIN WELL SAMPLES, AVERAGE COLUMN HEIGHTS

	OIL WCR Data	OIL 46API, 1.01 brine	OIL 57API, 1.01 brine	OIL 61API, 1.01 brine	OIL 49API (av), 1.05 brine	Average Oil Column (m)	GAS 0.1g/c 15/0	GAS 0.1g/c 30/0	Average Gas Column (m)	GAS 0.1g/c 15/0	GAS 0.1g/c 30/0	Average Gas Column (m)	Average Oil Height (m)
Bass-2, 1164.5 m, Shelf; lam. mdst/sltst	389	474	389	367	379	400	111	223	167	111	223	167	400
Bass-2, 1261 m, Coastal plain, lam sltstone	160	169	142	135	154	152	44	88	66	44	88	66	152
Cormorant-1, 1999.3 m, Lagoon, lam mudstone	1157	1344	1103	1040	1075	1144	316	631	474	316	631	474	1144
Cormorant-1, 2231.6 m, Interdistributary bay/lake, sltstone/vfg siltone	806	936	768	725	749	797	220	440	330	220	440	330	797
Dondu-1, 2342 m, Lower shoreface, mud/siltstone	1515	1609	1320	1246	1287	1395	378	756	567	378	756	567	1395
Durroon-1, 3021.9 m, Fluvial floodplain, mudstone/ vfgsandstone	1073	1139	935	882	911	988	268	535	402	268	535	402	988

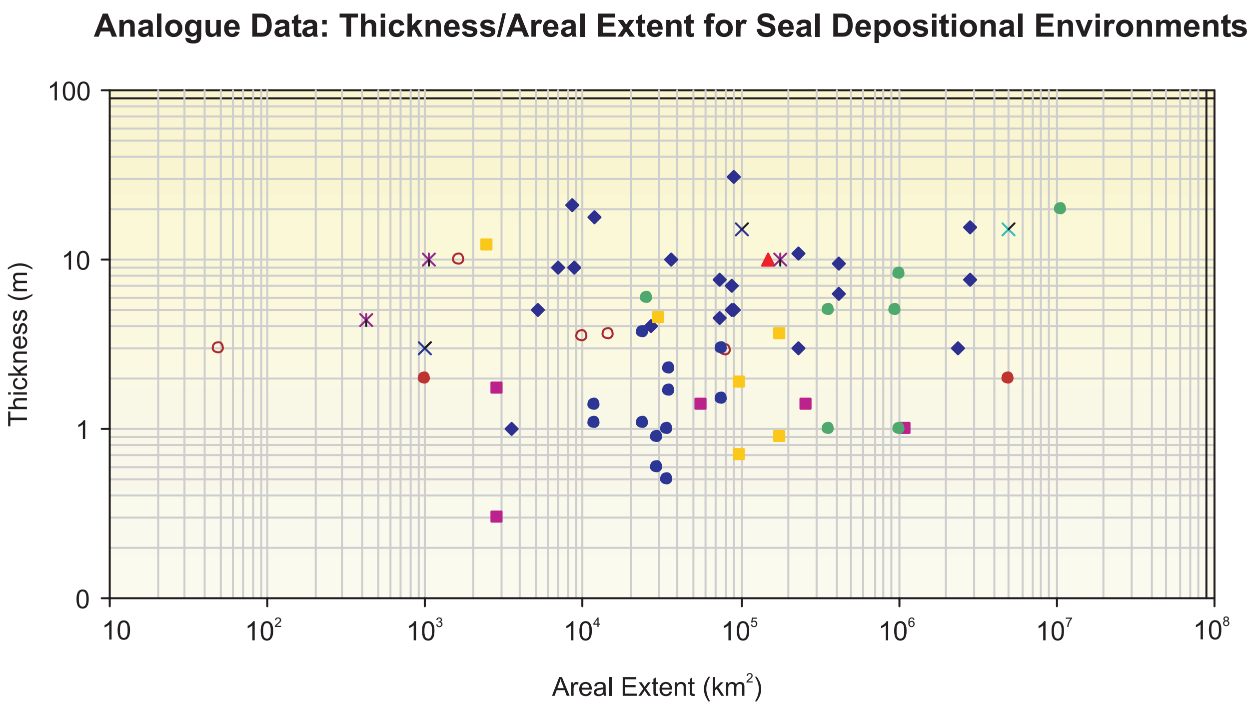
Pelican-5, 2863.8 m, Interdistributary bay/lake, lam siltstone/vfg sandstone	723	759	645	614	750	698	209	417	313	209	417	313	698
Pelican-5, 2890.8 m, Inner shelf, lam siltstone	882	927	788	750	916	853	255	509	382	255	509	382	853
Poonboon-1, 2474 m, Fluvial floodplain, lam sltstone	193	201	177	170	266	201	68	135	102	68	135	102	201
Poonboon-1, 2689 m, Back barrier berm, siltstone/vfgsandstone	99	103	91	87	136	103	35	69	52	35	69	52	103
Poonboon-1, 3035 m, Interdistributary swamp, siltstone	387	401	354	341	532	403	135	271	203	135	271	203	403
Poonboon-1, 3259.8 m, Lacustrine/ marine shelf, mudstone	545	565	499	481	749	568	191	381	286	191	381	286	568
Tilana-1, 1667 m siltstone/vfg sandstone	4	5	4	4	5	4	1	3	2	1	3	2	4
Tilana-1, 2800 m, Fluvial channel (abndnd), carb mudstone	947	998	838	795	911	898	259	518	389	259	518	389	898
Yolla-2, 3039.5 m, Fluvial floodplain, lam siltstone/vfgsandstone	578	406	474	447	462	473	136	271	204	136	271	204	473
Average Column	631	669	568	539	619	605	175	350	262	175	350	262	605

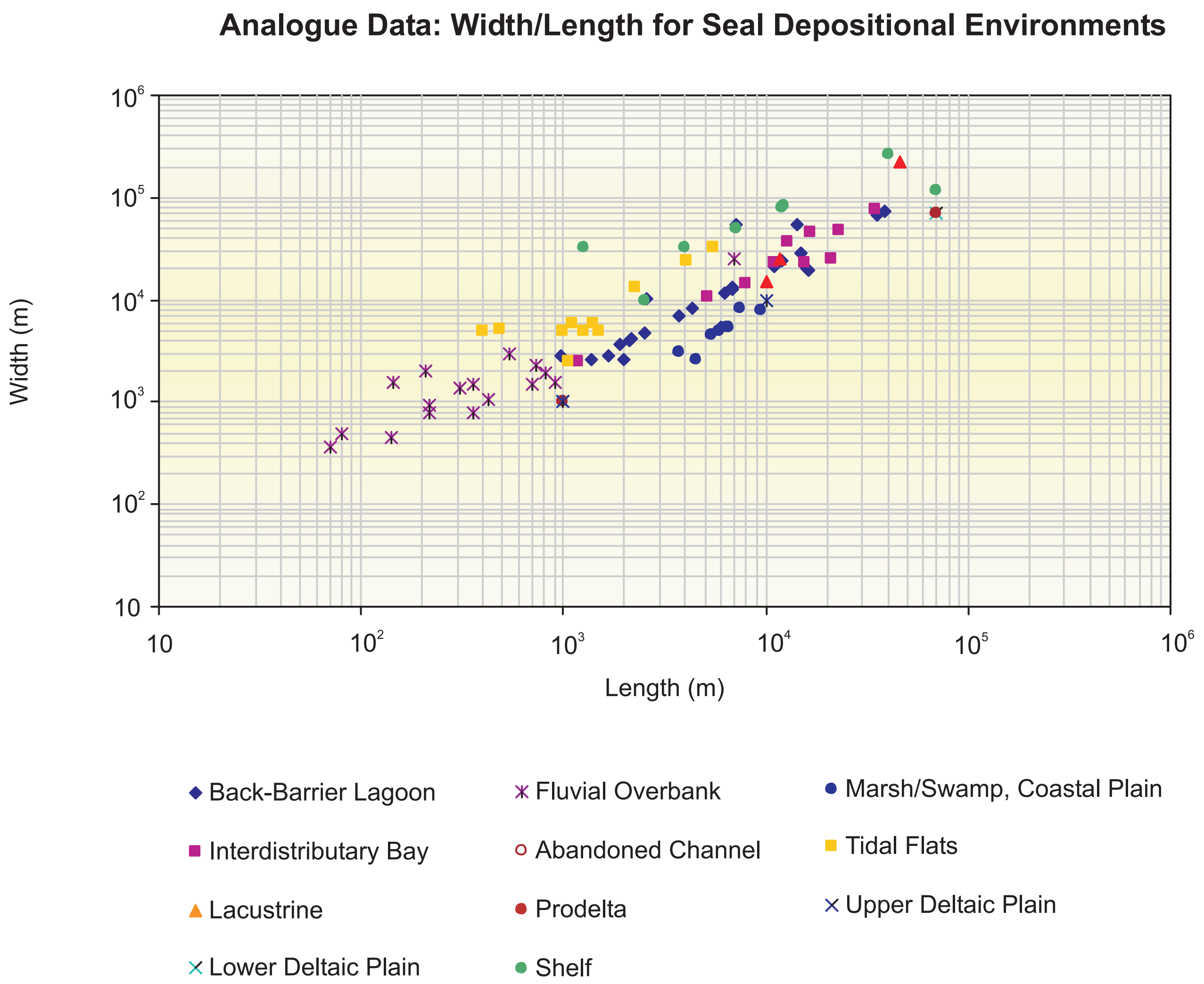
APPENDIX L. SEAL ANALYSIS RESULTS, BASS BASIN WELLS

WELL NAME	DEPTH		Seal Capacity (m)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	BIOZONE	Expected Length	Expected Width	Length/Width& Orientation
	METRES	*FEET*							
Bass-2	1164.49	3820.50	400	Carbonaceous, finely-laminated mudstone-siltstone	Shelf	*(?) P. asperopolus - Upper N. Asperus*	Several 10,000's to several 100,000s	Several 10,00's to a few 100,000's	~5 parallel w/ shoreline
Bass-2	1261.87	4140.00	152	Finely laminated siltstone, w/ carbonaceous chaff	Coastal plain, Interdistributary floodplain	*(?) P. asperopolus - Upper N. Asperus*	n/a	n/a	n/a
Cormorant-1	1999.30	6559.38	1144	Finely laminated mudstone	Back barrier lagoon/lake	*P. asperopolus - Upper M. diversus*	Few 1000's to a few 10,000's	A few 1000's to ~10,000	~3 parallel w/ shoreline
Cormorant-1	2231.60	7321.52	797	Interbedded siltstone and very fine-grained sandstone--starved and lenticular bedding, bioturbation	Interdistributary bay/lake	*Upper M. diversus*	Few 10,000's to several 10,000's	~10,000 to a few 10,000's	~2 parallel w/ shoreline
Cormorant-1	2648.10	8687.99	ts/micp	Carbonaceous mudstone w/ rare interbedded very fine-grained sandstone--starved ripple bedding	n/a	*Middle M. diversus*	n/a	n/a	n/a
Cormorant-1	2685.30	8810.04	ts/micp	Finely interbedded, very fine-grained sandstone and variably carbonaceous mudstone--biotrubated	n/a	*Middle M. diversus*	n/a	n/a	n/a
Dondu-1	2342.00	7683.73	1395	Moderately carbonaceous mudstone-siltsone	Lower shoreface	*Upper L. balmei*	Few 10,000's to several 10,000's	several 100 to several 1000's	~9 parallel w/ shoreline

WELL NAME	DEPTH		Seal Capacity (m)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	BIOZONE	Expected Length	Expected Width	Length/Width& Orientation
	METRES	*FEET*							
Durroon-1	1690.73	5547.00	ts/micp	Very fine- to fine-grained sandstone	Fluvial overbank	*P. mawsonii*	Few 100 to several 100	Several 100 to several 1000's(?)	~10 parallel to main channel orientation
Durroon-1	3021.88	9914.30	988	Cemented, mudstone and fine-grained sandstone	Fluvial floodplain associated with stacked crevasse channels	*Early Cretaceous*	Few 100 to several 100	Several 100 to several 1000's(?)	~10 parallel to main channel orientation
Pelican-5	2805.20	9203.41	micp	Cemented(?) mudstone	n/a	*M. diversus*	n/a	n/a	n/a
Pelican-5	2863.80	9395.67	698	Very finely interbedded siltstone and very fine-grained sandstone--ripple laminated and bioturbated	Interdistributary bay/lake	*M. diversus*	Few 10,000's to several 10,000's	~10,000 to a few 10,000's	~2 parallel w/ shoreline
Pelican-5	2890.80	9484.25	853	Finely-laminated siltstone	Lower shoreface-inner-shelf and foreshore/upper shoreface	*M. diversus*	Few 10,000's to several 10,000's	several 100 to several 1000's	~9 parallel w/ shoreline
Poonboon-1	1954.20	6411.42	ts/micp	Siltstone	Lower shoreface-inner-shelf and foreshore/upper shoreface	*Middle N. asperus*	Few 10,000's to several 10,000's	several 100 to several 1000's	~9 parallel w/ shoreline
Poonboon-1	2473.80	8116.14	201	Finely laminated siltstone, w/ carbonaceous chaff	Fluvial floodplain	*Middle M. diversus*	Few 100 to several 100		~10 parallel to main channel orientation
Poonboon-1	2689.60	8824.15	136	Parallel stratified and ripple cross-laminated very fine-grained sandstone--bioturbated	Back-barrier beach berm	*Lower M. diversus*	n/a	n/a	n/a

WELL NAME	DEPTH		Seal Capacity (m)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	BIOZONE	Expected Length	Expected Width	Length/Width& Orientation
	METRES	*FEET*							
Poonboon-1	3035.00	9957.35	403	Siltstone--root traces	Interdistributary swamp/marsh	*Lower L. balmei*	n/a	n/a	n/a
Poonboon-1	3259.80	10694.88	568	Massive mudstone	Lacustrine or marine shelf	*Lower L. balmei*	Several 10,000's to several 100,000s	Several 10,00's to a few 100,000's	n/a
Tilana-1	1667.40	5470.47	4	Siltstone to very fine-grained sandstone w/ carbonaceous chaff	n/a	*Upper L. balmei*	n/a	n/a	n/a
Tilana-1	2800.00	9186.35	898	Massive, fissile, carbonaceous mudstone	Fluvial channel (abandoned)	*Upper L. balmei*	Several 1000's to several 10,000's (?)	Few 100 to a few 1000's	~15 parallel to channel orientation
Yolla-2	3039.45	9971.95	473	very finely interbedded siltstone and very fine-grained sandstone--ripple laminated	Fluvial floodplain	n/a	Few 100 to several 100	Several 100 to several 1000's(?)	~10 parallel to main channel orientation


Analogue Data: Thickness/Areal Extent for Seal Depositional Environments
Thickness (m)
100
10
1
0
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
Areal Extent (km^2)


Analogue Data: Width/Length for Seal Depositional Environments
Width (m)
10^6
10^5
10^4
10^3
10^2
10
10
10^2
10^3
10^4
10^5
10^6
Length (m)
Back-Barrier Lagoon
Fluvial Overbank
Marsh/Swamp, Coastal Plain
Interdistributary Bay
Abandoned Channel
Tidal Flats
Lacustrine
Prodelta
Upper Deltaic Plain
Lower Deltaic Plain
Shelf

L4. ANALYTICAL EQUIPMENT DETAILS, MICROMERITICS AUTOPORE 9410, MERCURY INJECTION POROSIMETER

General Arrangement of the System

The Autopore 9410 machine is composed of two separate systems, one for low pressure runs and the second for the high pressure runs. The low pressure run must always be done first, followed quickly by the high pressure run, to preclude the possibility of extra mercury intrusion into the sample by capillary action while the sample is held at atmospheric pressure at the conclusion of the low pressure run.

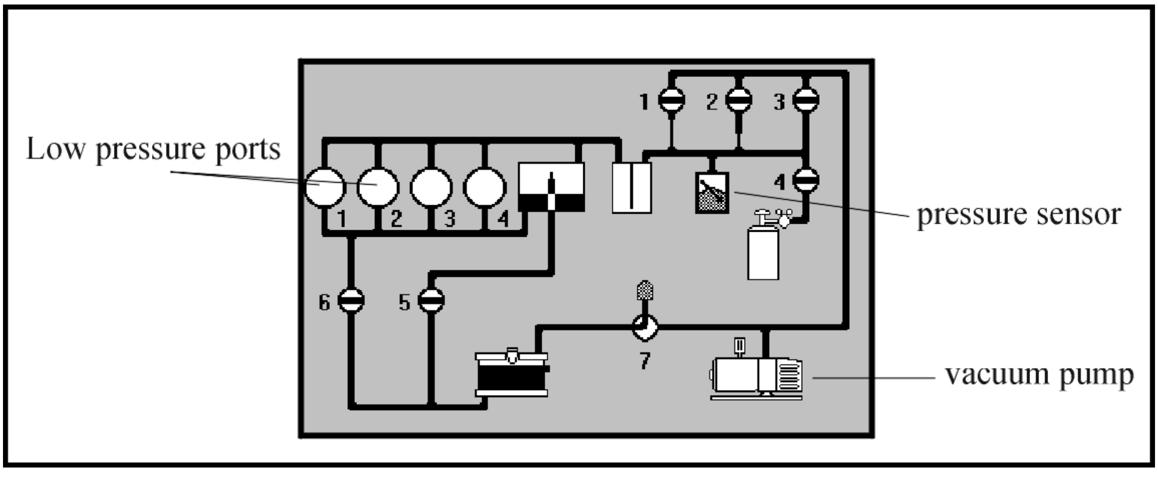
The system can operate using either the equilibration by time method - after the required pressure for a reading is attained it is held for twenty seconds to allow the amount of mercury entering the pores to stabilise – or the equilibration by intrusion rate method – the sample is held at the required pressure until the mercury volume has stabilised. This is done because the process of mercury filling the pores is not an instantaneous one. Mercury begins entering the pores as soon as the pressure exceeds the value required for the pore throats' diameter, but the time required to fill the pores depends on the volume and shape of the pores. The equilibration by time process allows the pores to fill. If equilibration is not allowed then the filling may not be complete when the reading is taken, which leads to estimation of lower pore volumes and smaller pore sizes than is actually the case. It is this method which is generally used here.

The system is controlled by a personal computer running the proprietary Micromeritics Autopore software under Windows 95. The program is simple to run, but can fail at times due to electrical problems and occasional unknown causes.

Low Pressure System

The low pressure system consists of two sample ports, a vacuum pump, a mercury reservoir and associated mercury fill chamber, an air pump, a pressure sensor and the associated valves, switches, electronics and piping (Figure L1).

Figure L1. Schematic layout of a Micromeritics Autopore porosimeter low pressure section.



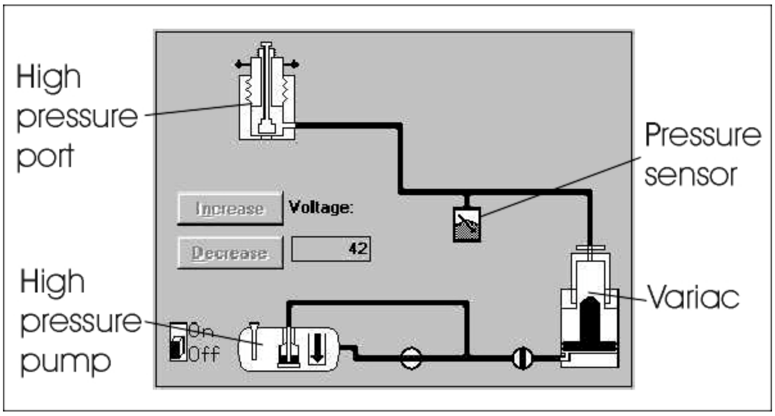
To operate the system, a weighed sample is placed in a penetrometer which is sealed and then placed in a low pressure port. The vacuum pump is switched on and the program is initiated. Any modifications to the running parameters are made at this point, and the run file, which lists the selected pressures for intrusion readings, is chosen. The particulars of the sample are then entered and the evacuation of the system is carried out to a vacuum of 0.5 torr. Once this value is reached the vacuum is held for a previously chosen period, usually five minutes. At the end of this time mercury is pumped from the reservoir to the fill chamber, from which it fills the penetrometer. The excess mercury is then drained back to the reservoir. The low pressure readings are taken from 2 psia up to a maximum of 50 psia (40 psia is the currently used pressure)and the sample is returned to atmospheric pressure at the conclusion of the run. Once atmospheric pressure is reached the penetrometer is removed from the low pressure port and weighed (this is the 'assembly weight'), the data being entered when starting the high pressure run. The low pressure run is then complete.

High Pressure System

The high pressure system (Figure L2.) consists of a high pressure port, a pump, a variac, pressure sensors and the associated valves, piping and electronics. The high pressure system can operate to pressures of 60,000 psia.

Data, including the name of the low pressure run data file and the assembly weight is entered. The penetrometer is placed in the high pressure port which is then closed and screwed down tight. The seal is closed and the run is commenced, at pressures from 45 psia to 60,000 psia and then back down to atmospheric pressure, with 20 second equilibration. The penetrometer is then removed from the high pressure port.

Figure L2. Schematic layout of a Micromeritics Autopore porosimeter high pressure section.



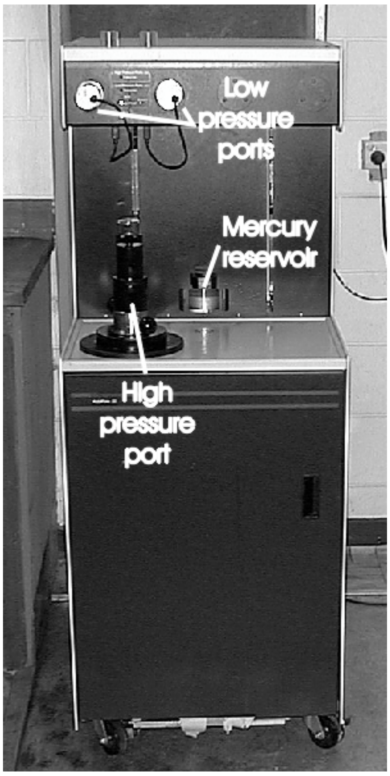
General Layout of the System

The mercury porosimetry instrument is located in Room H1-10b, immediately off H1-10. The desktop computer which controls the instrument is located in Room H1-10a adjacent to the mercury laboratory. The instrument and the computer are connected by a cable which travels via the ceiling and connects to them via 9 pin 'D' connectors. On the computer connection is made via the COM1 port. There is only one port on the instrument. The main power switch is located at the lower right rear of the instrument, near the power connection. The vacuum pump runs at all times when the instrument is turned on.

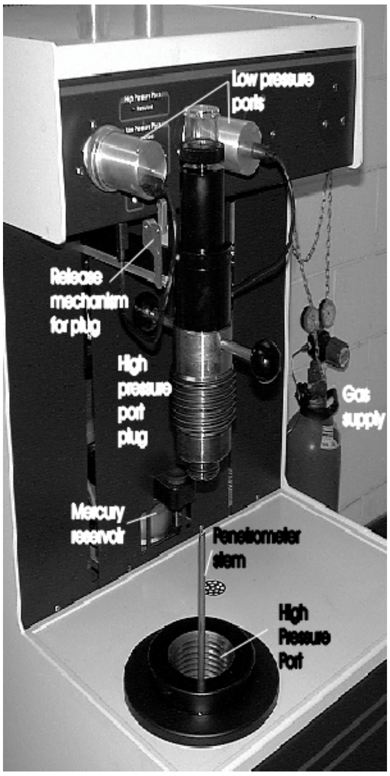
The instrument (Appendix Figures 1.3 and 1.4) is arranged with the two low pressure ports above and behind the high pressure port. Below the tray bearing the high pressure port are the vacuum pump, the high pressure pump and the variac. The mercury reservoir is situated above and behind the tray, with the filling hole located in front of it. There is a viewing window in the reservoir for checking the mercury level. The gas supply to the low pressure system is located on the wall to the right of the machine, connected by a copper gas line to a port on the left rear of the machine, next to the computer interface connection. Between the two low pressure ports are the warning lamps for mercury up, low pressure system pressurised and high pressure system pressurised.

The low pressure ports consist of a tube embedded in the machine with rubber seals inside an inner tube, which is threaded at the outer end with a machined grip ring which accepts the cap. This cap, which contains the electrode for taking the capacitance readings, is connected to the body of the machine by a cable. The high pressure ports consist of a pressure vessel which has an electrode in the base and which contains the hydraulic fluid used for pressurisation, a large threaded plug which screws into the pressure vessel and a vent with a small Perspex cup and lid on top. The top of the plug is able to rotate to ensure better centering of the penetrometer and the plug.

The Micromeritics Autopore 9410 mercury injection porosimeter.



A closer view of the Micromeritics Autopore 9410 mercury injection porosimeter.



L5. INJECTION ANALYSIS DATA FOR BASS BASIN WELLS

The following graphs are water saturation curves for the samples presented as a series of composite coloured graphs of normal (linear) and lognormal parameters. The average hydrocarbon height and displacement pressure is highlighted on each graph. The log normal graphs are more definitive as a result of larger scale values in the lower height range. Sensitivities used for the study were determined from Bass Basin well completion reports, corroborated with data from adjacent areas. Results for the following well samples are shown. Note that the Excel spreadsheets containing the MICP analystical data are not included in this PDF file. These spreadsheets are available in the "Seal Analyses Results" folder on the CD-ROM and should be access using Windows Explorer.

Samples from Bass Basin wells analysed by MICP

Well Name	Depth, metres	Sample type	Rock type
Bass-2	1164.5	Core	Carbonaceous laminated siltstone/mudstone
Bass-2	1261.0	Core	Carbonaceous laminated siltstone
Cormorant-1	1687	Core	Laminated siltstone/mudstone
Cormorant-1	1999	Core	Laminated mudstone
Cormorant-1	2231	Core	Very-fine grained sandstone/siltstone
Cormorant-1	2685	Core	Very-fine grained sandstone, carbonaceous siltstone
Dondu-1	2342	Core	Carbonaceous mudstone/siltstone
Durroon-1	1690	Core	Mudstone, very-fine grained cemented sandstone
Durroon-1	3021	Core	Mudstone, very-fine grained sandstone
Pelican-1	2805	Core	Mudstone cemented
Pelican-5	2863	Core	Siltstone/sandstone
Pelican-5	2890	Core	Laminated siltstone
Poonboon-1	1954	Core	Siltstone
Poonboon-1	2474	Core	Carbonaceous laminated siltstone
Poonboon-1	2689	Core	Very-fine grained sandstone
Poonboon-1	3035	Core	Siltstone
Poonboon-1	3259	Core	Mudstone
Tilana-1	1667	Core	Carbonaceous siltstone, very-fine grained sandstone
Tilana-1	2800	Core	Carbonaceous mudstone
Yolla-2	3039	Core	Siltstone, very-fine grained sandstone

L6. REFERENCES

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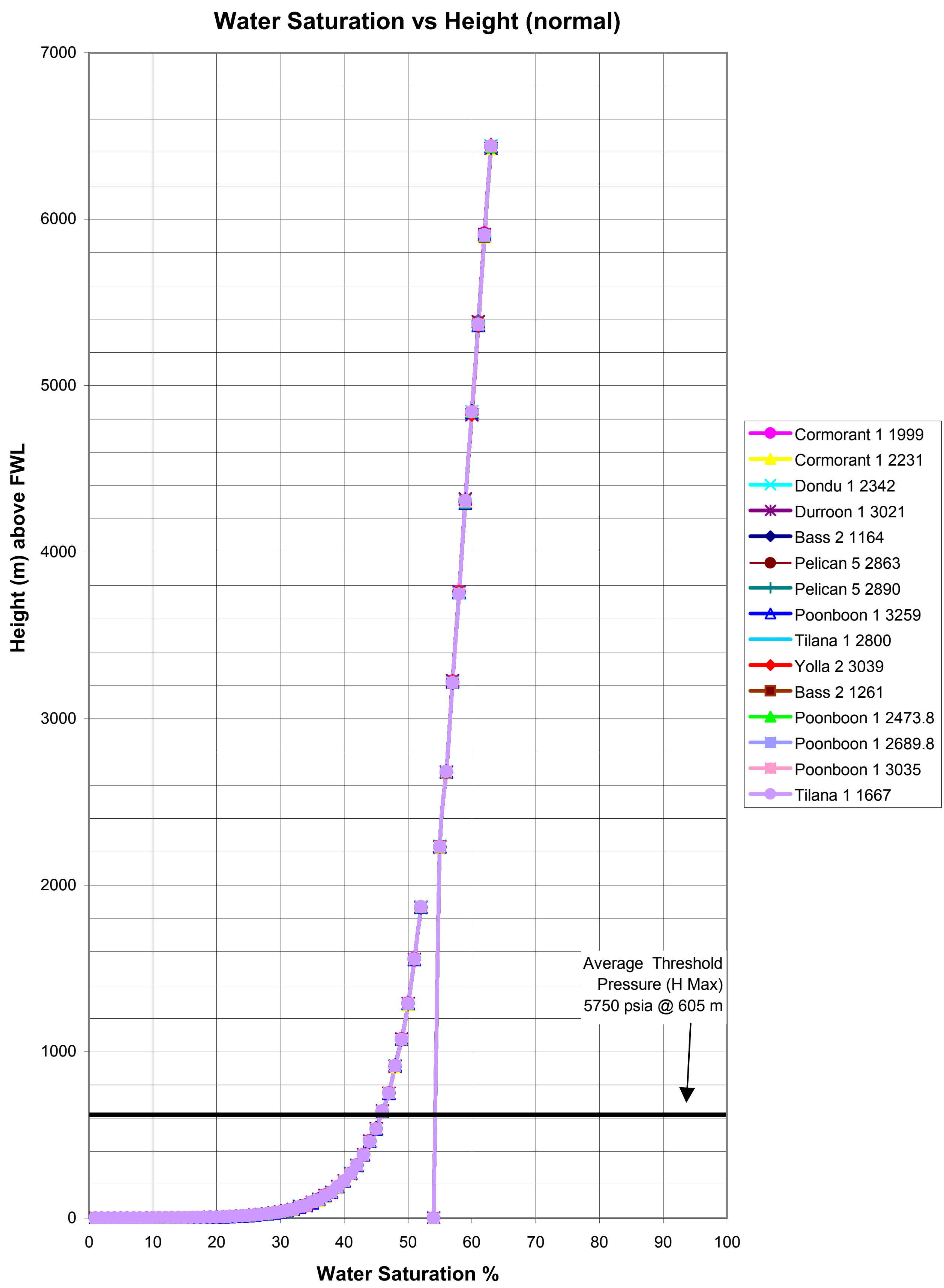
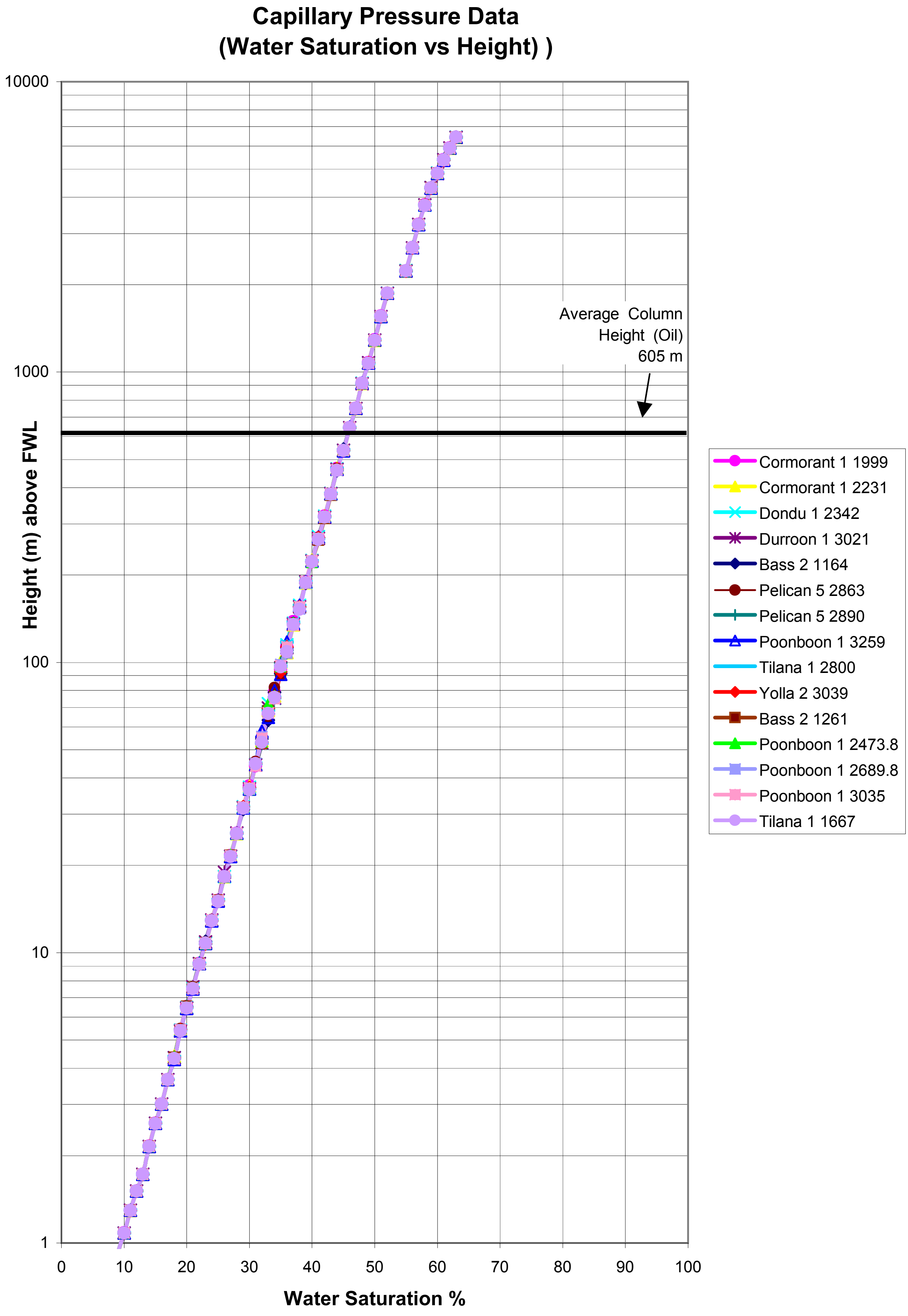
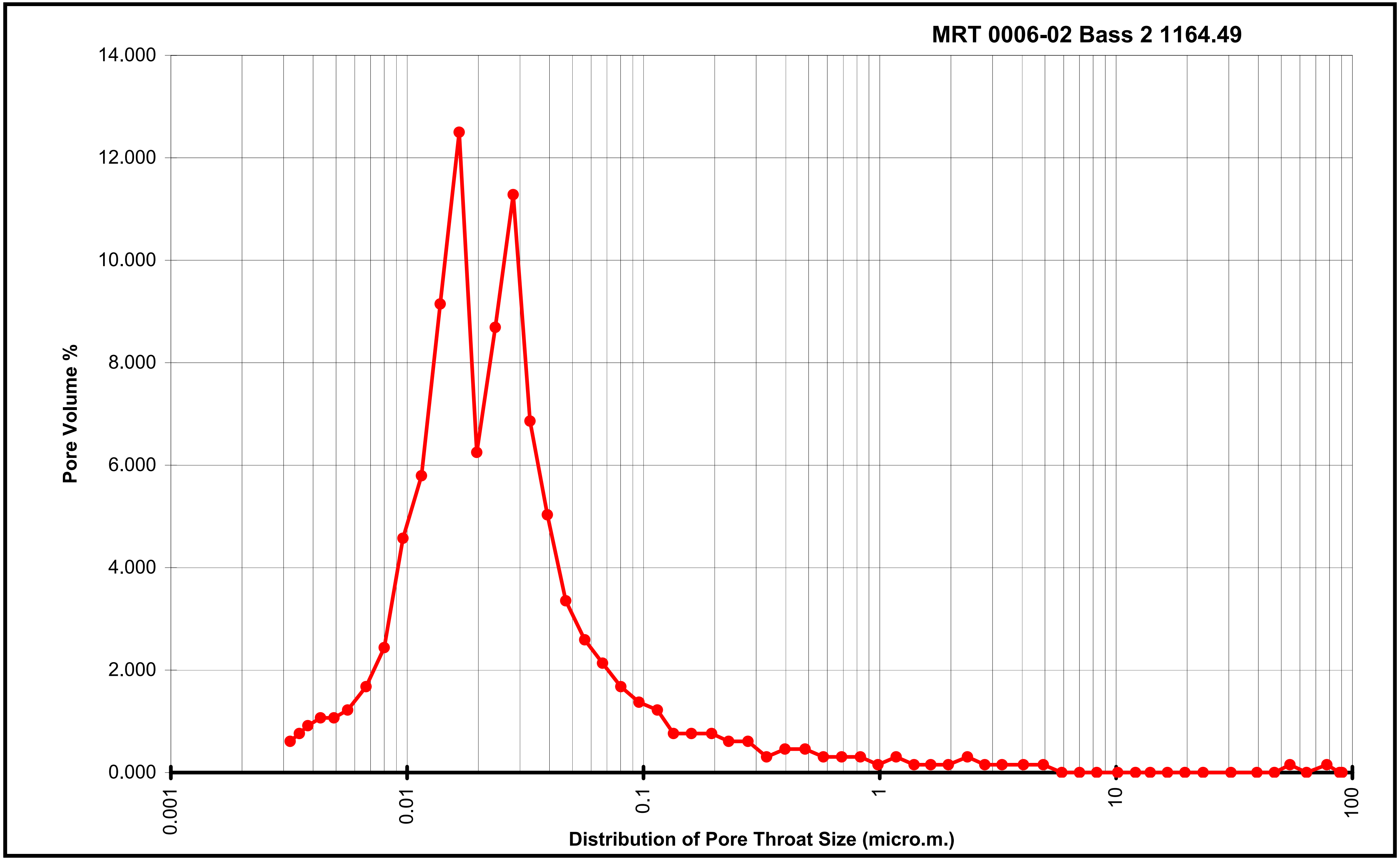
Wardlaw, N.C., and M. McKellar, 1981. Mercury porosimetry and the interpretation of pore geometry in sedimentary rocks and artificial models. Powder Technology v. 29, p. 127 – 143.

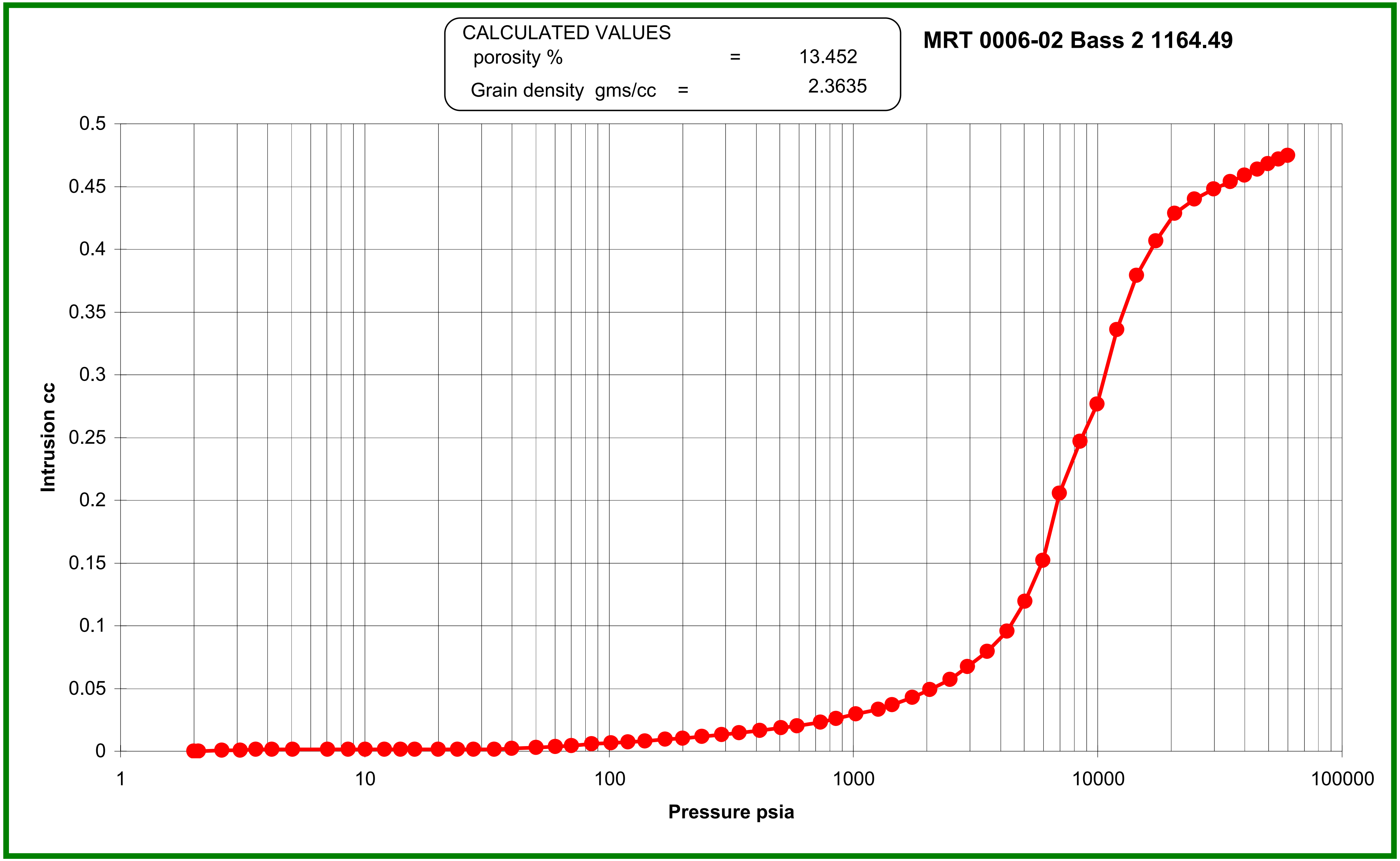

Water Saturation vs Height (normal)
Height (m) above FWL
Water Saturation %
0
1000
2000
3000
4000
5000
6000
7000
0
10
20
30
40
50
60
70
80
90
100
Average Threshold Pressure (H Max) 5750 psia @ 605 m
Cormorant 1 1999
Cormorant 1 2231
Dondu 1 2342
Durroon 1 3021
Bass 2 1164
Pelican 5 2863
Pelican 5 2890
Poonboon 1 3259
Tilana 1 2800
Yolla 2 3039
Bass 2 1261
Poonboon 1 2473.8
Poonboon 1 2689.8
Poonboon 1 3035
Tilana 1 1667



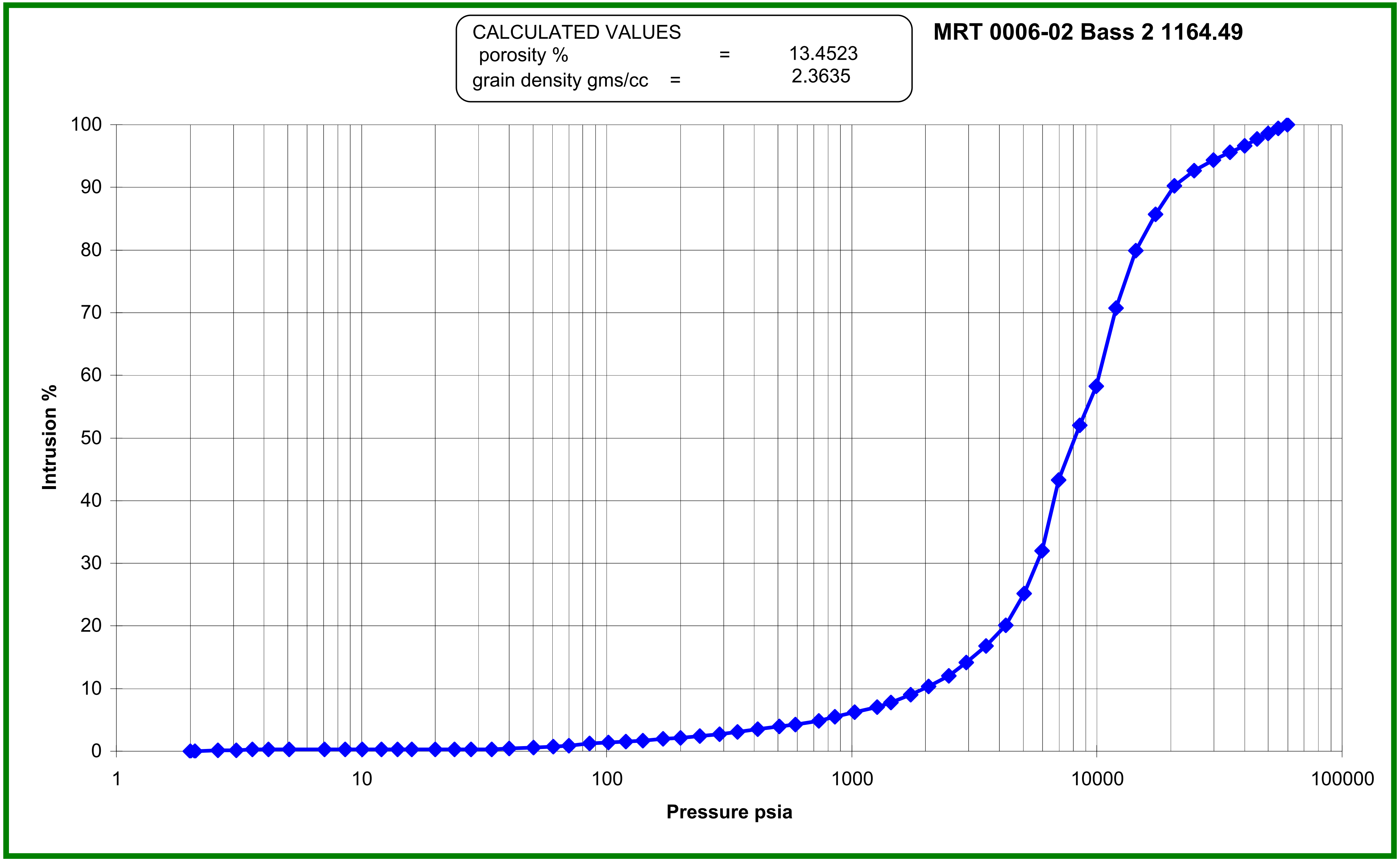
Capillary Pressure Data
(Water Saturation vs Height))
10000
1000
100
10
1
Height (m) above FWL
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %
Average Column
Height (Oil)
605 m
Cormorant 1 1999
Cormorant 1 2231
Dondu 1 2342
Durroon 1 3021
Bass 2 1164
Pelican 5 2863
Pelican 5 2890
Poonboon 1 3259
Tilana 1 2800
Yolla 2 3039
Bass 2 1261
Poonboon 1 2473.8
Poonboon 1 2689.8
Poonboon 1 3035
Tilana 1 1667

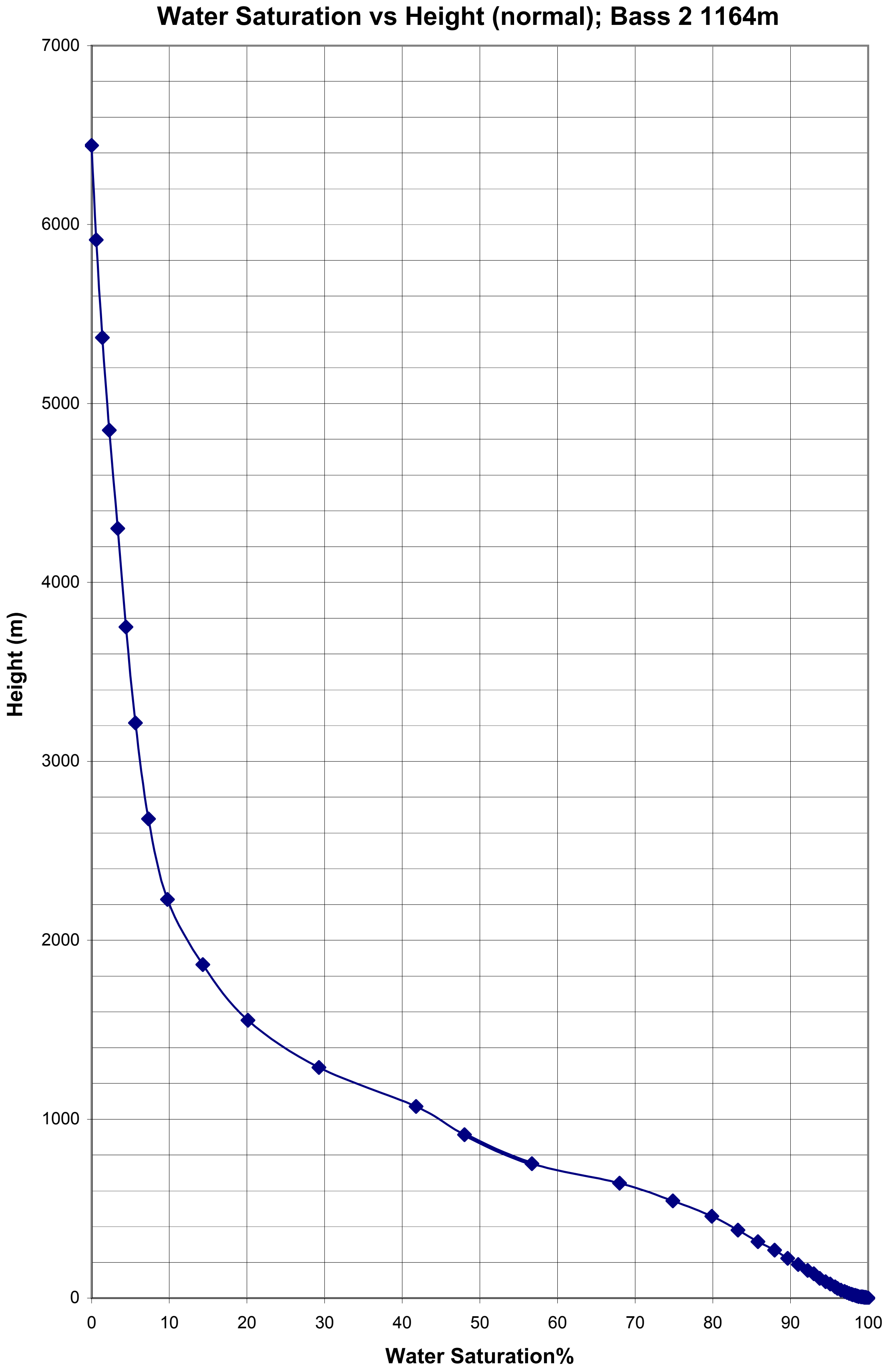
Bass_2_1164m.xls



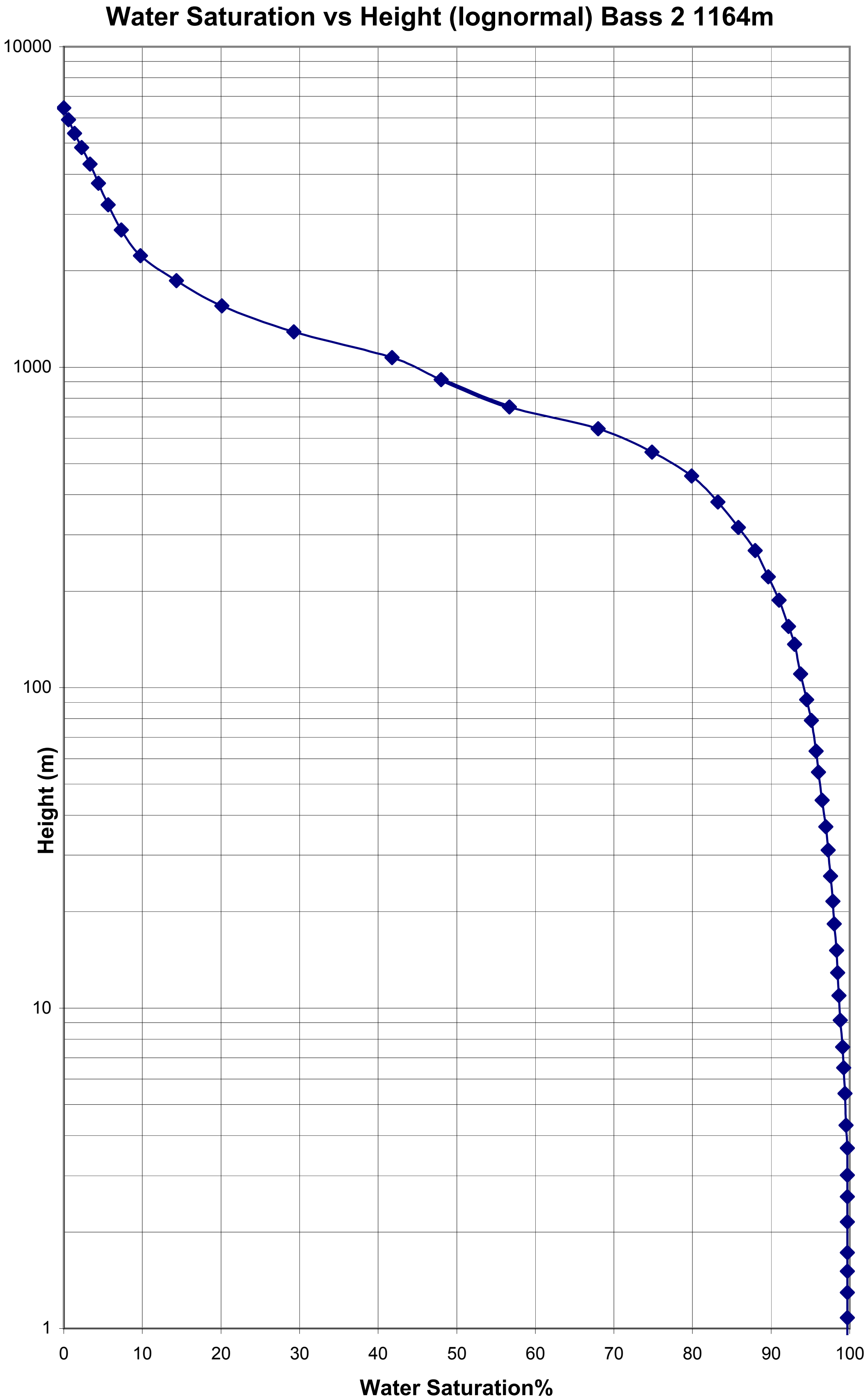

CALCULATED VALUES
porosity % = 13.452
Grain density gms/cc = 2.3635
MRT 0006-02 Bass 2 1164.49
Intrusion cc
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
Pressure psia

Bass_2_1164m.xls



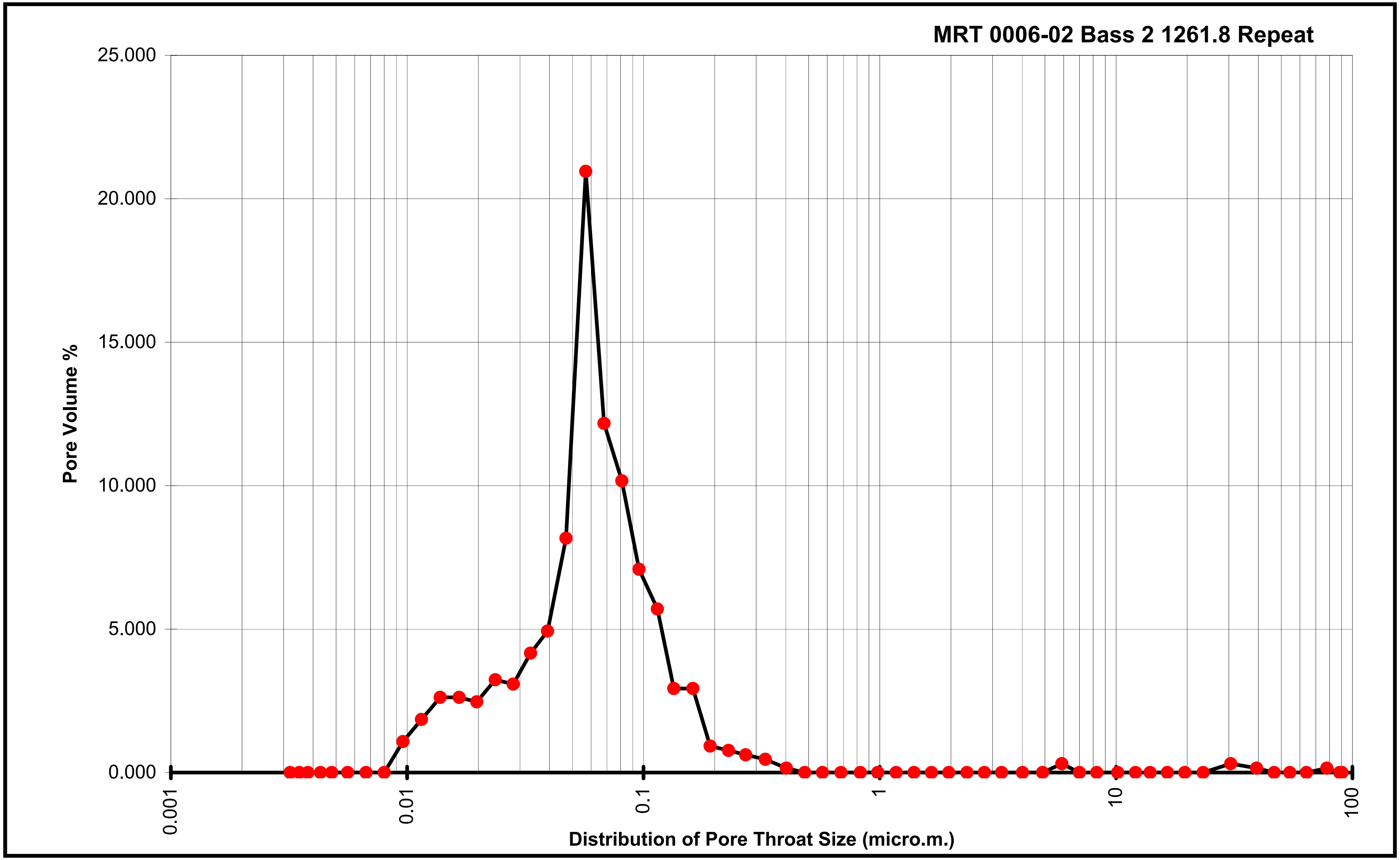


Water Saturation vs Height (normal); Bass 2 1164m
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation%

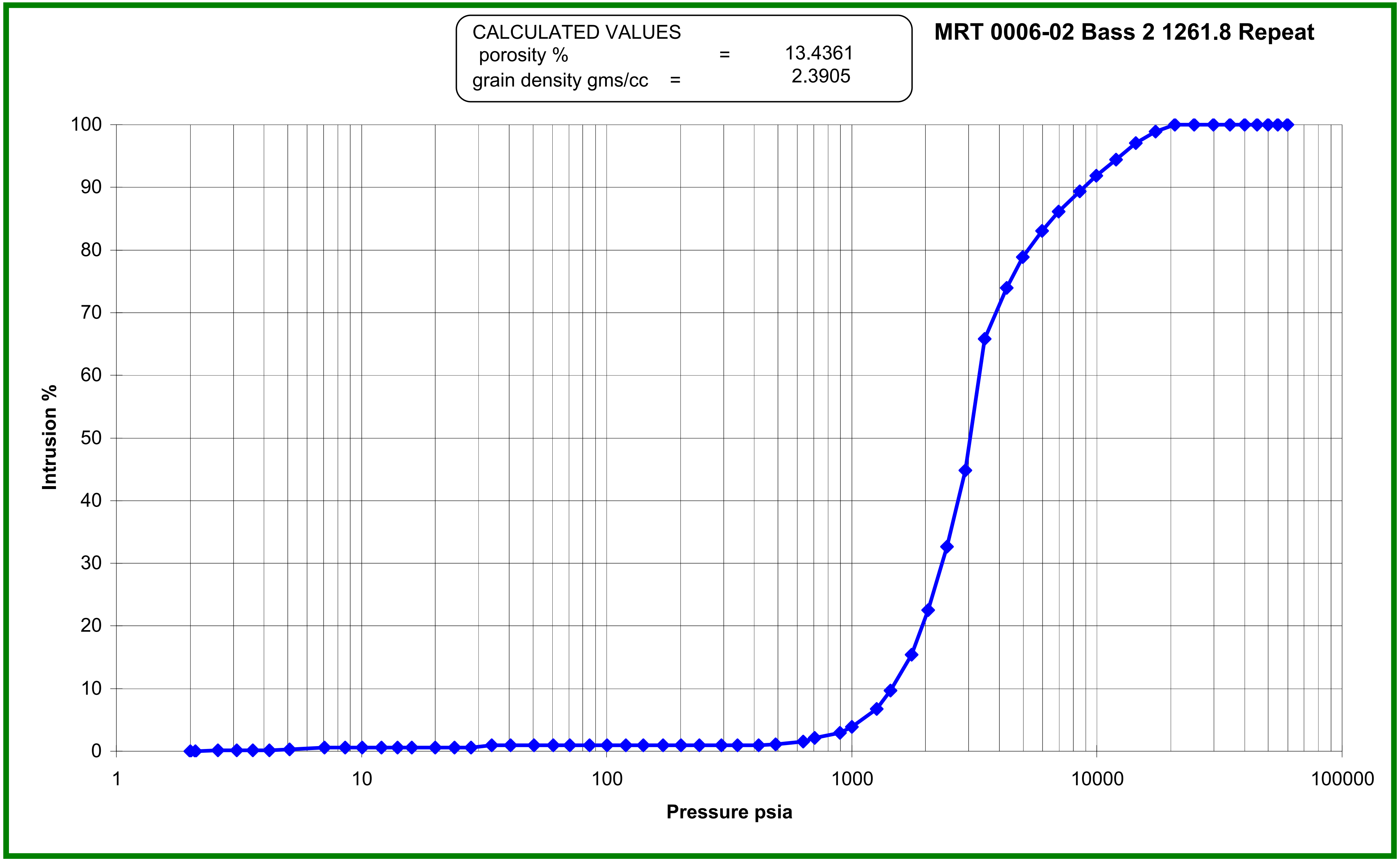


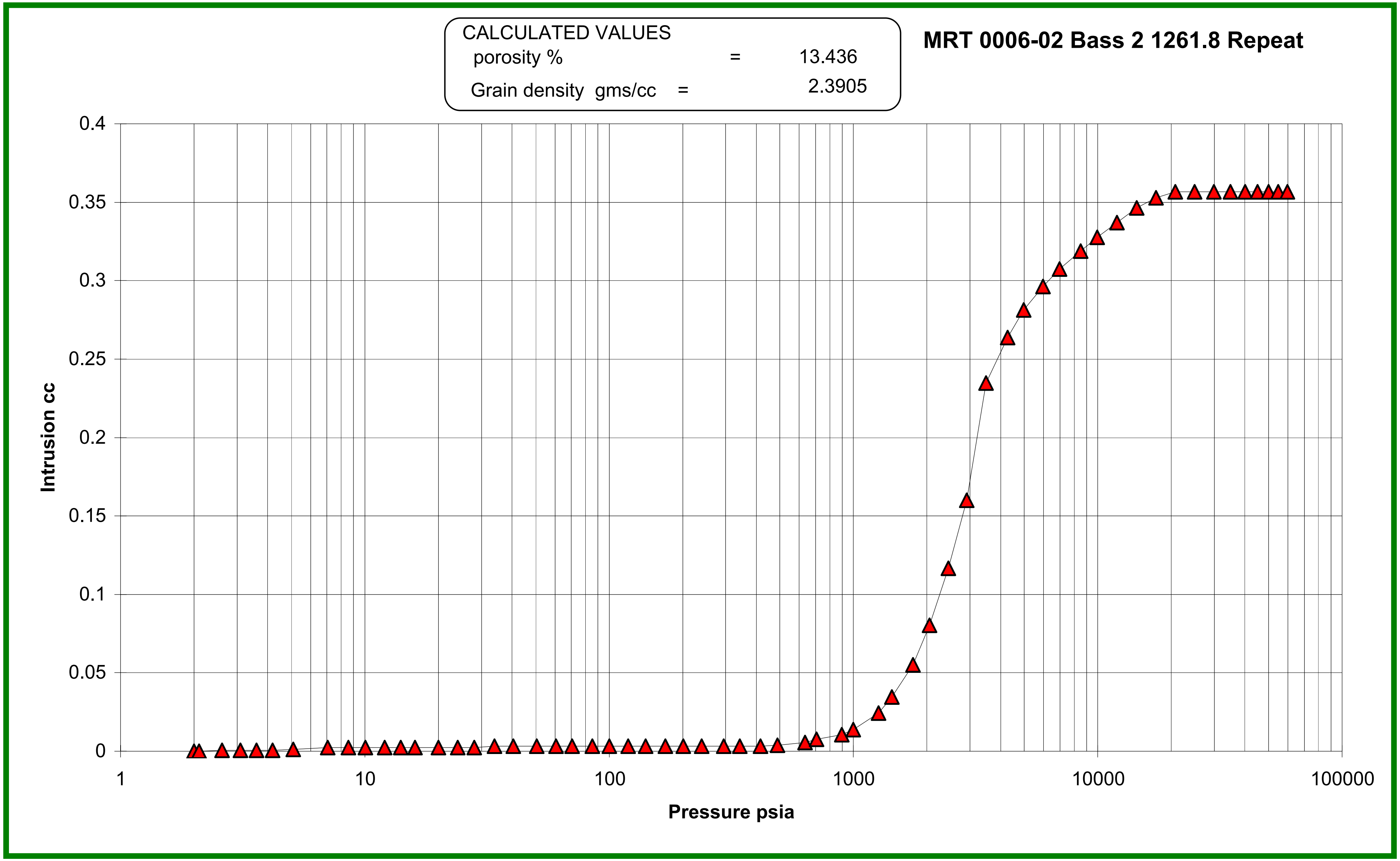
Water Saturation vs Height (lognormal) Bass 2 1164m
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation%

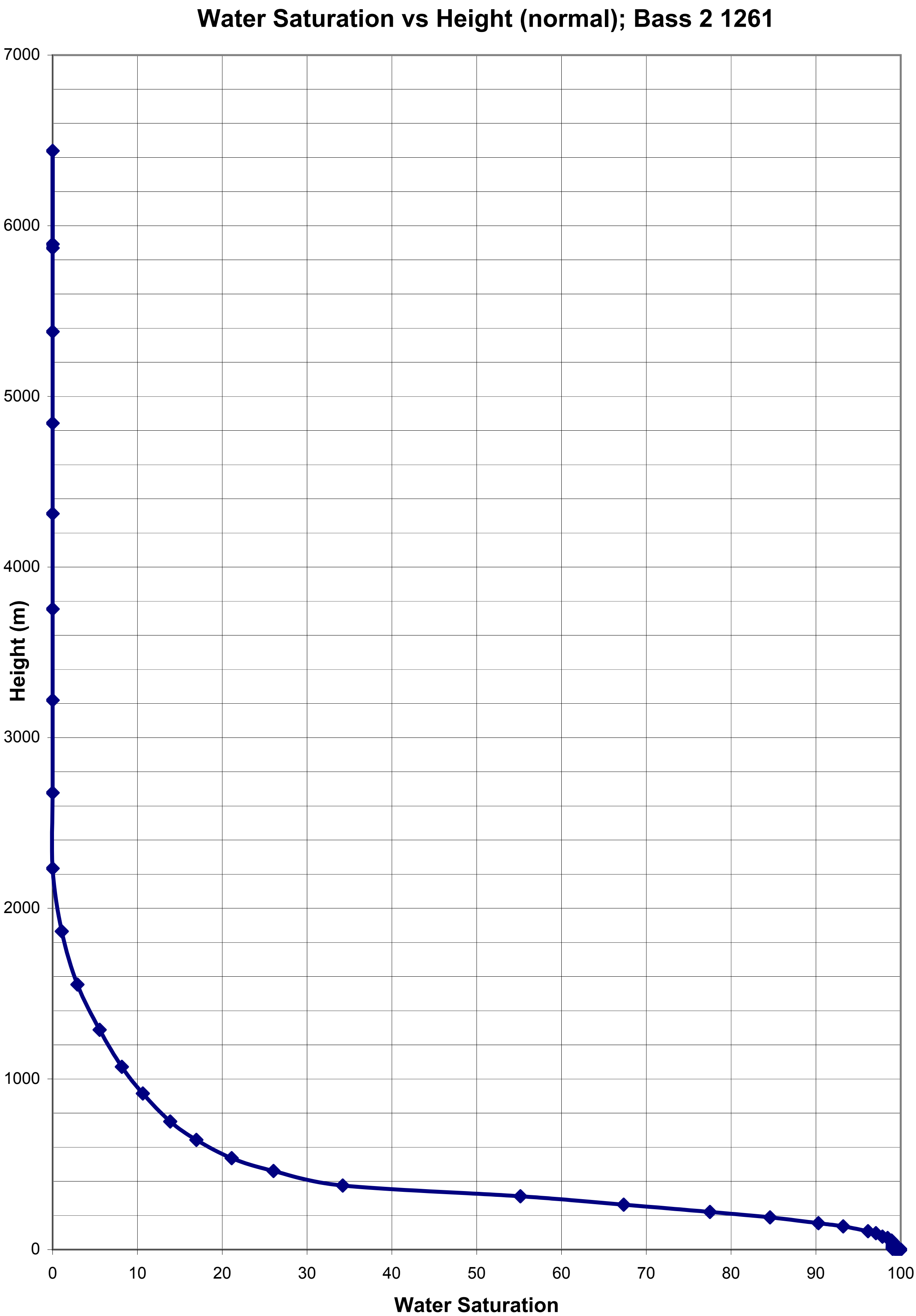
Bass_2_1261m.xls

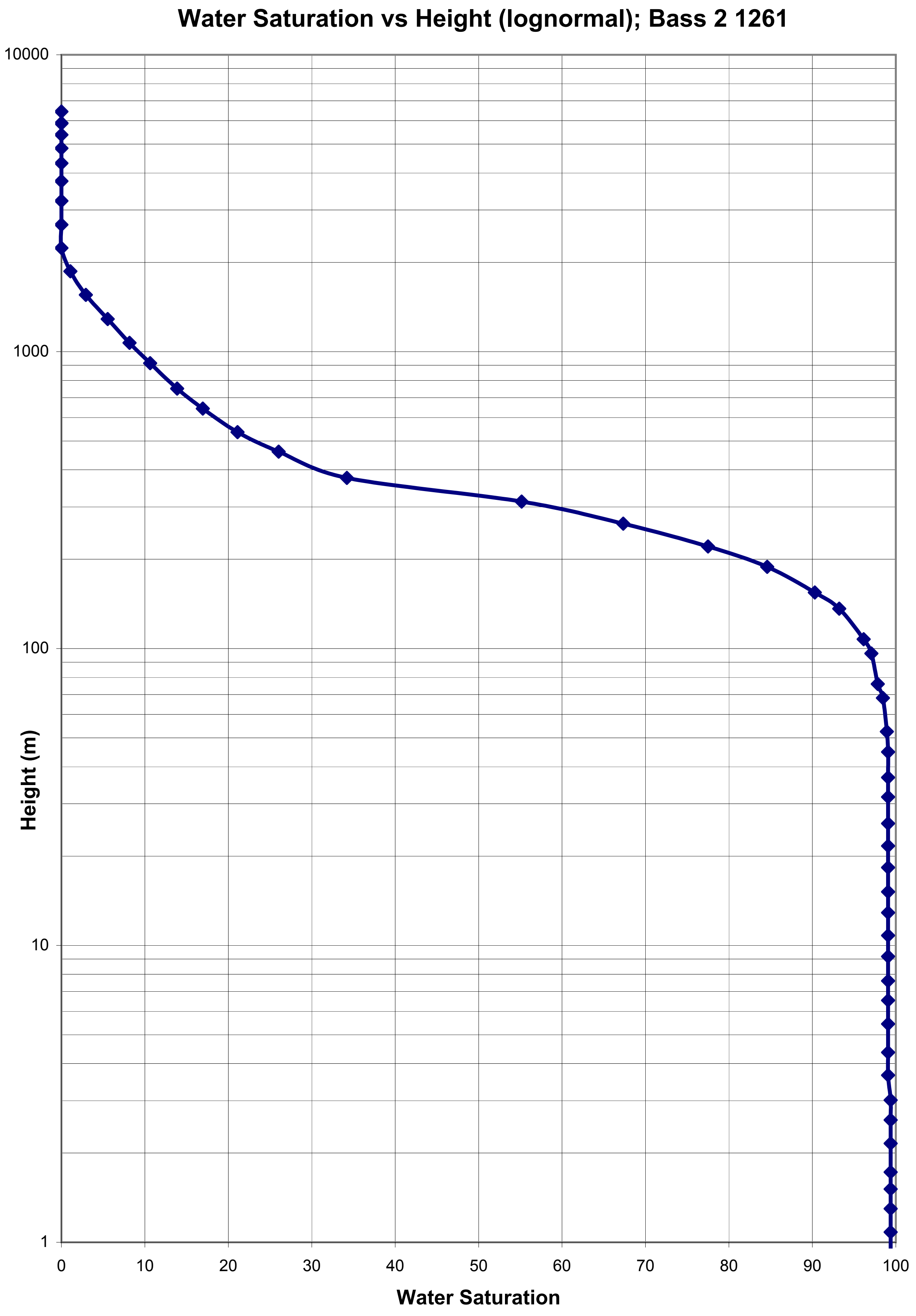


Bass_2_1261m.xls

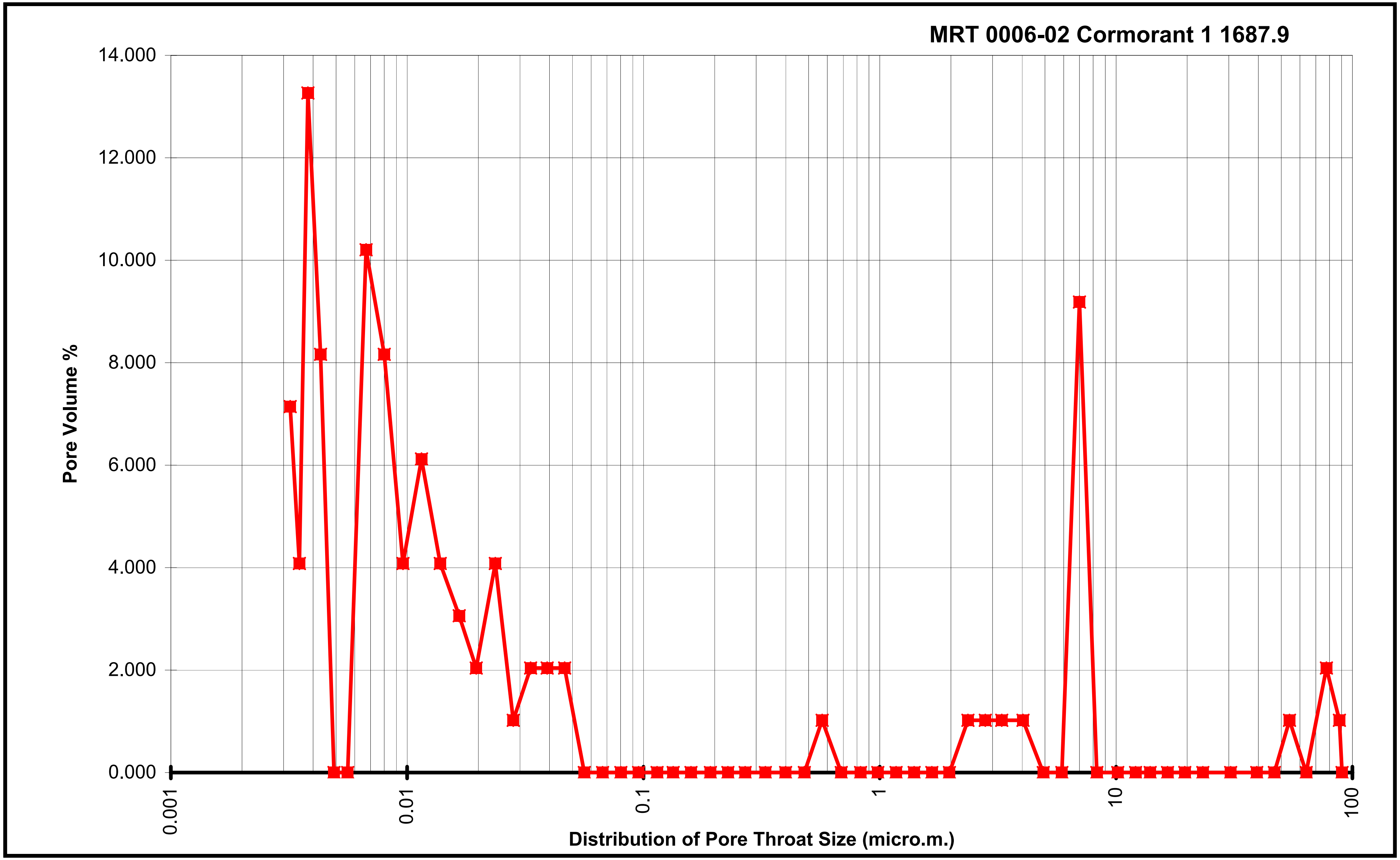


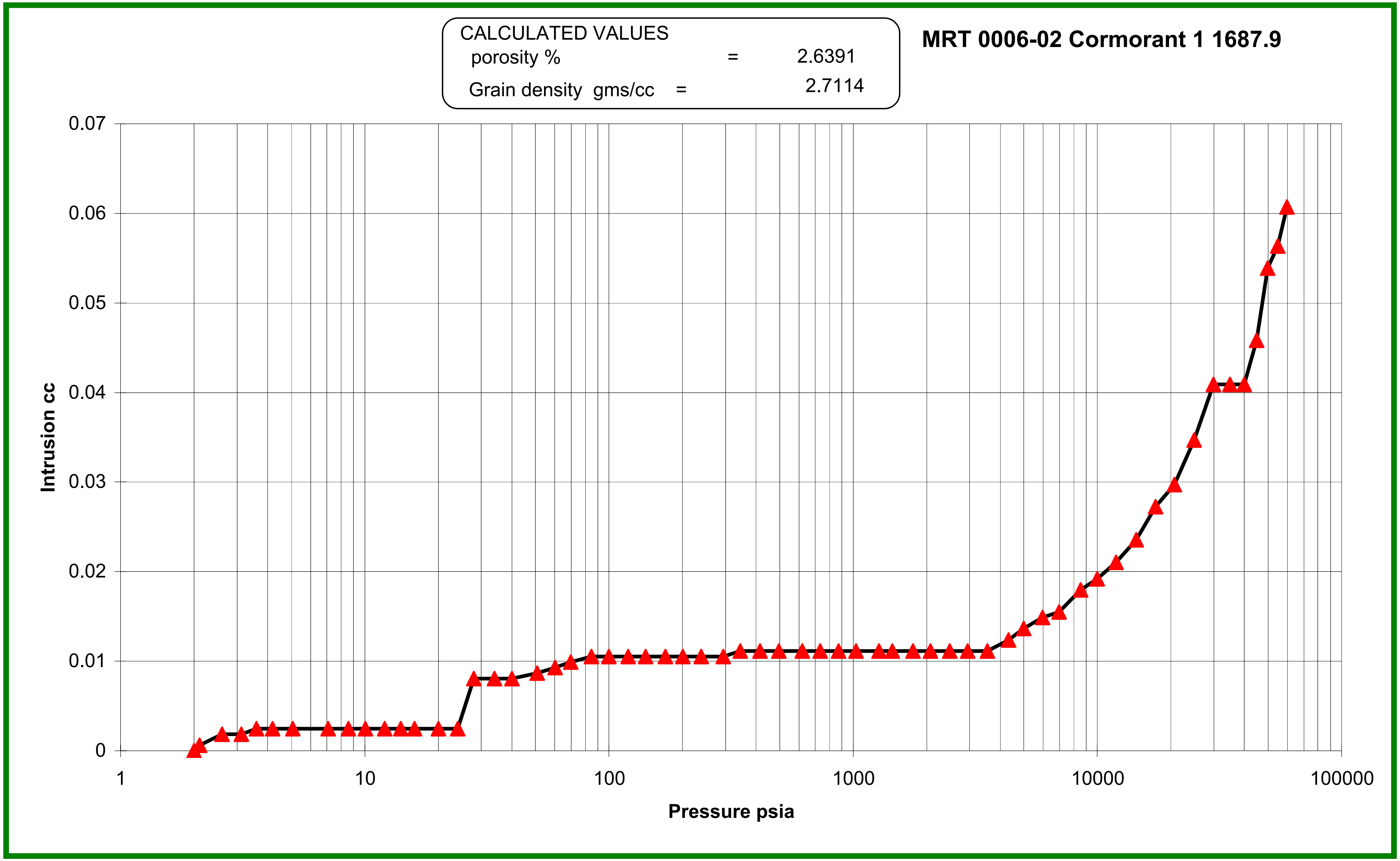

CALCULATED VALUES
porosity % = 13.436
Grain density gms/cc = 2.3905
MRT 0006-02 Bass 2 1261.8 Repeat
Intrusion cc
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
Pressure psia


Water Saturation vs Height (normal); Bass 2 1261
Height (m)
Water Saturation
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100

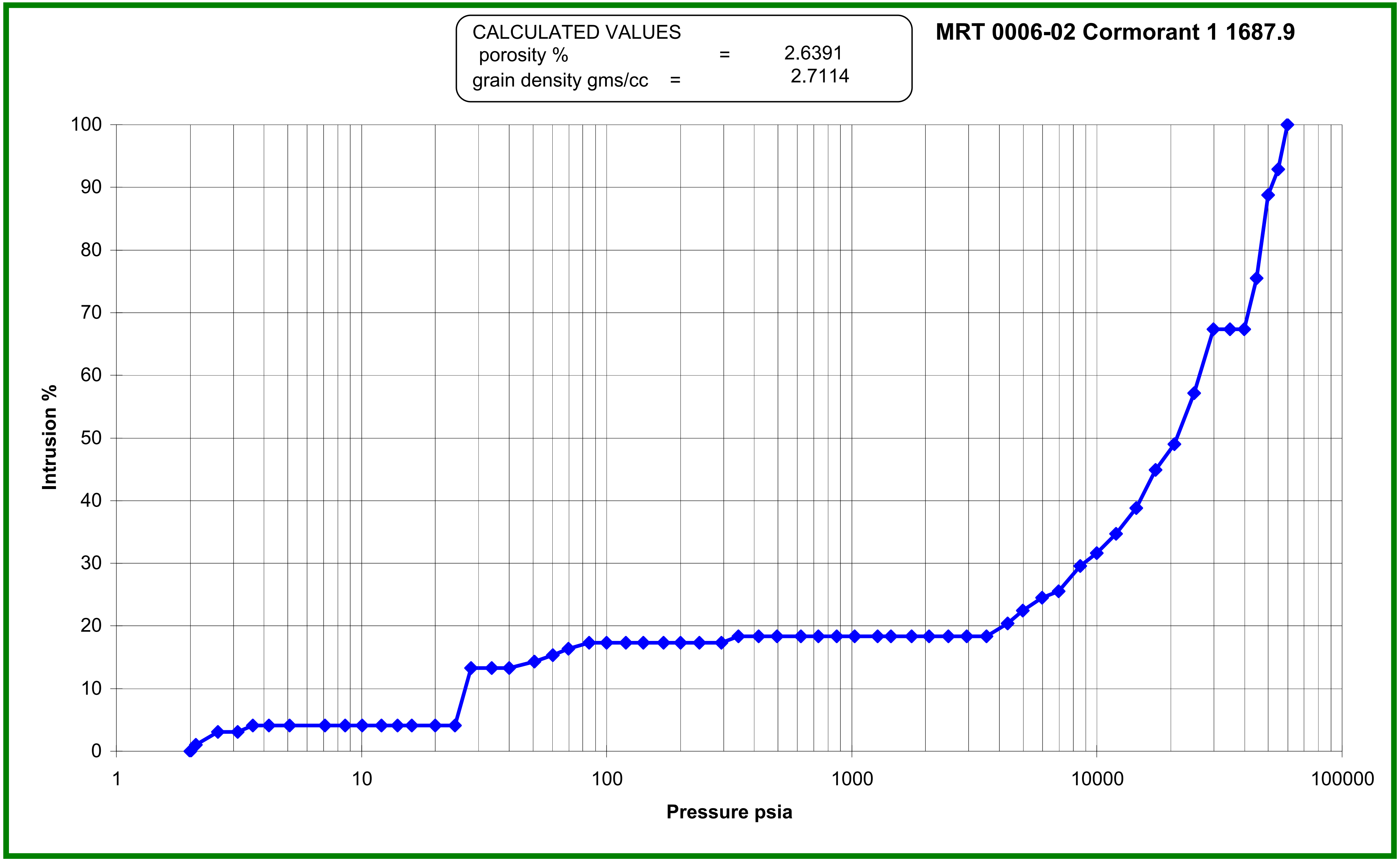

Water Saturation vs Height (lognormal); Bass 2 1261
Height (m)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Water Saturation

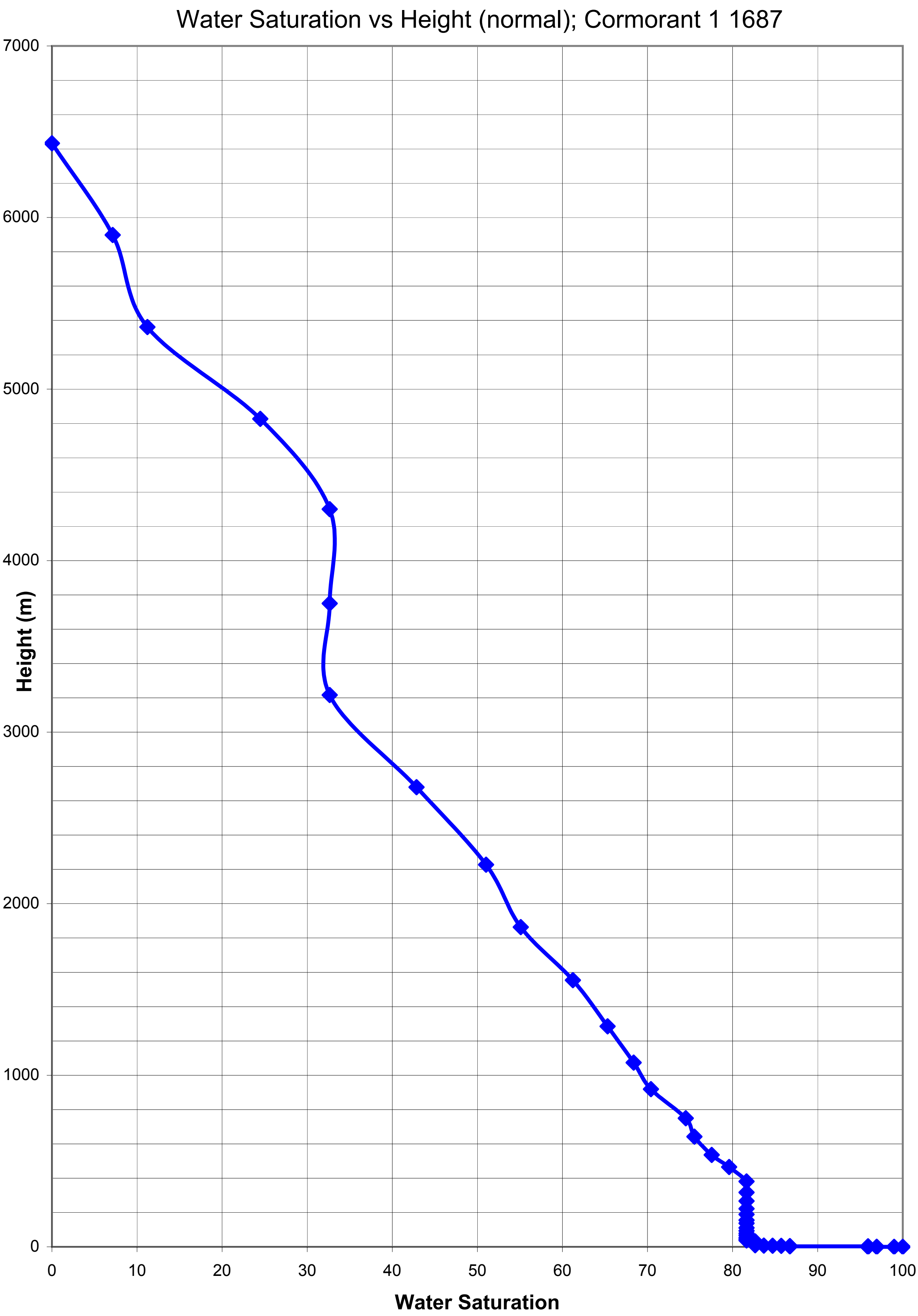
Cormorant_1_1687m.xls



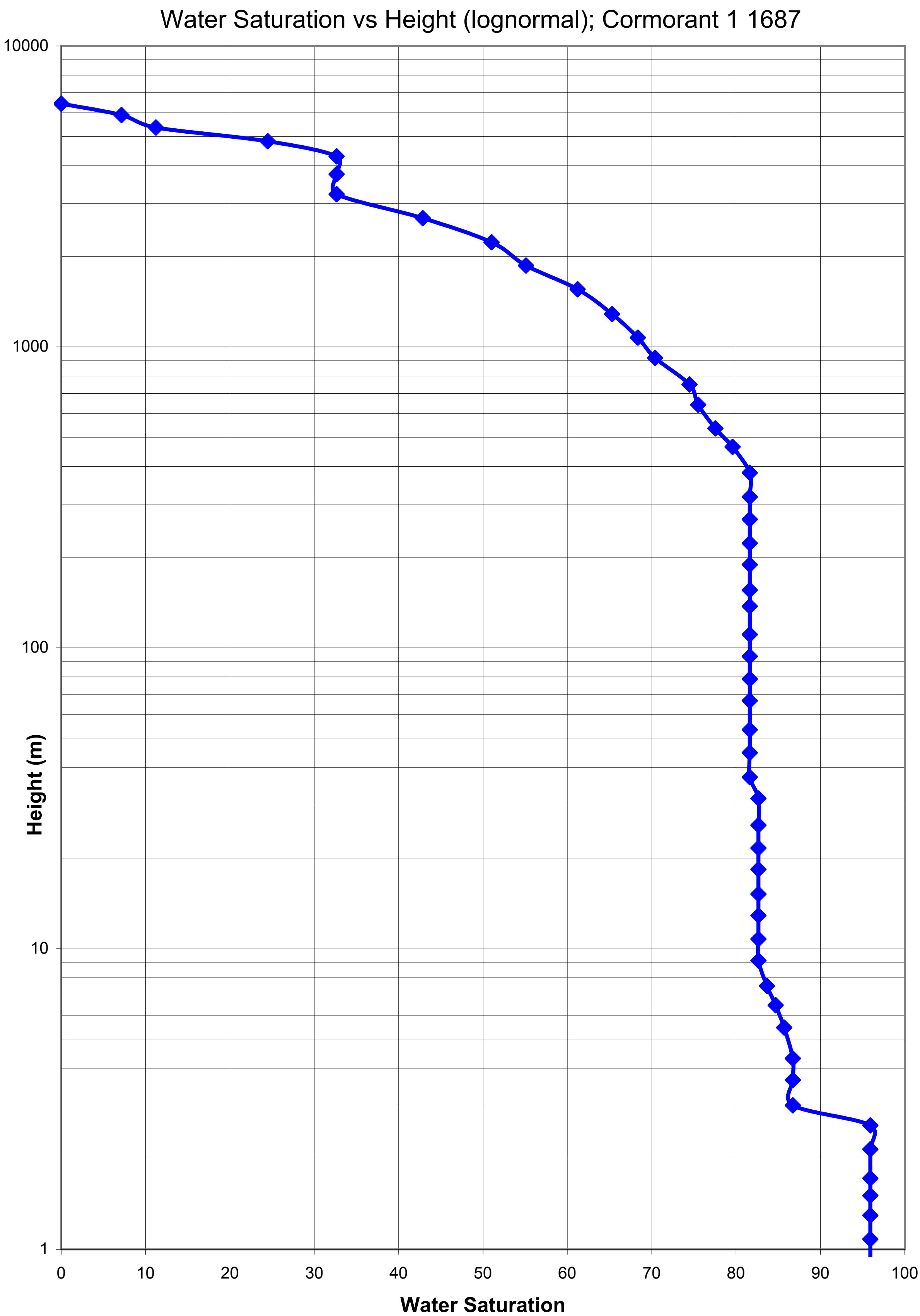

CALCULATED VALUES
porosity % = 2.6391
Grain density gms/cc = 2.7114
MRT 0006-02 Cormorant 1 1687.9
Intrusion cc
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1
10
100
1000
10000
100000
Pressure psia

Cormorant_1_1687m.xls



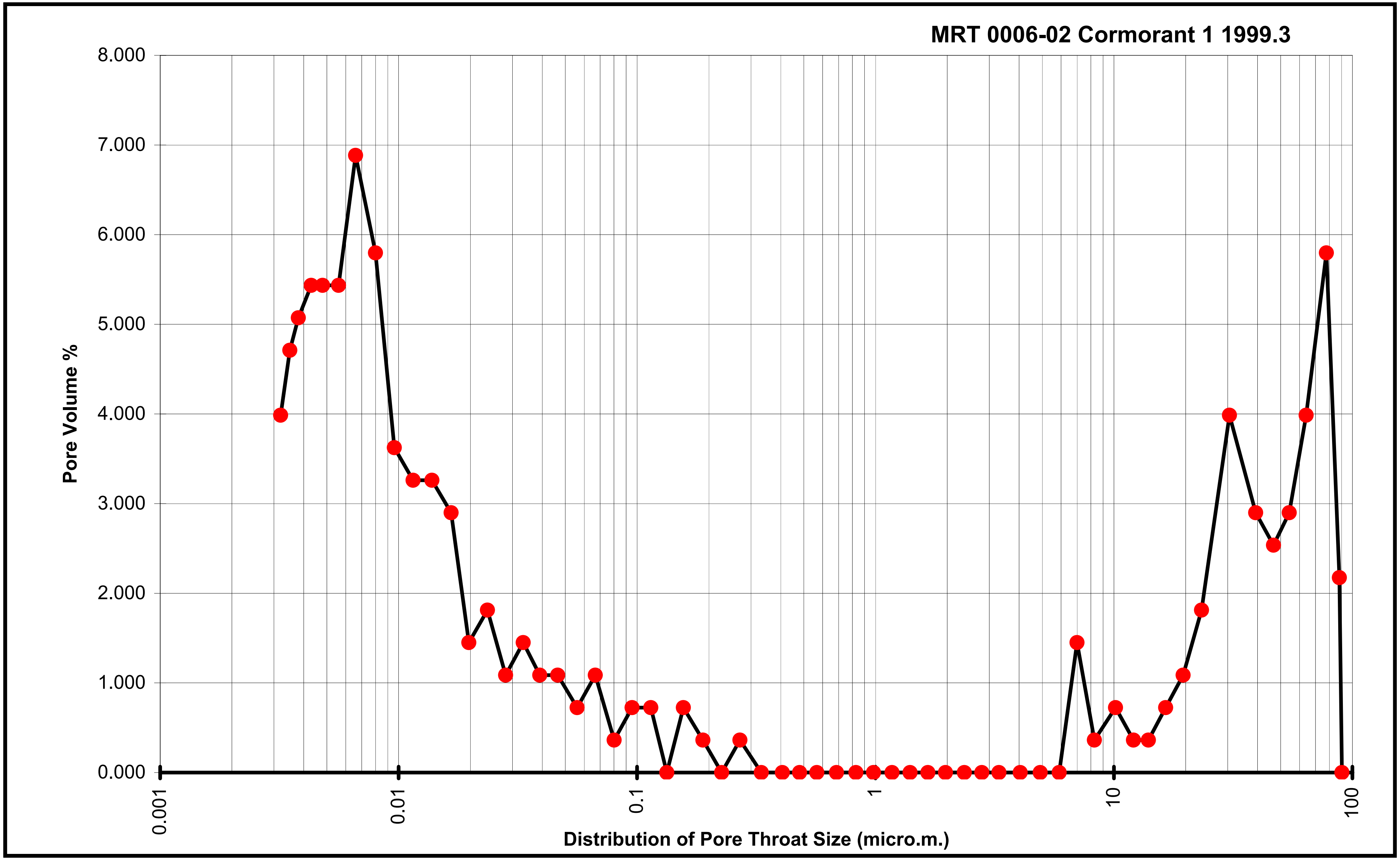


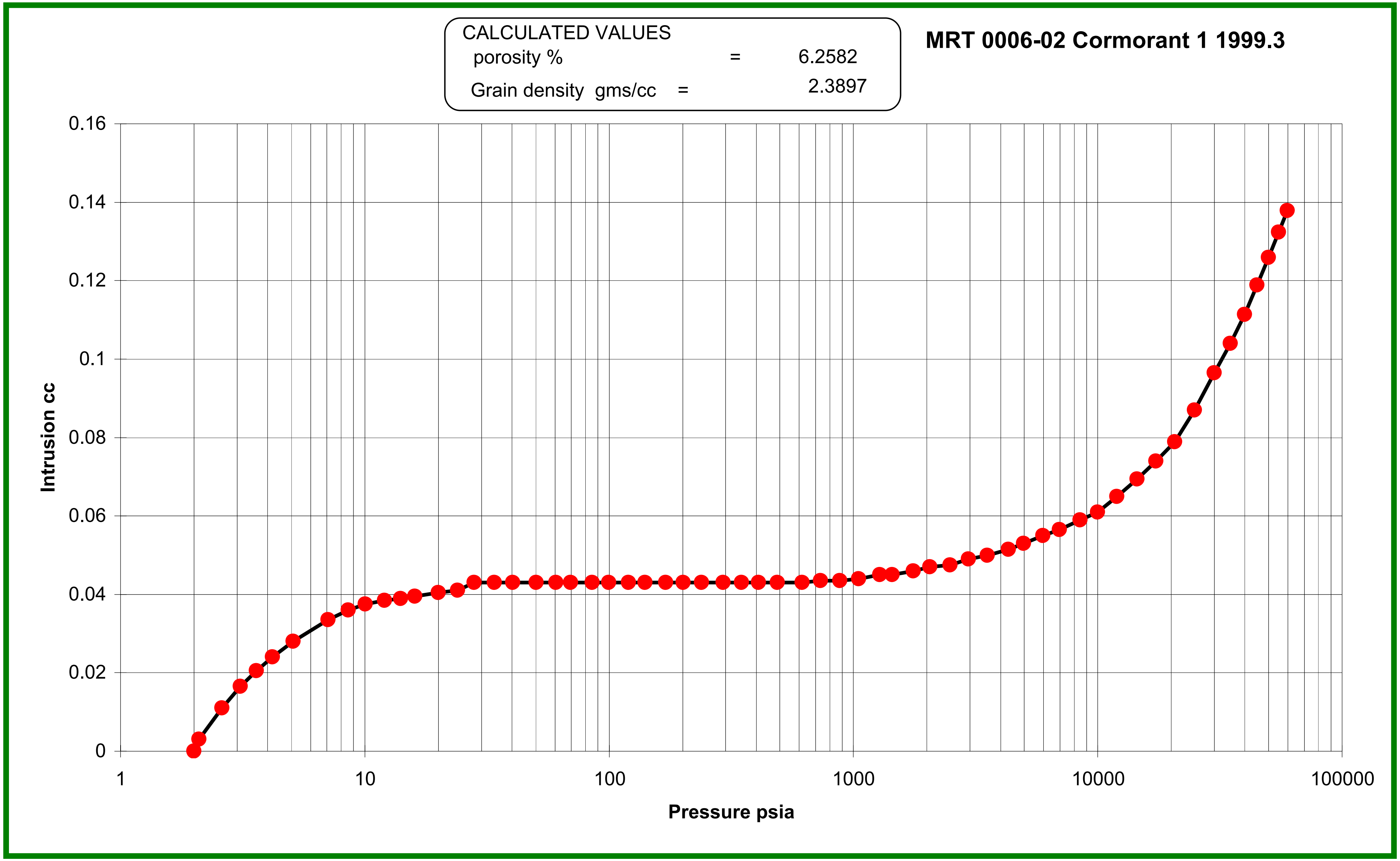
Water Saturation vs Height (normal); Cormorant 1 1687
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation

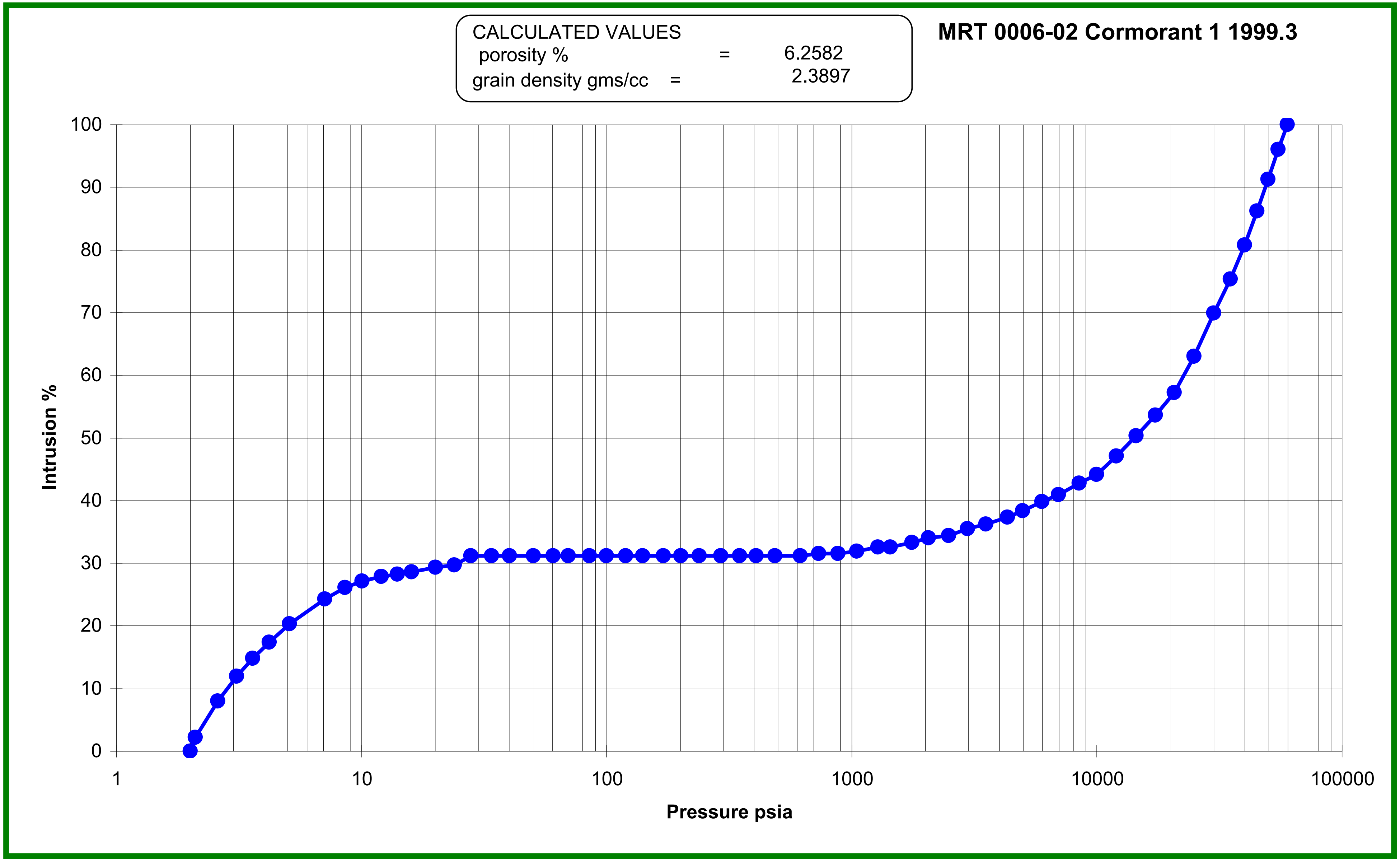


Water Saturation vs Height (lognormal); Cormorant 1 1687
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation

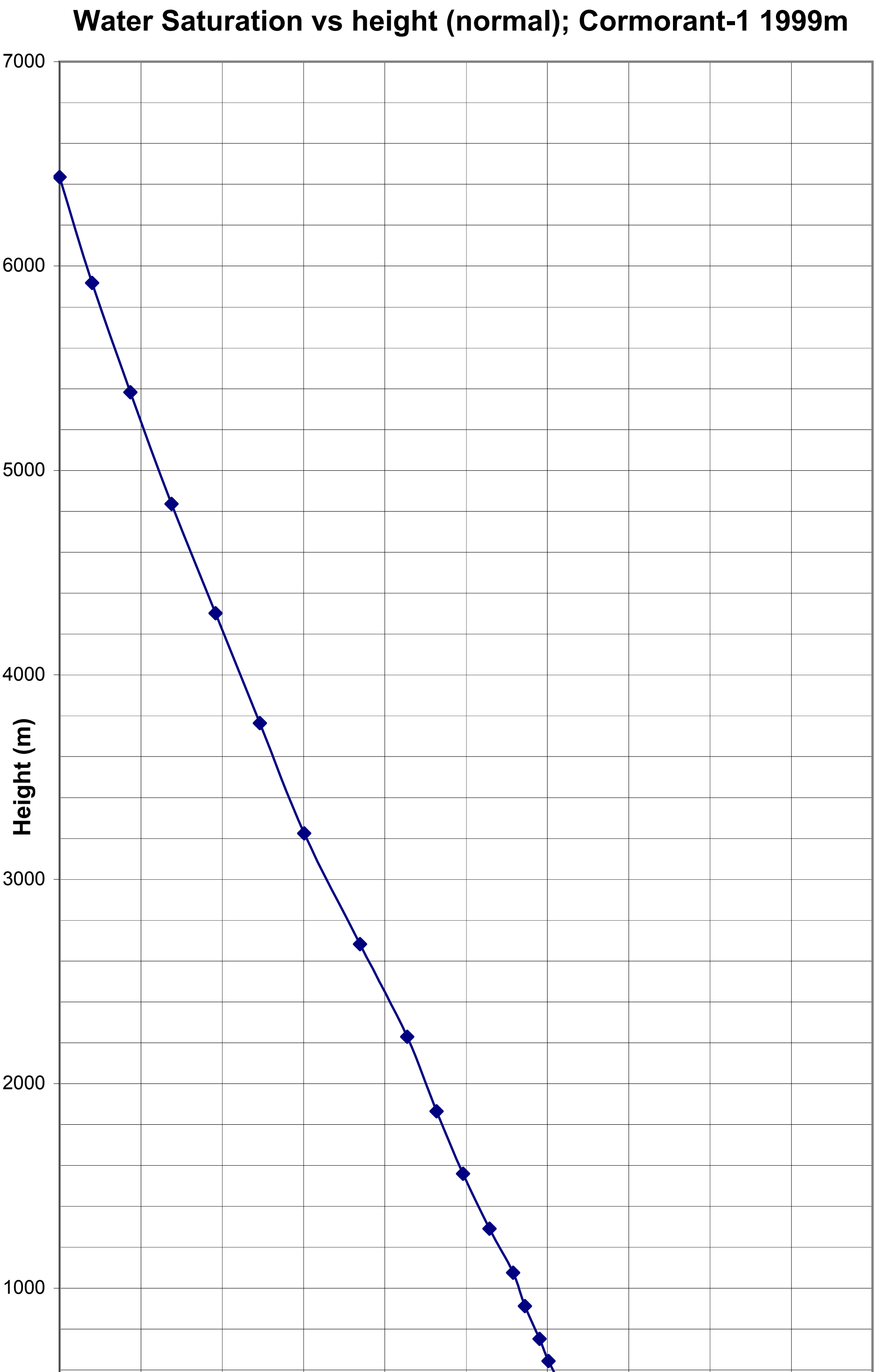
Cormorant_1_1999m.xls

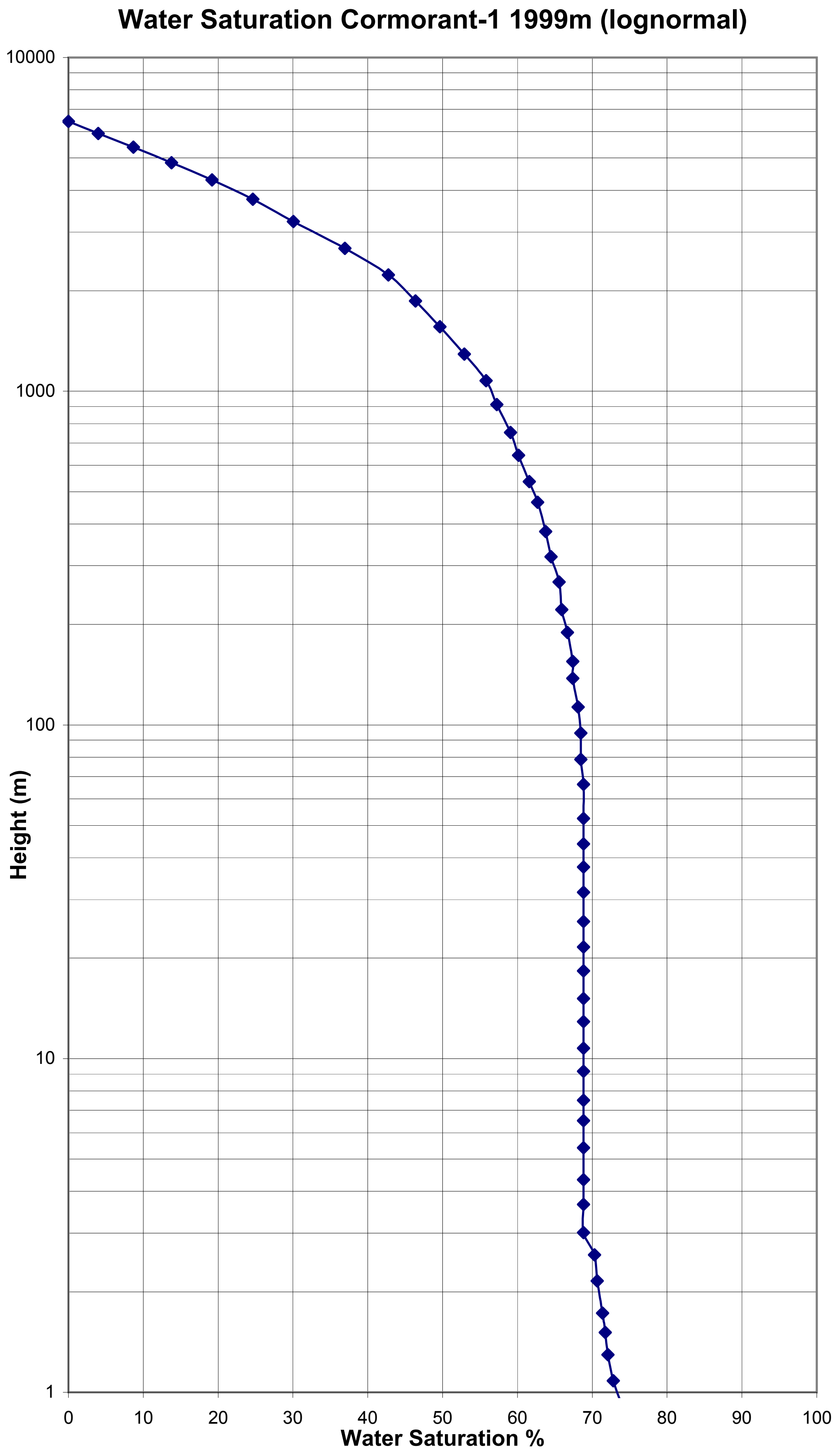



CALCULATED VALUES
porosity % = 6.2582
Grain density gms/cc = 2.3897
MRT 0006-02 Cormorant 1 1999.3
Intrusion cc
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
10
100
1000
10000
100000
Pressure psia

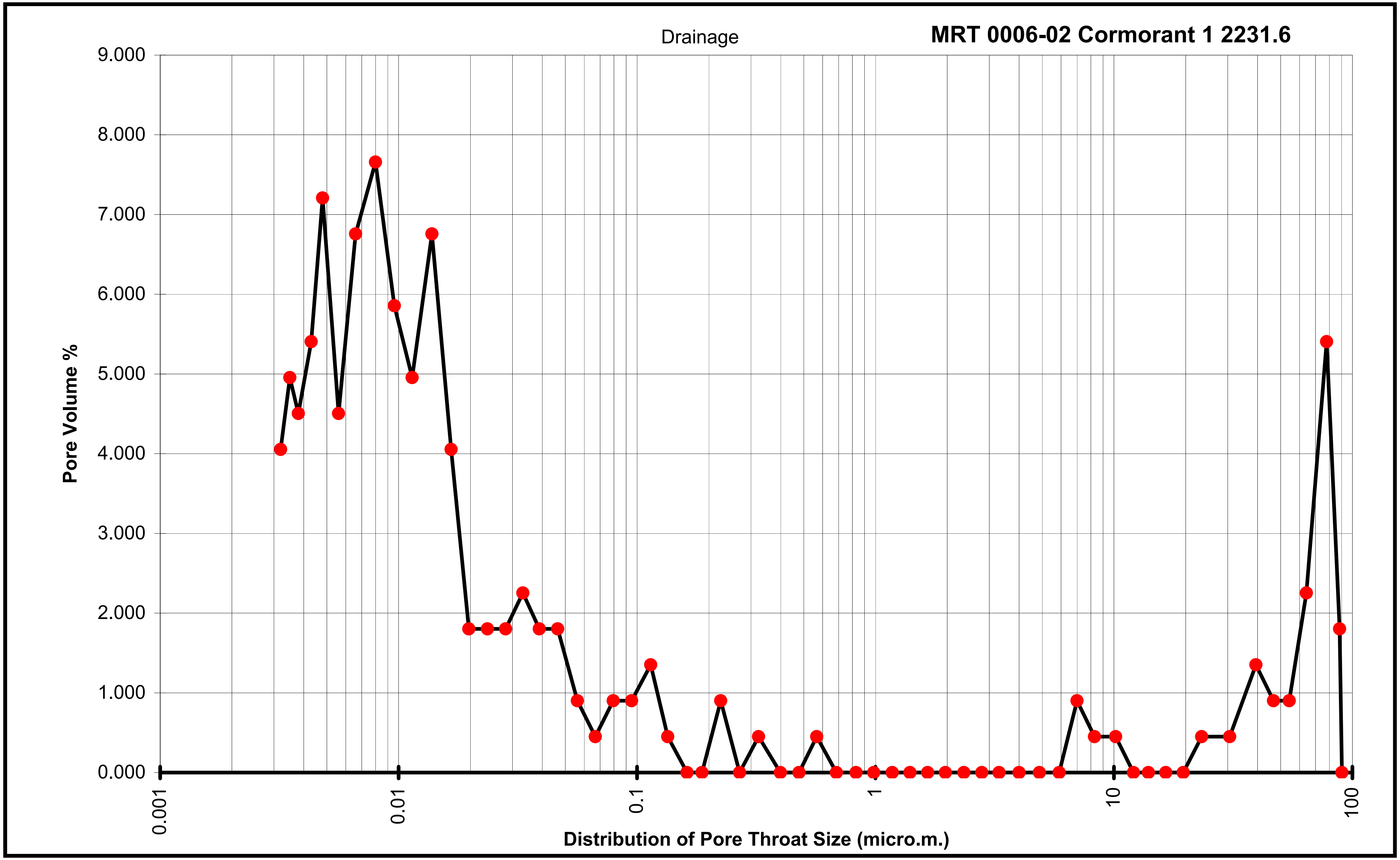


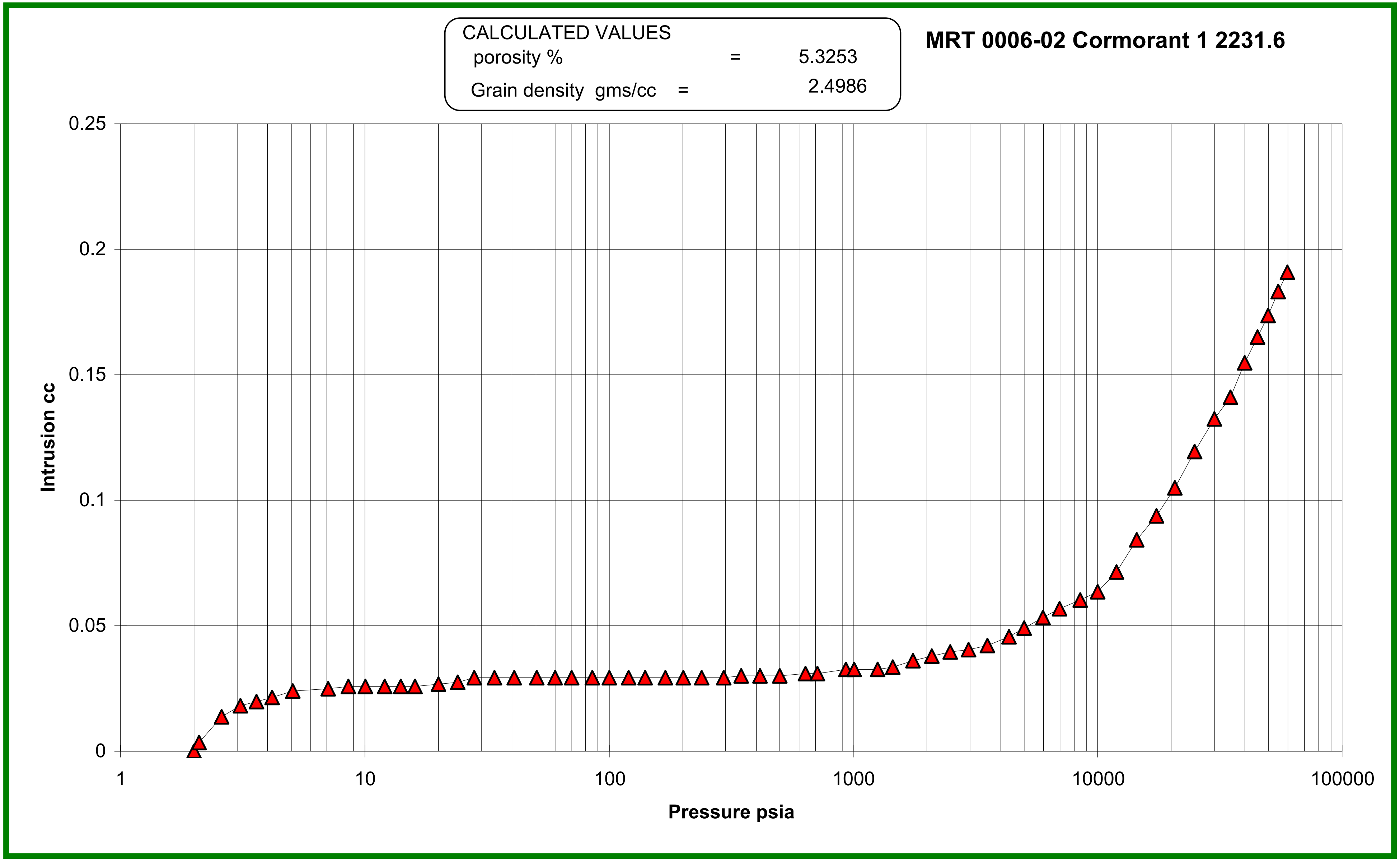
CALCULATED VALUES
porosity % = 6.2582
grain density gms/cc = 2.3897
MRT 0006-02 Cormorant 1 1999.3
Intrusion %
Pressure psia
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000

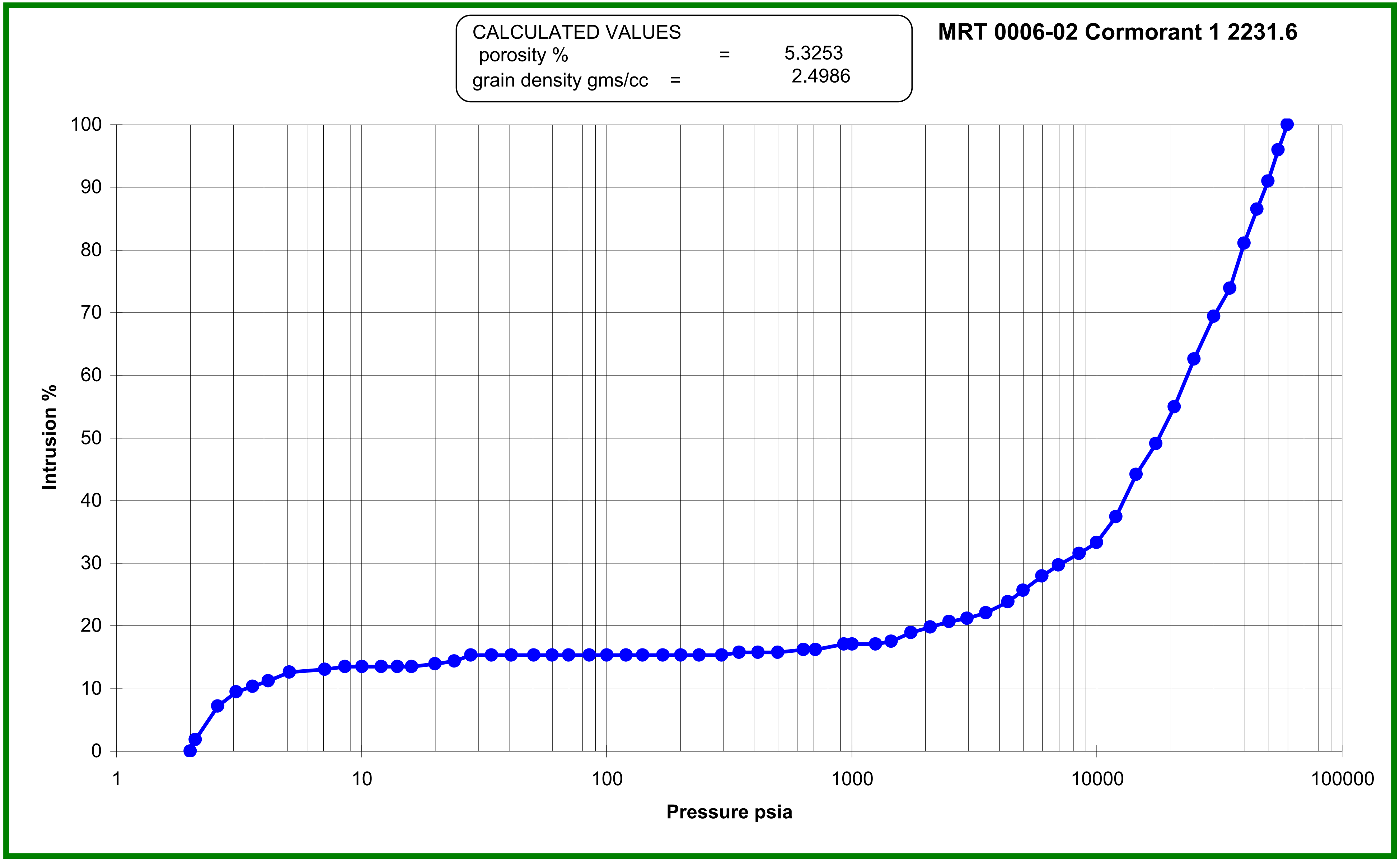

Water Saturation vs height (normal); Cormorant-1 1999m
Height (m)
Water Saturation %
0
1000
2000
3000
4000
5000
6000
7000
0
10
20
30
40
50
60
70
80
90
100

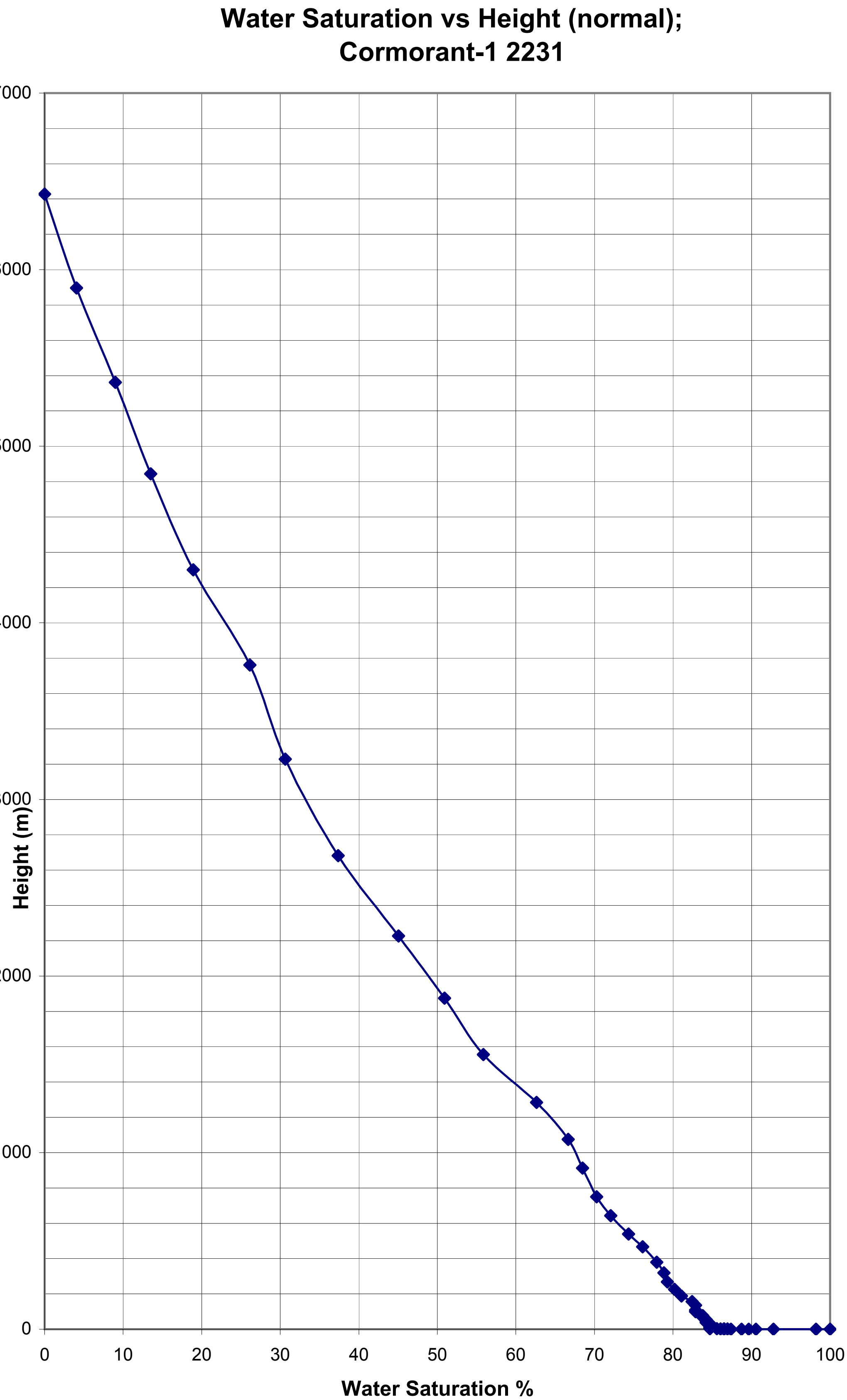

Water Saturation Cormorant-1 1999m (lognormal)
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

Cormorant_1_2231m.xls

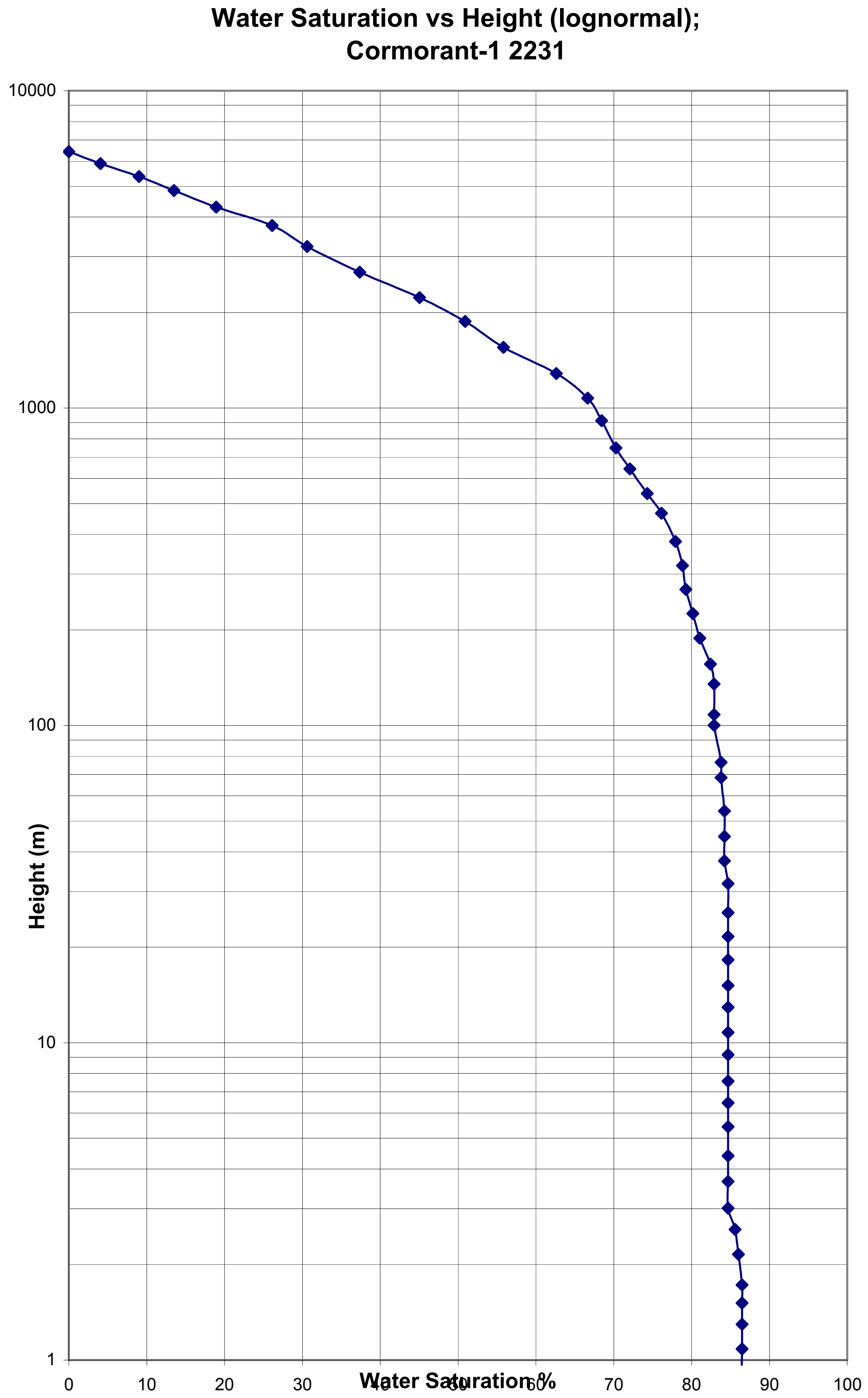



CALCULATED VALUES
porosity % = 5.3253
Grain density gms/cc = 2.4986
MRT 0006-02 Cormorant 1 2231.6
0.25
0.2
0.15
0.1
0.05
0
Intrusion cc
1
10
100
1000
10000
100000
Pressure psia


CALCULATED VALUES
porosity % = 5.3253
grain density gms/cc = 2.4986
MRT 0006-02 Cormorant 1 2231.6
Intrusion %
Pressure psia
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000

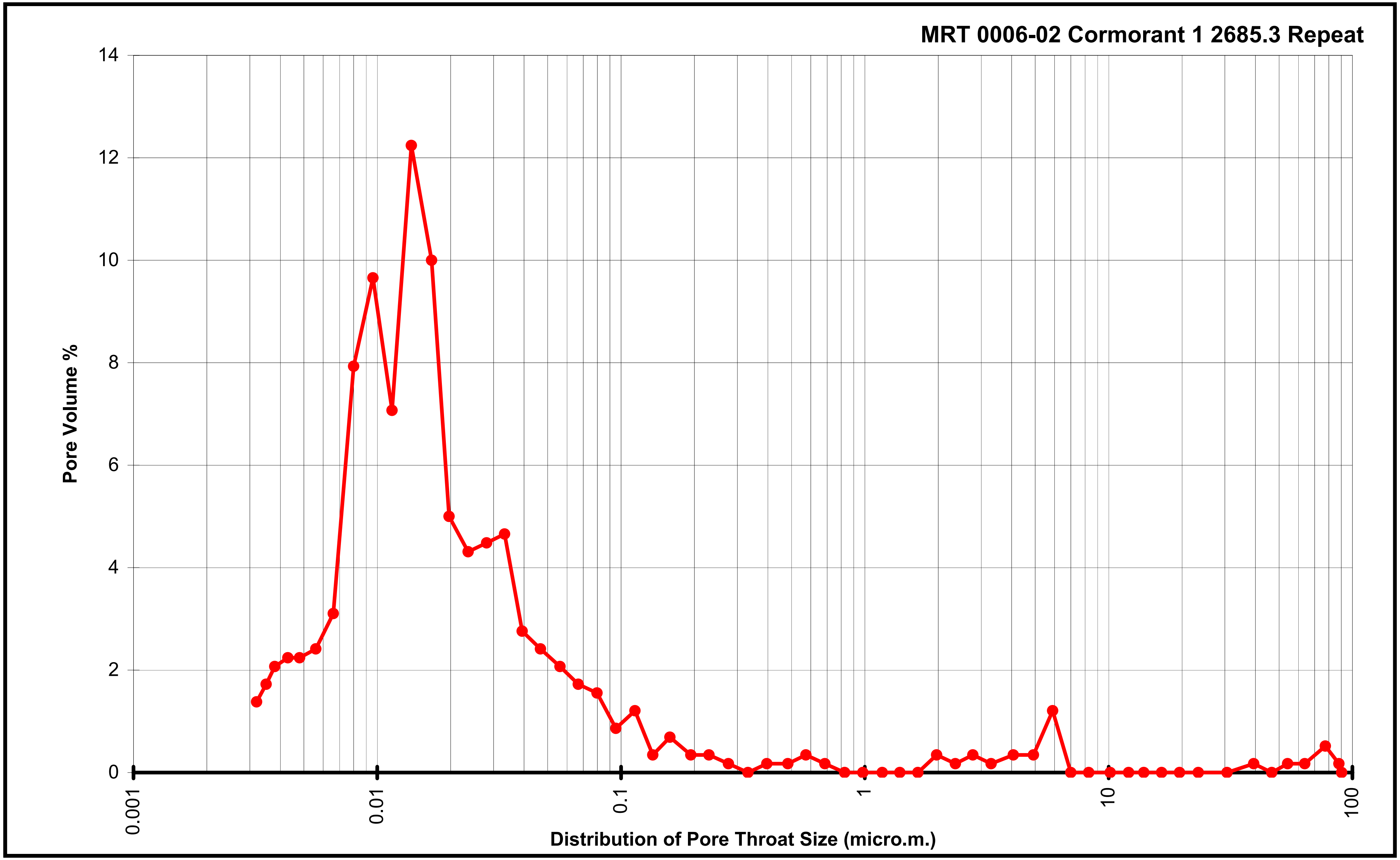


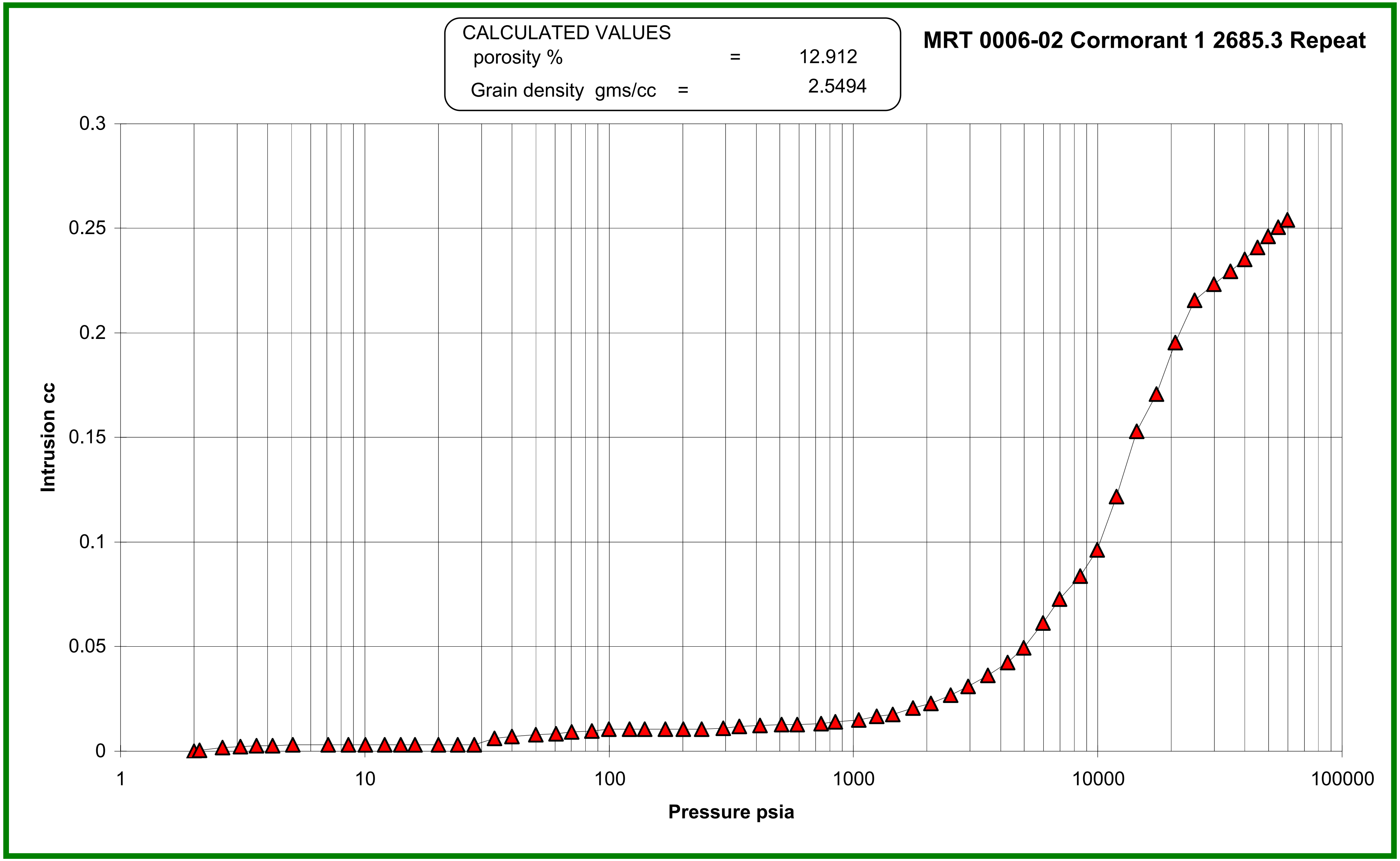
Water Saturation vs Height (normal);
Cormorant-1 2231
7000
6000
5000
4000
3000
2000
1000
0
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

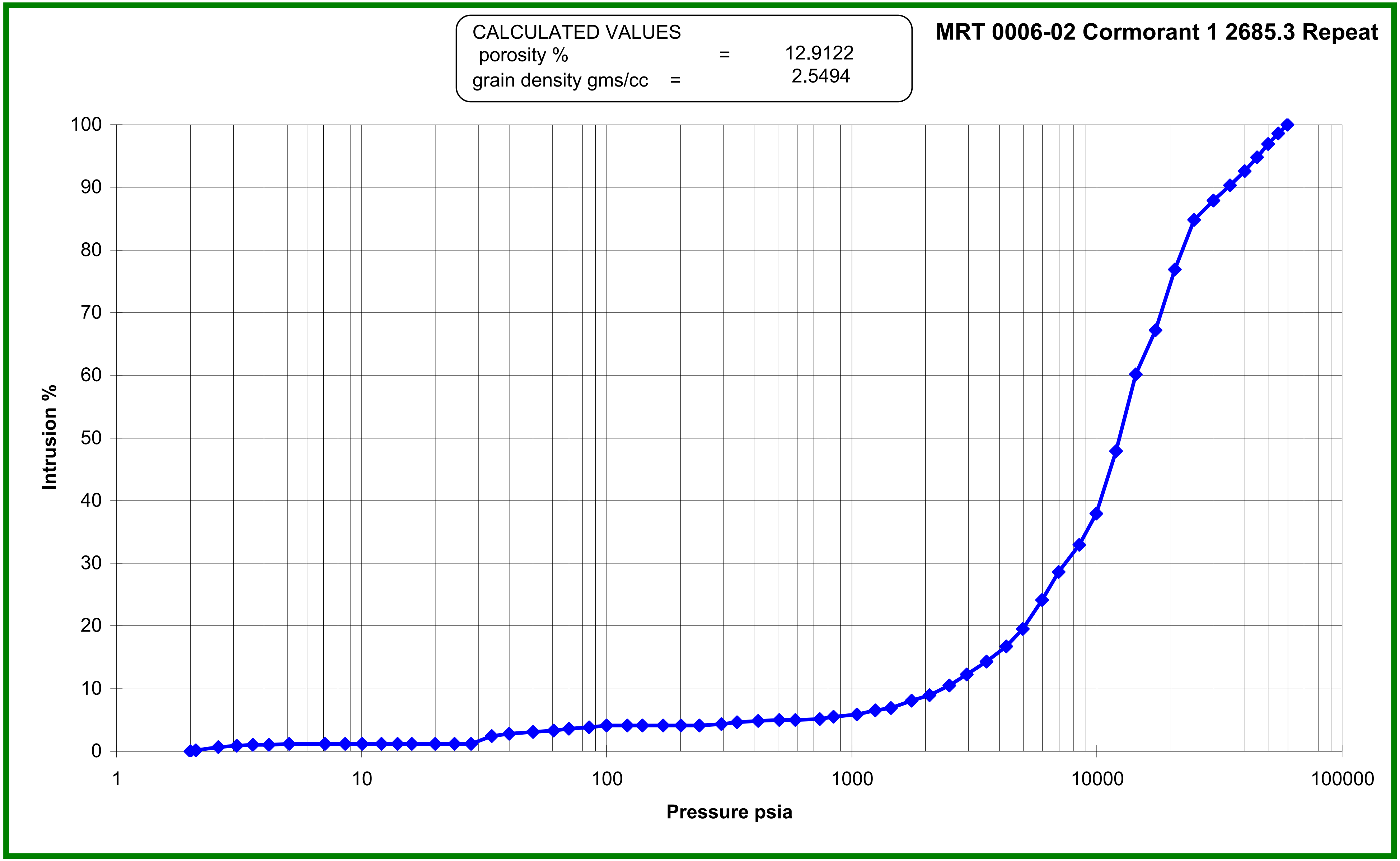


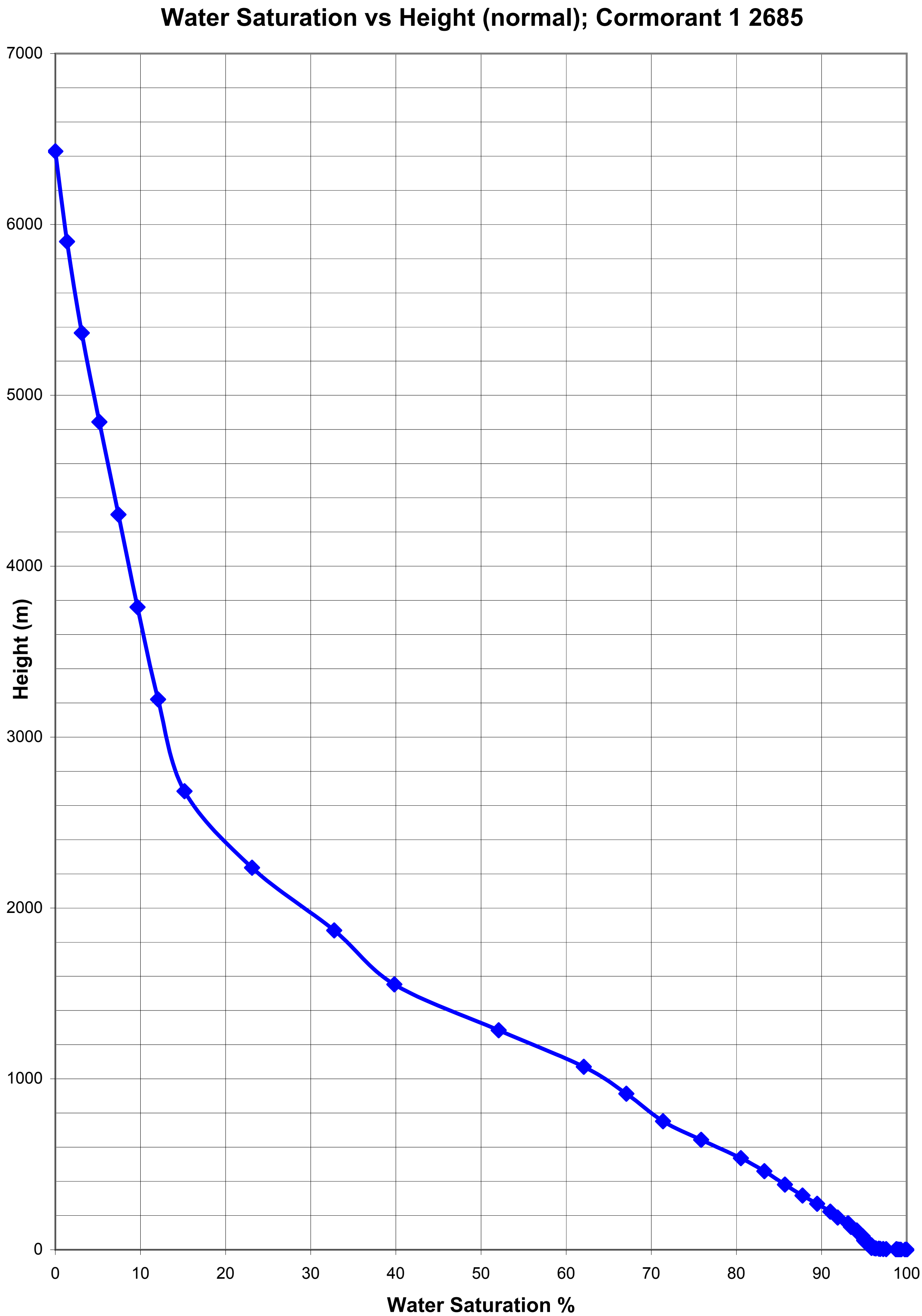
Water Saturation vs Height (lognormal);
Cormorant-1 2231
Height (m)
Water Saturation %
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100

Cormorant_1_2685m.xls

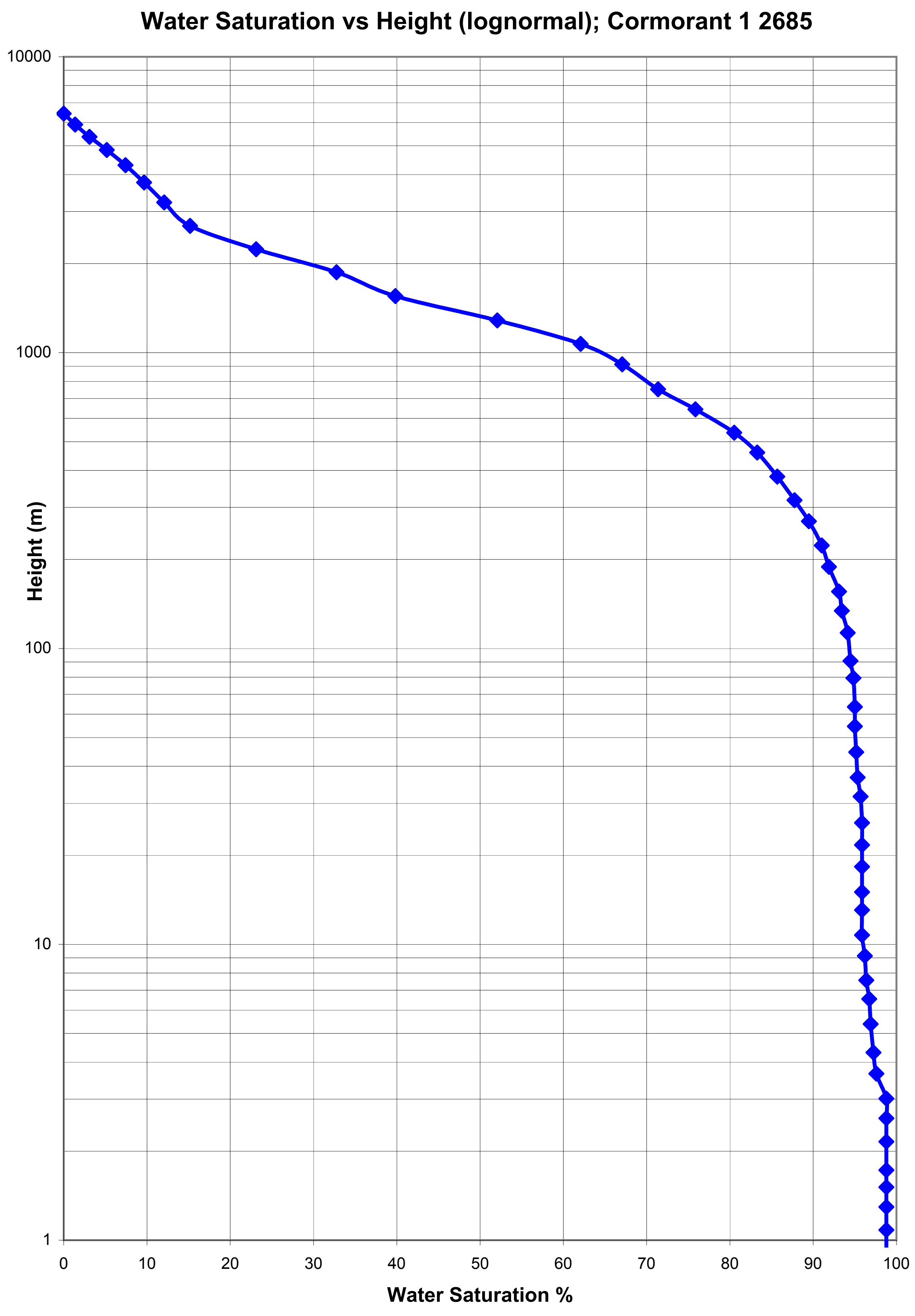



CALCULATED VALUES
porosity % = 12.912
Grain density gms/cc = 2.5494
MRT 0006-02 Cormorant 1 2685.3 Repeat
Intrusion cc
0.3
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
Pressure psia


CALCULATED VALUES
porosity % = 12.9122
grain density gms/cc = 2.5494
MRT 0006-02 Cormorant 1 2685.3 Repeat
Intrusion %
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000
Pressure psia

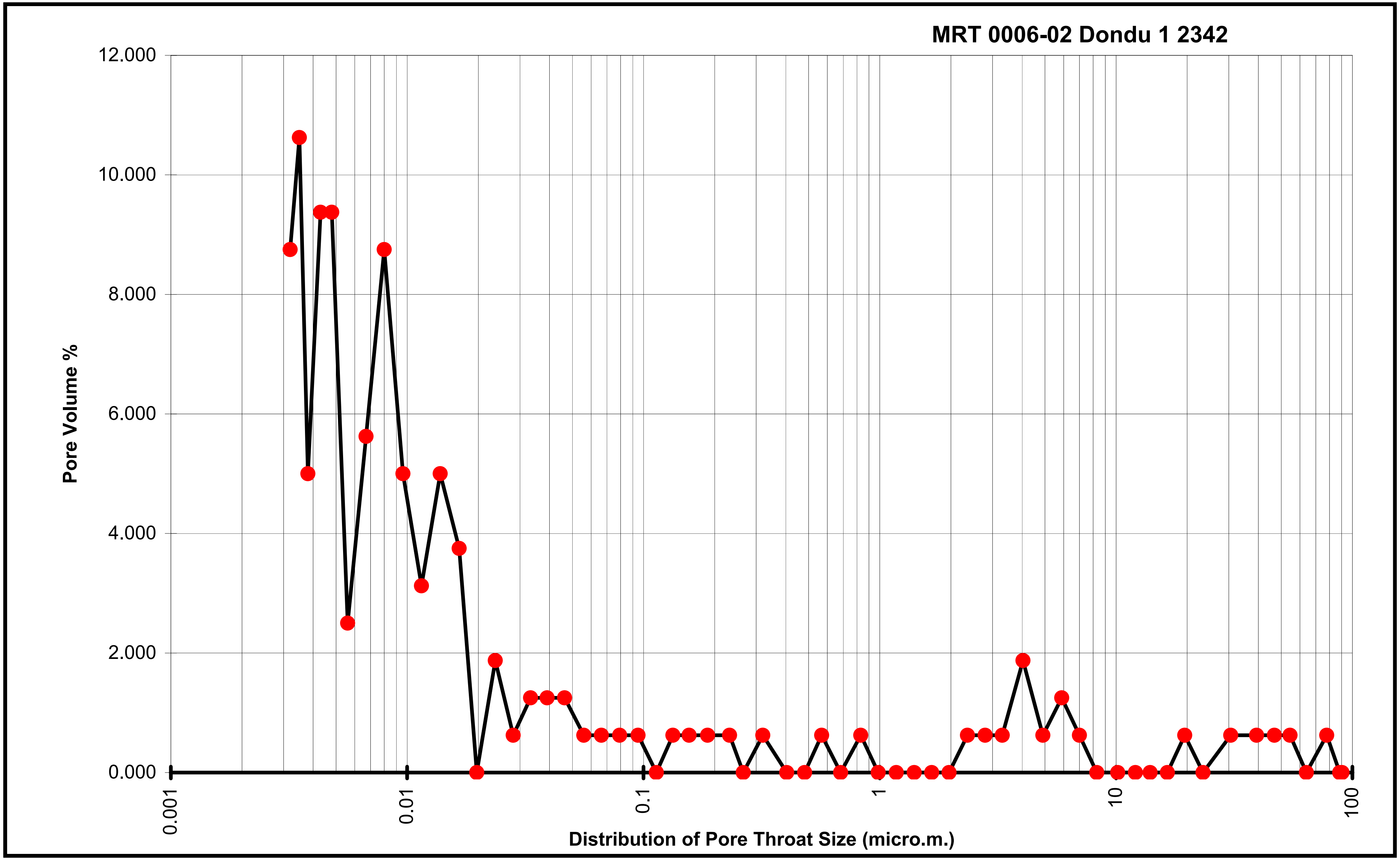


Water Saturation vs Height (normal); Cormorant 1 2685
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

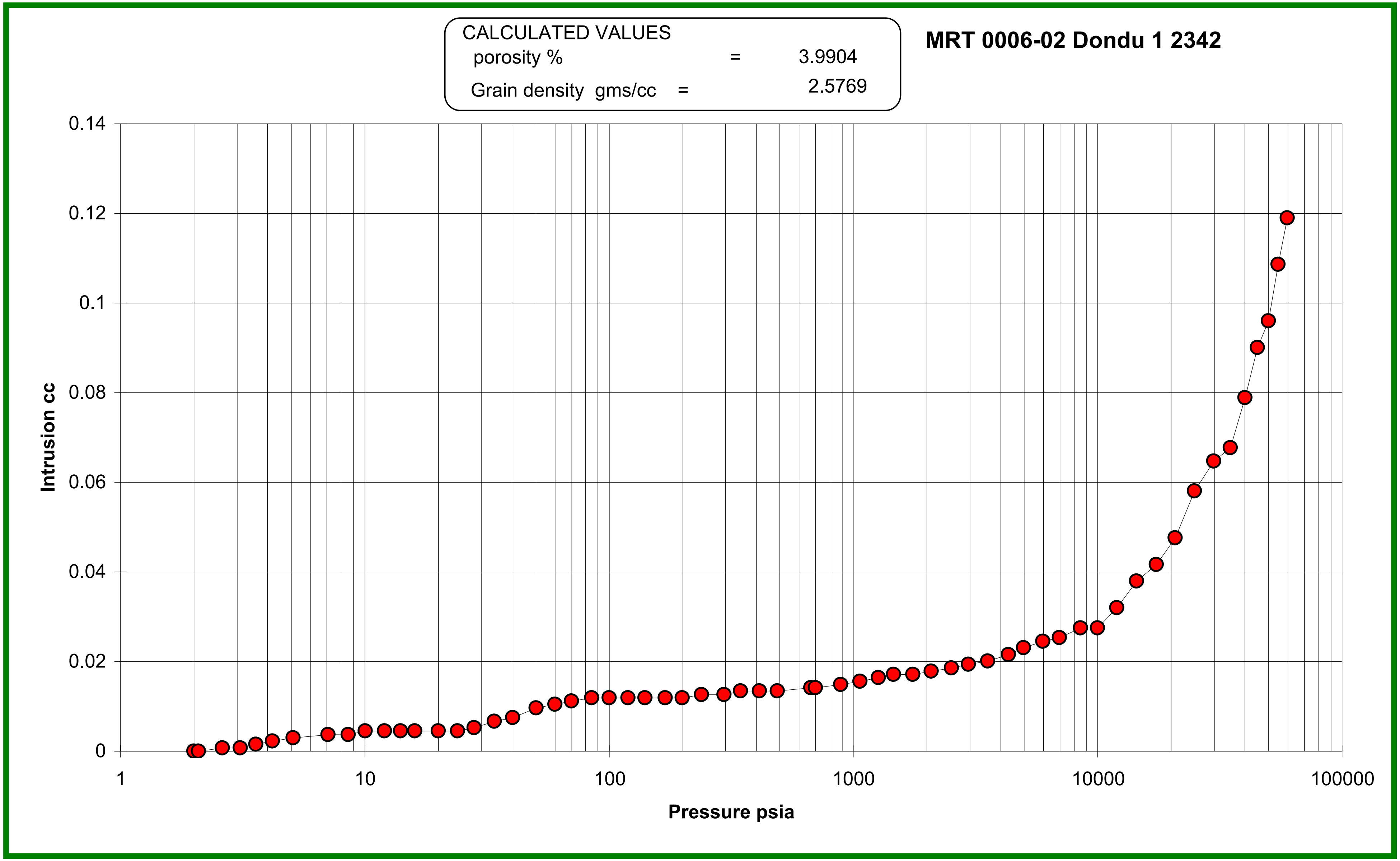


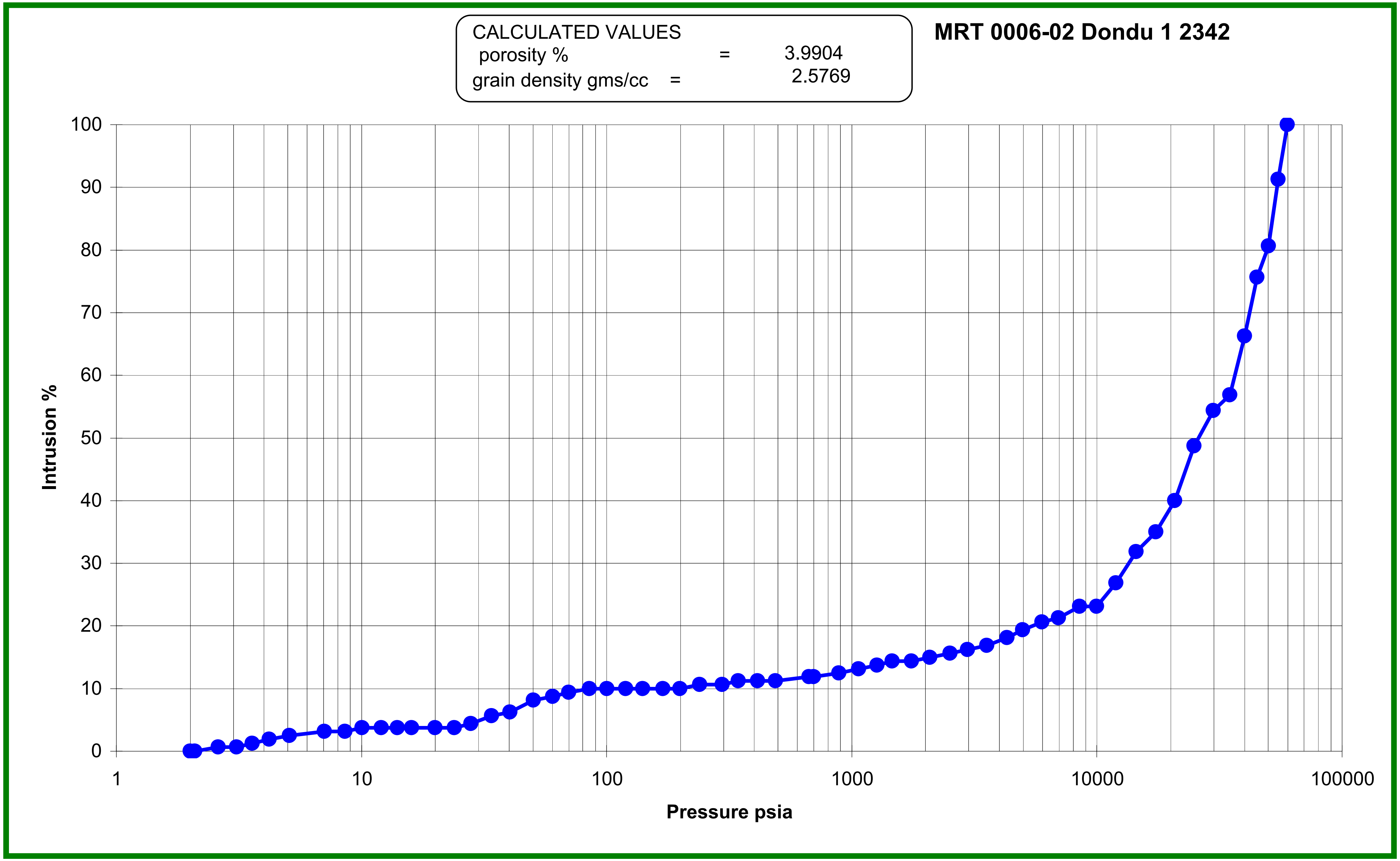
Water Saturation vs Height (lognormal); Cormorant 1 2685
Height (m)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

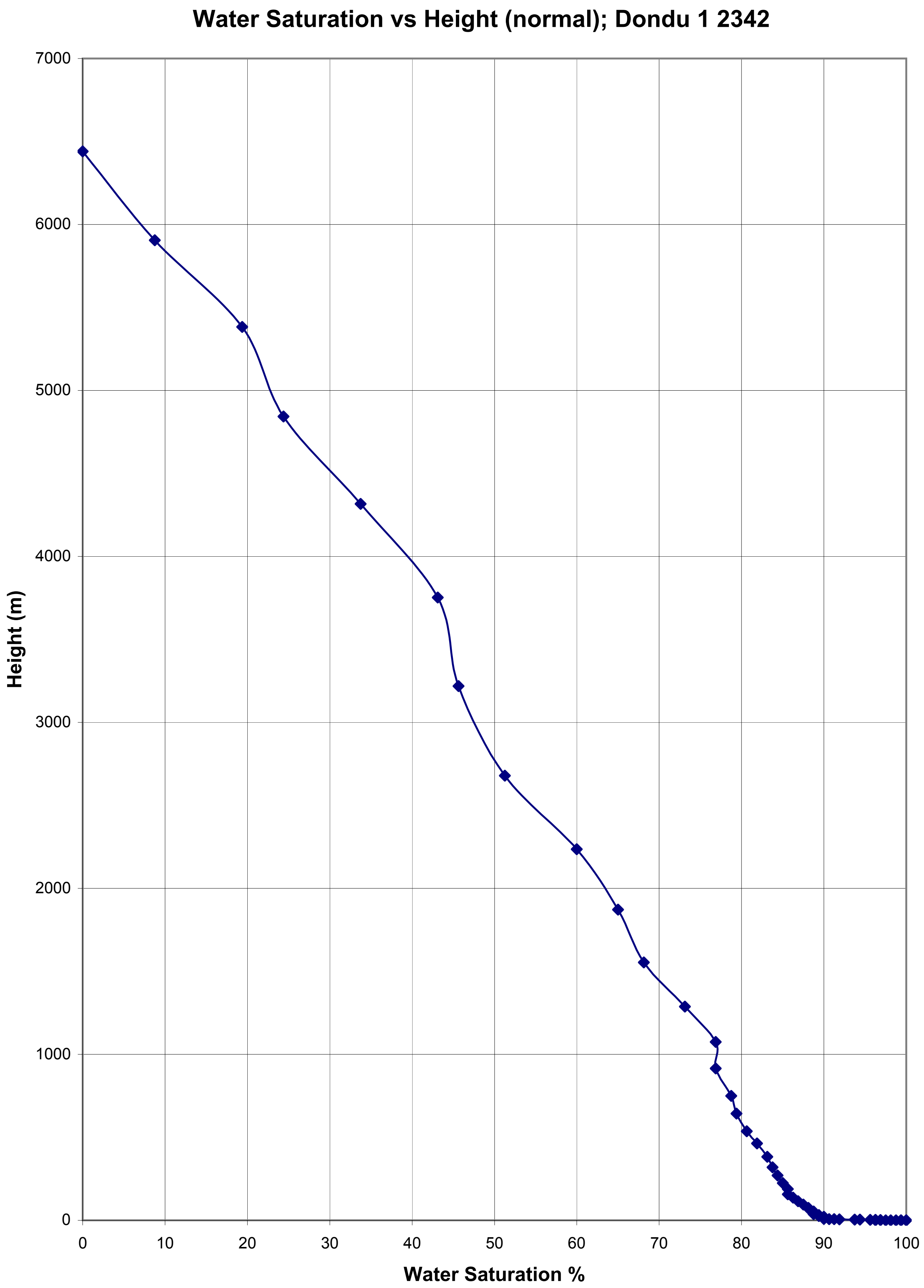
Dondu_1_2342m.xls



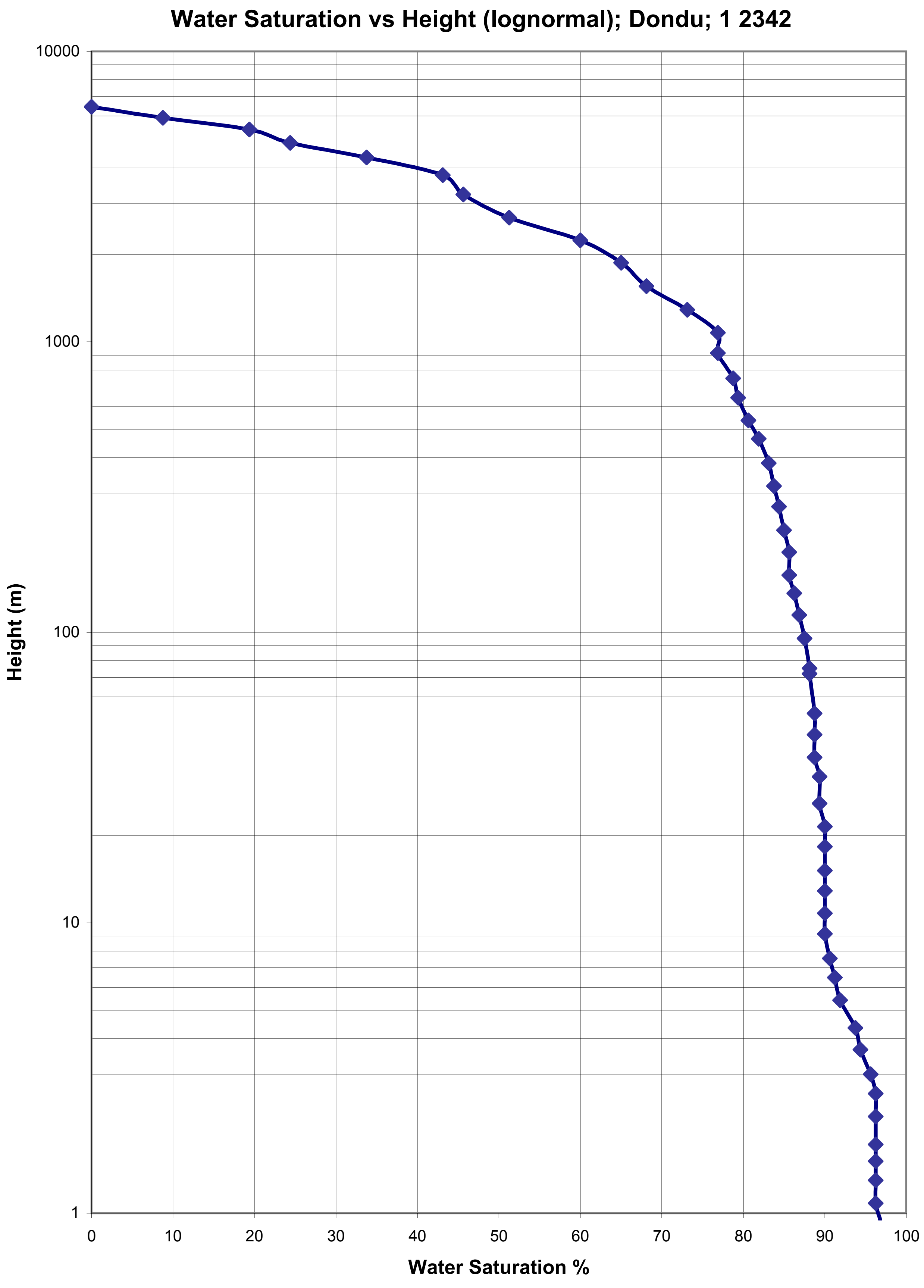
Dondu_1_2342m.xls



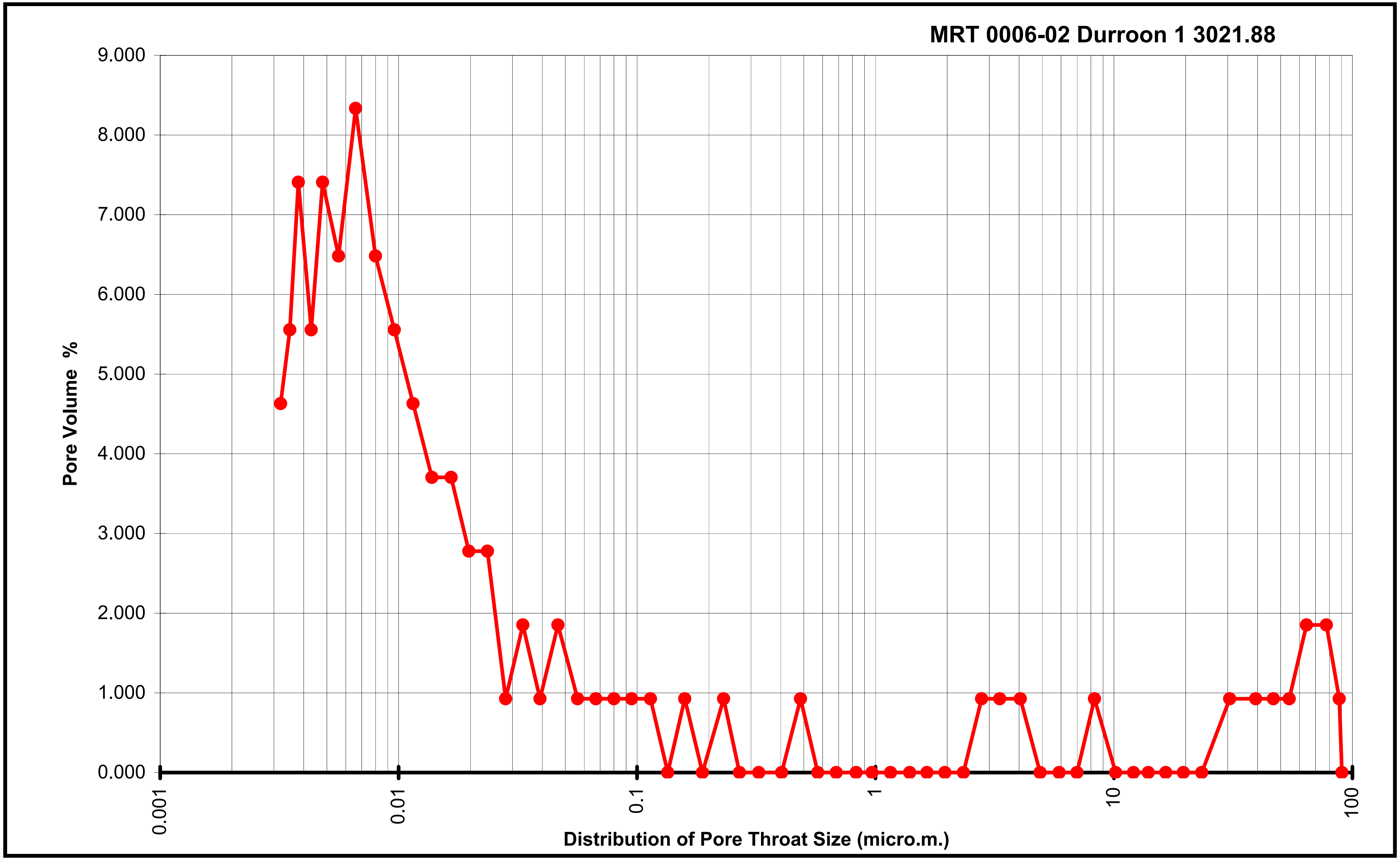

CALCULATED VALUES
porosity % = 3.9904
grain density gms/cc = 2.5769
MRT 0006-02 Dondu 1 2342
Intrusion %
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000
Pressure psia



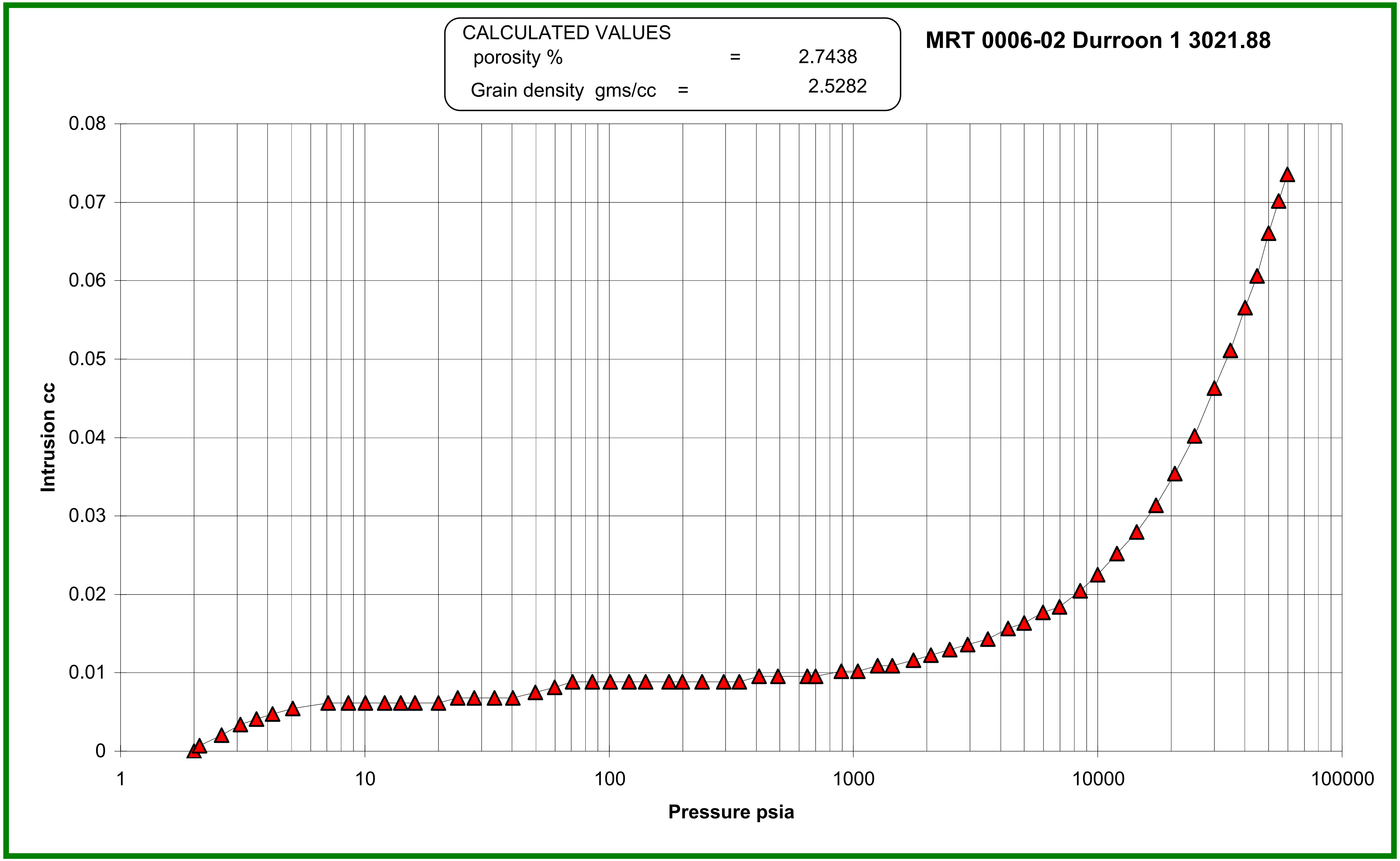
Water Saturation vs Height (normal); Dondu 1 2342
7000
6000
5000
4000
3000
2000
1000
0
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

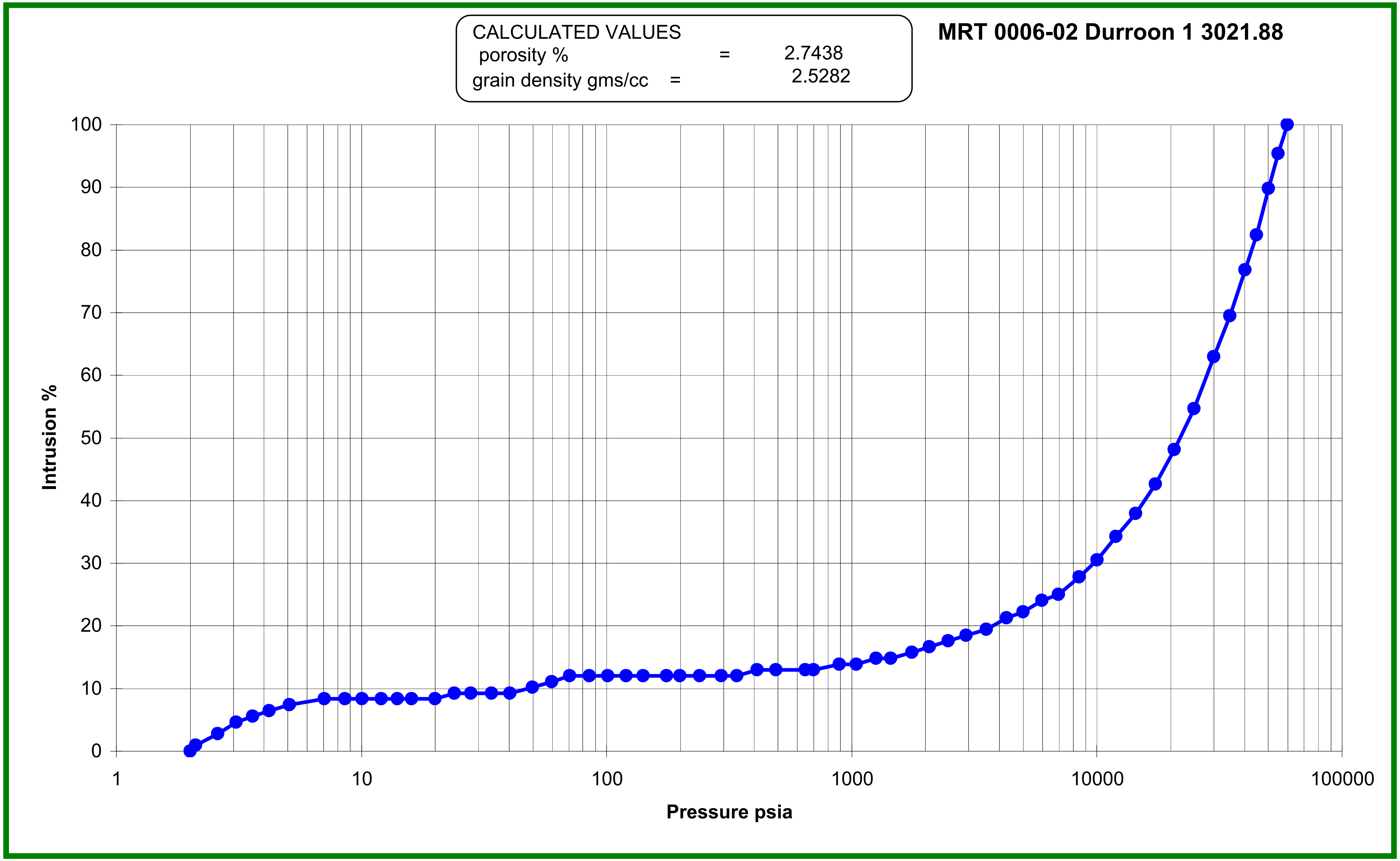

Water Saturation vs Height (lognormal); Dondu; 1 2342
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

Durroon_1_3021m.xls

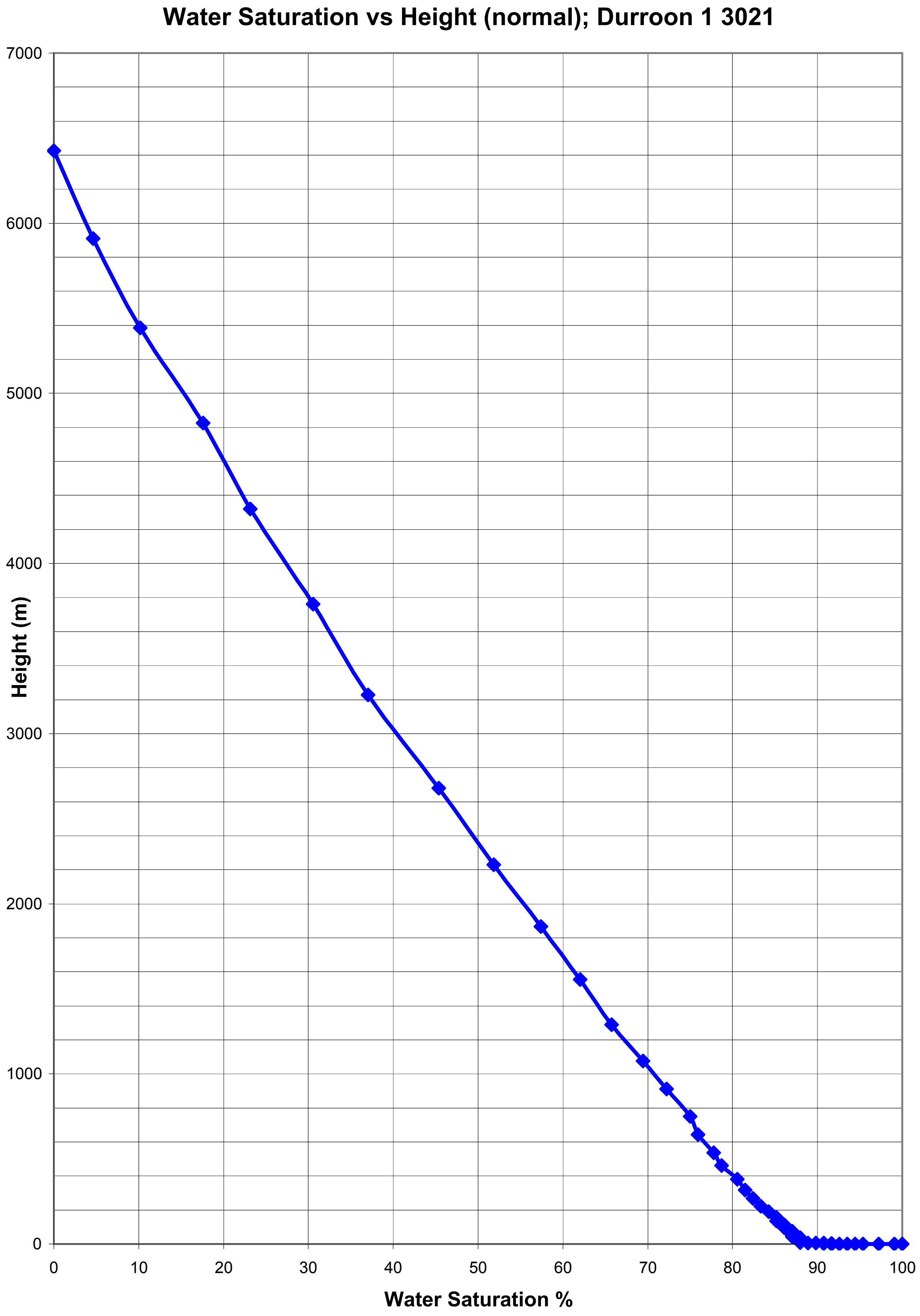


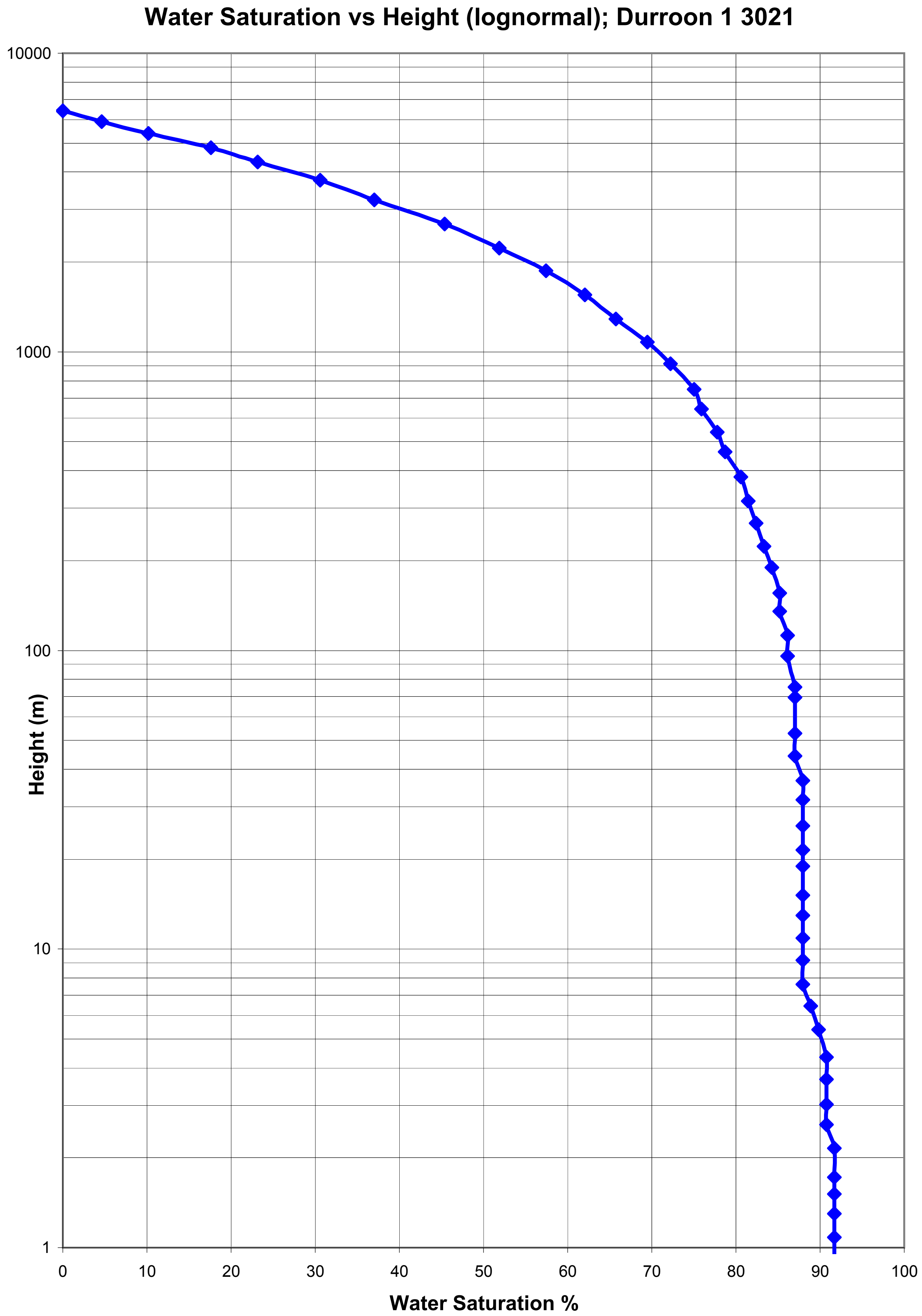
Durroon_1_3021m.xls





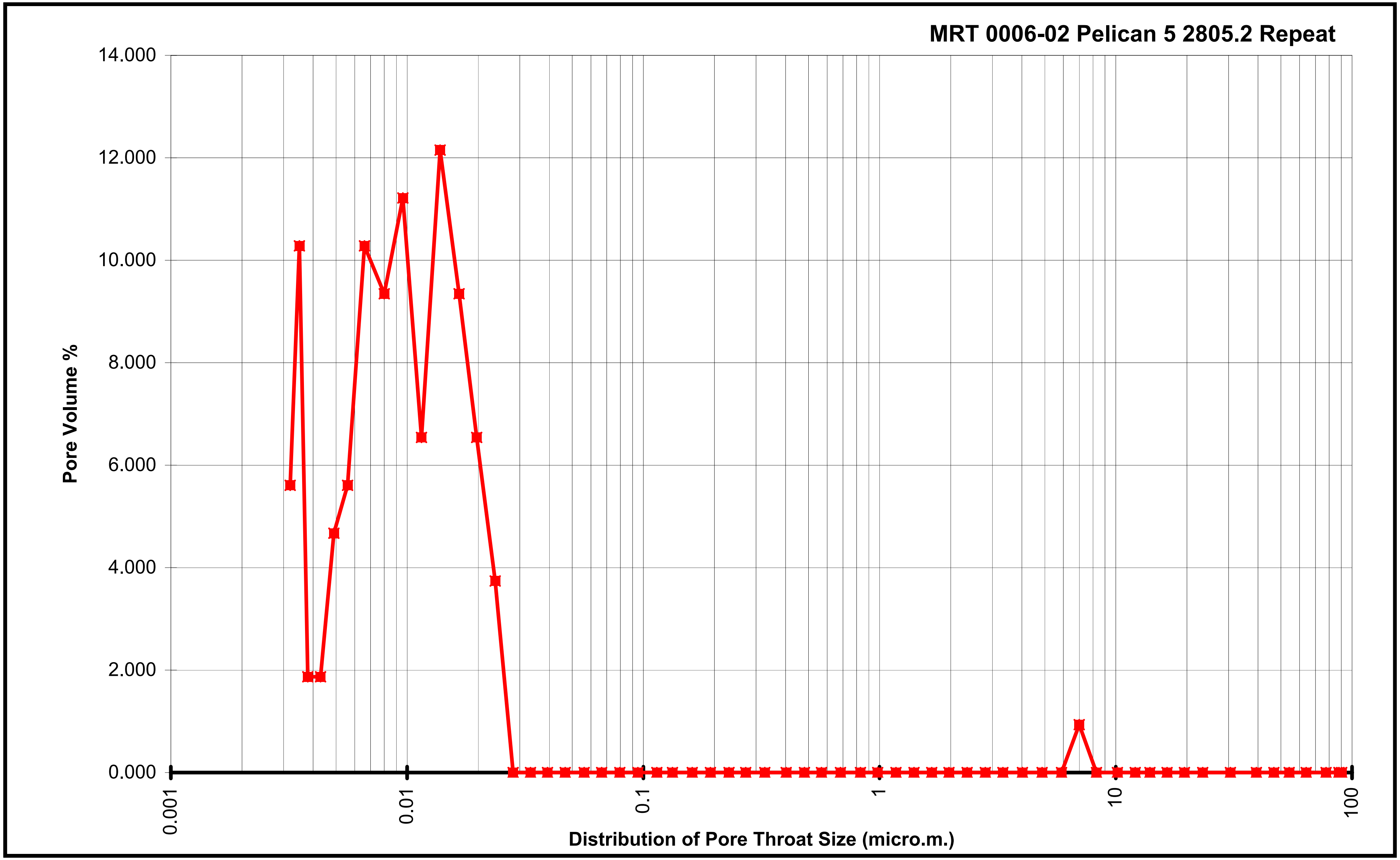
CALCULATED VALUES
porosity % = 2.7438
grain density gms/cc = 2.5282
MRT 0006-02 Durroon 1 3021.88
Intrusion %
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000
Pressure psia

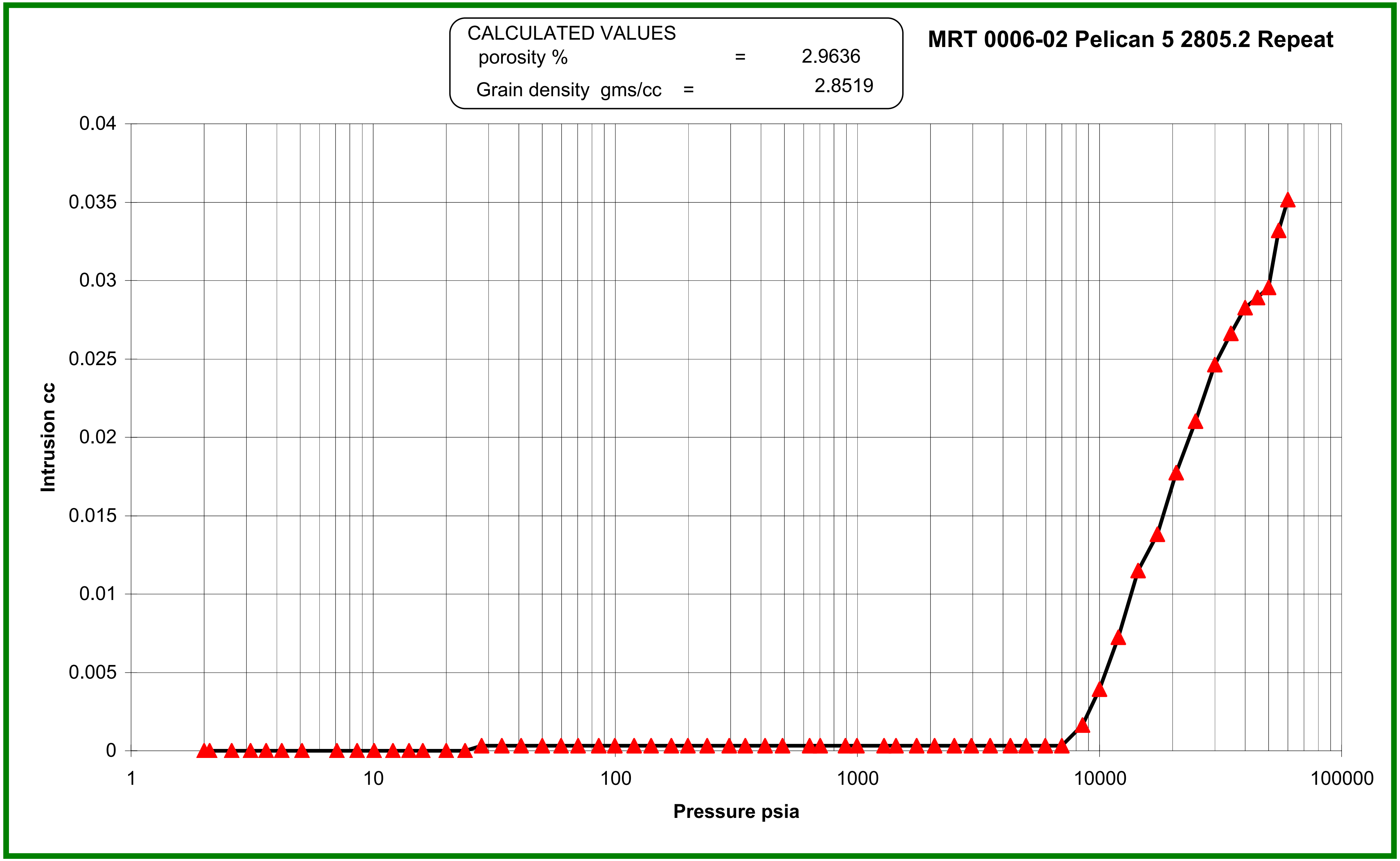

Water Saturation vs Height (normal); Durroon 1 3021
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

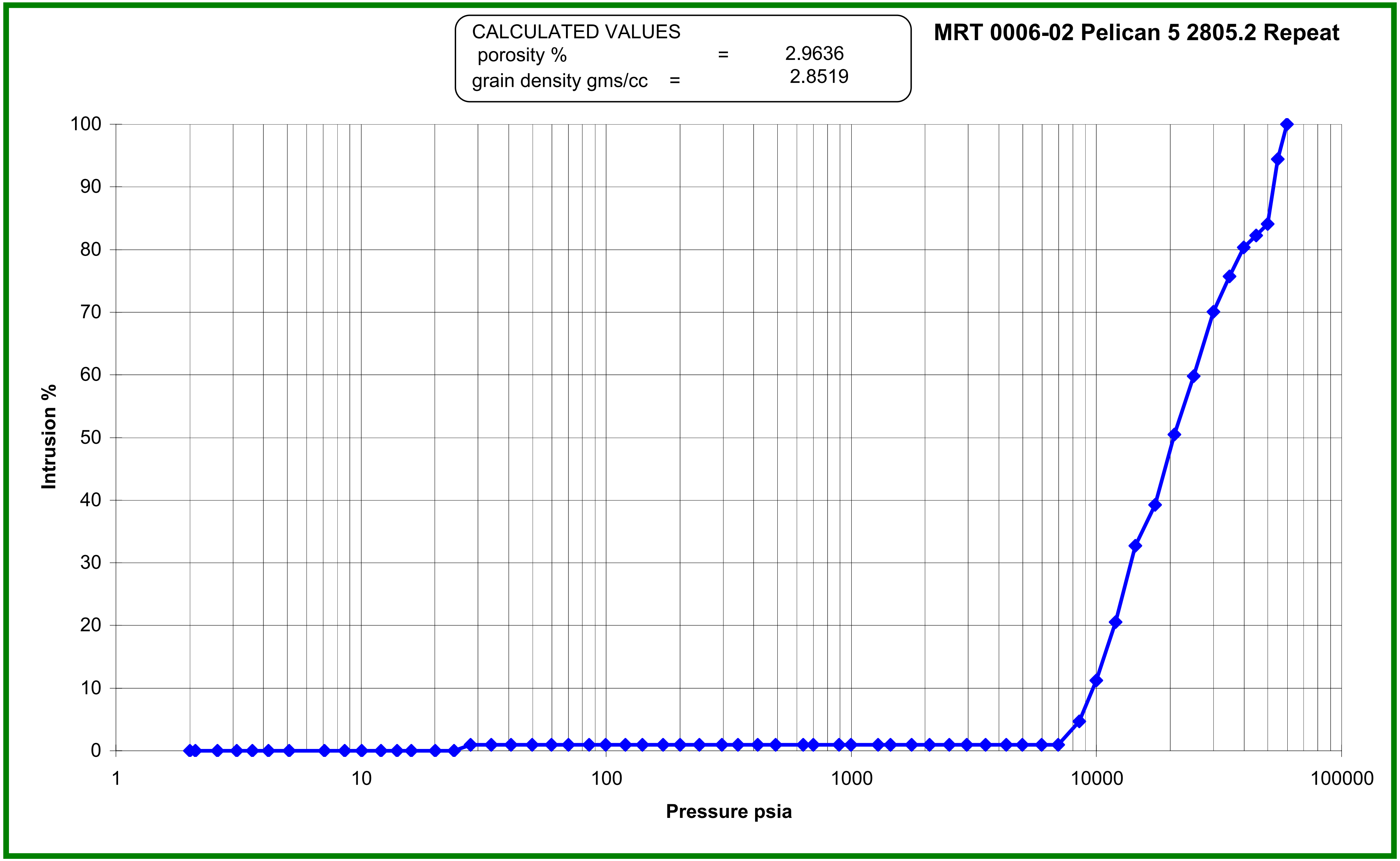


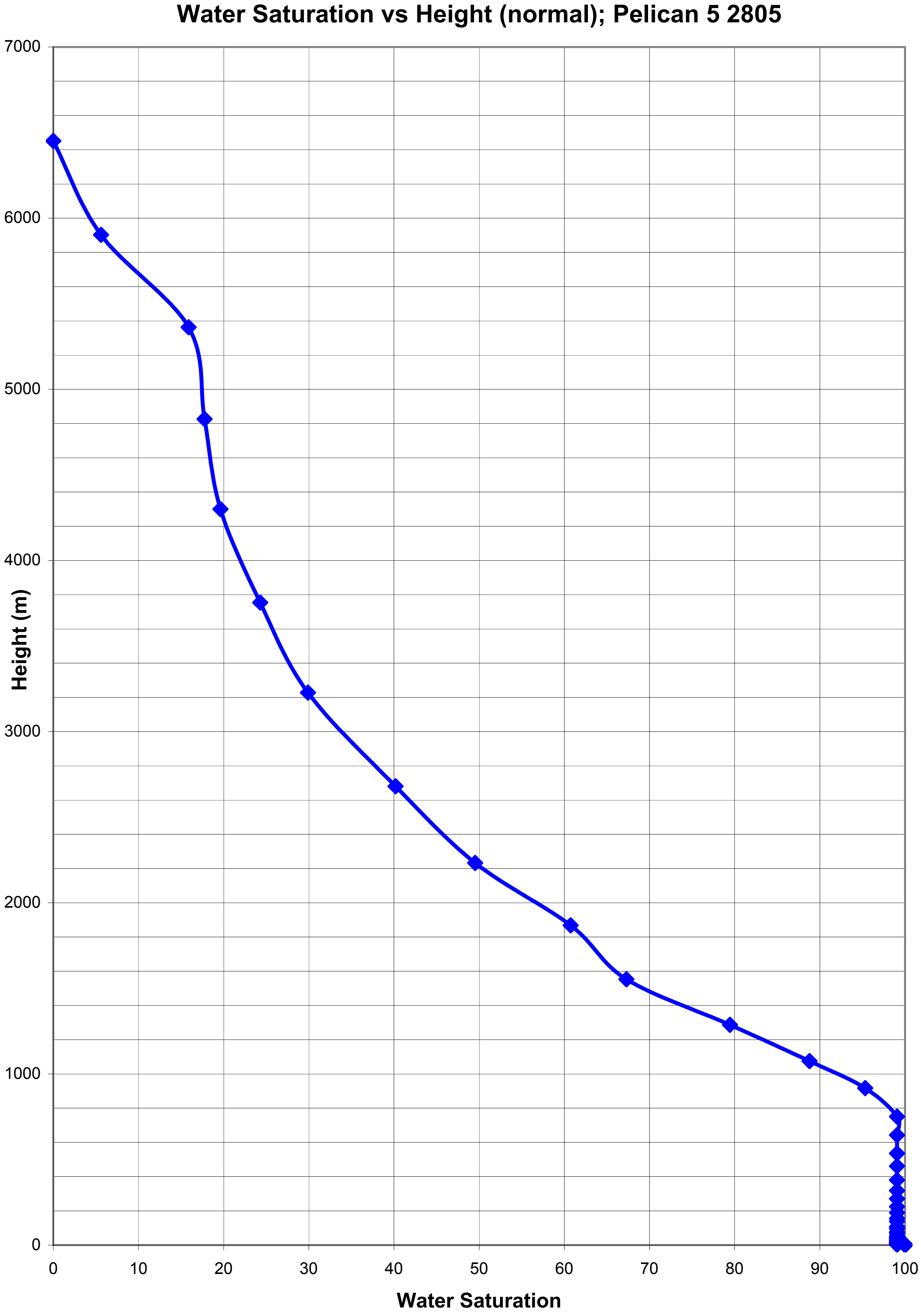
Water Saturation vs Height (lognormal); Durroon 1 3021
Height (m)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

Pelican_5_2805m.xls



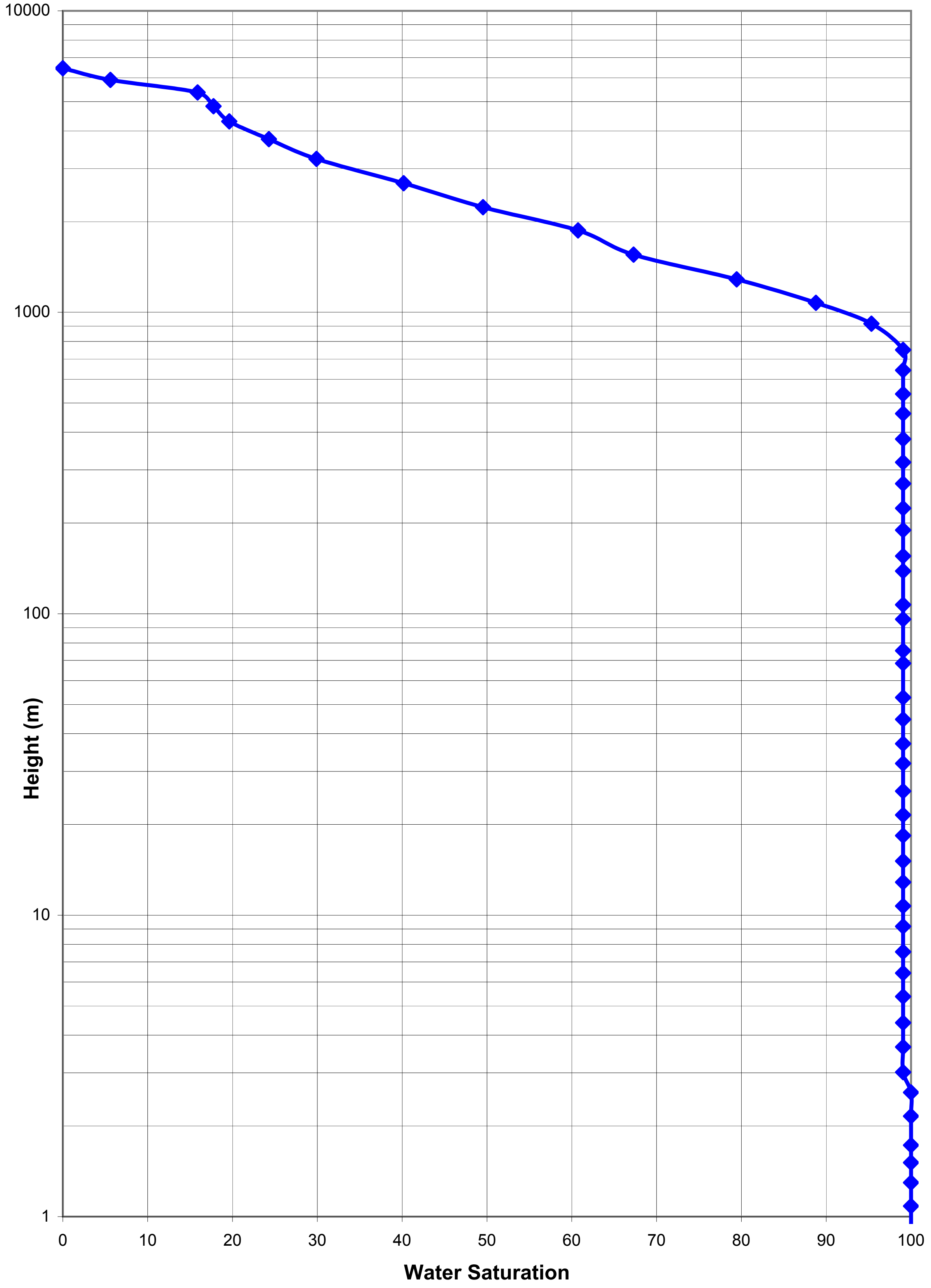

CALCULATED VALUES
porosity % = 2.9636
Grain density gms/cc = 2.8519
MRT 0006-02 Pelican 5 2805.2 Repeat
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Intrusion cc
1
10
100
1000
10000
100000
Pressure psia


CALCULATED VALUES
porosity % = 2.9636
grain density gms/cc = 2.8519
MRT 0006-02 Pelican 5 2805.2 Repeat
Intrusion %
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000
Pressure psia

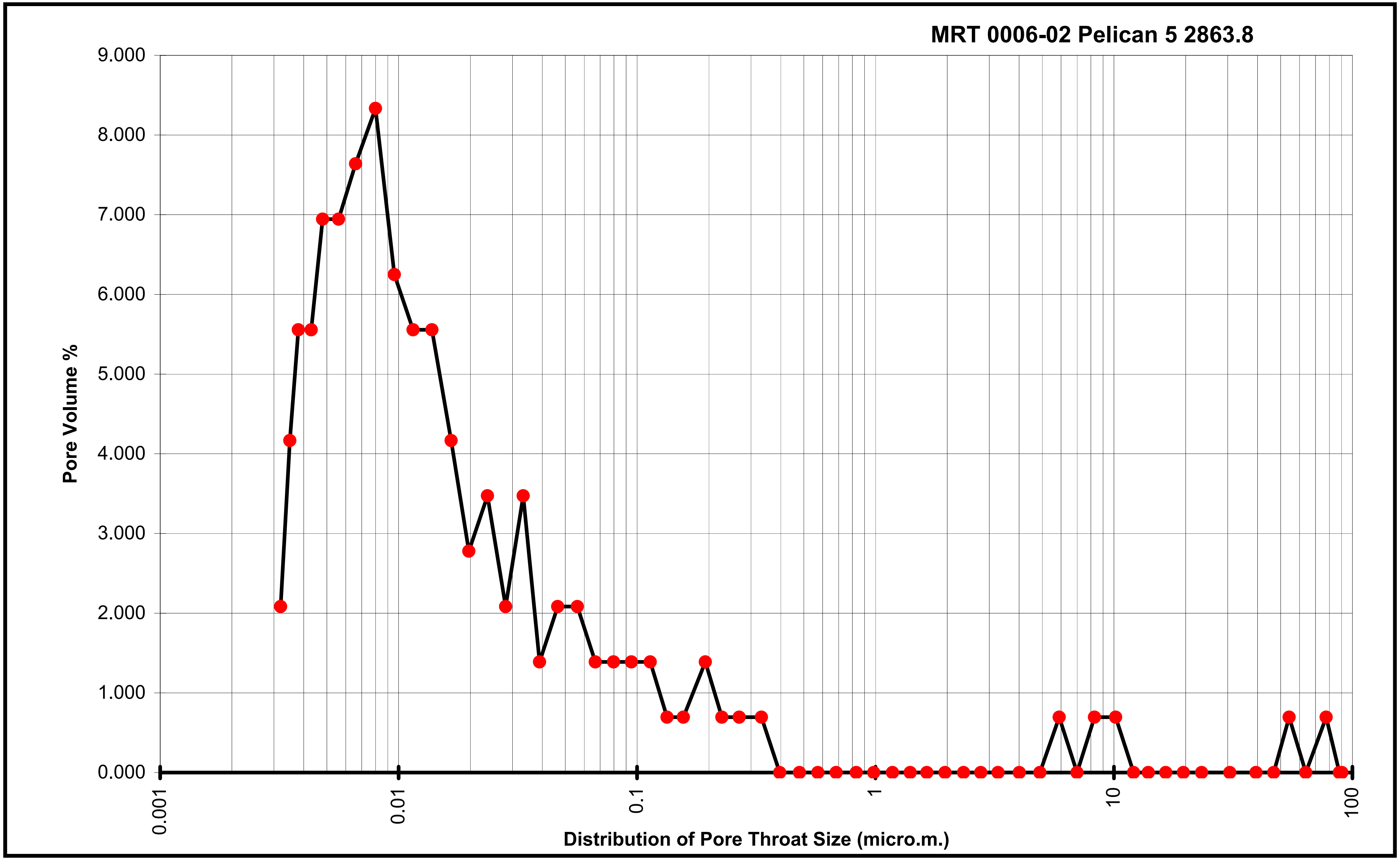


Water Saturation vs Height (normal); Pelican 5 2805
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation

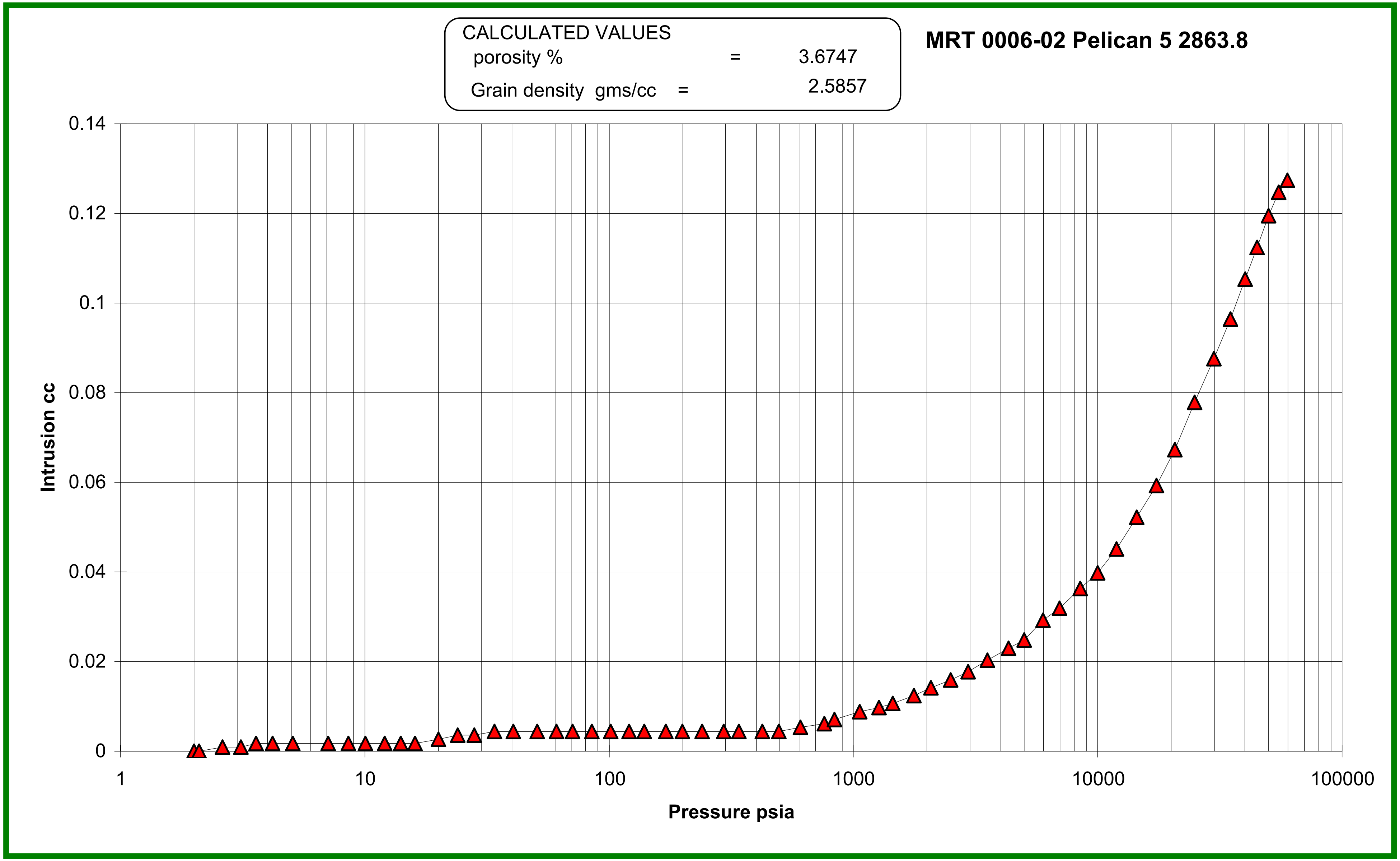
Water Saturation vs Height (lognormal); Pelican 5 2805

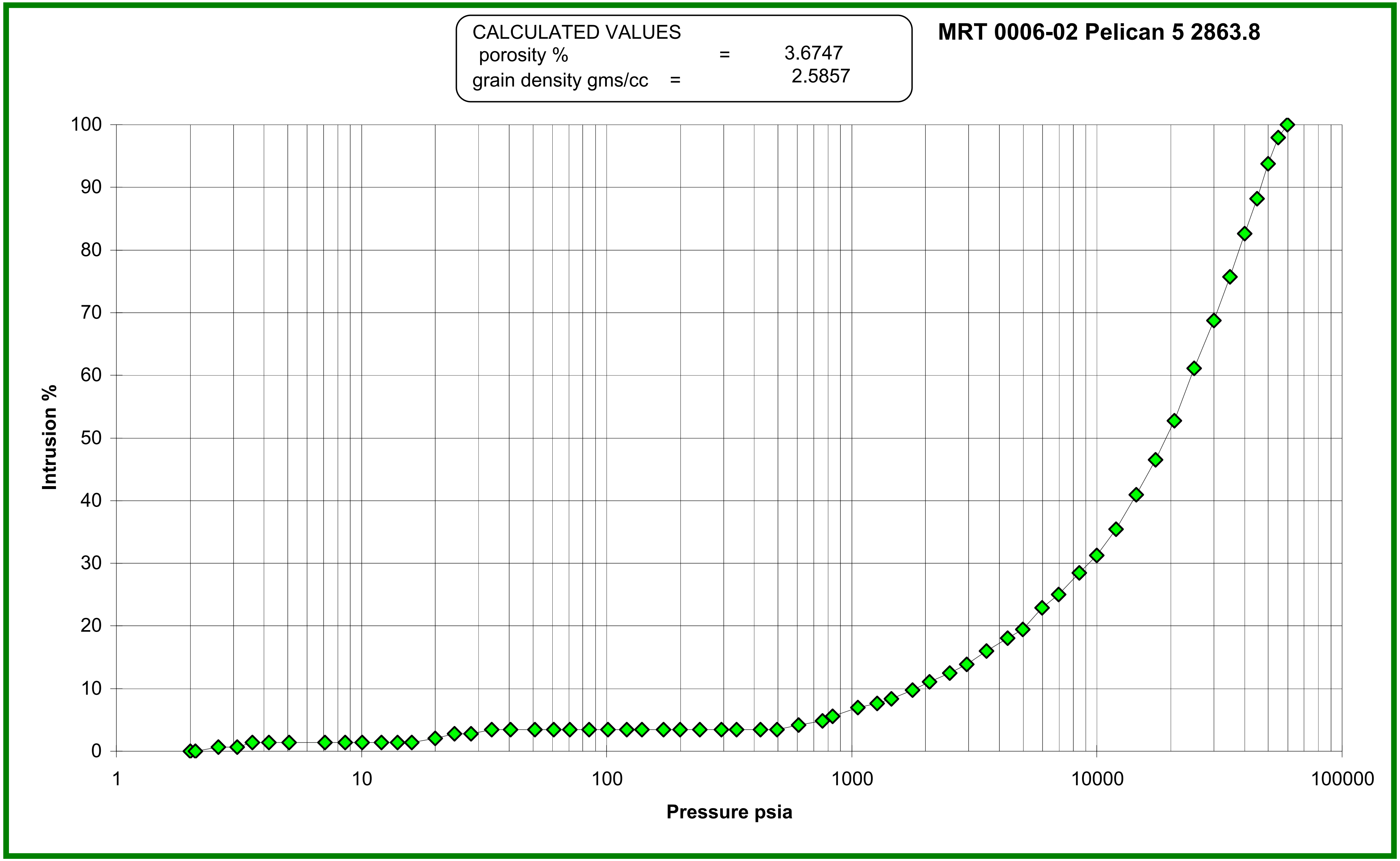


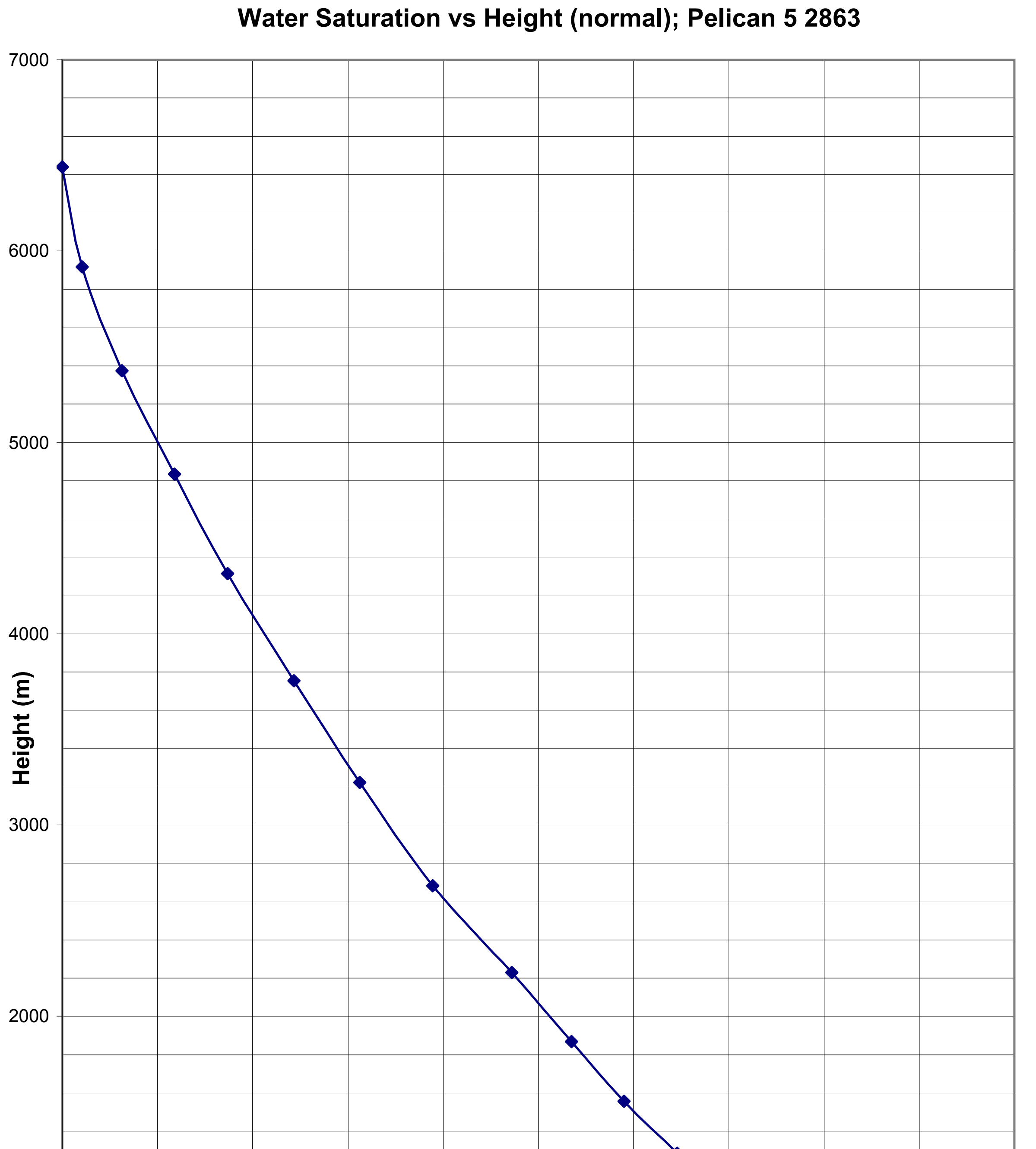
Pelican_5_2863m.xls

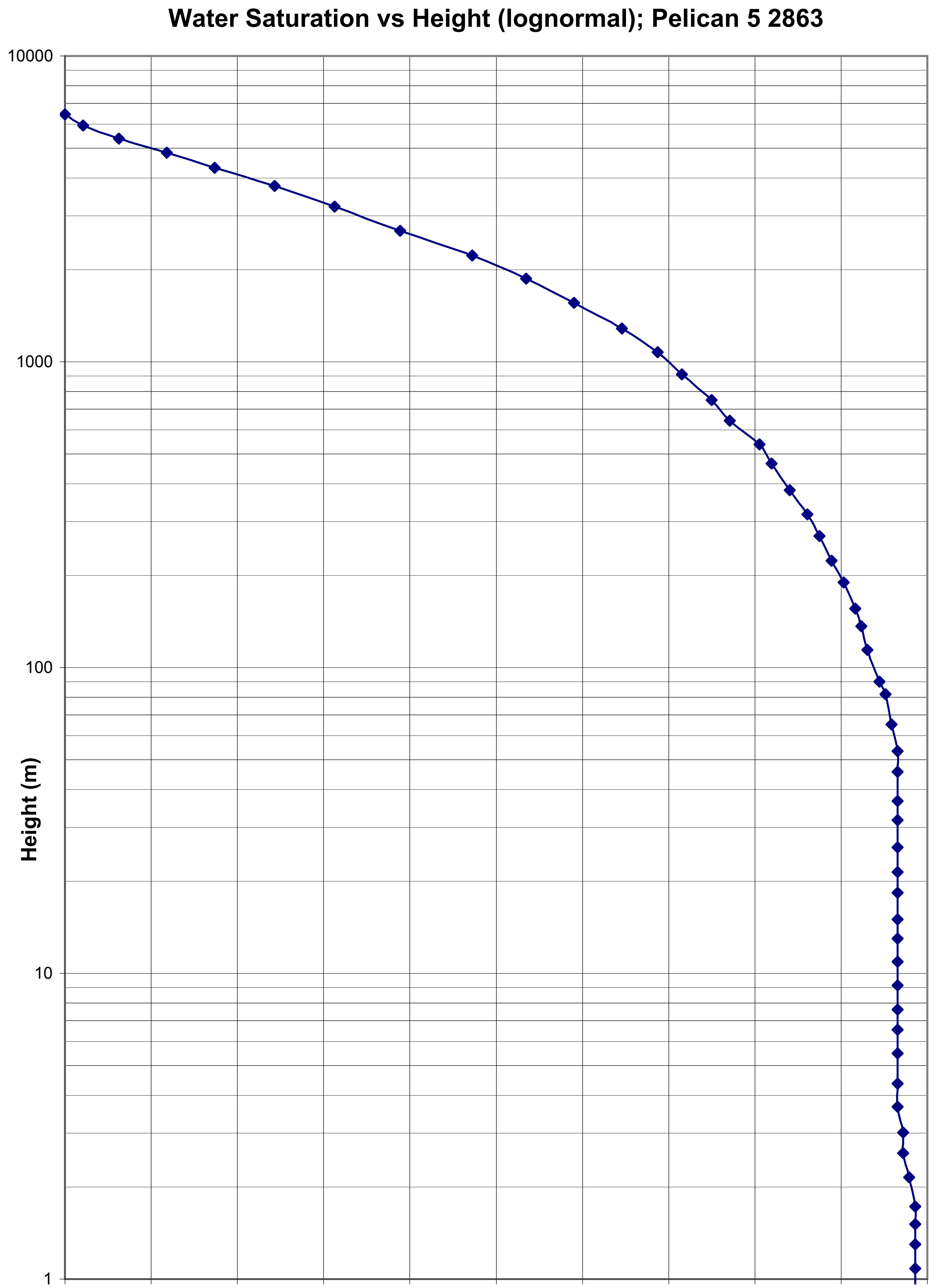


Pelican_5_2863m.xls



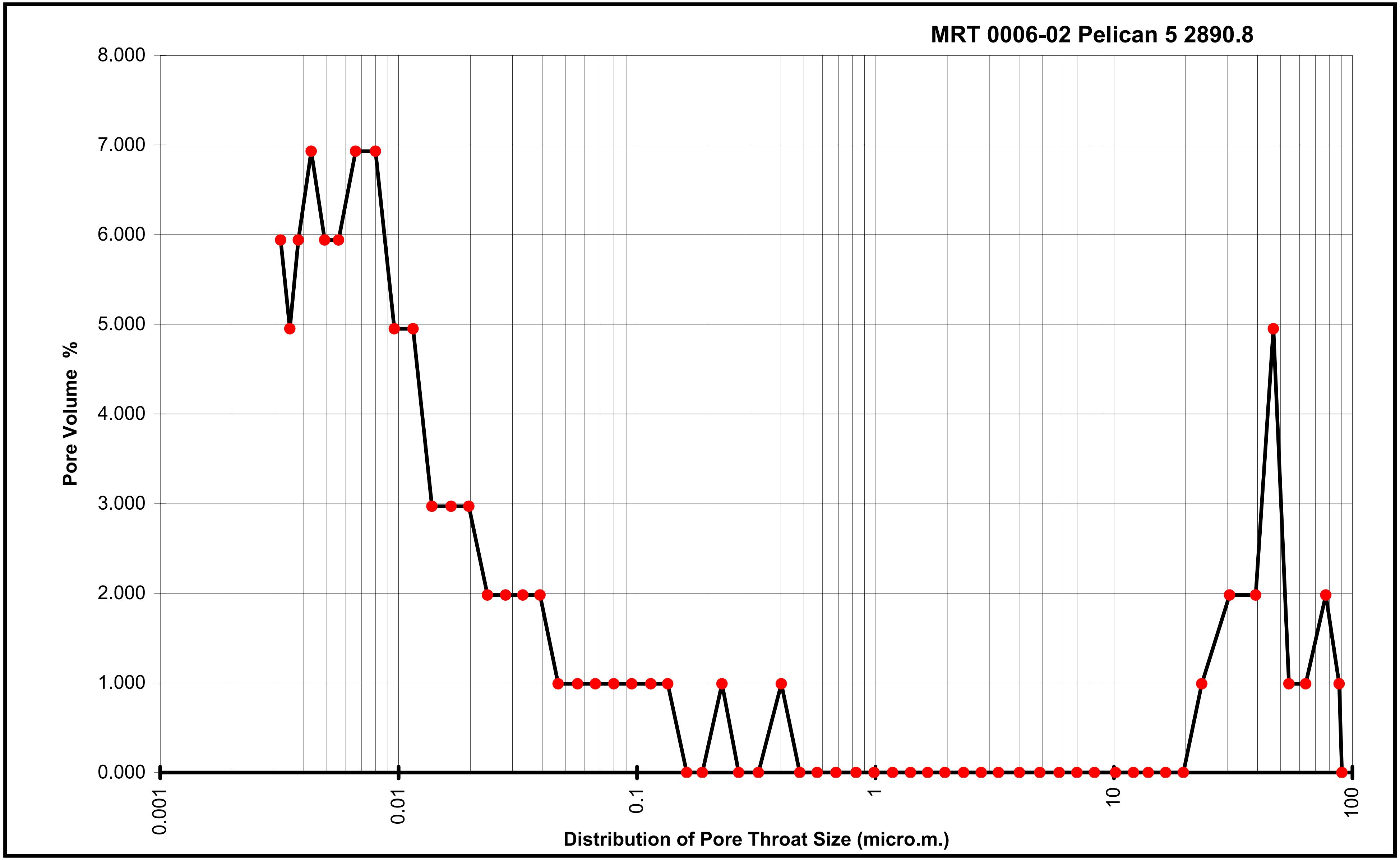

CALCULATED VALUES
porosity % = 3.6747
grain density gms/cc = 2.5857
MRT 0006-02 Pelican 5 2863.8
Intrusion %
Pressure psia
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000


Water Saturation vs Height (normal); Pelican 5 2863
Height (m)
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100

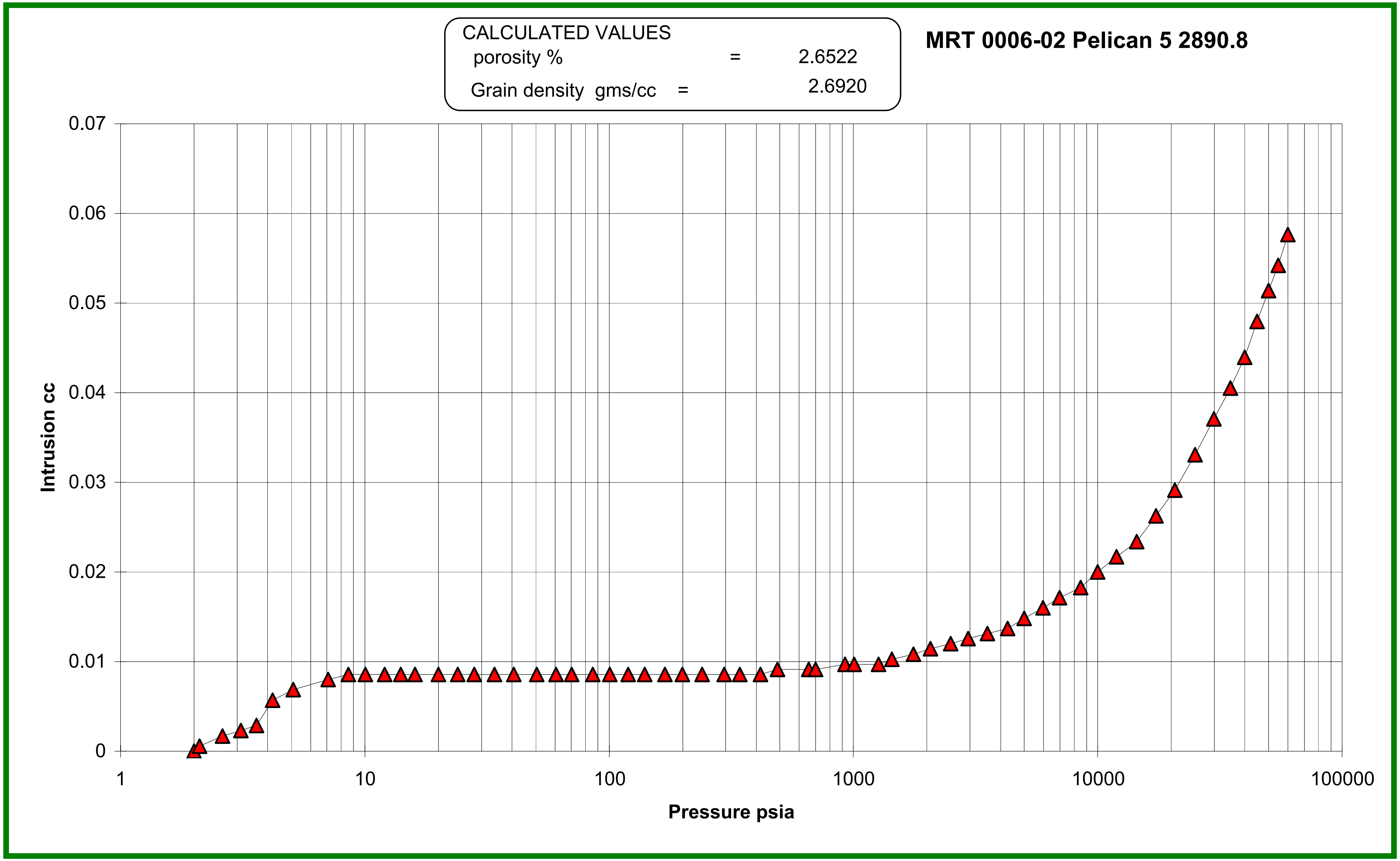


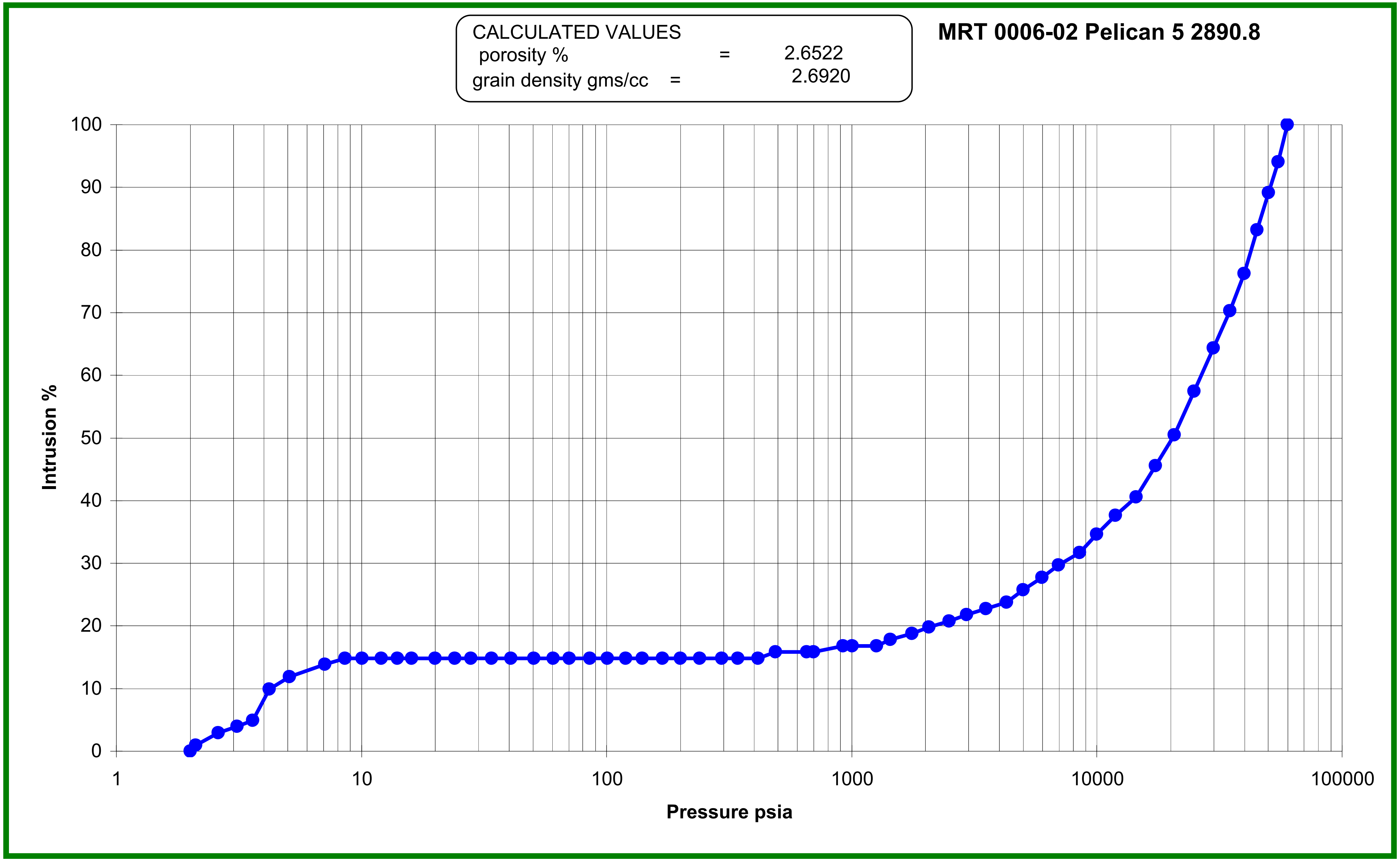
Water Saturation vs Height (lognormal); Pelican 5 2863
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

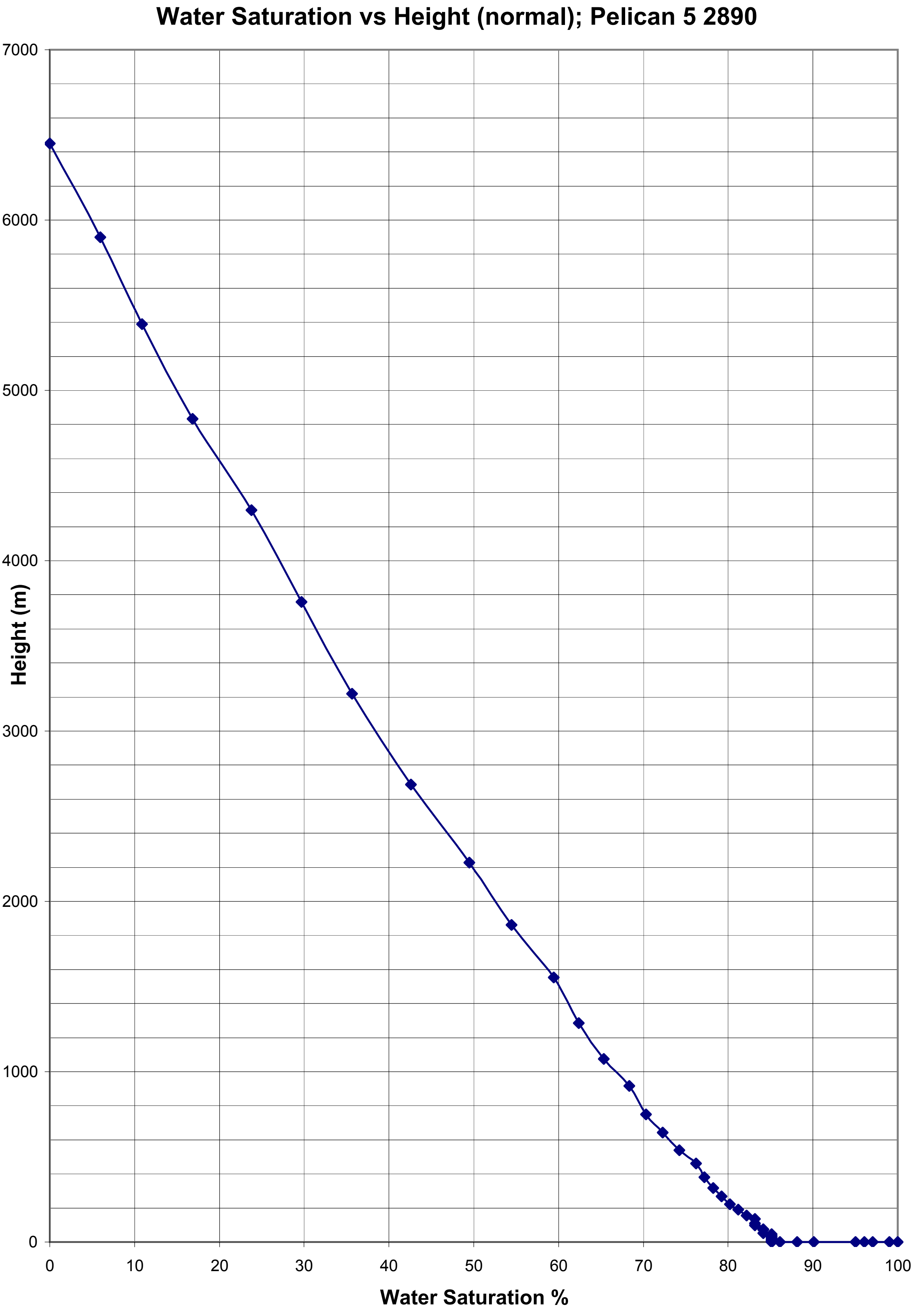
Pelican_5_2890m.xls



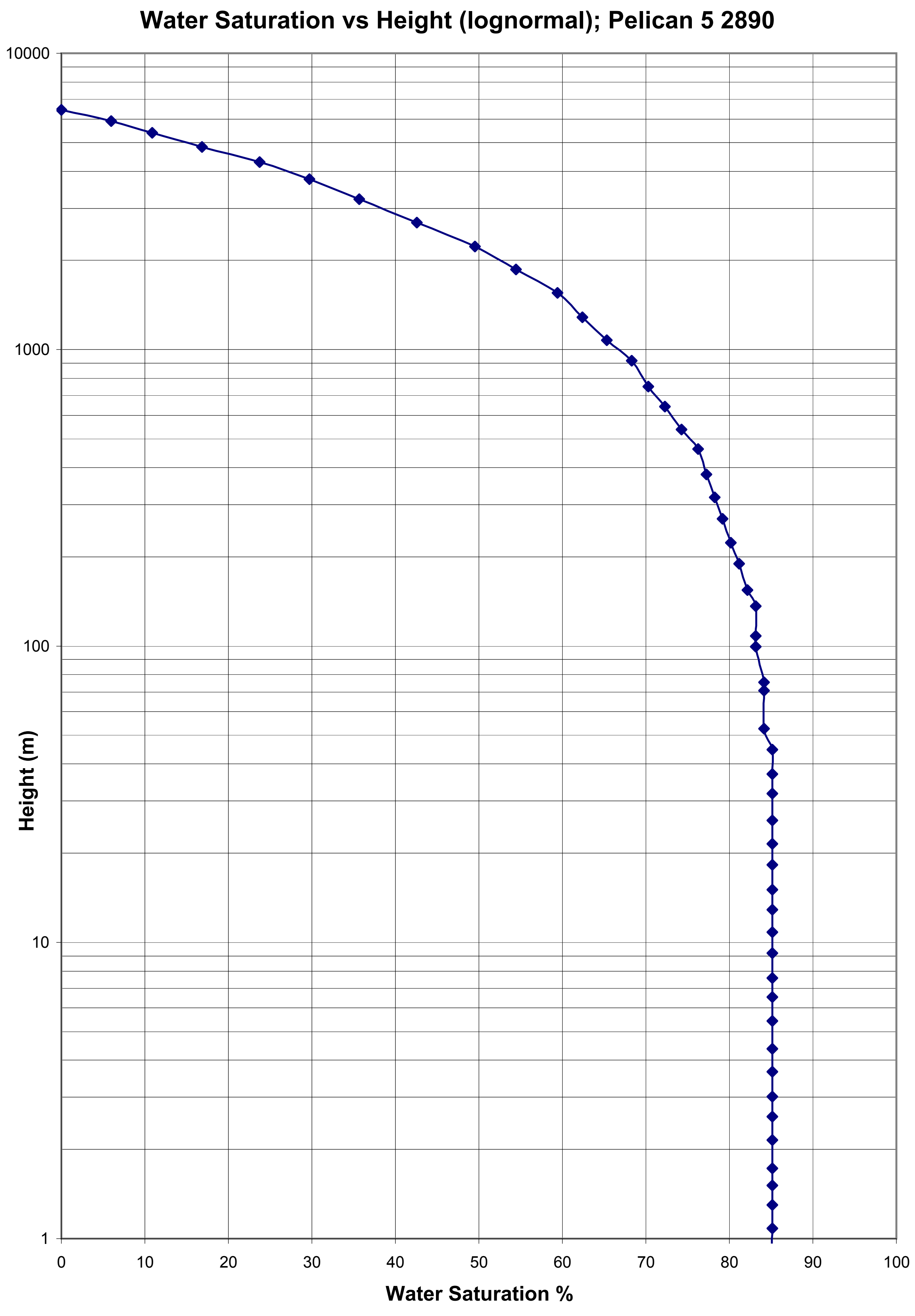
Pelican_5_2890m.xls




CALCULATED VALUES
porosity % = 2.6522
grain density gms/cc = 2.6920
MRT 0006-02 Pelican 5 2890.8
100
90
80
70
60
50
40
30
20
10
0
Intrusion %
1
10
100
1000
10000
100000
Pressure psia

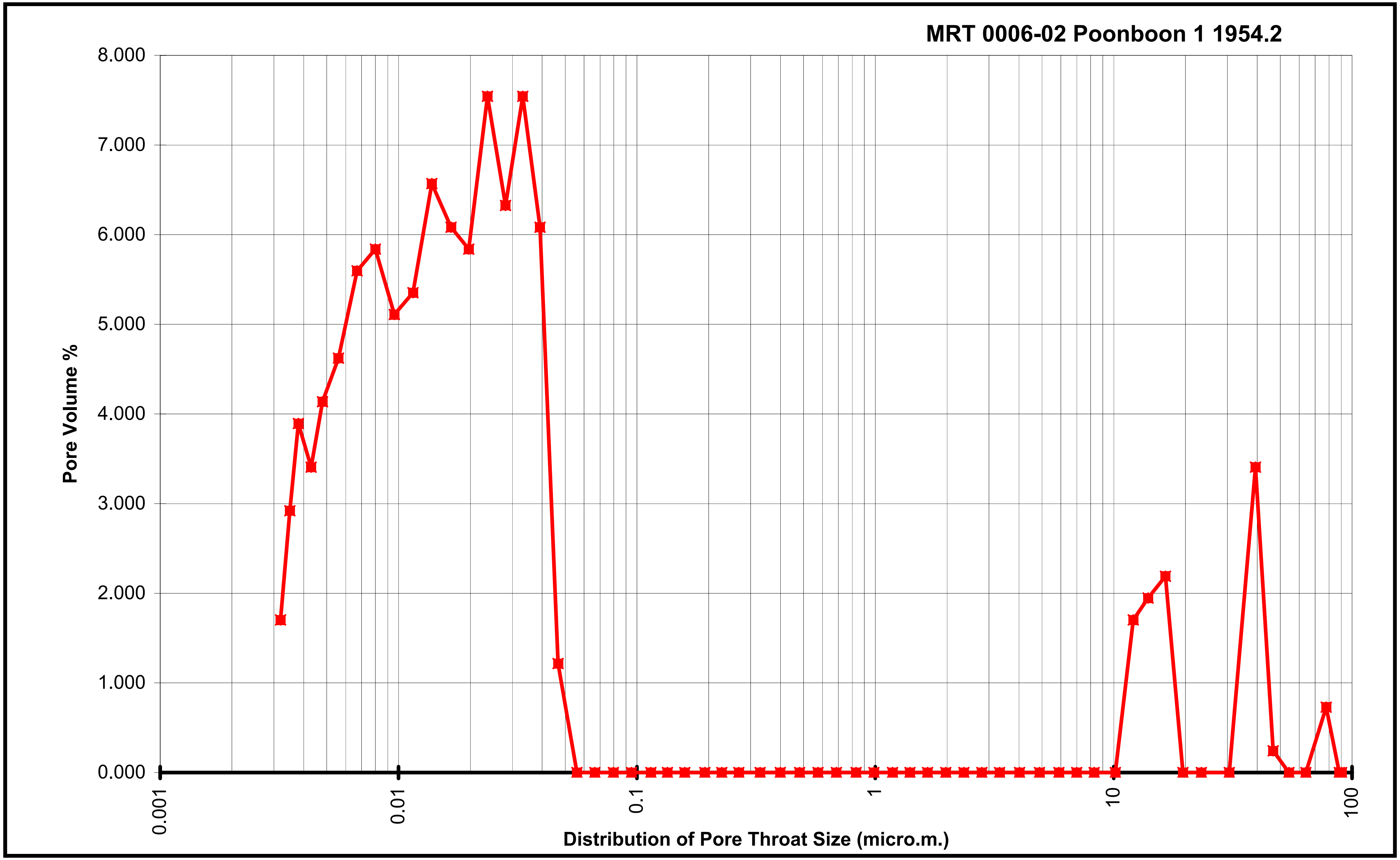


Water Saturation vs Height (normal); Pelican 5 2890
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

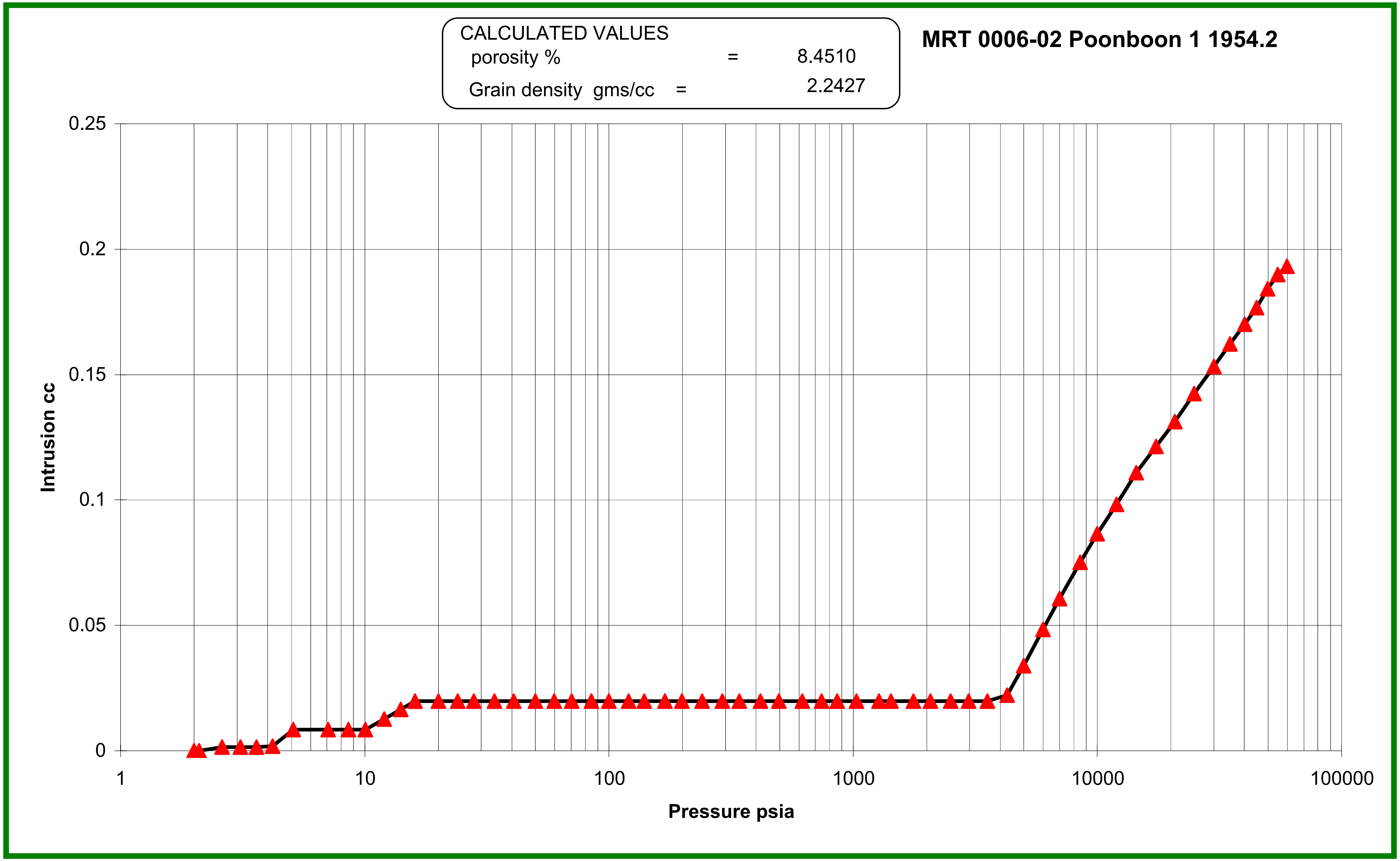


Water Saturation vs Height (lognormal); Pelican 5 2890
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

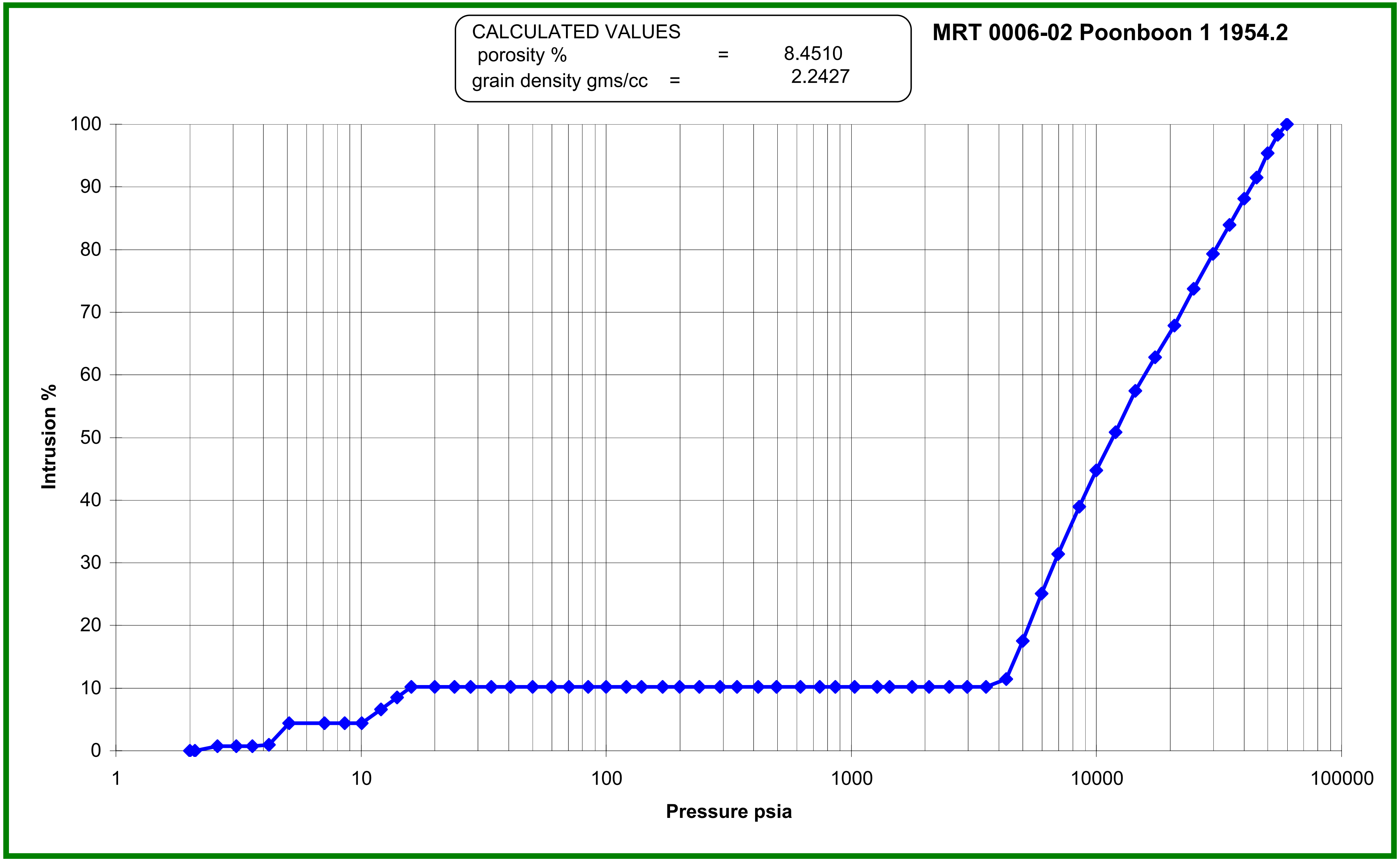
Poonboon_1_1954m.xls

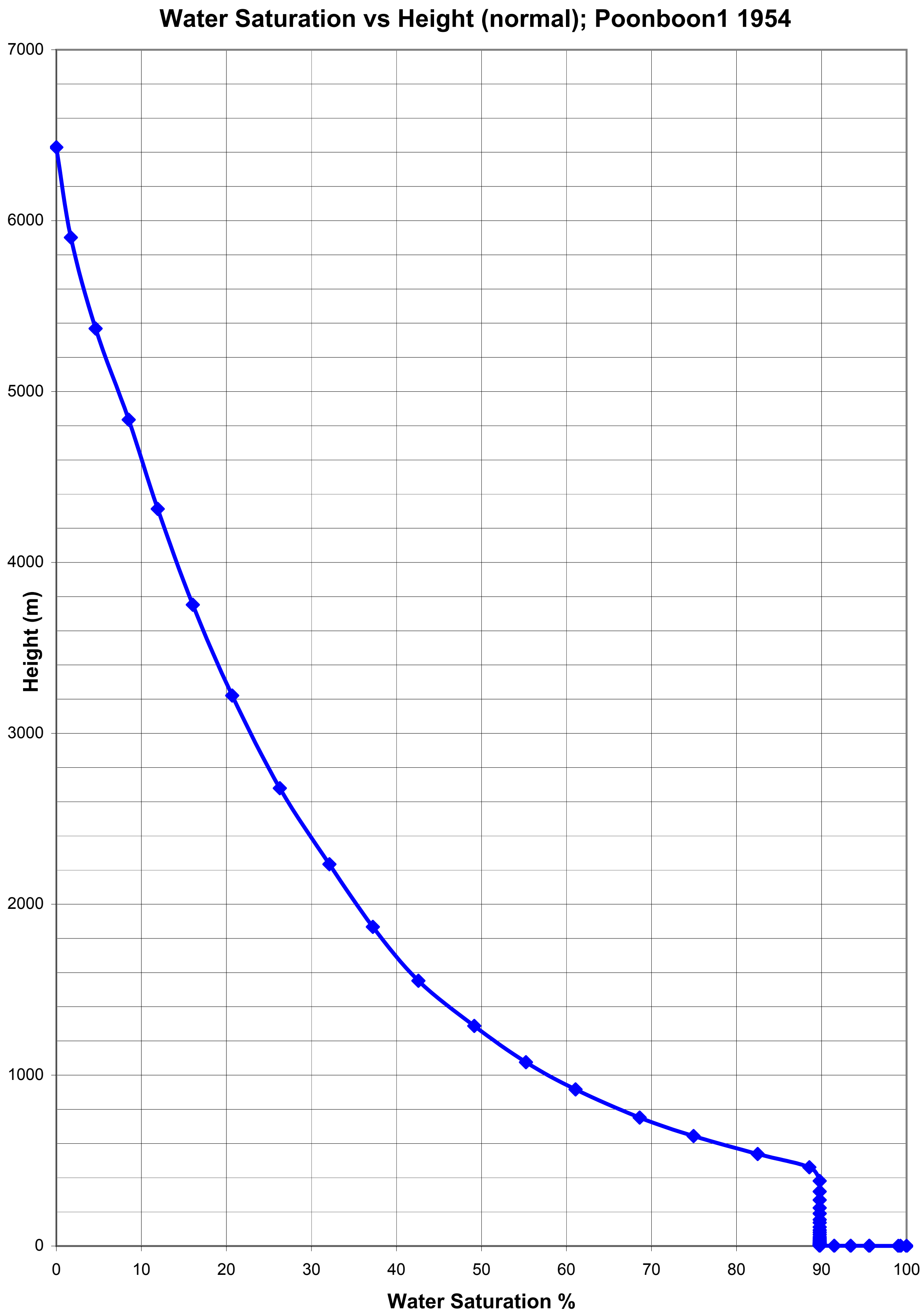


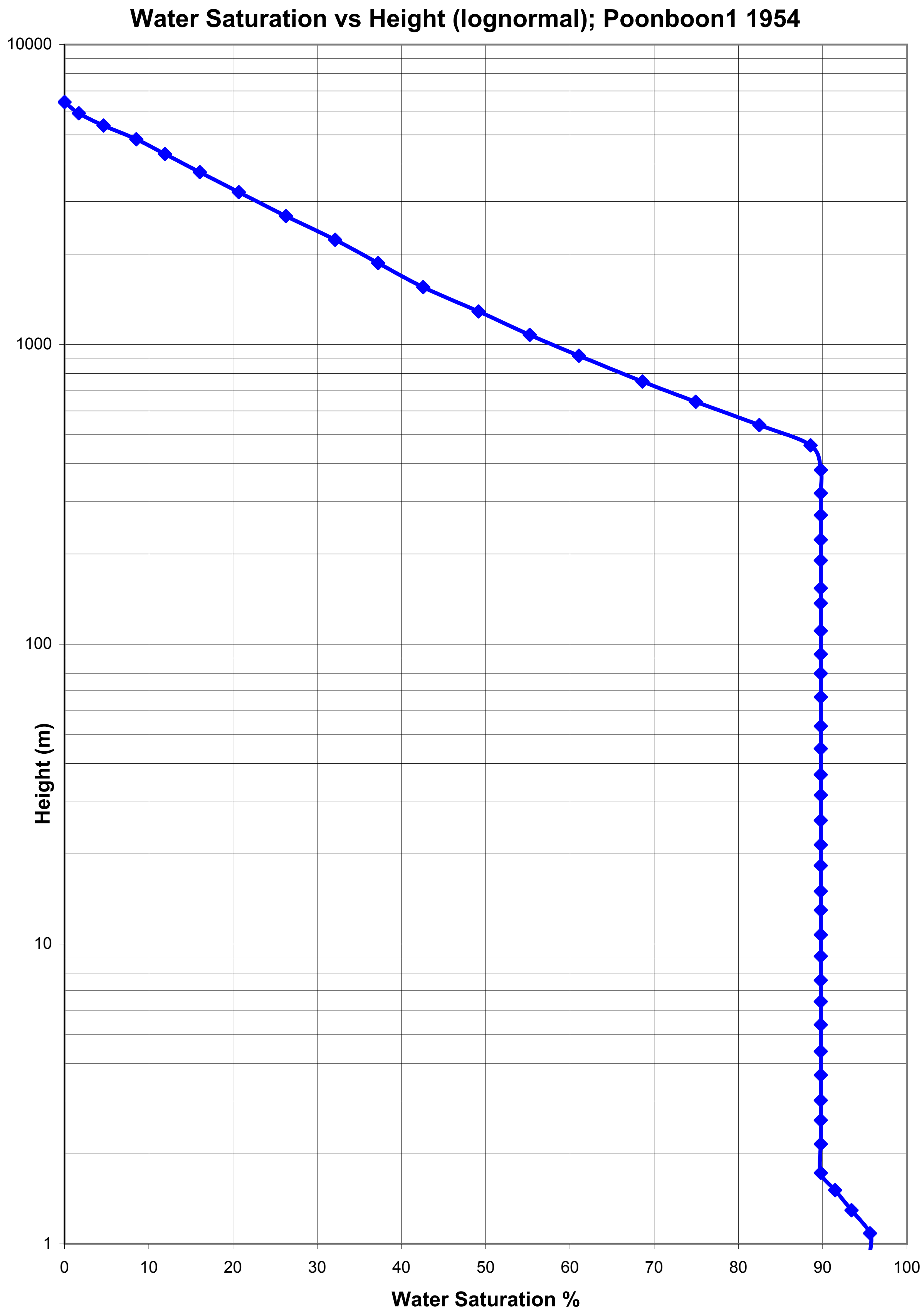
Poonboon_1_1954m.xls



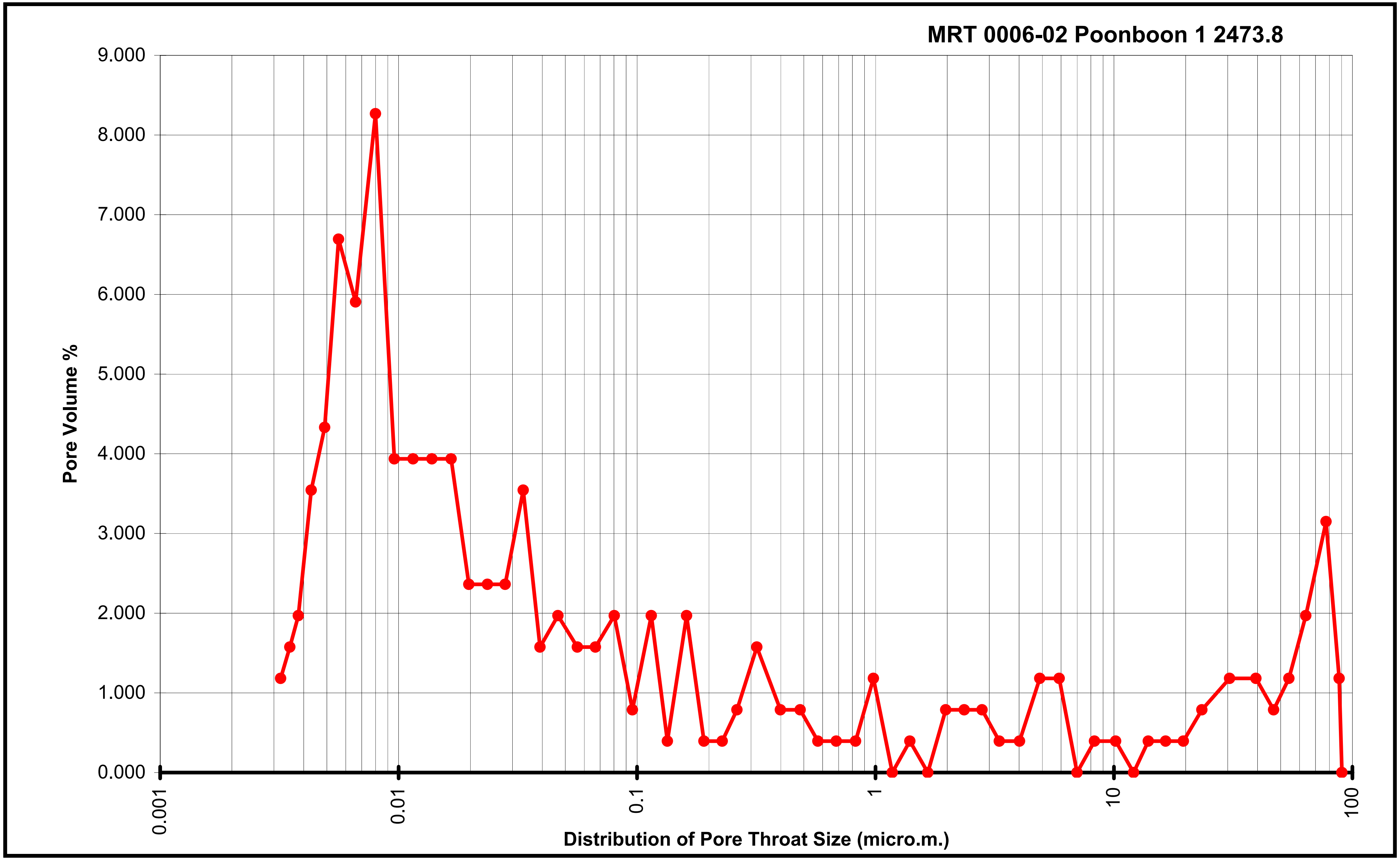
Poonboon_1_1954m.xls

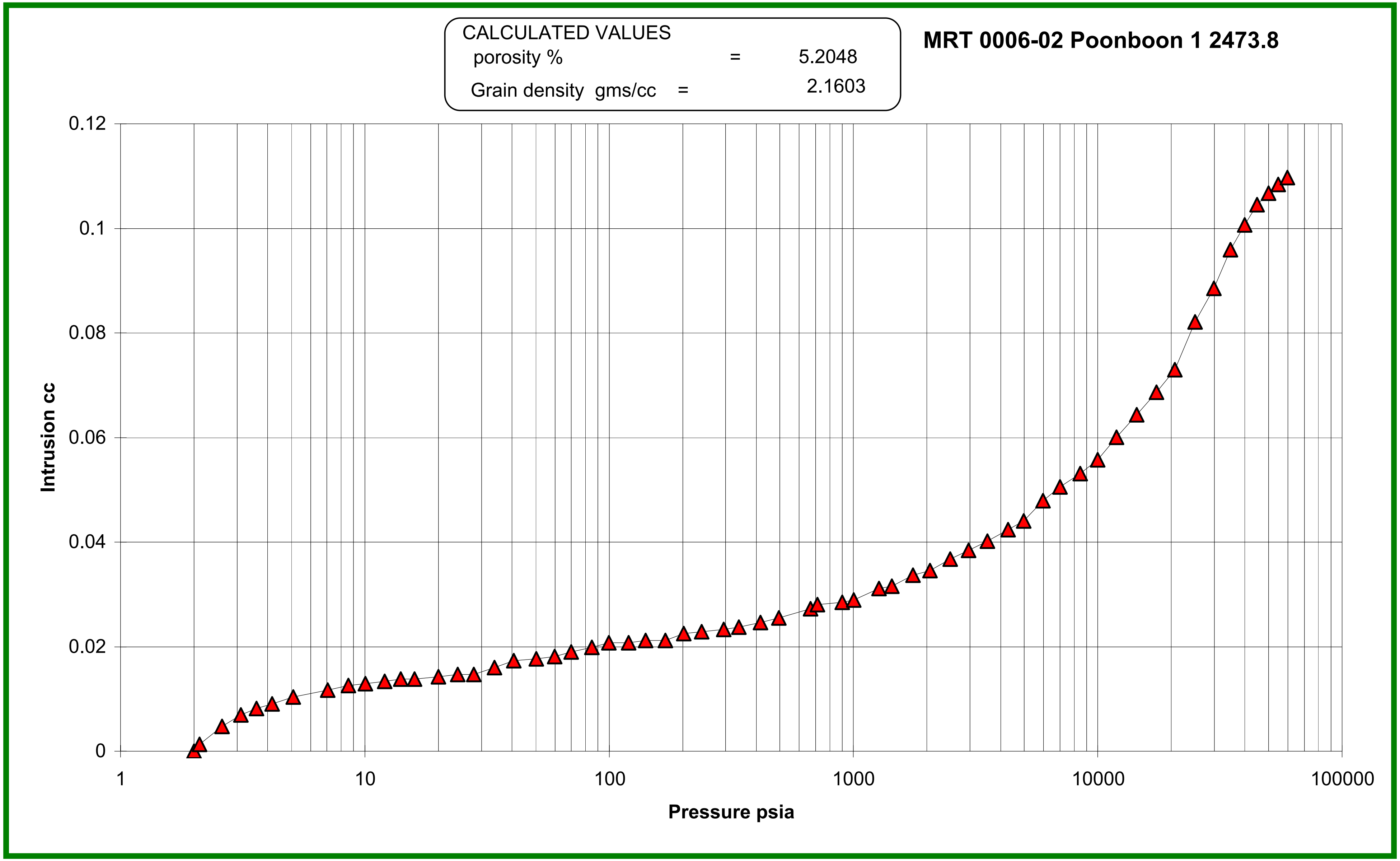


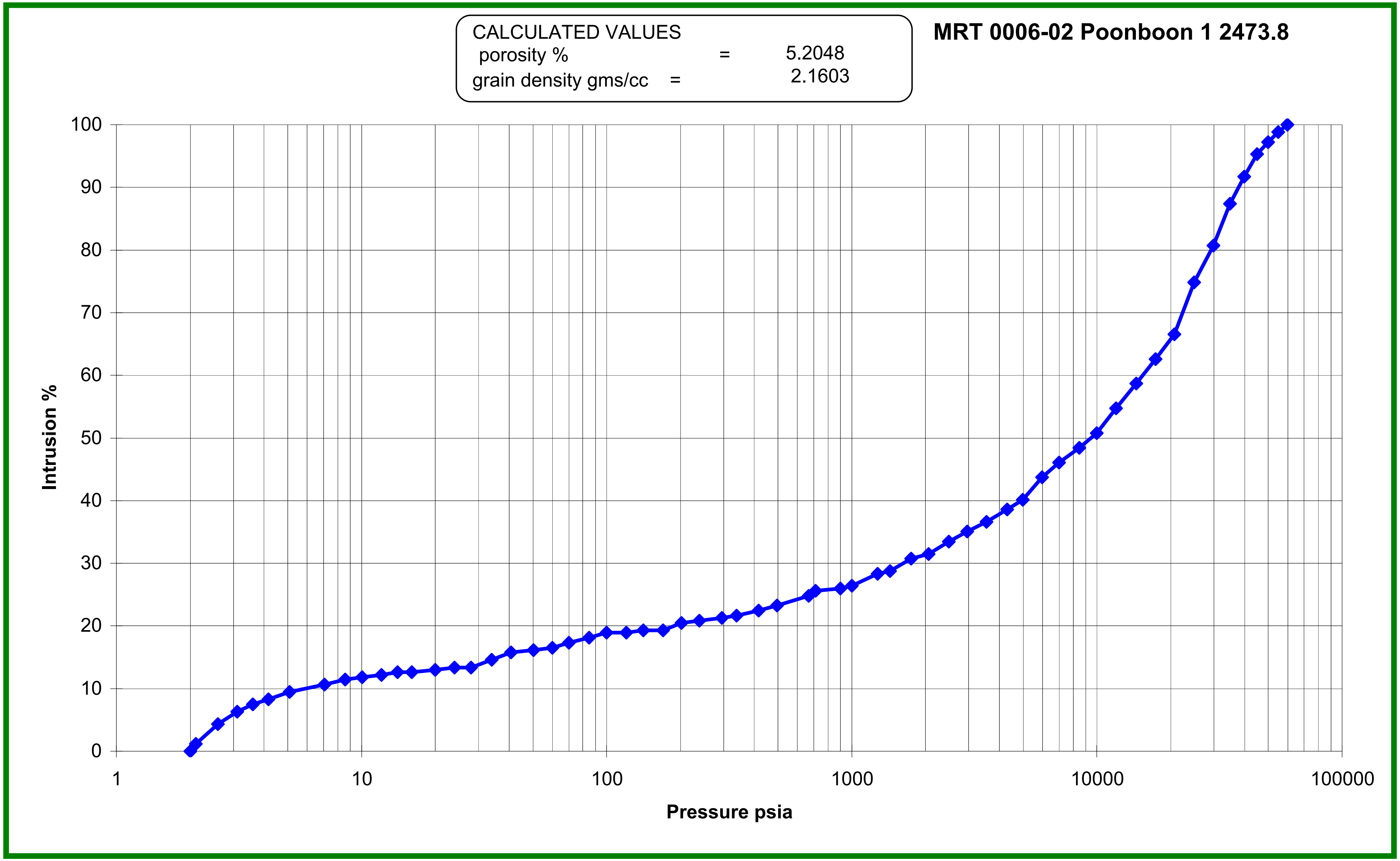

Water Saturation vs Height (normal); Poonboon1 1954
Height (m)
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100

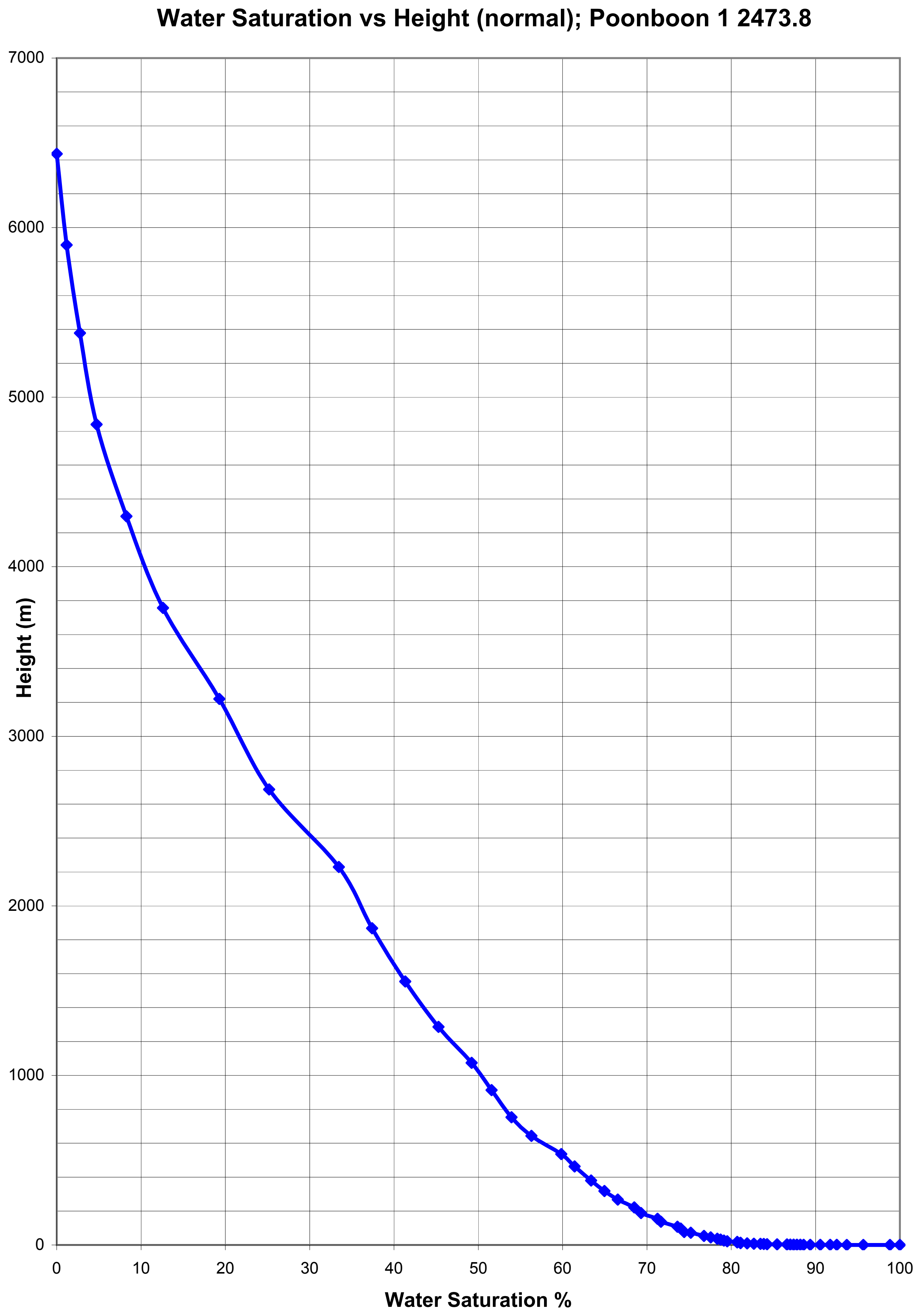

Water Saturation vs Height (lognormal); Poonboon1 1954
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

Poonboon_1_2474m.xls



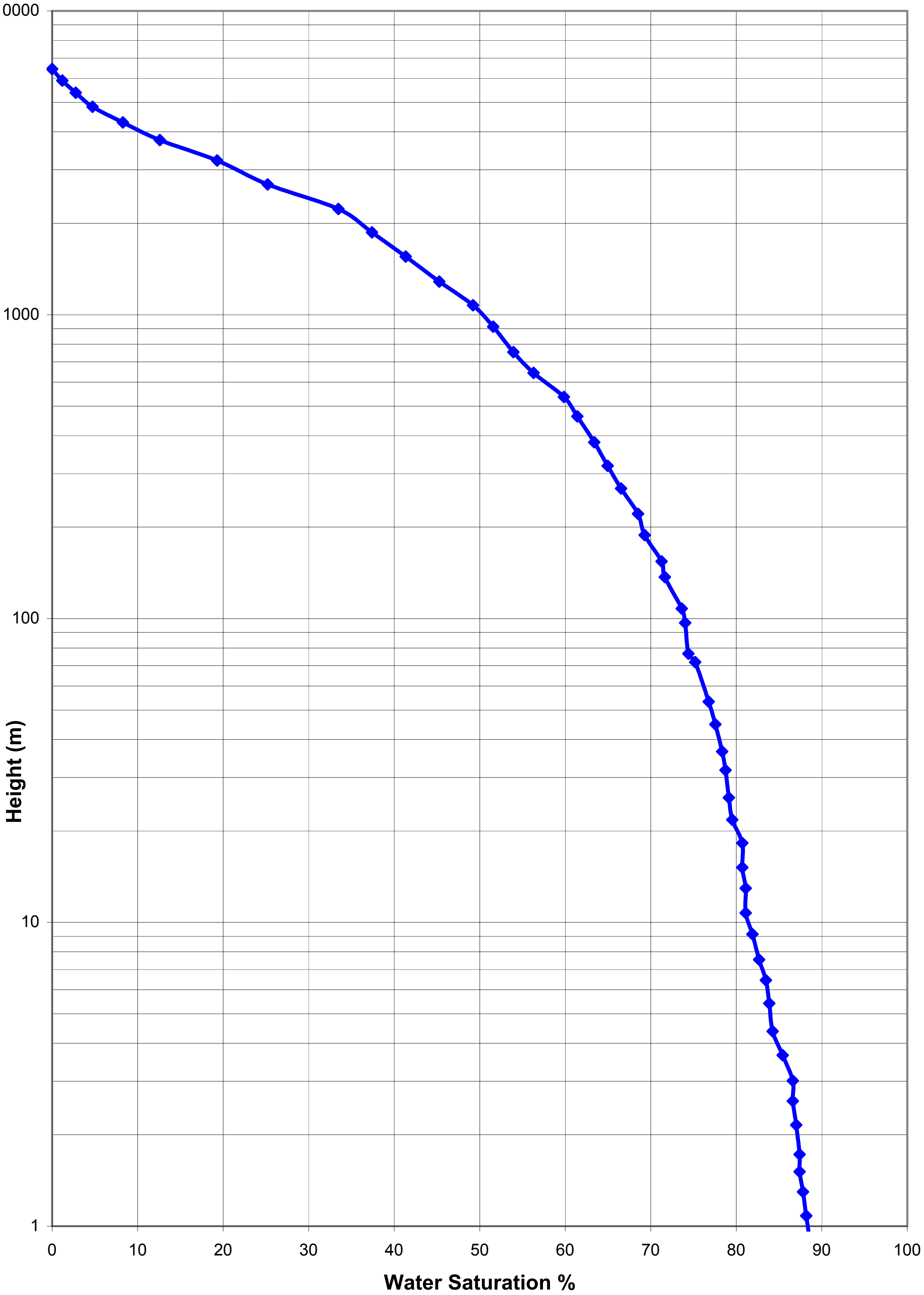

CALCULATED VALUES
porosity % = 5.2048
Grain density gms/cc = 2.1603
MRT 0006-02 Poonboon 1 2473.8
Intrusion cc
0.12
0.1
0.08
0.06
0.04
0.02
0
1
10
100
1000
10000
100000
Pressure psia

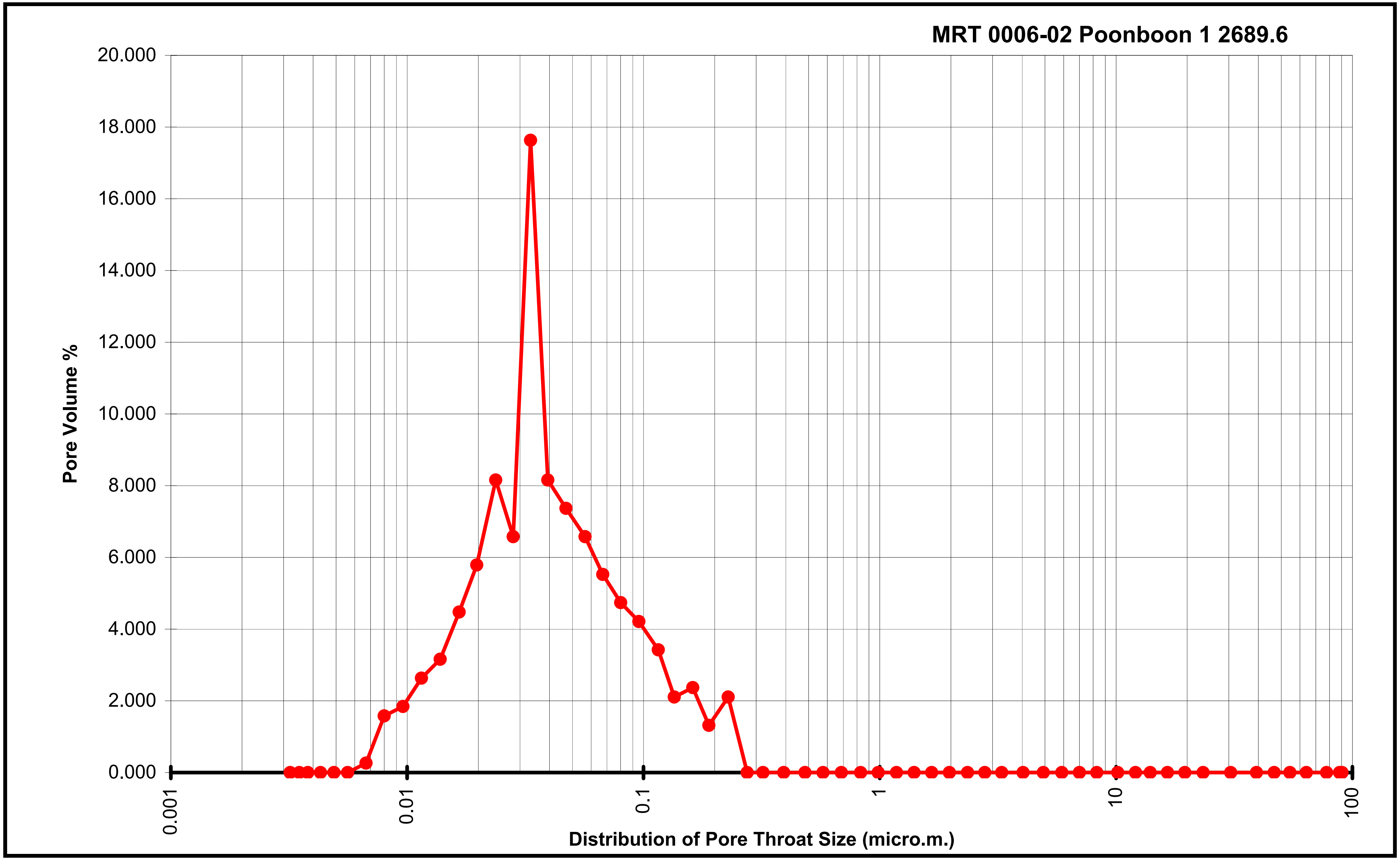

CALCULATED VALUES
porosity % = 5.2048
grain density gms/cc = 2.1603
MRT 0006-02 Poonboon 1 2473.8
Intrusion %
Pressure psia
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000



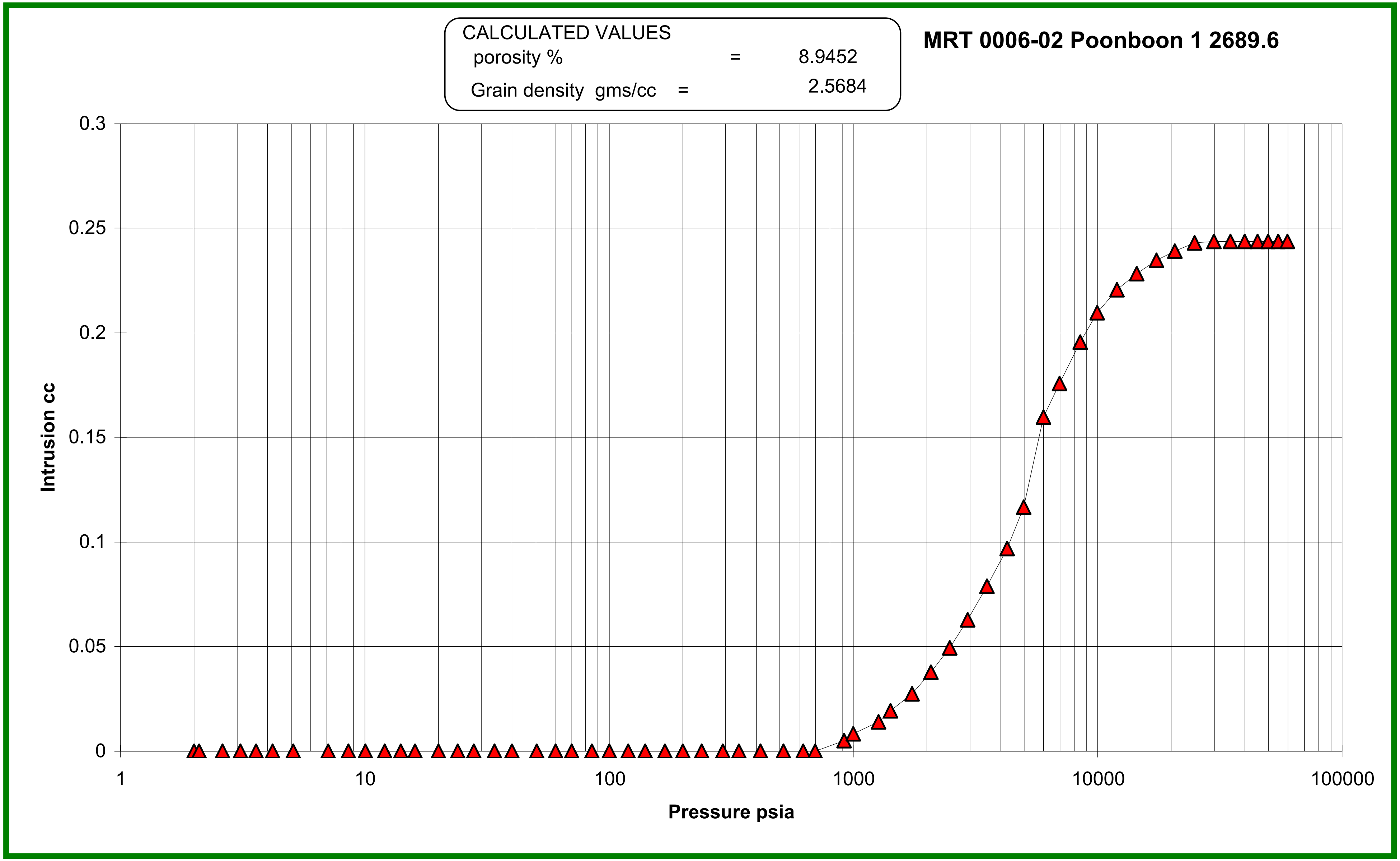
Water Saturation vs Height (normal); Poonboon 1 2473.8
Height (m)
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100

Water Saturation vs Height (lognormal); Poonboon 1 2473.8

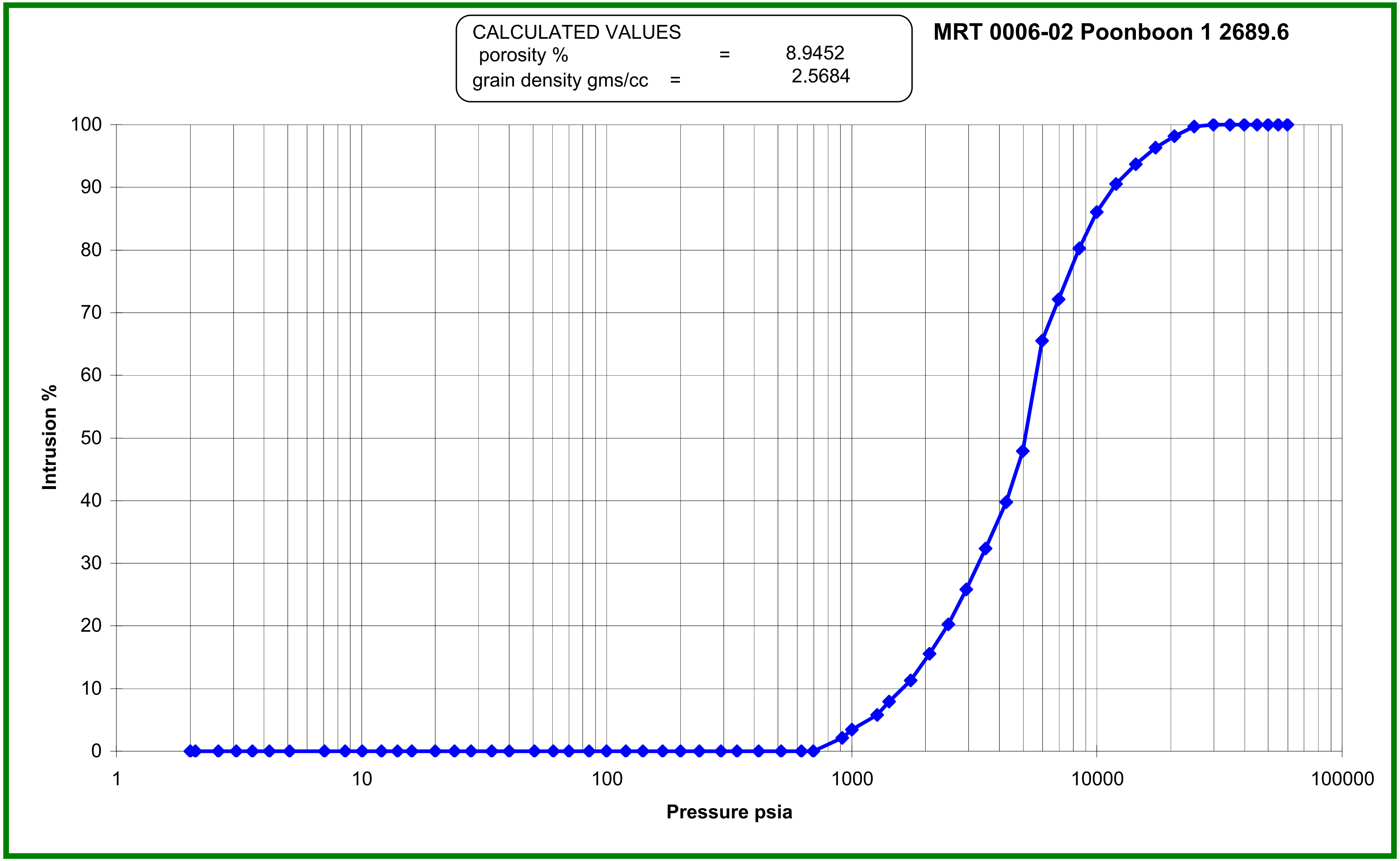


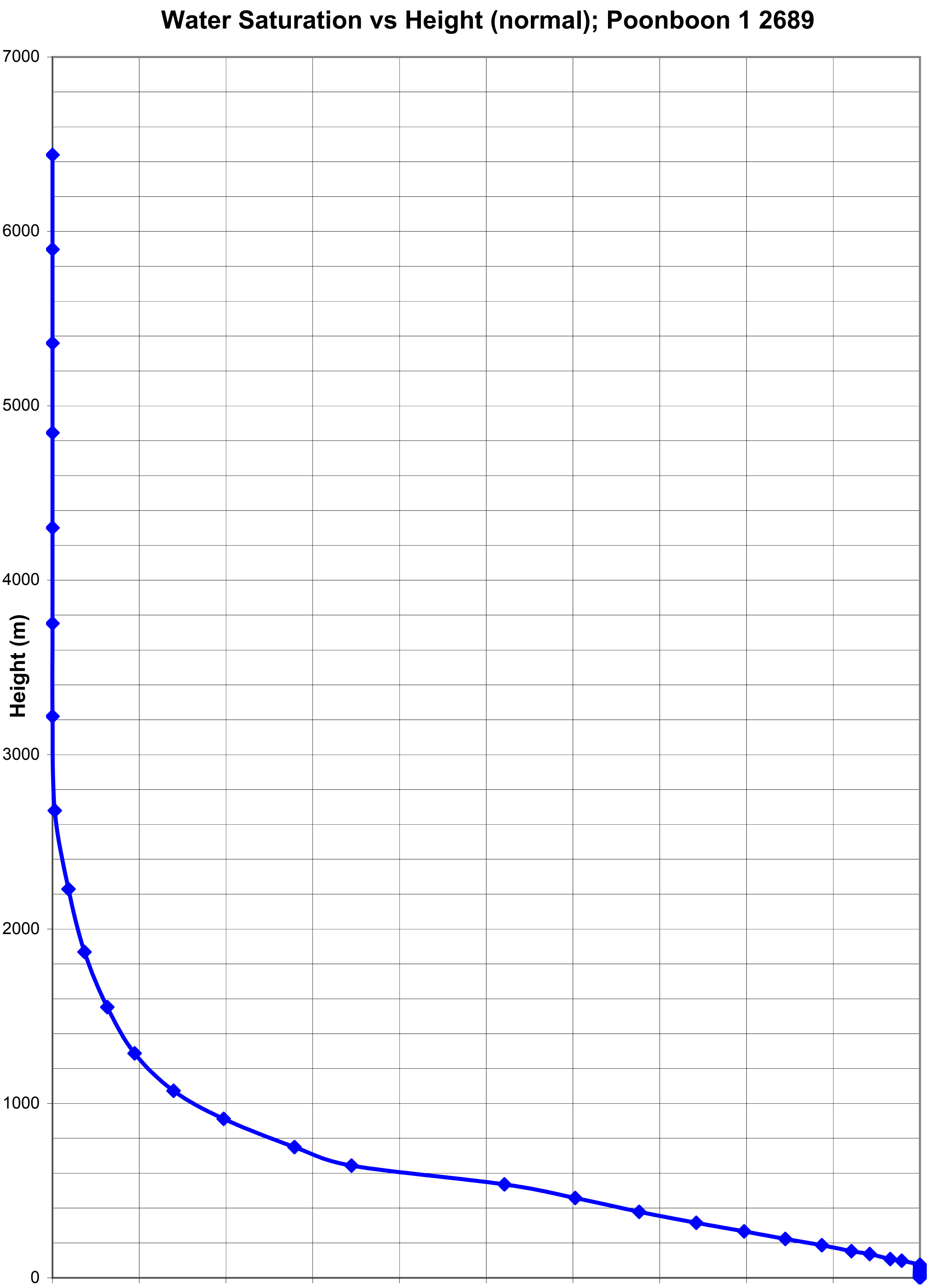

MRT 0006-02 Poonboon 1 2689.6
Pore Volume %
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
0.001
0.01
0.1
1
10
100
Distribution of Pore Throat Size (micro.m.)

Poonboon_1_2689m.xls

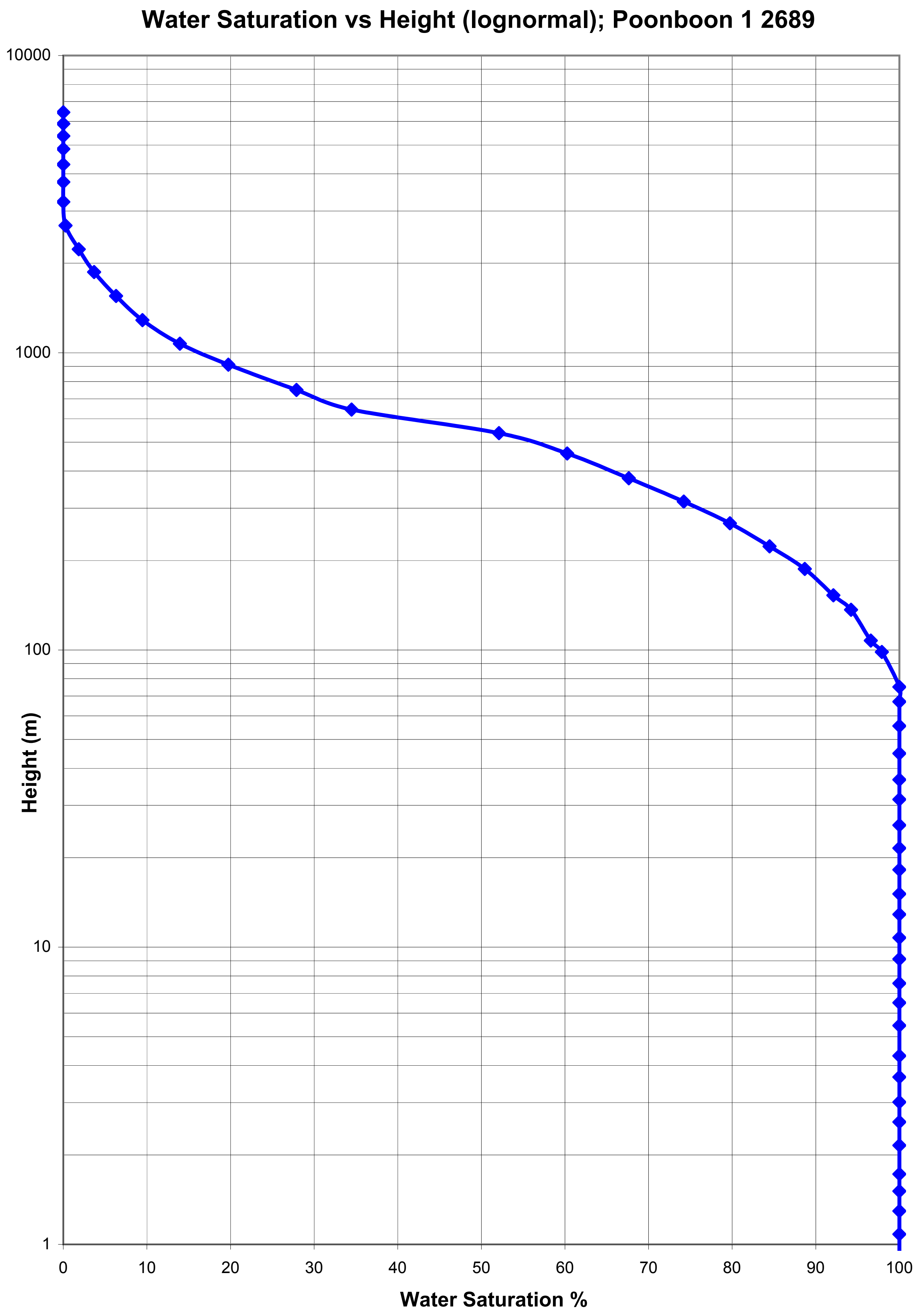


Poonboon_1_2689m.xls

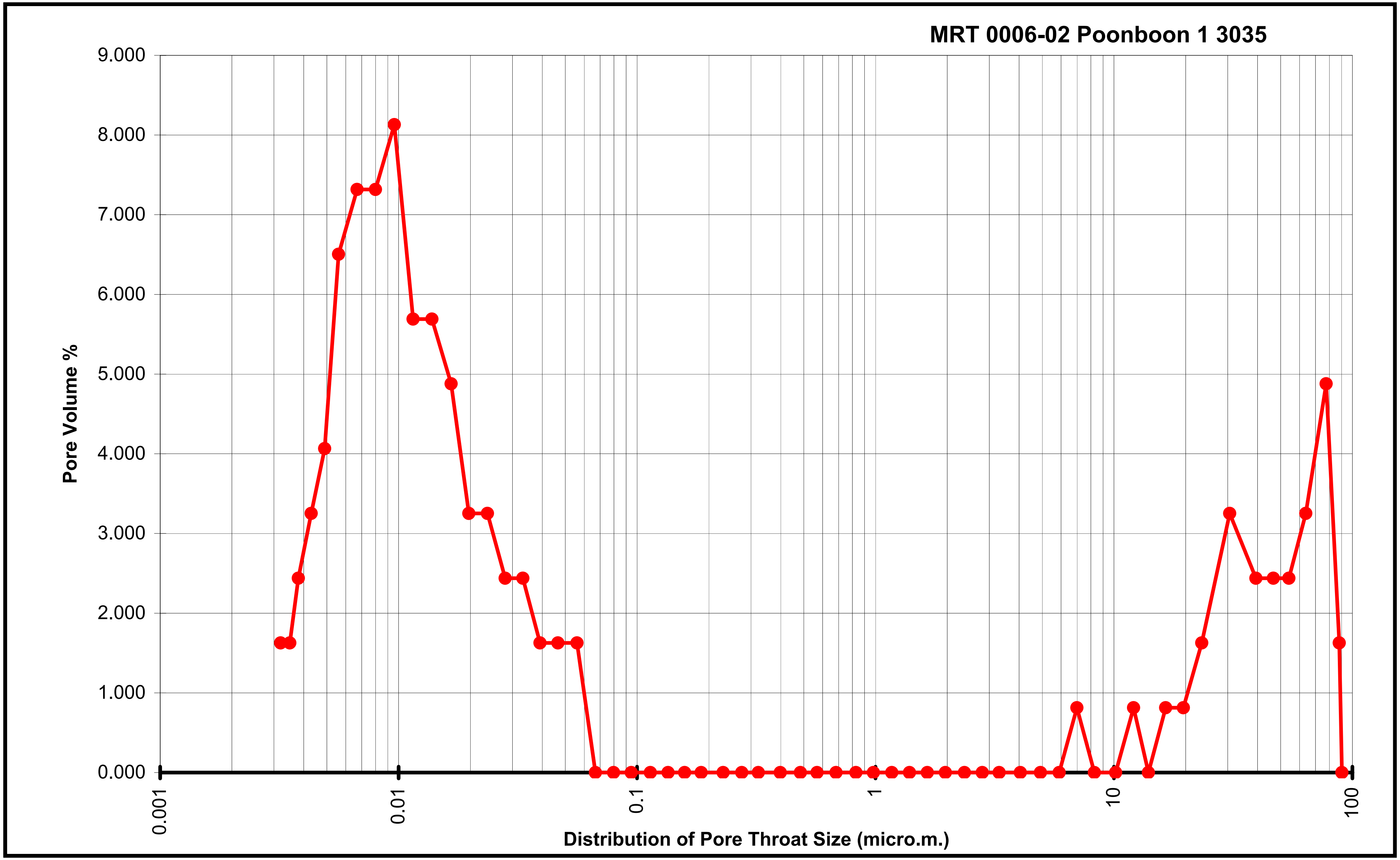




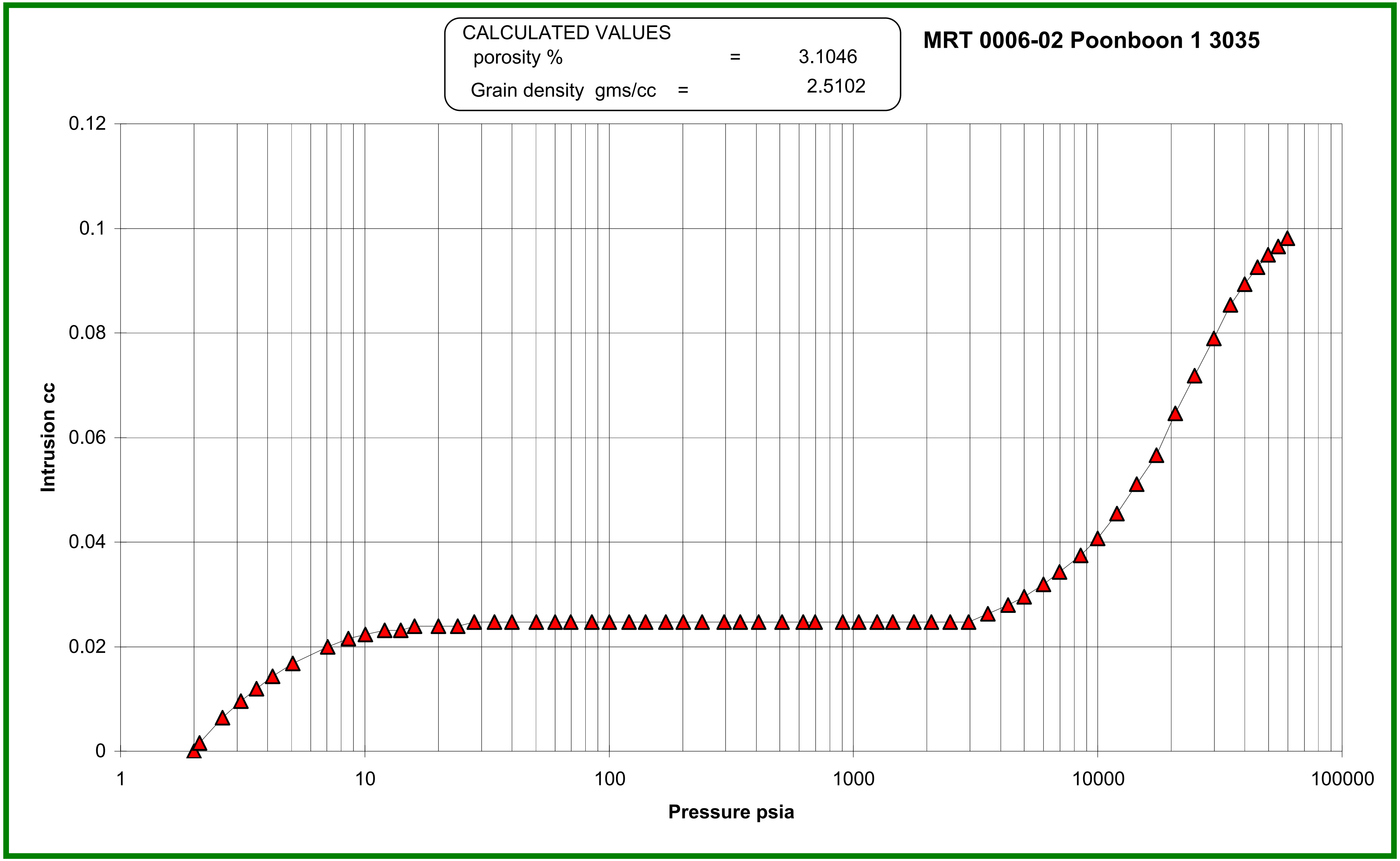
Water Saturation vs Height (normal); Poonboon 1 2689
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %


Water Saturation vs Height (lognormal); Poonboon 1 2689
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

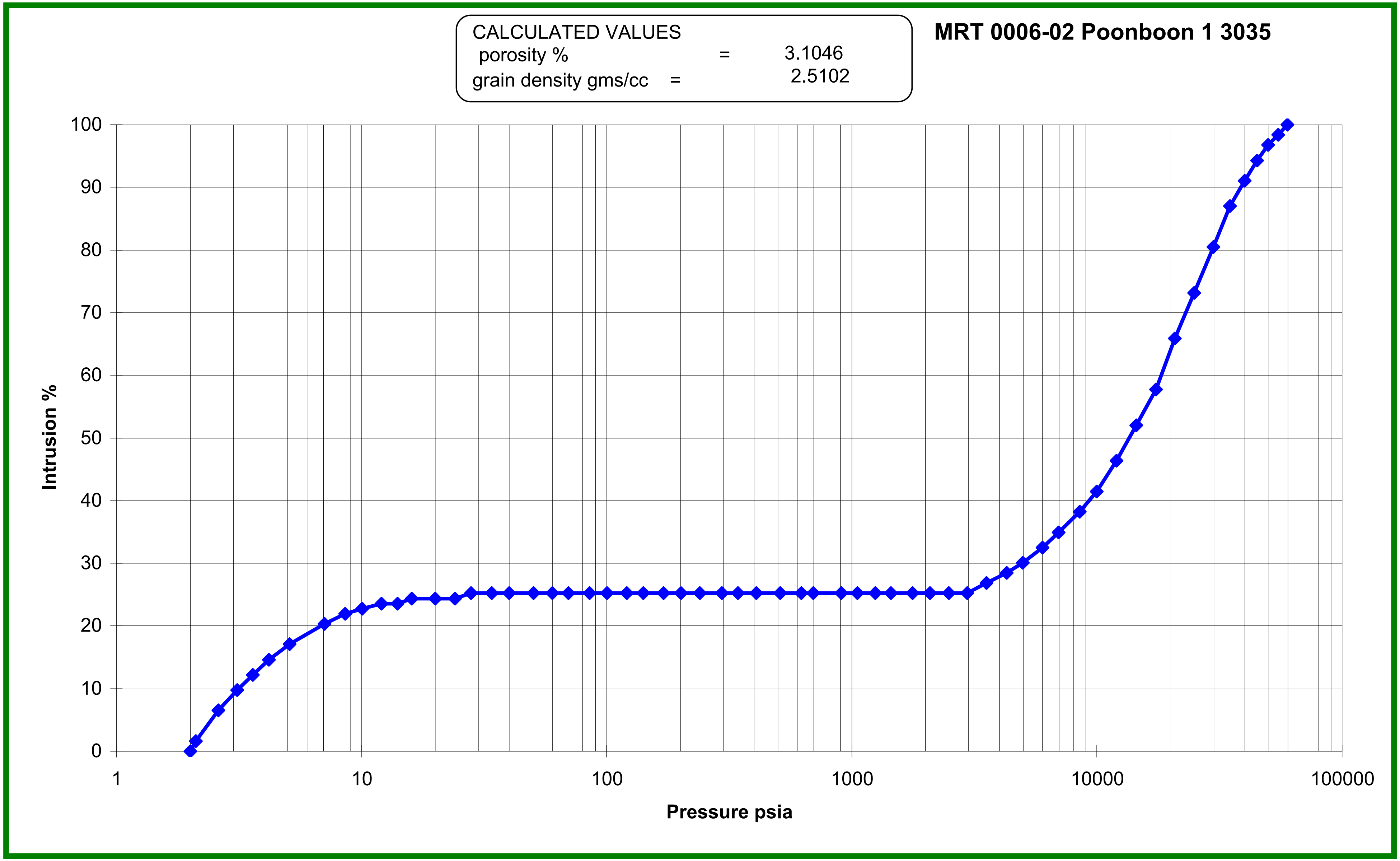
Poonboon_1_ 3035m.xls

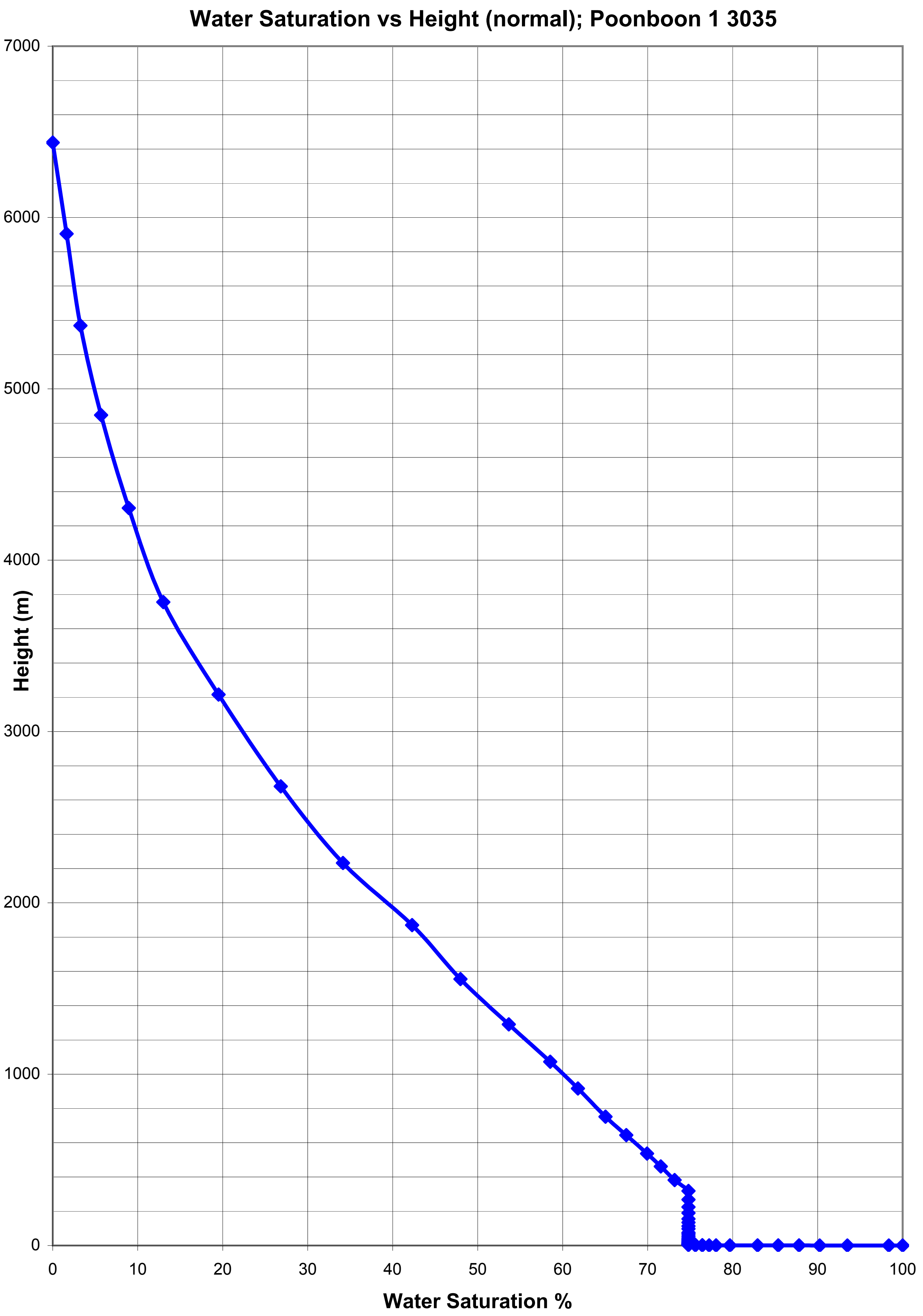


Poonboon_1_ 3035m.xls

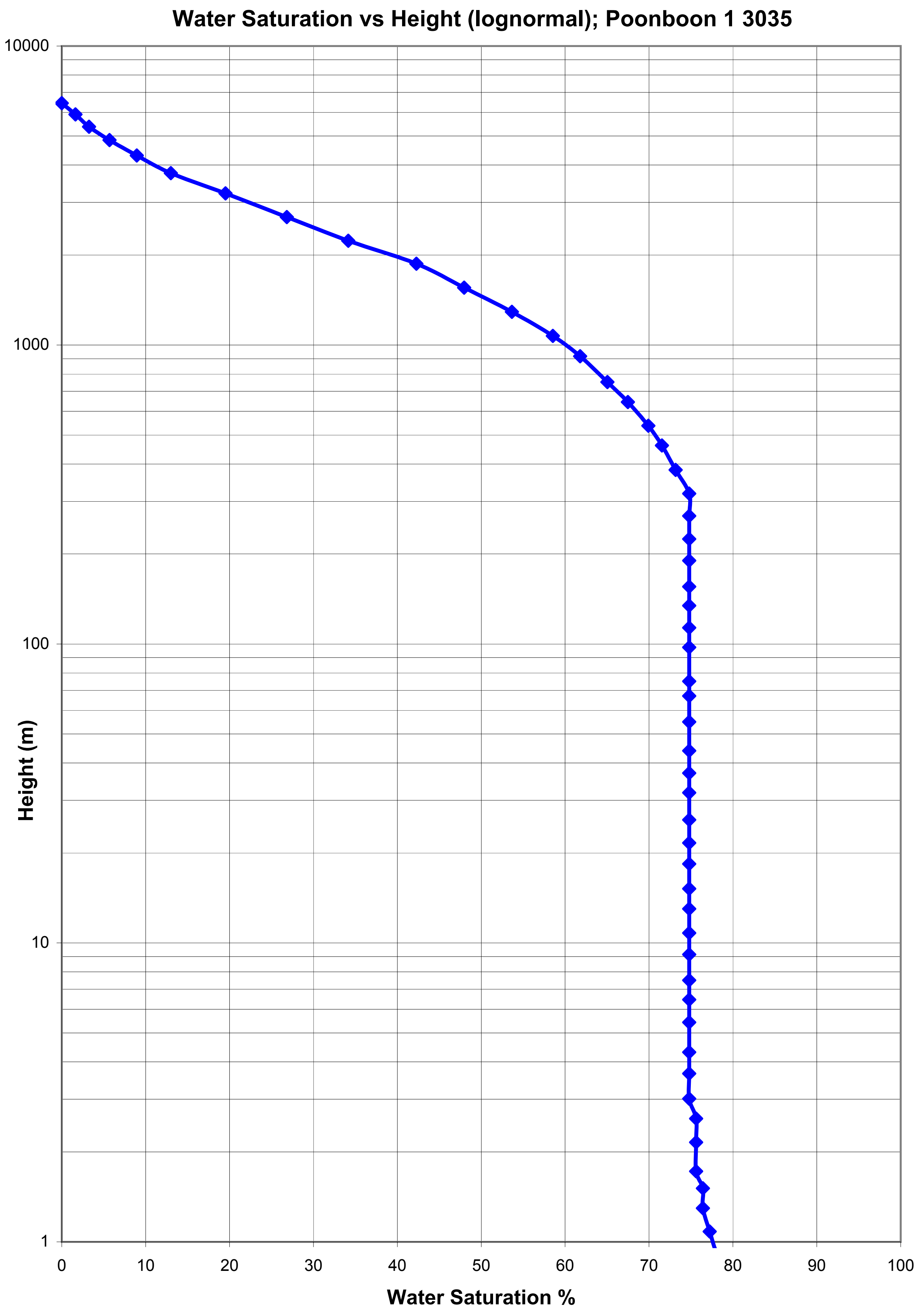


Poonboon_1_ 3035m.xls



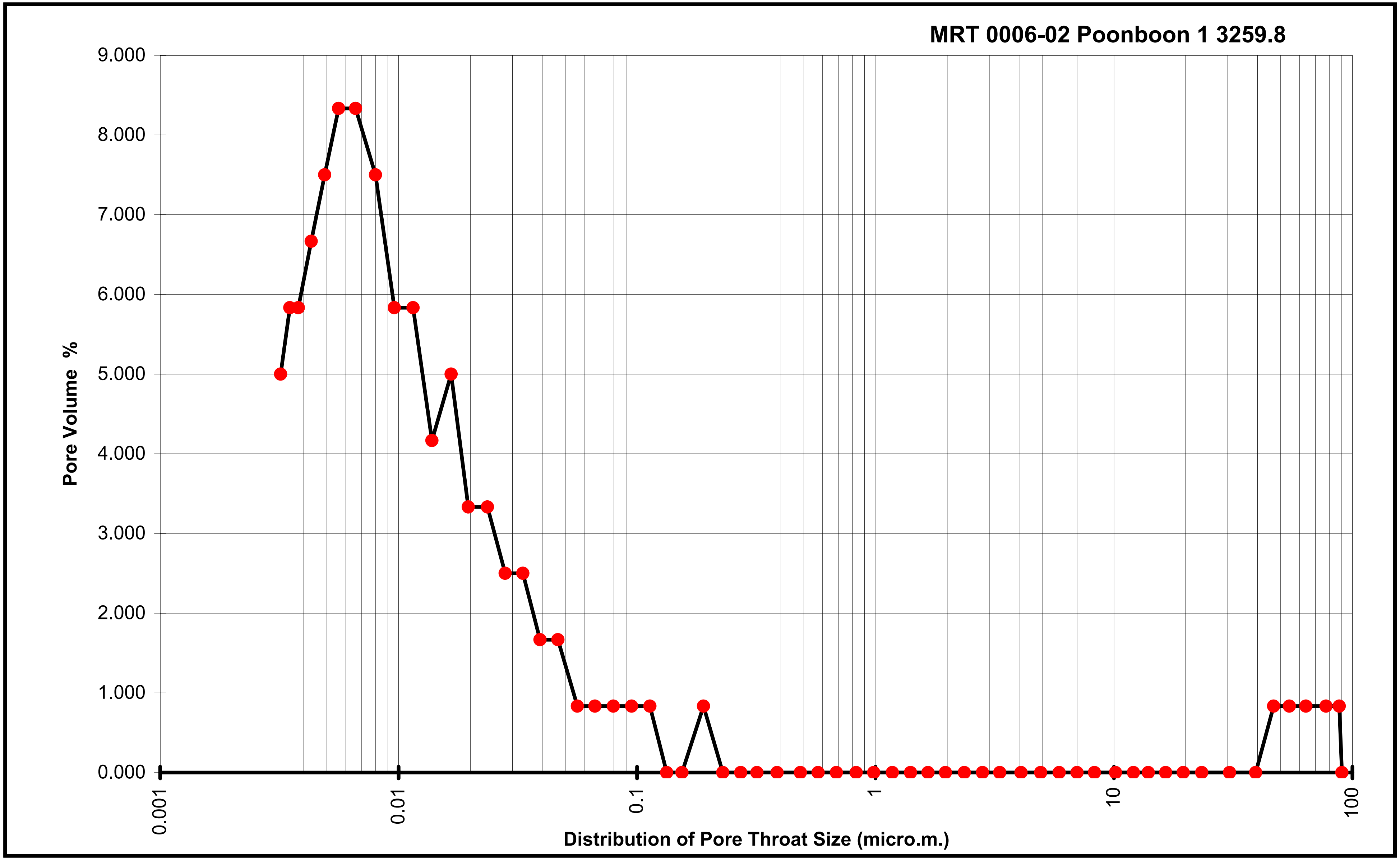


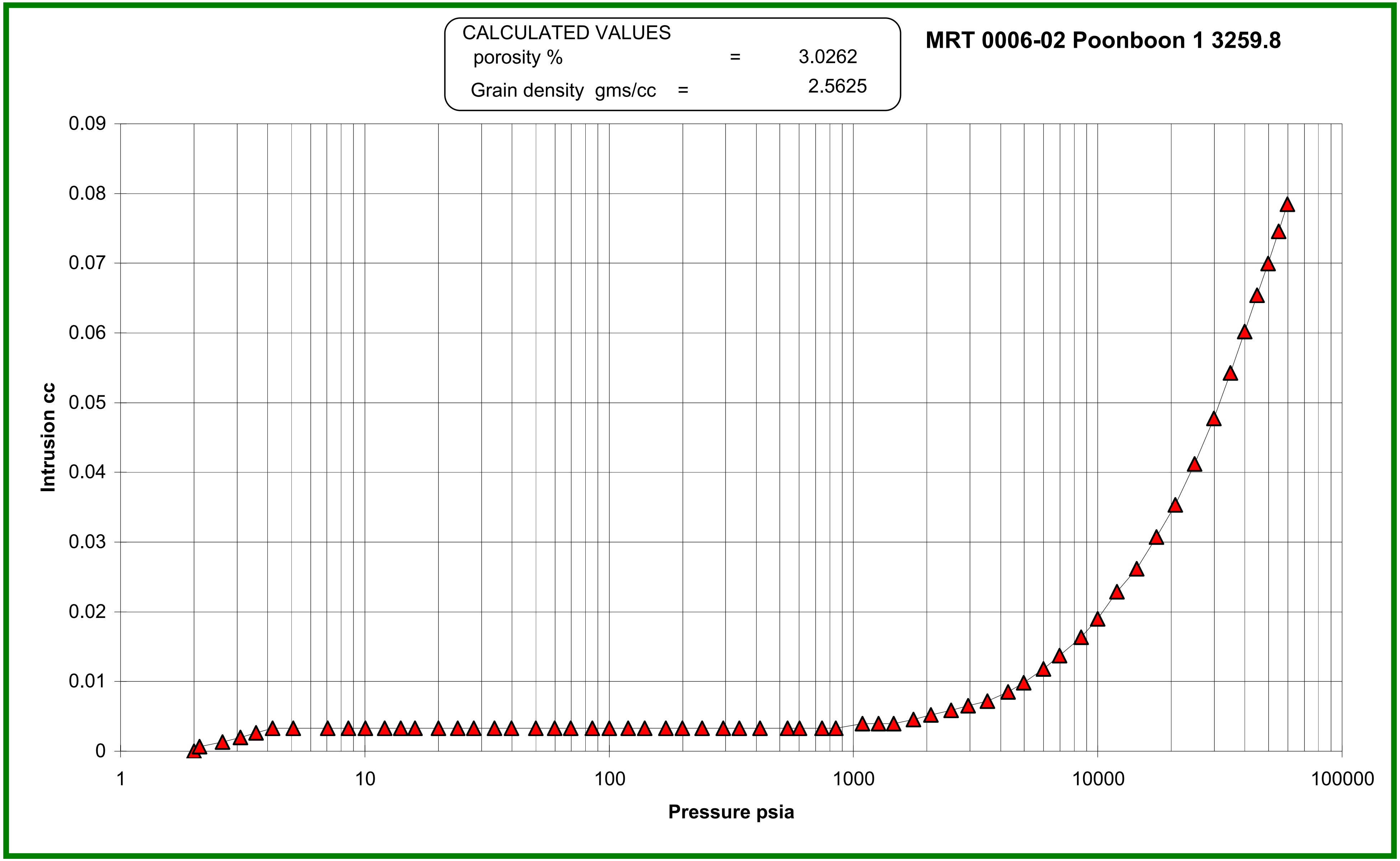
Water Saturation vs Height (normal); Poonboon 1 3035
Height (m)
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100



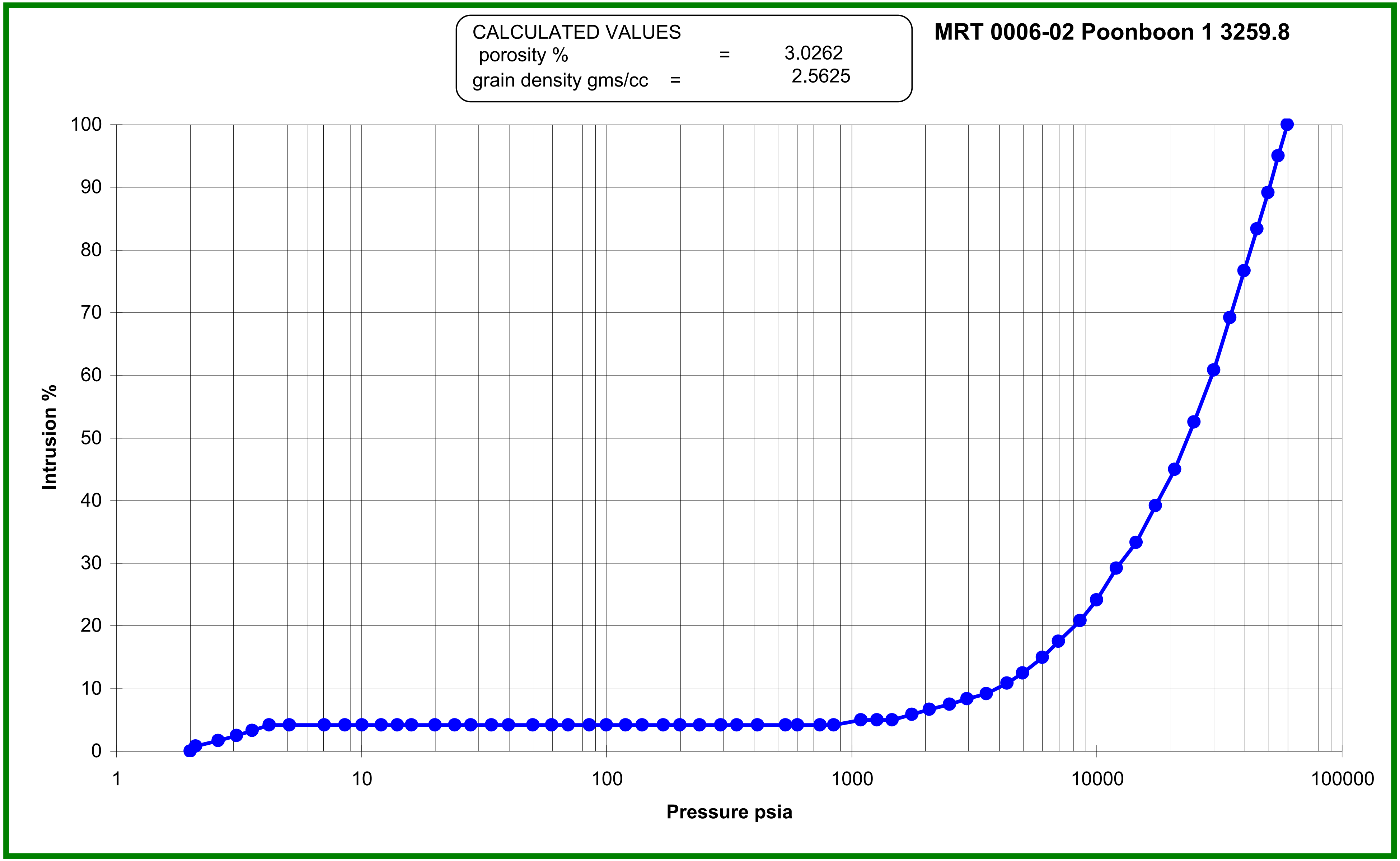
Water Saturation vs Height (lognormal); Poonboon 1 3035
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

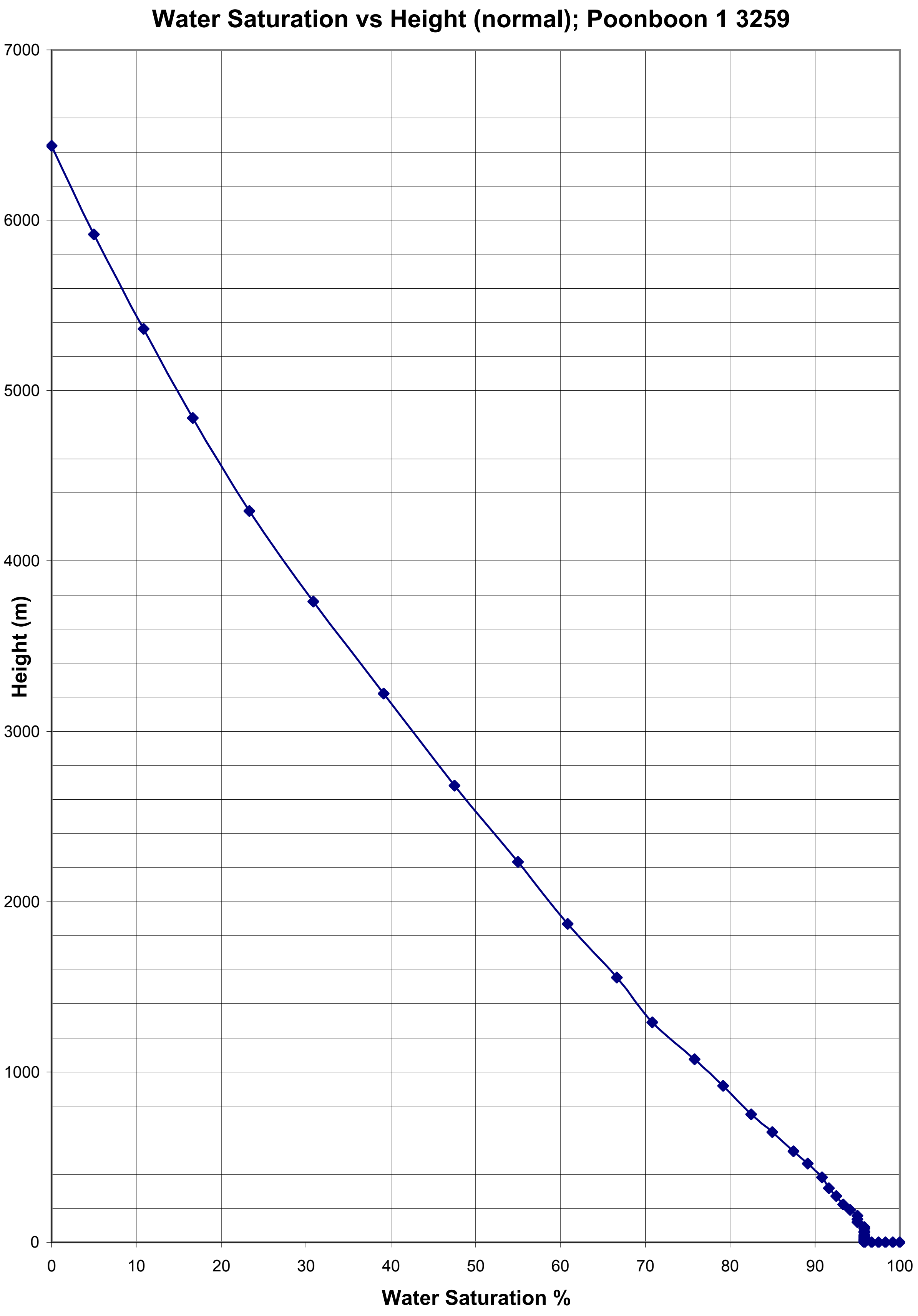
Poonboon_1_3259m.xls

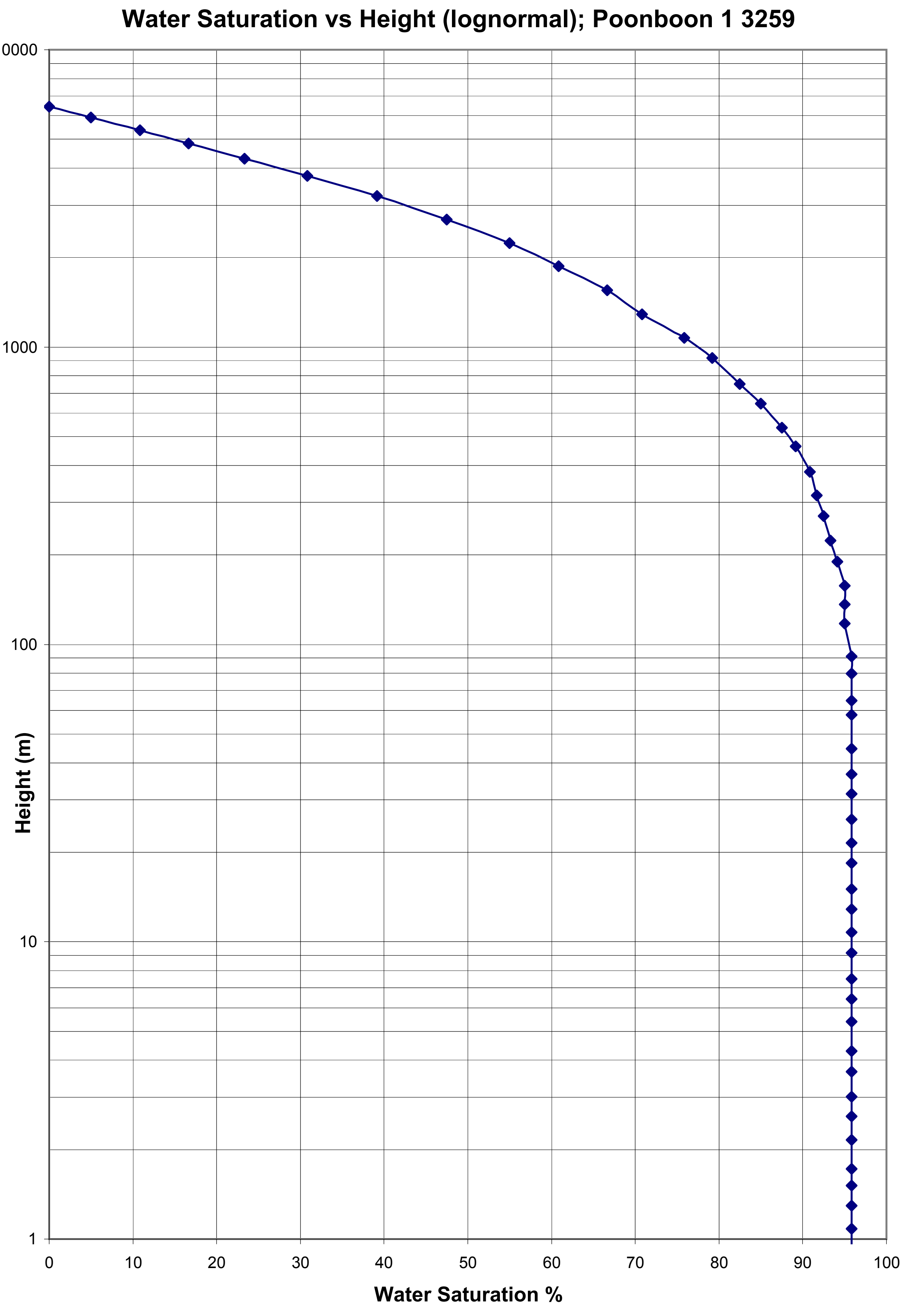



CALCULATED VALUES
porosity % = 3.0262
Grain density gms/cc = 2.5625
MRT 0006-02 Poonboon 1 3259.8
Intrusion cc
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1
10
100
1000
10000
100000
Pressure psia

Poonboon_1_3259m.xls

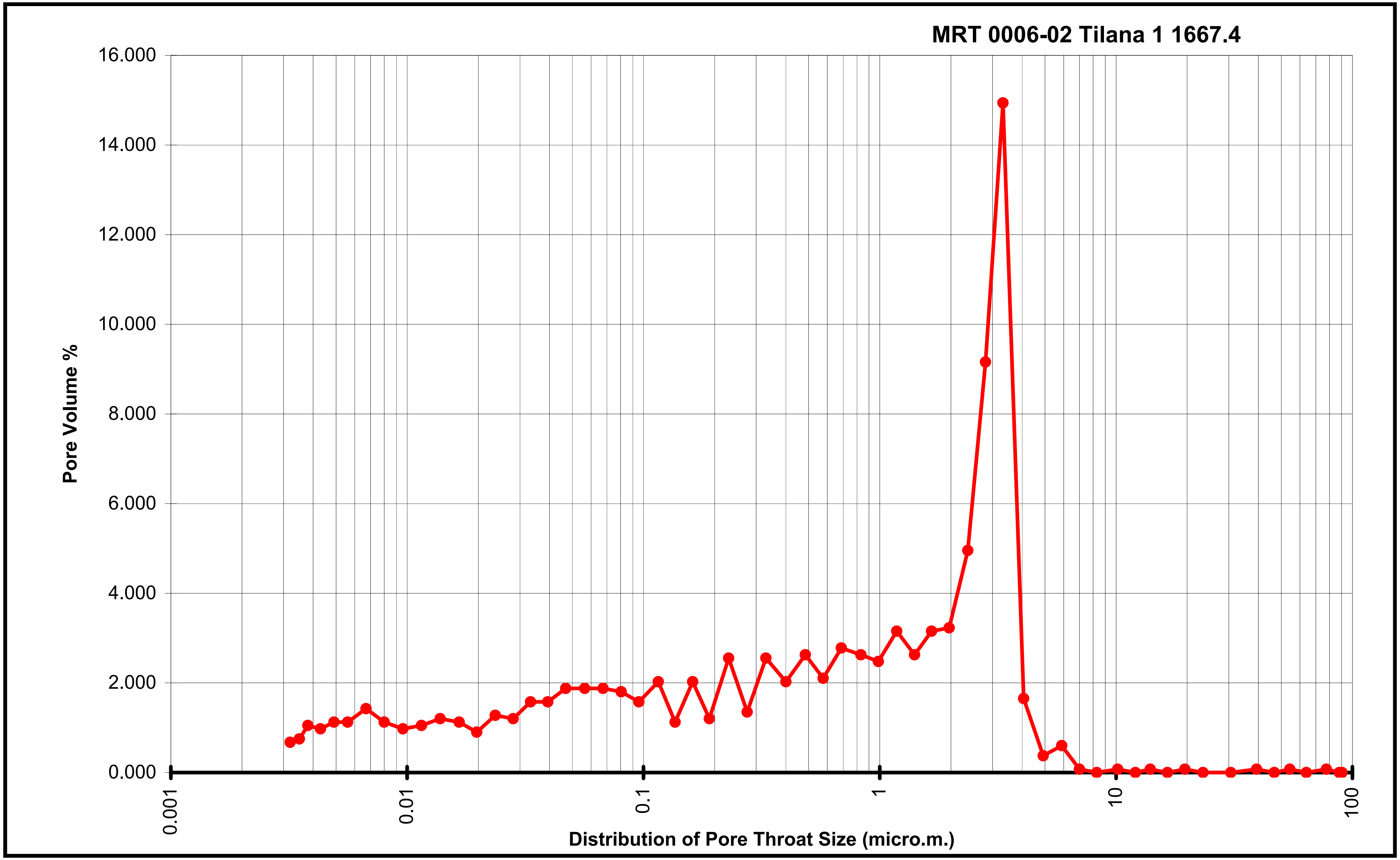



Water Saturation vs Height (normal); Poonboon 1 3259
Height (m)
Water Saturation %
0
1000
2000
3000
4000
5000
6000
7000
0
10
20
30
40
50
60
70
80
90
100

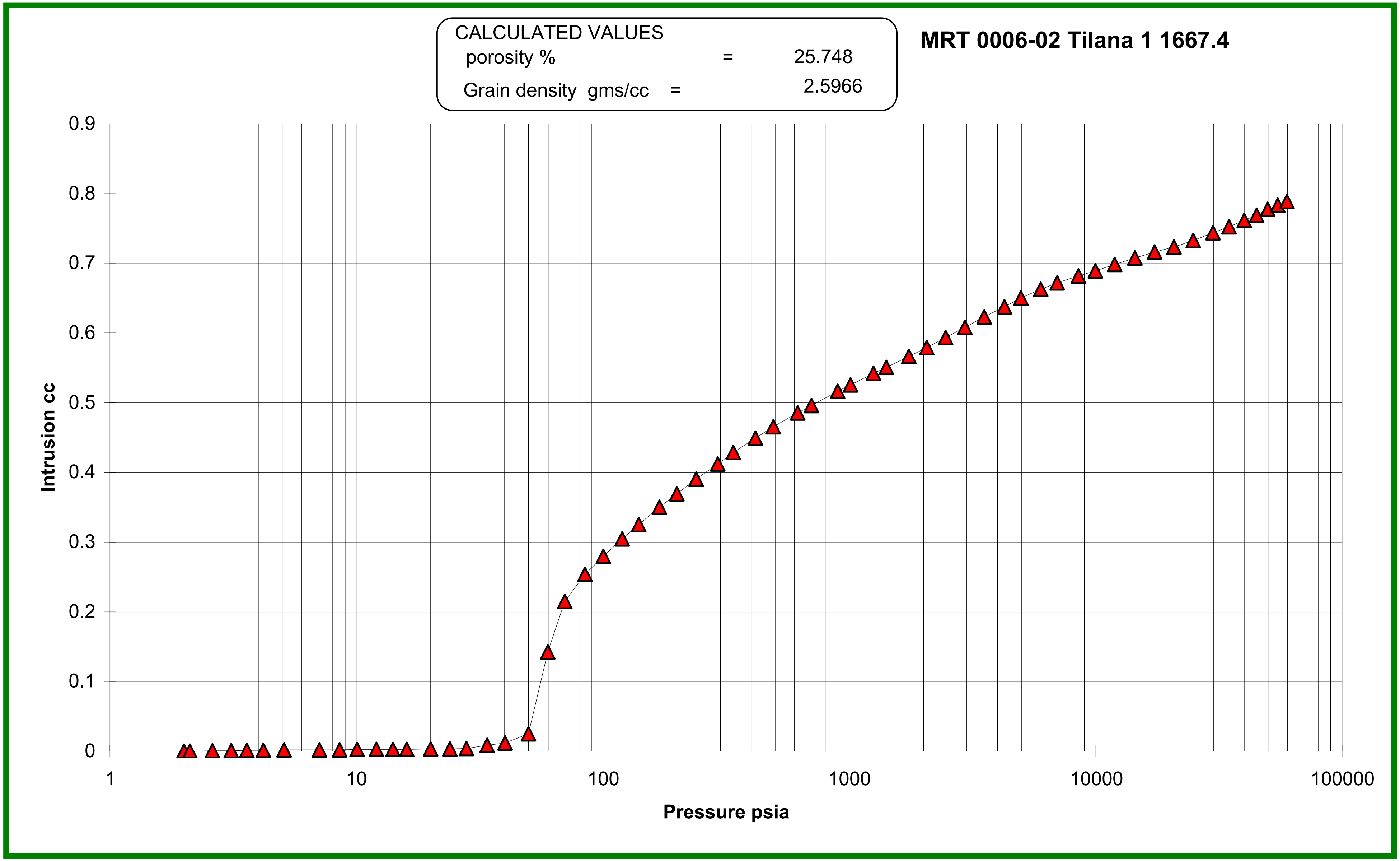


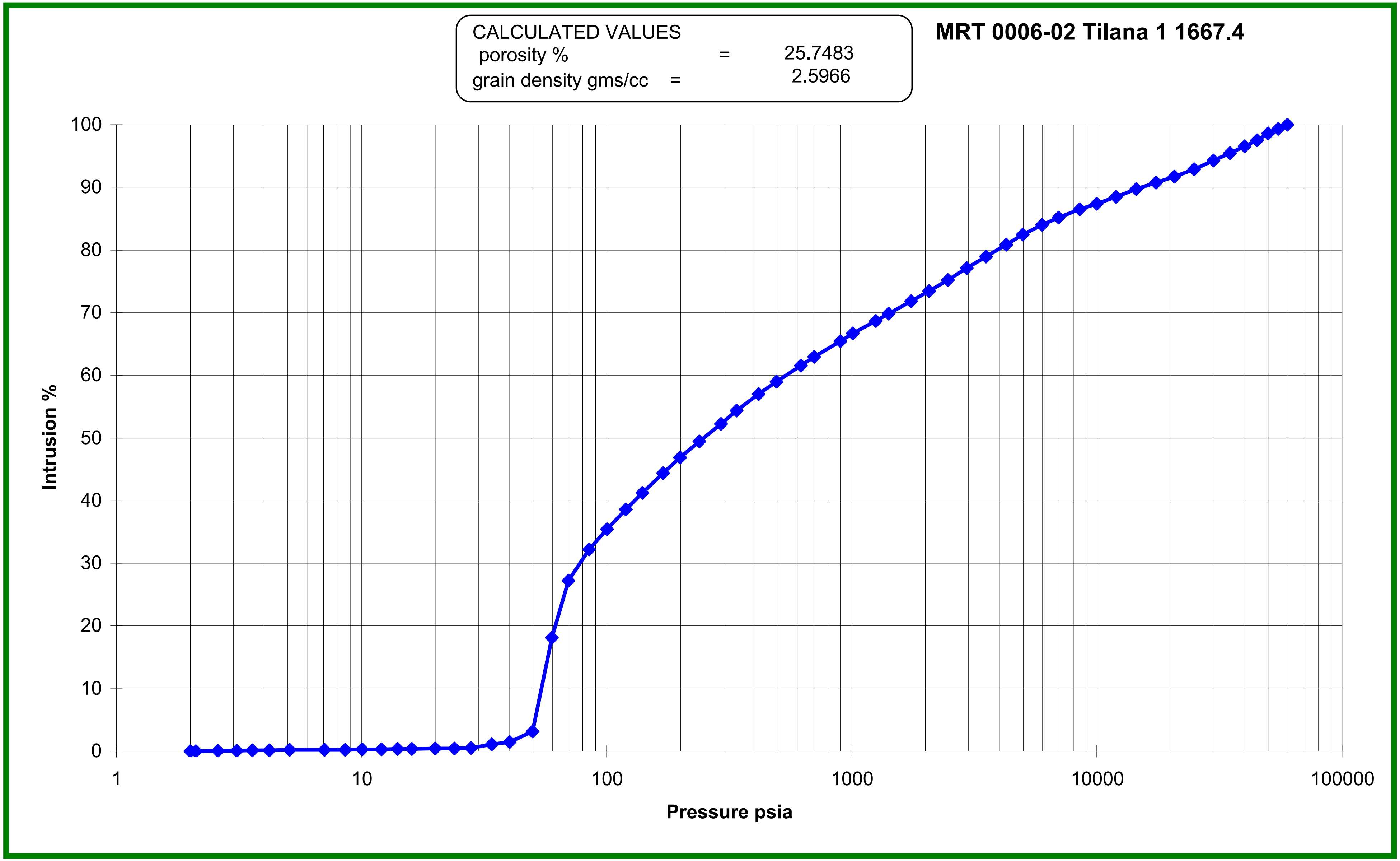
Water Saturation vs Height (lognormal); Poonboon 1 3259
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

Tilana_1_1667m.xls

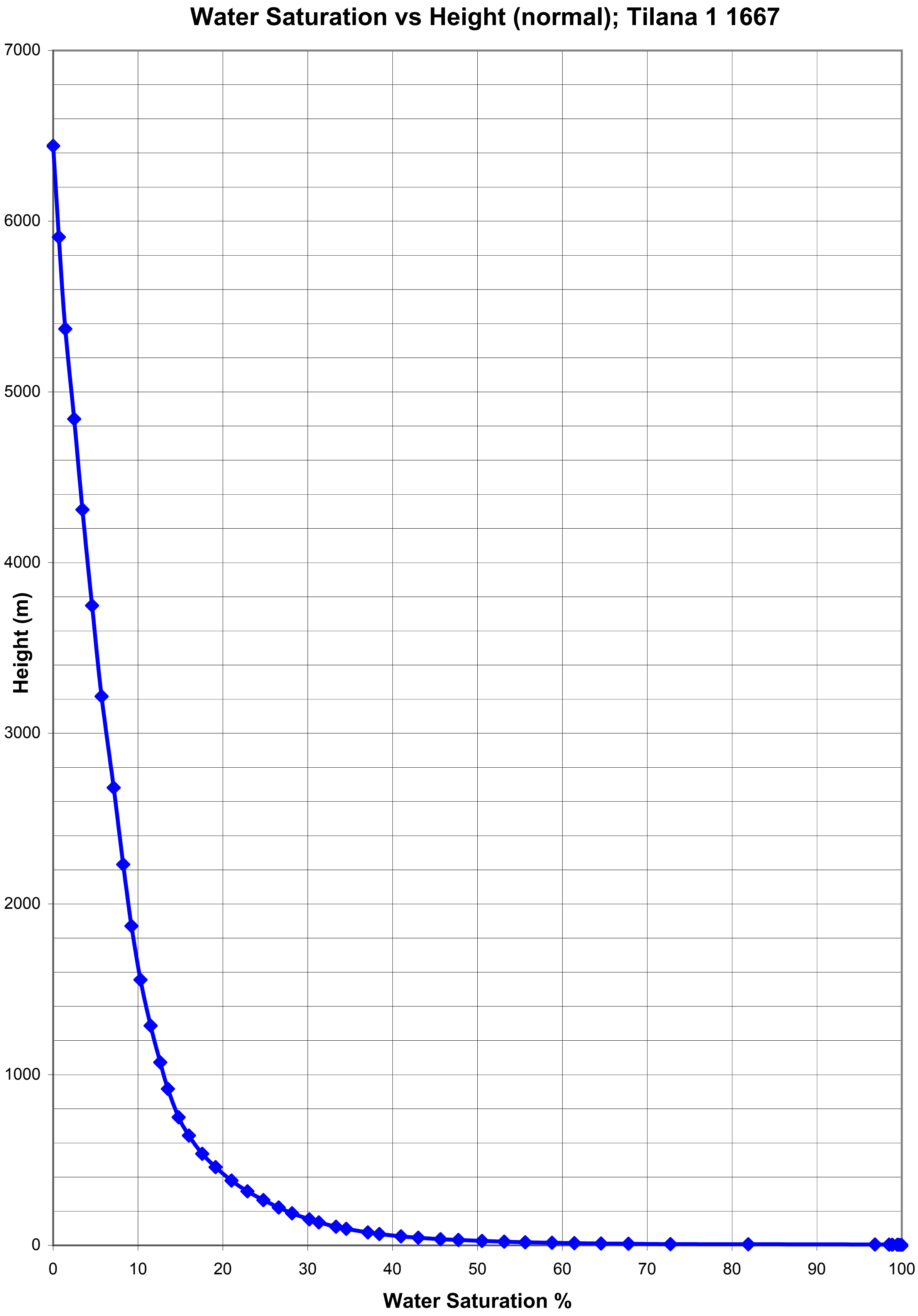


Tilana_1_1667m.xls

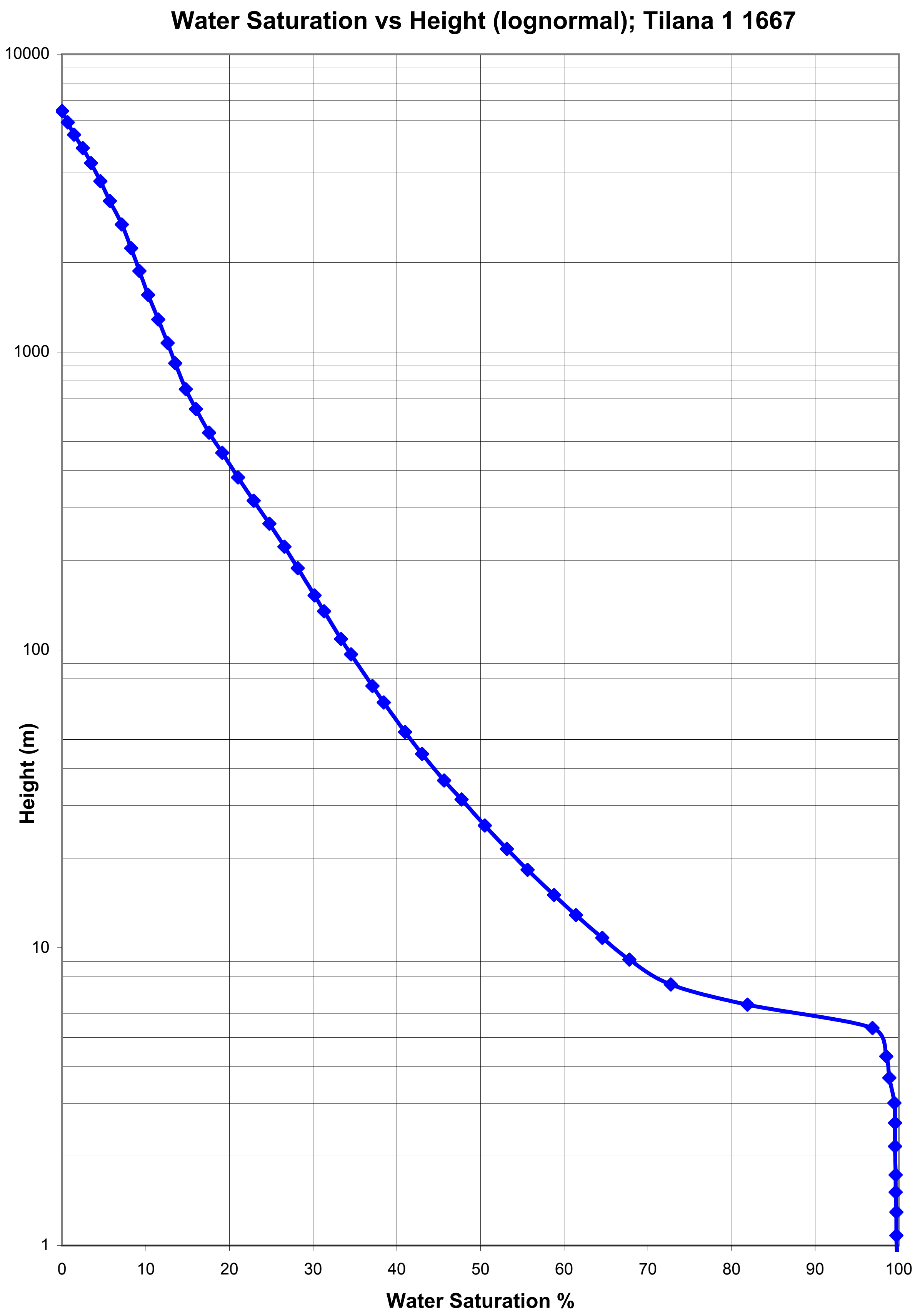




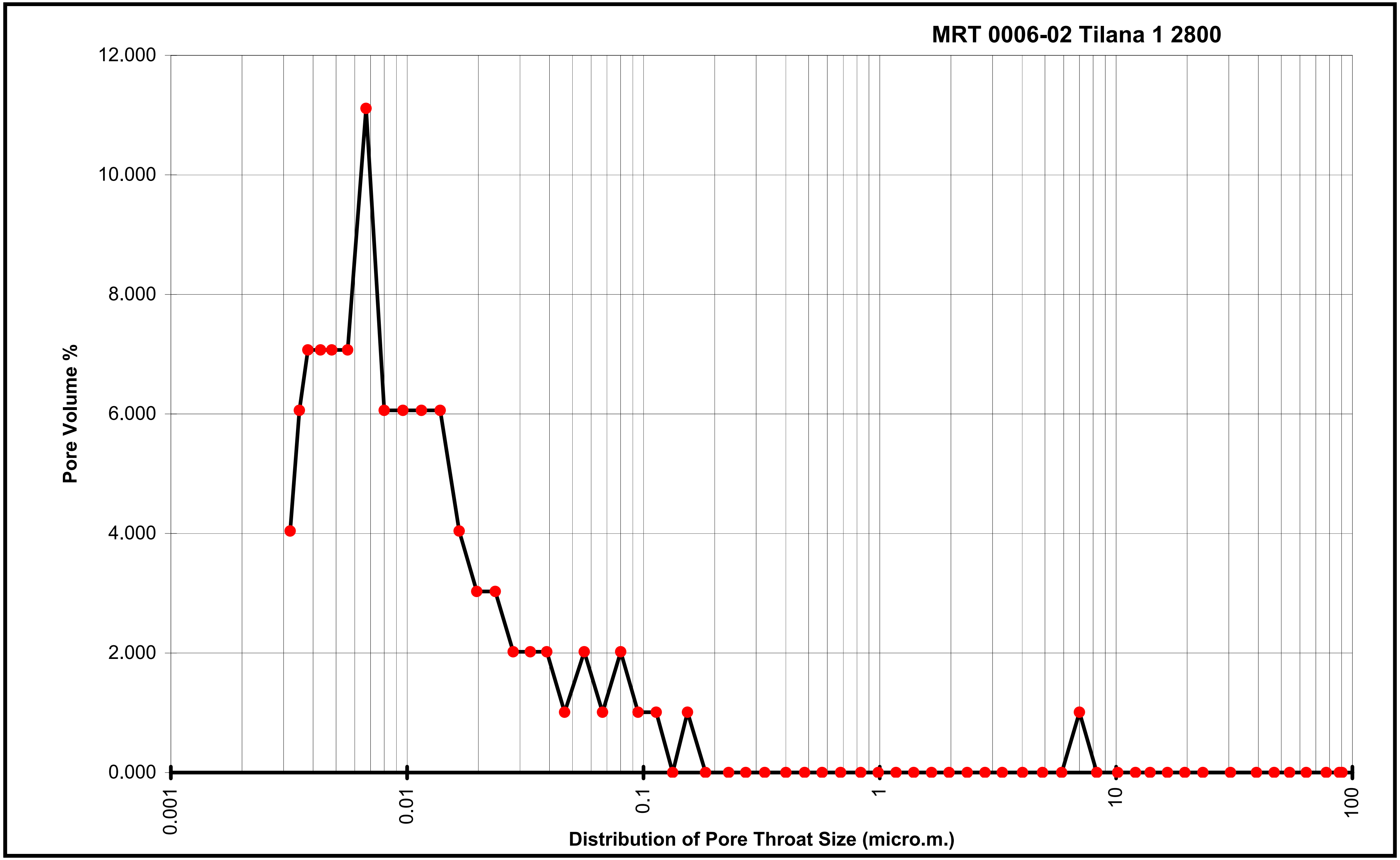
CALCULATED VALUES
porosity % = 25.7483
grain density gms/cc = 2.5966
MRT 0006-02 Tilana 1 1667.4
Intrusion %
Pressure psia
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000

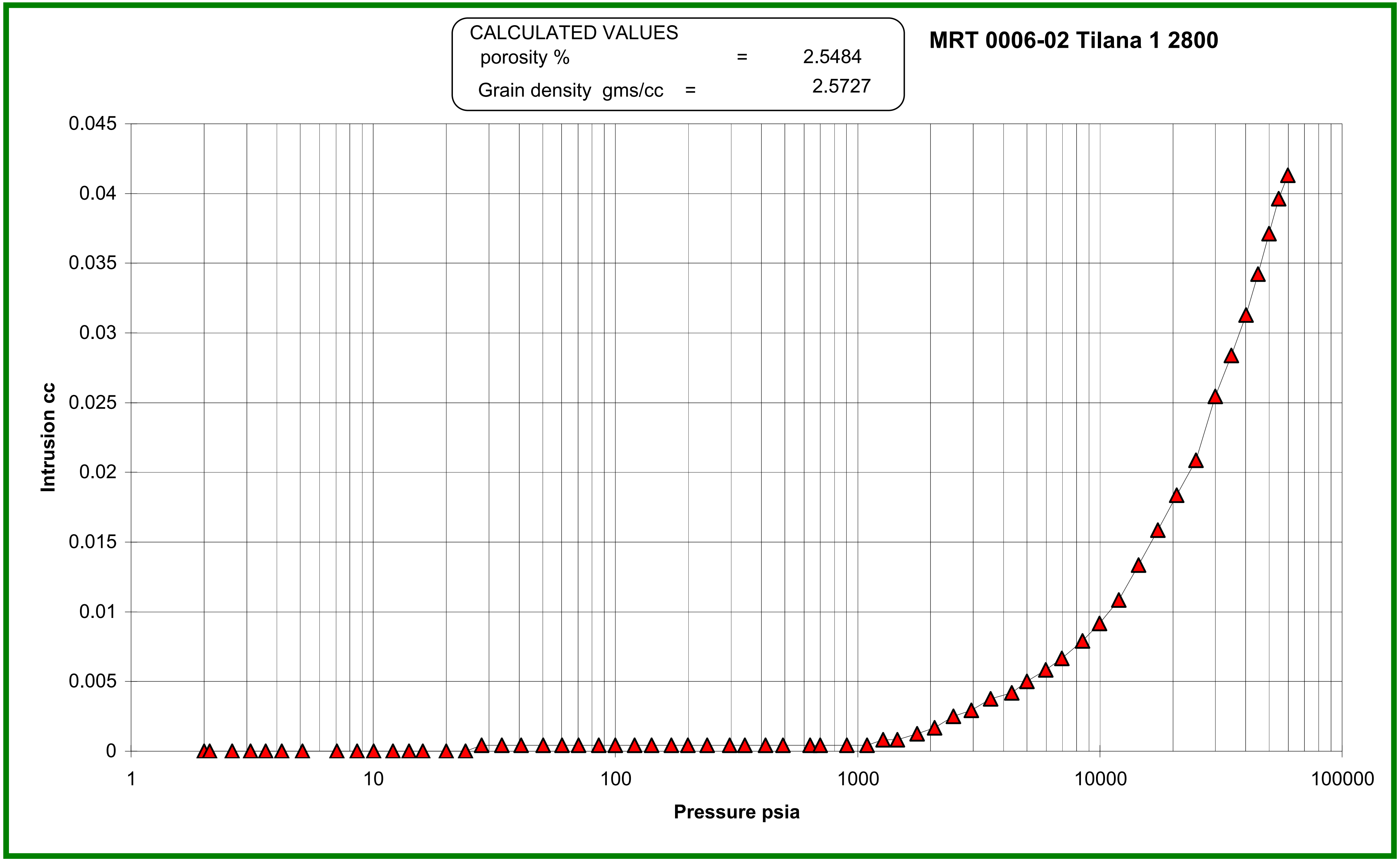


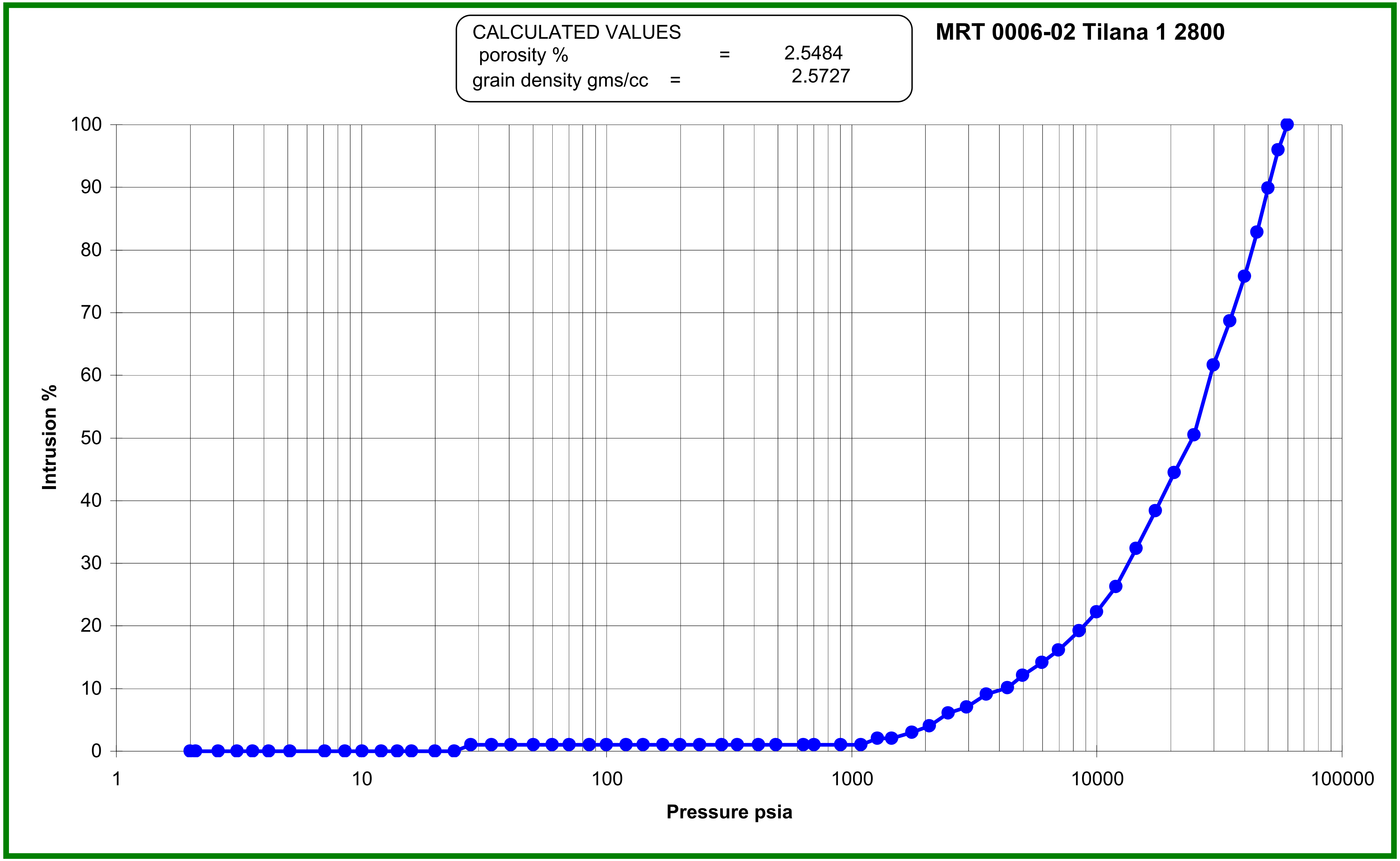
Water Saturation vs Height (normal); Tilana 1 1667
Height (m)
Water Saturation %
0
1000
2000
3000
4000
5000
6000
7000
0
10
20
30
40
50
60
70
80
90
100

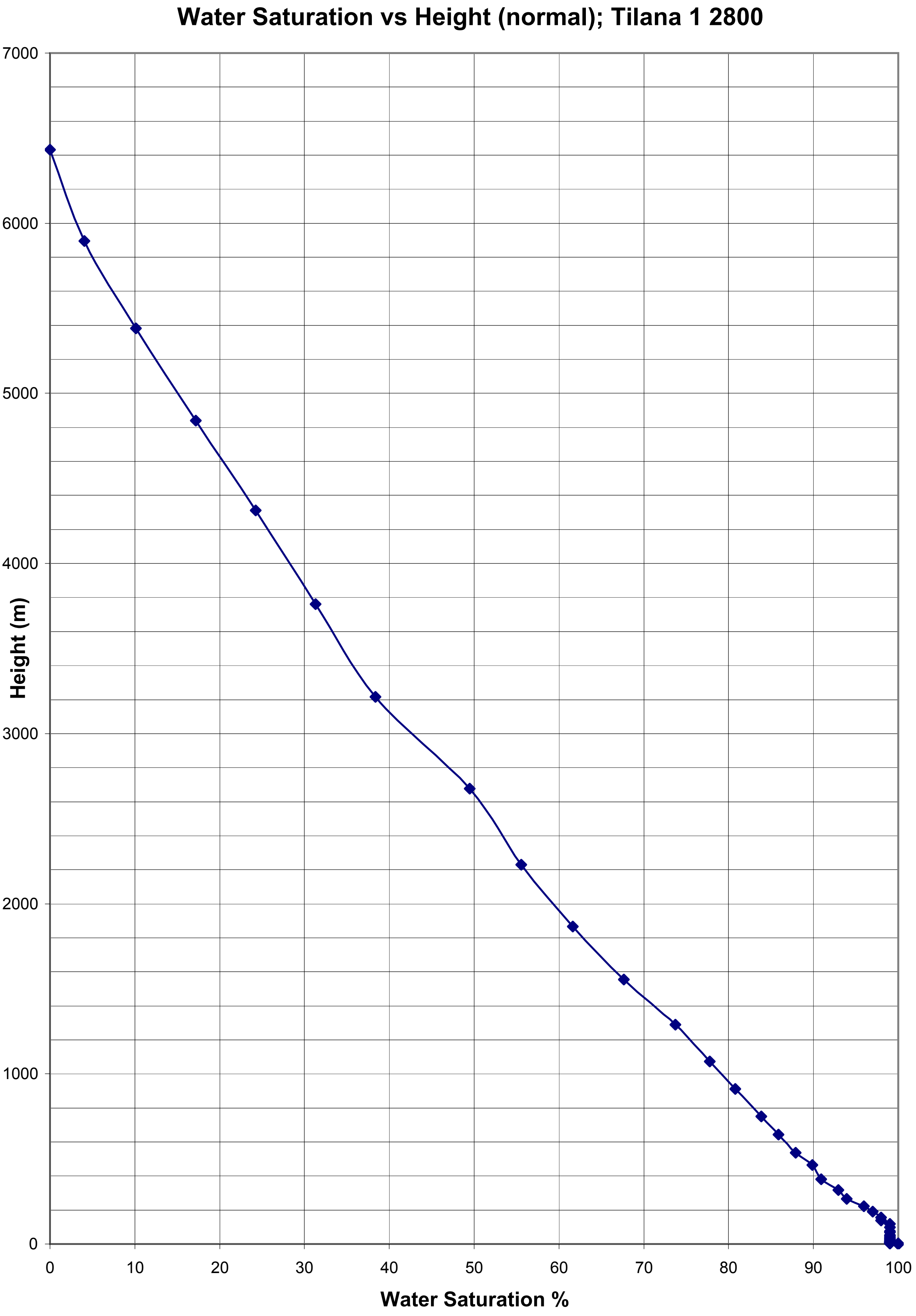


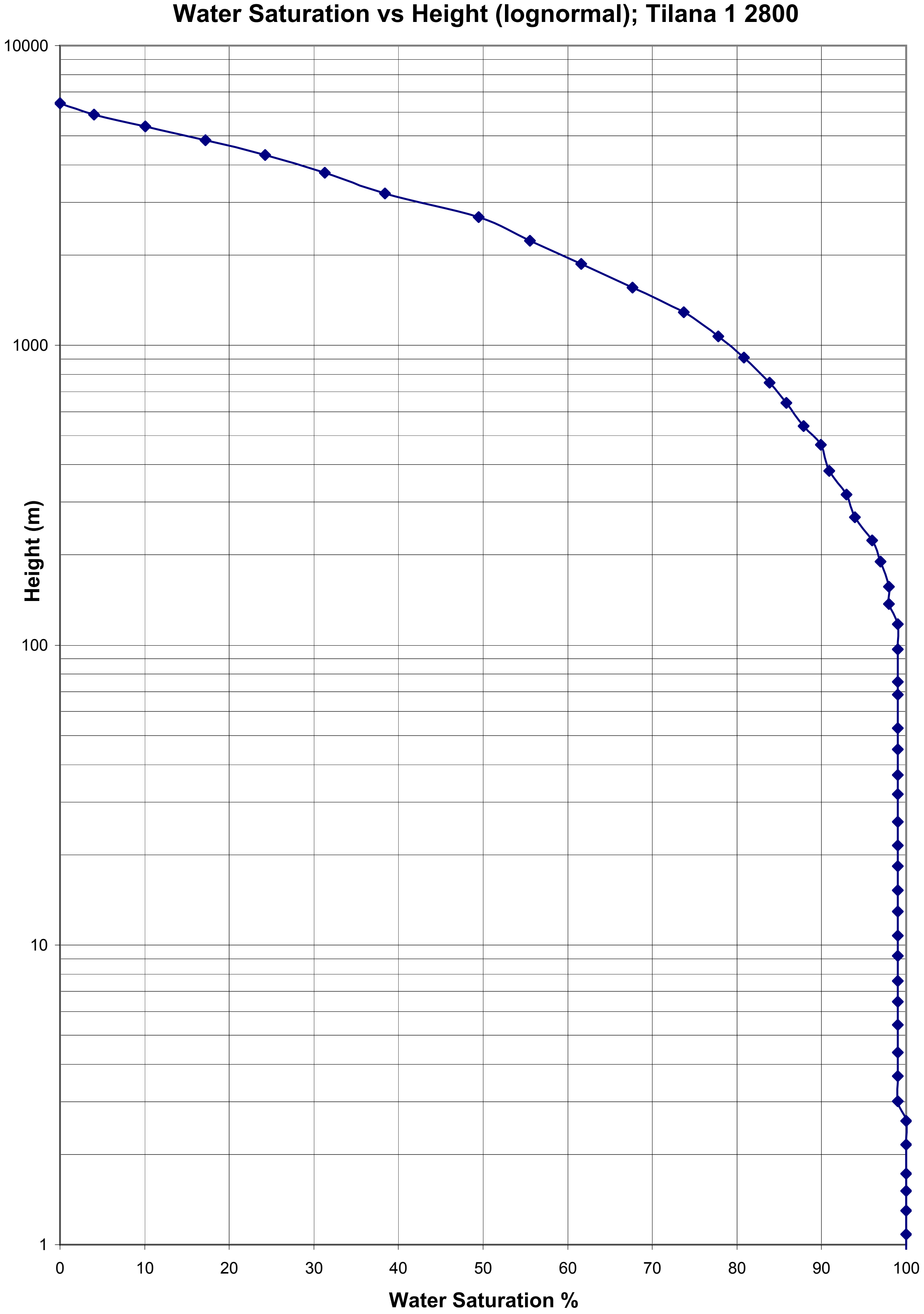
Water Saturation vs Height (lognormal); Tilana 1 1667
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %


MRT 0006-02 Tilana 1 2800
12.000
10.000
8.000
6.000
4.000
2.000
0.000
Pore Volume %
0.001
0.01
0.1
1
10
100
Distribution of Pore Throat Size (micro.m.)

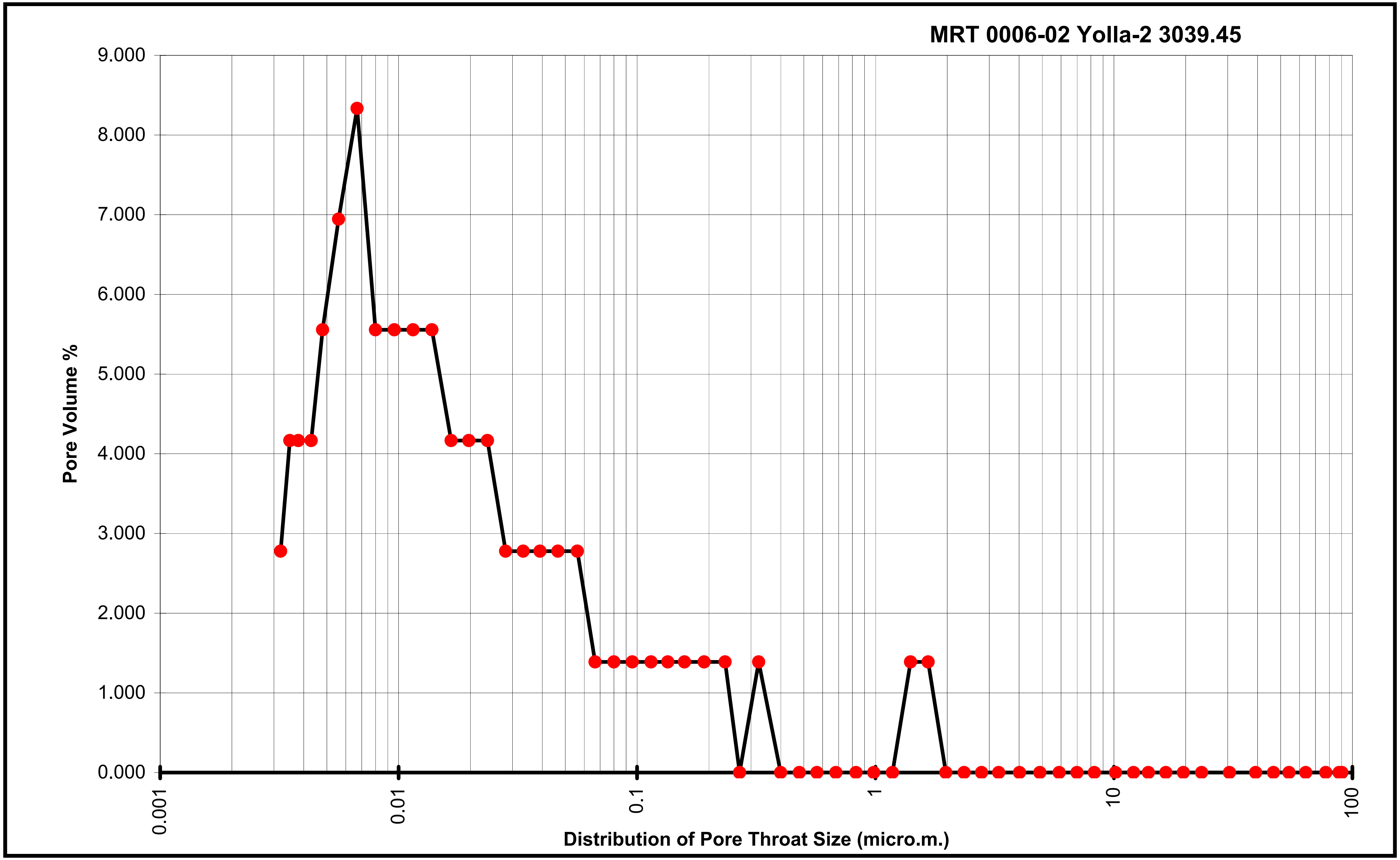

CALCULATED VALUES
porosity % = 2.5484
Grain density gms/cc = 2.5727
MRT 0006-02 Tilana 1 2800
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Intrusion cc
1
10
100
1000
10000
100000
Pressure psia


CALCULATED VALUES
porosity % = 2.5484
grain density gms/cc = 2.5727
MRT 0006-02 Tilana 1 2800
Intrusion %
0
10
20
30
40
50
60
70
80
90
100
1
10
100
1000
10000
100000
Pressure psia

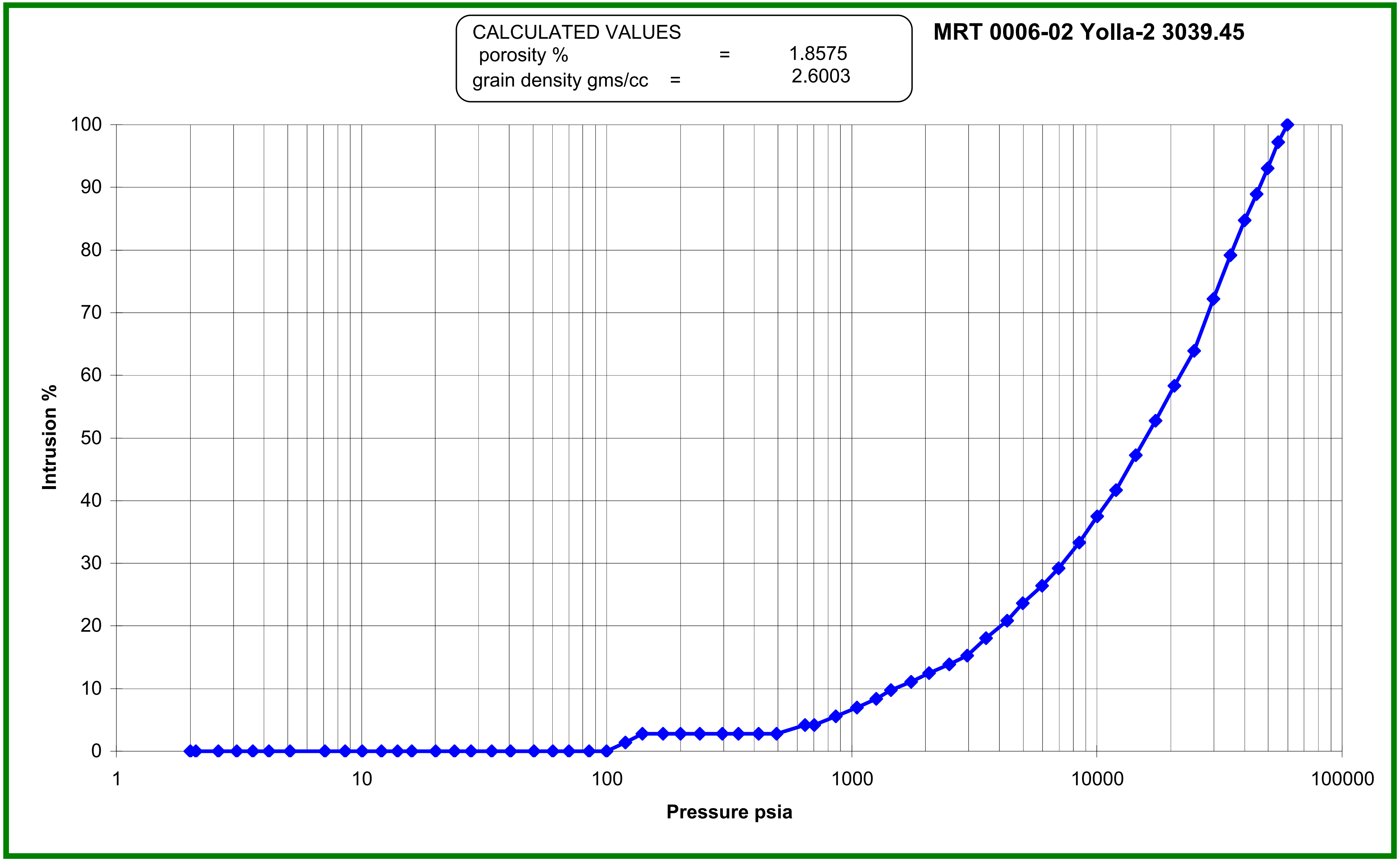

Water Saturation vs Height (normal); Tilana 1 2800
Height (m)
Water Saturation %
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100

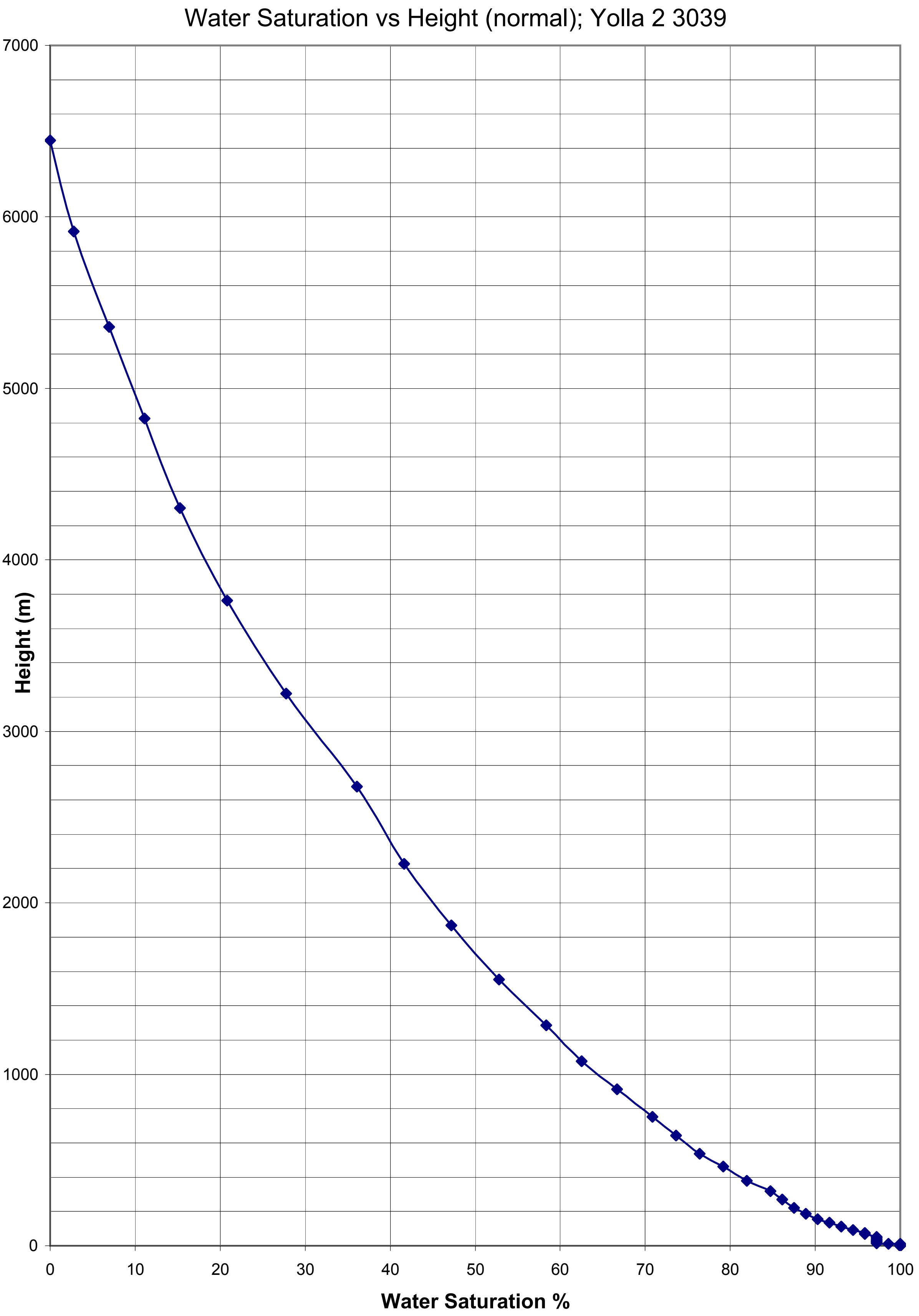


Water Saturation vs Height (lognormal); Tilana 1 2800
10000
1000
100
10
1
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

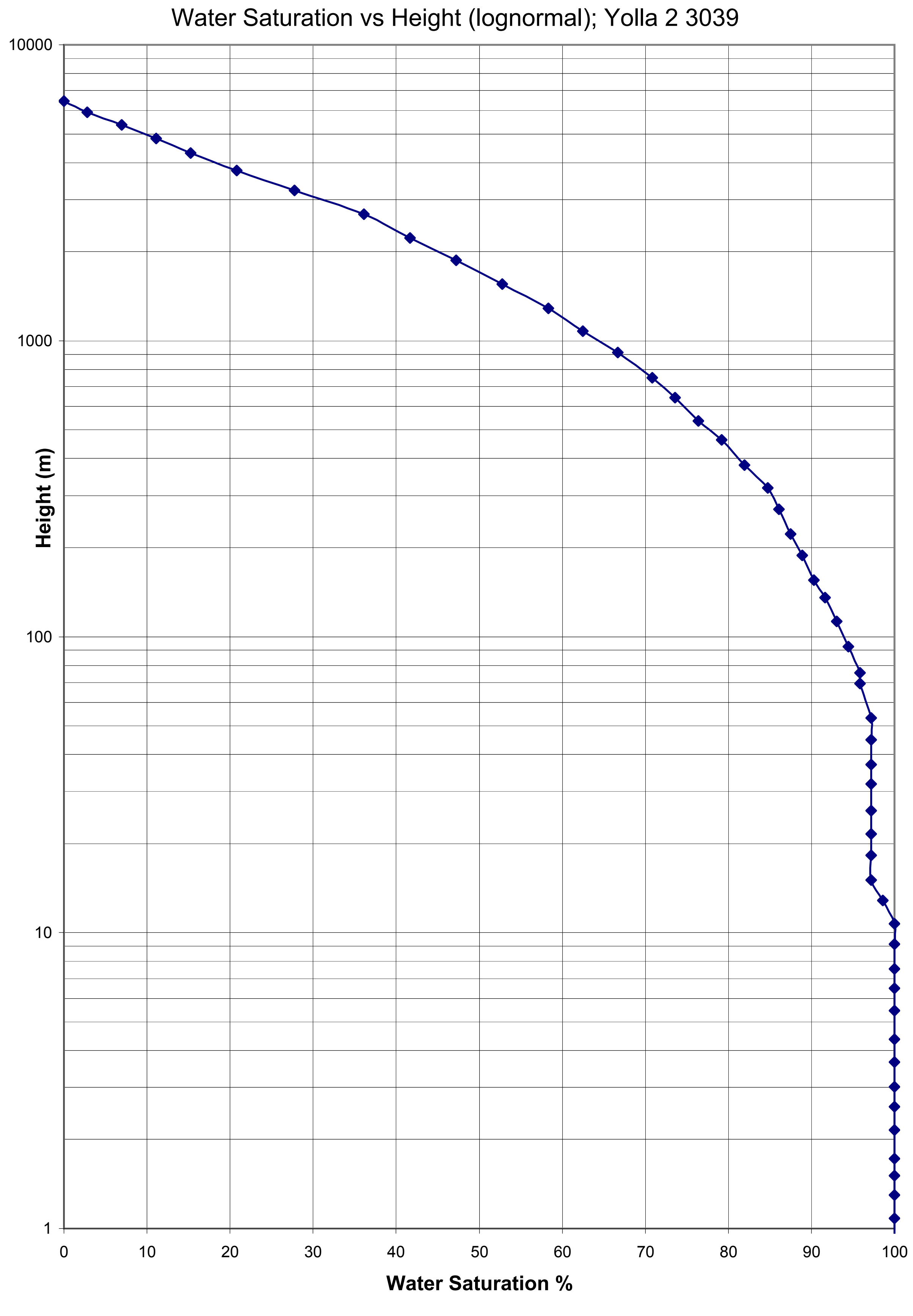

MRT 0006-02 Yolla-2 3039.45
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Pore Volume %
0.001
0.01
0.1
1
10
100
Distribution of Pore Throat Size (micro.m.)

Yolla_2_3039m.xls





Water Saturation vs Height (normal); Yolla 2 3039
7000
6000
5000
4000
3000
2000
1000
0
Height (m)
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %



Water Saturation vs Height (lognormal); Yolla 2 3039
Height (m)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Water Saturation %

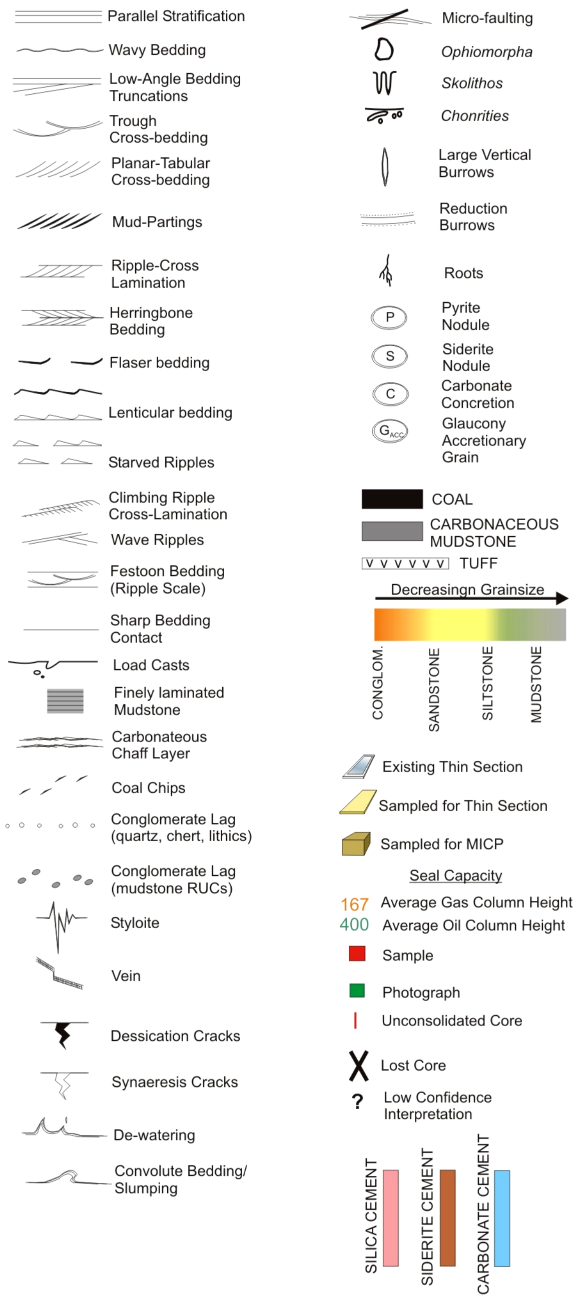
APPENDIX M.

DESCRIPTIONS AND PHOTOGRAPHS OF SELECTED CORES FROM THE BASS BASIN

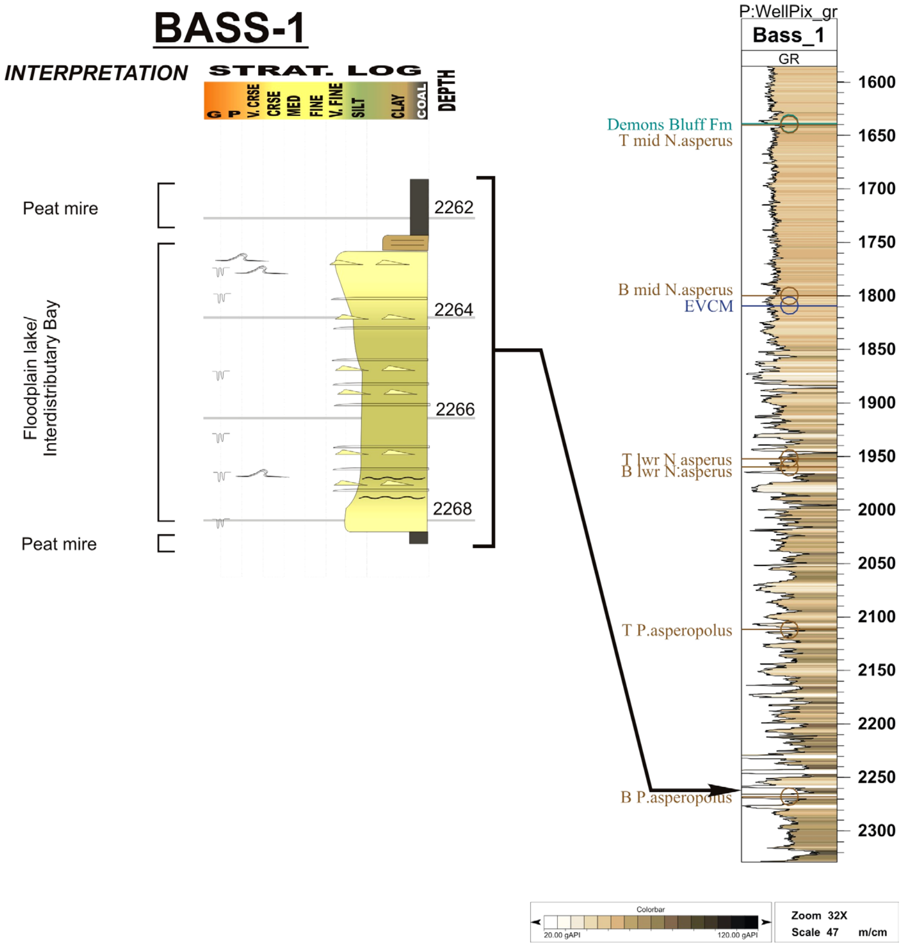
Simon Lang and Rob Root, National Centre for Petroleum Geology and Geophysics

Key for Interpreted Well Log (Gamma Ray)

KEY FOR GRAPHIC LOGS



Bass-1 Interpreted Well Log (Gamma Ray)



Bass-1 Core Photos

Core 11, 1793.14 – 1794.36 m

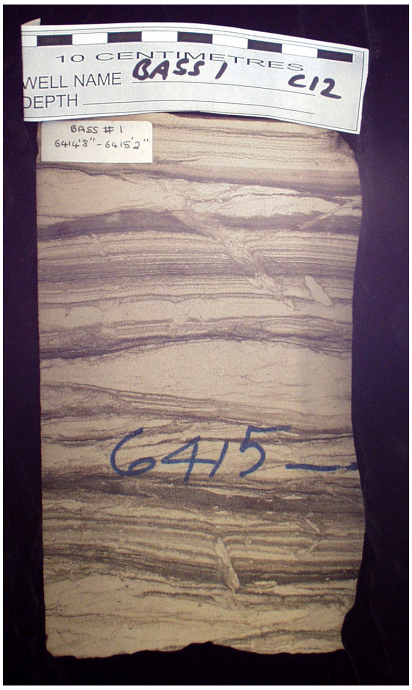
Core 11, 1798.02 m

Core 12, 1952.55 – 1943.38 m

Core 12, 1953.46 –1955.29 m

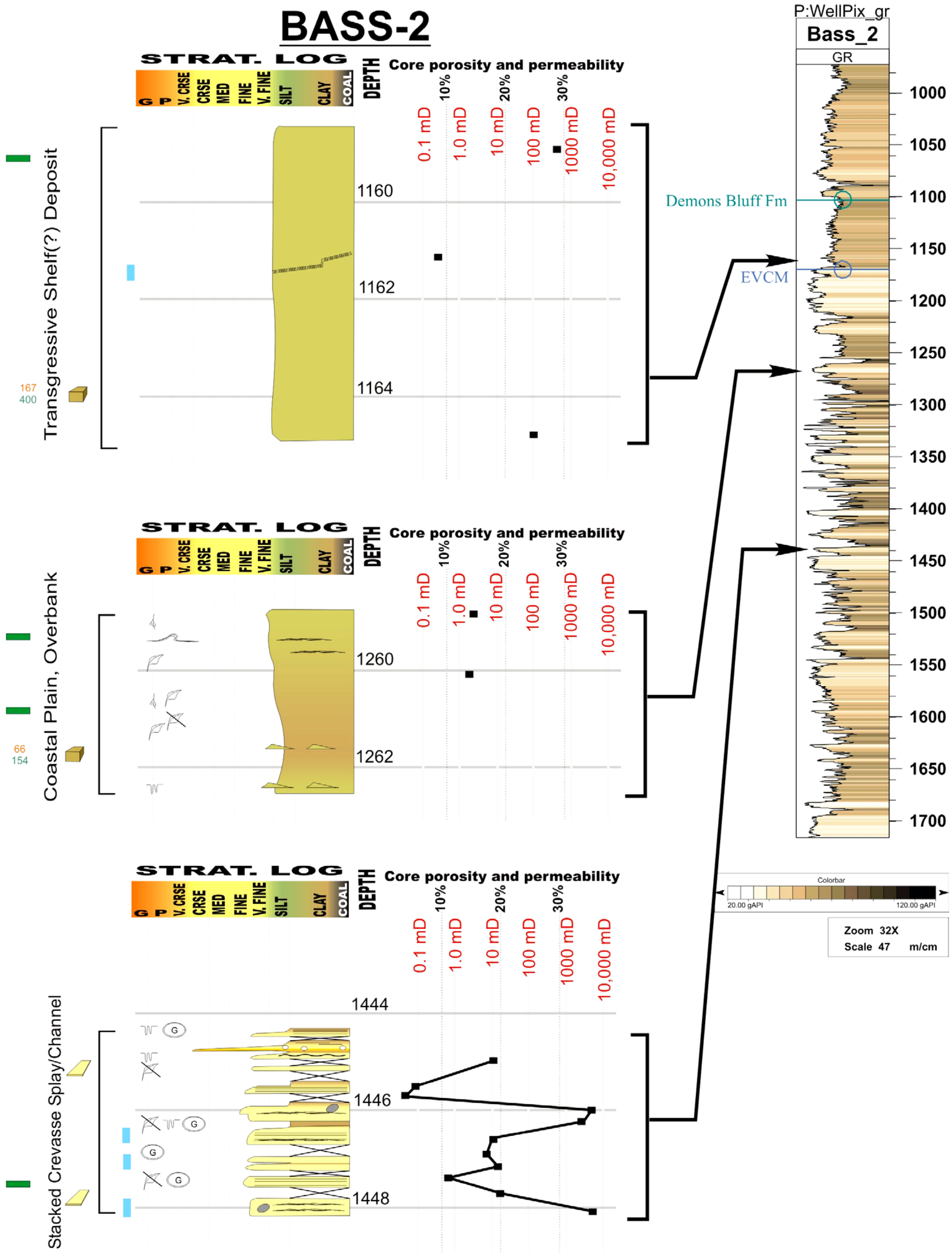
Bass-1 Core Photos

Core 12, 1955.29 m



Core 12, 1956.5 – 1958.34 m

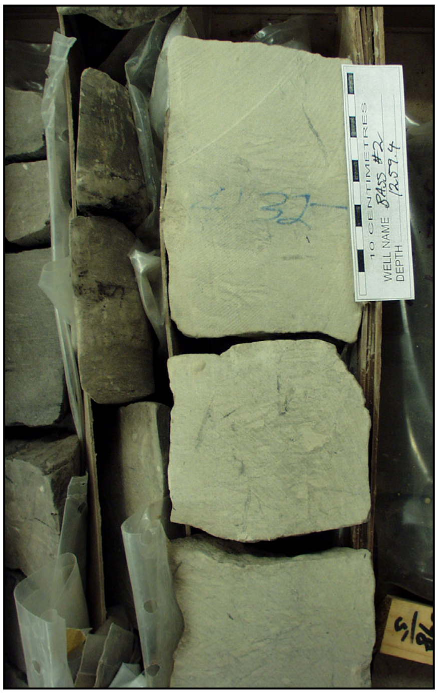
Bass-2 Interpreted Well Log (Gamma Ray)



Bass-2 Core Photos

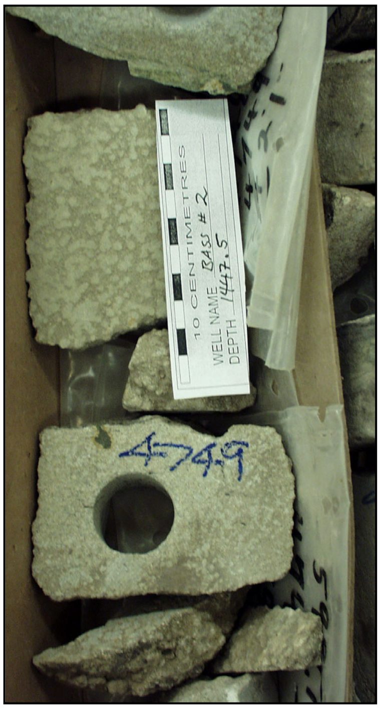
Core 4, 1159.62 m

Core 5, 1259.4 m

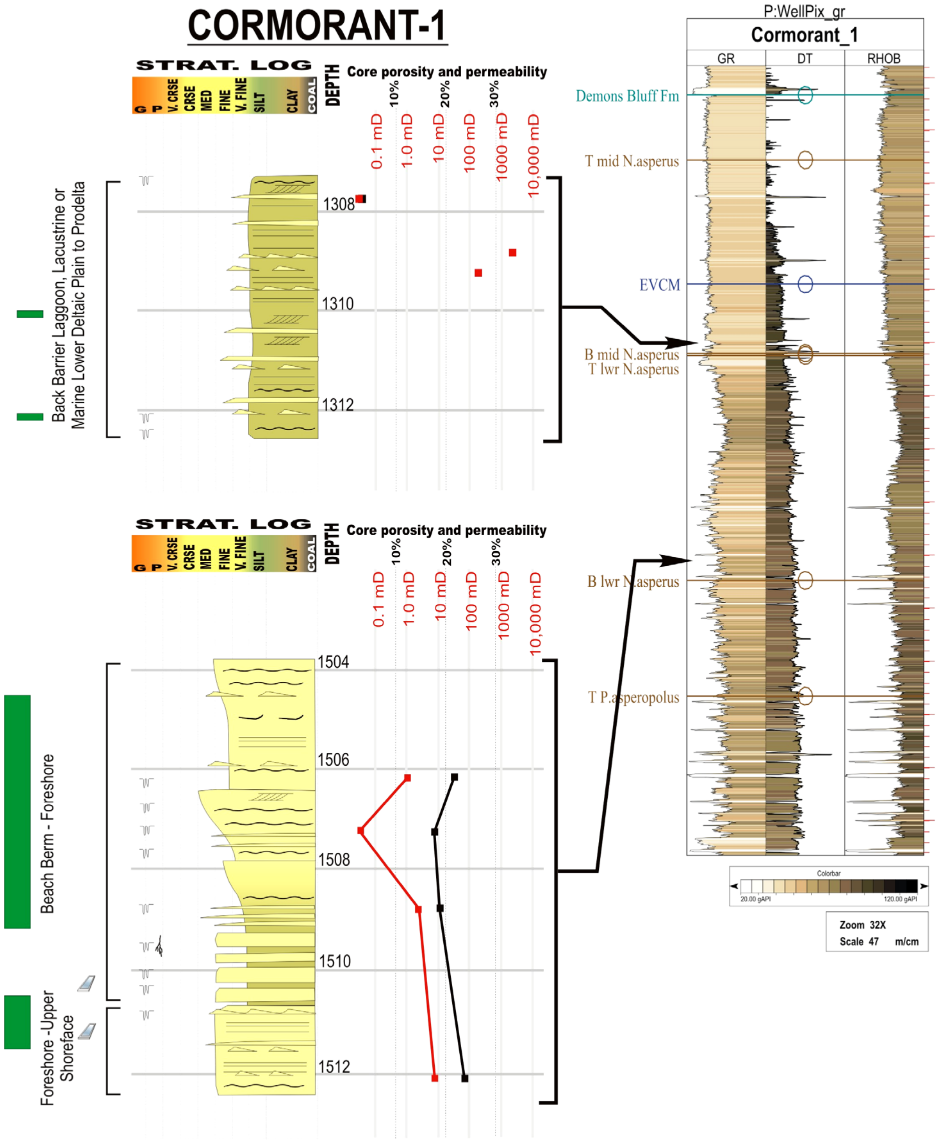


Core 5, 1260.9 m

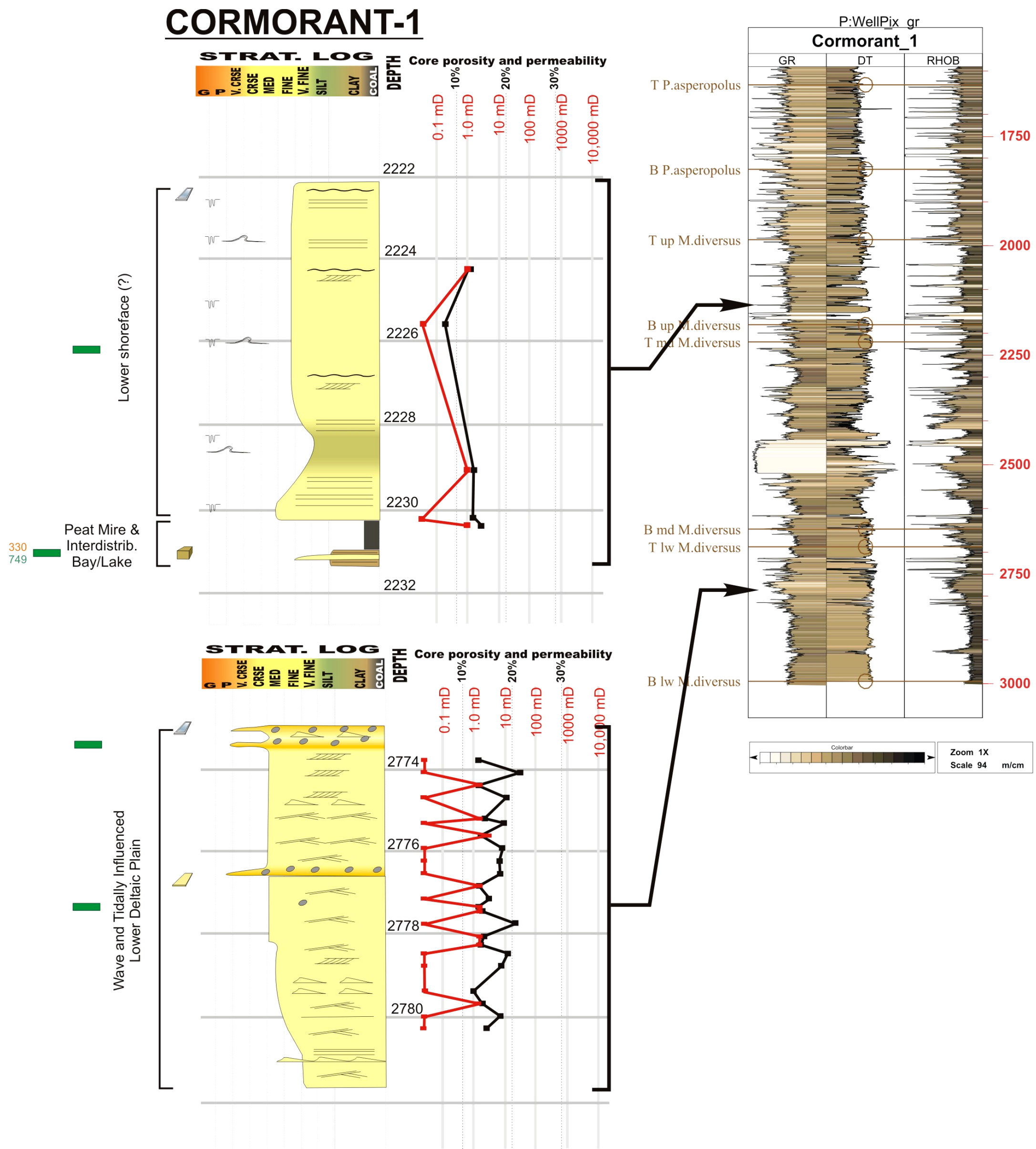
Core 7, 1447.5 m



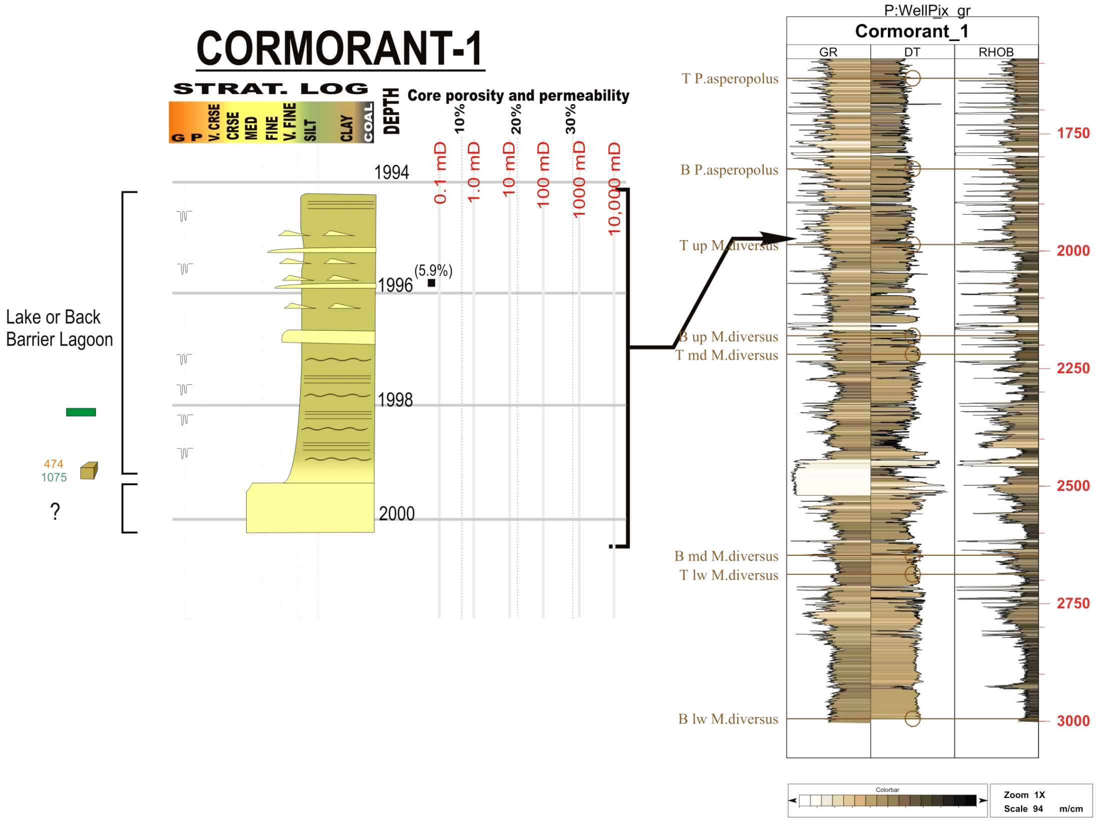
Cormorant-1 Interpreted Well Log (Gamma Ray)



Cormorant-1 Interpreted Well Log (Gamma Ray)

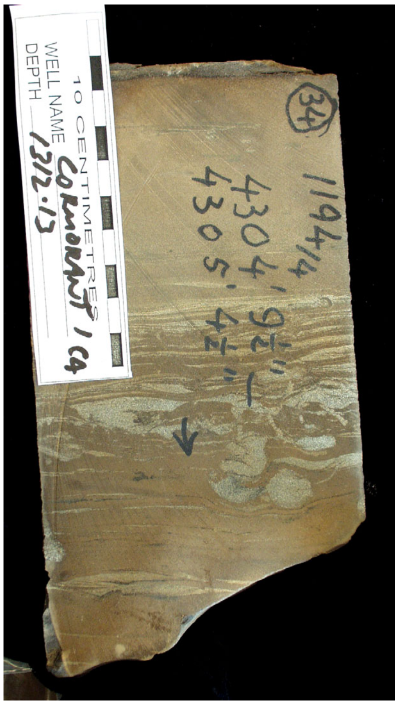


Cormorant-1 Interpreted Well Log (Gamma Ray)



Cormorant-1 Core Photos

Core 4, 1312.13 m



Core 3, 1310.33 m

Core 5, 1504.49 – 1506.93 m

Core 5, 1505.71 – 1507.88 m

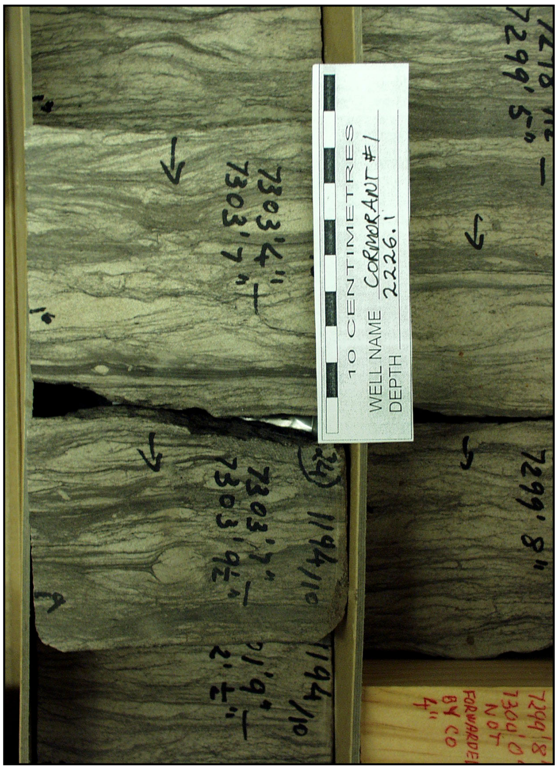
Cormorant-1 Core Photos

Core 5, 1507.54 – 1509.2 m

Core 5, 1510-57 – 1511.5 m

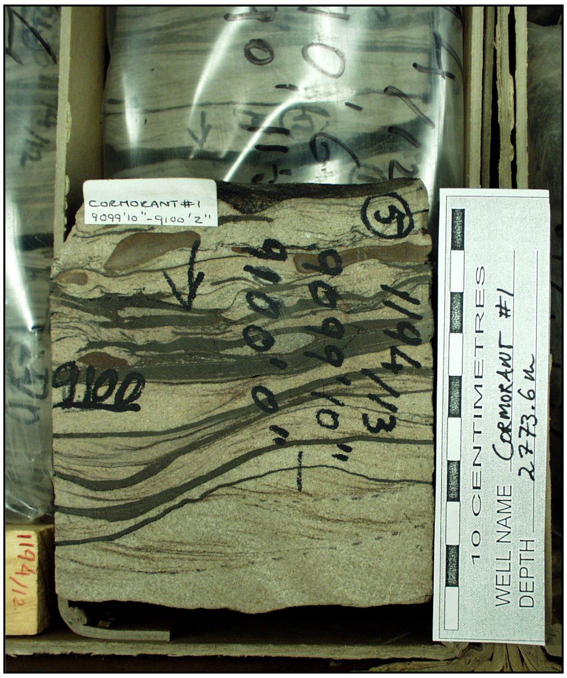
Core 9, 1998.2 m

Part Core, 2226.1m

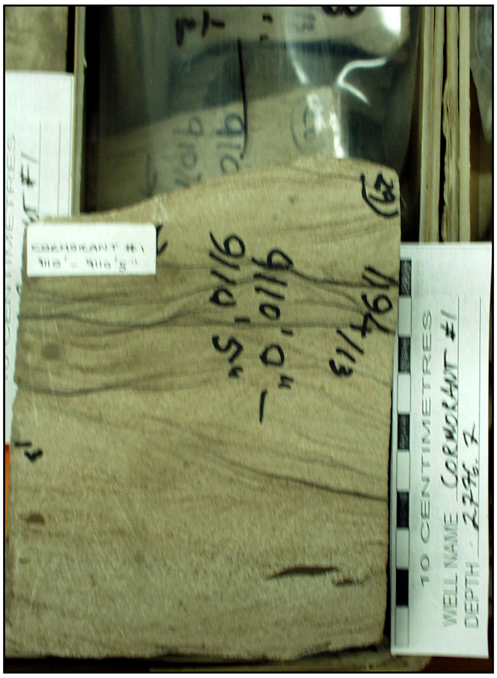


Cormorant-1 Core Photos

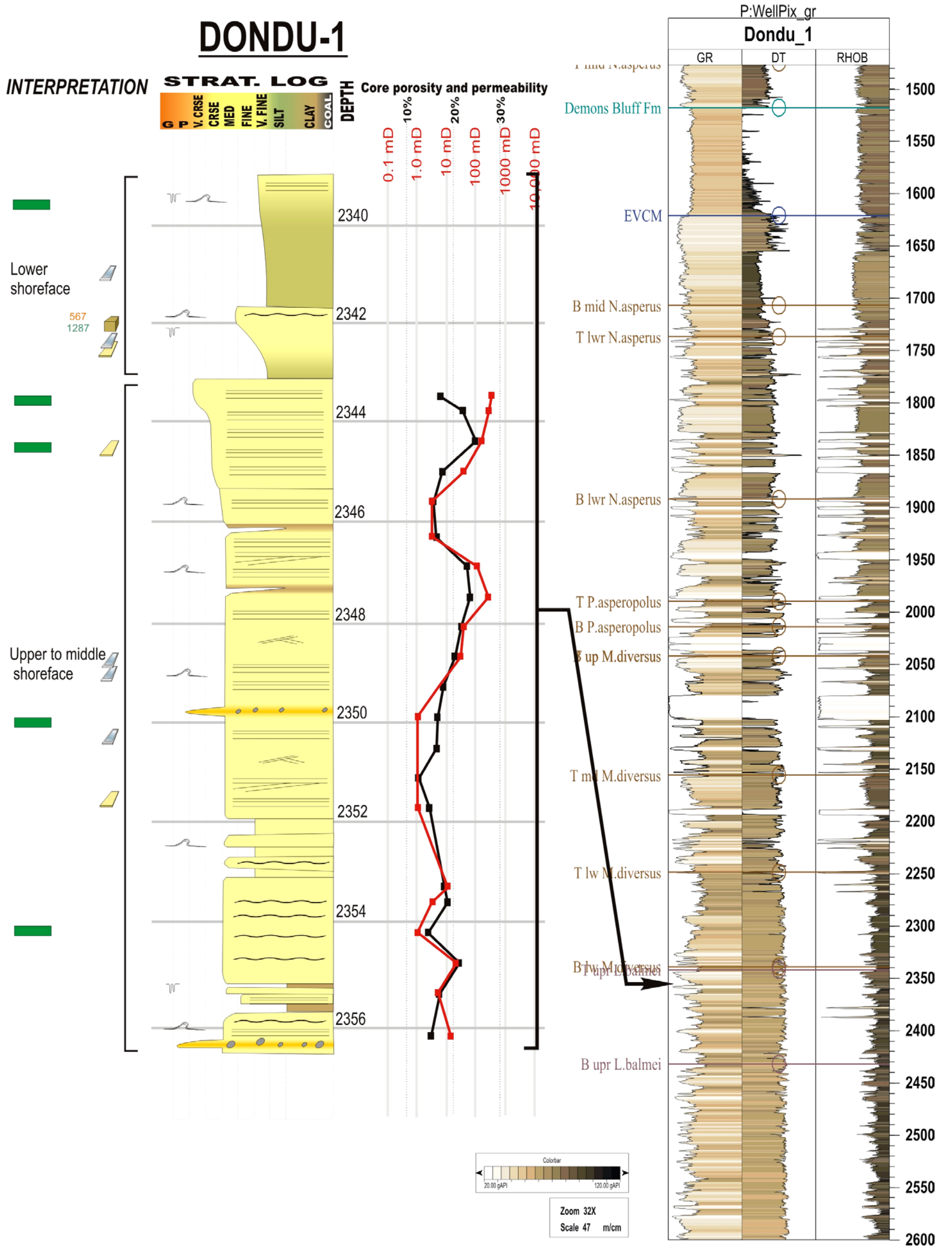
Core 12, 2773.6 m



Core 12, 2776.7 m



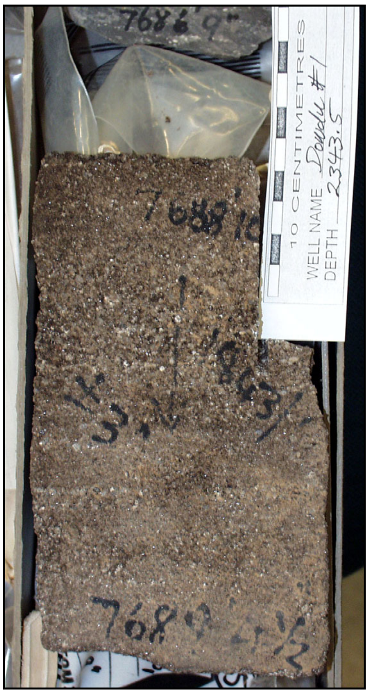
Dondu-1 Interpreted Well Log (Gamma Ray)



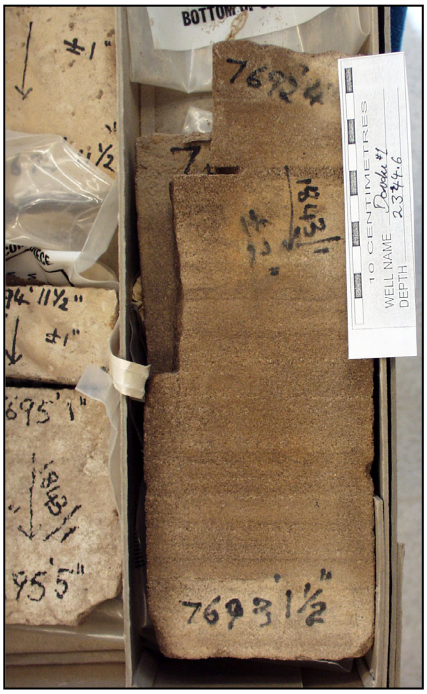
Dondu-1 Core Photos

Core 1, 2339.6 m

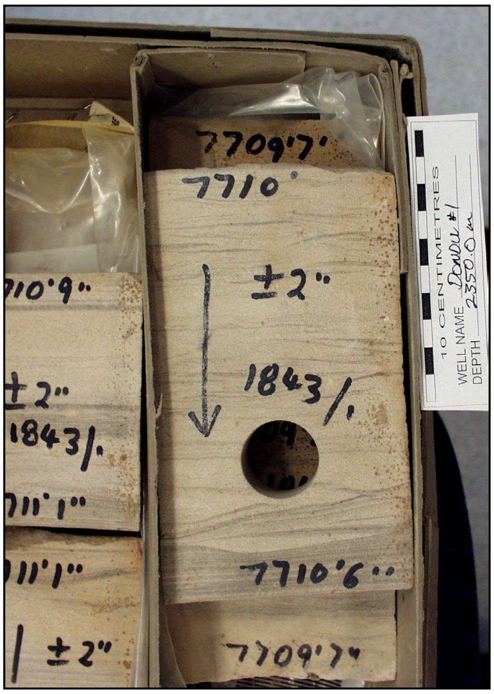
Core 1, 2343.5 m



Core 1, 2344.6 m

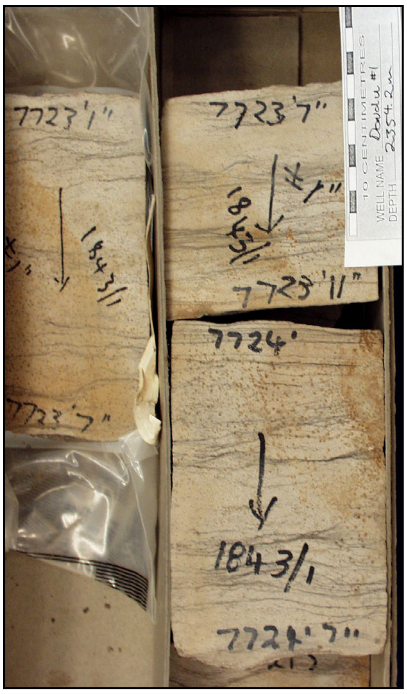


Core 1, 2350.0 m

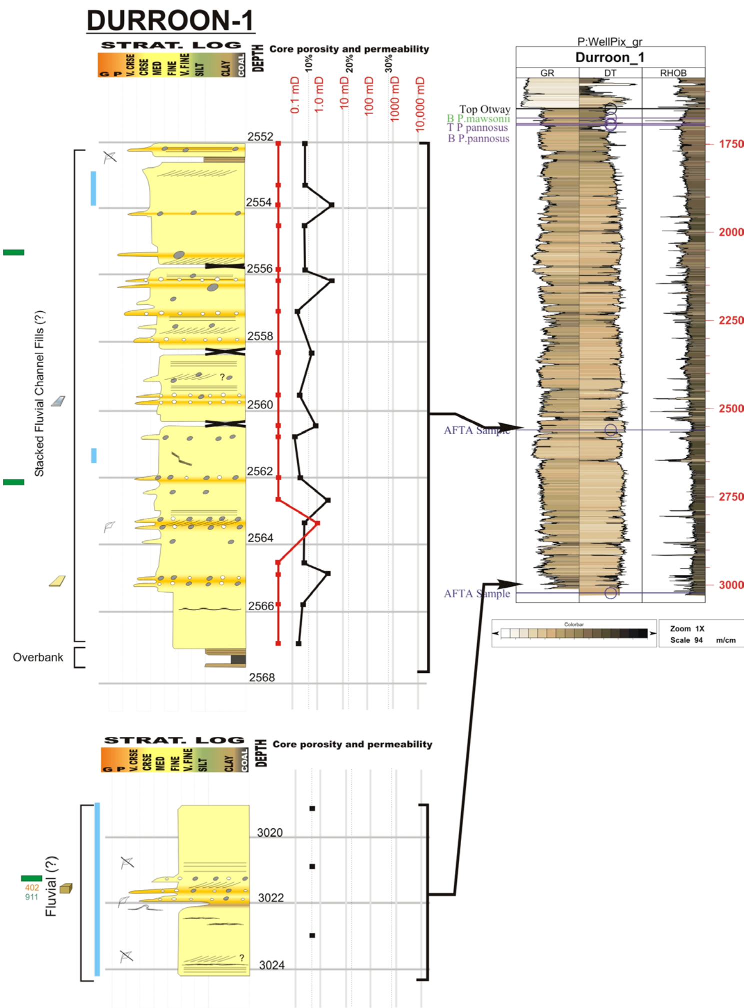


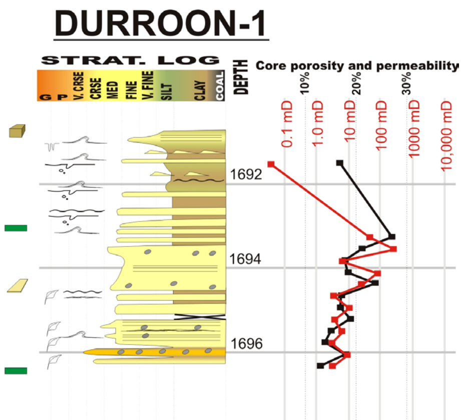
Dondu-1 Core Photos

Core 1, 2354.2 m



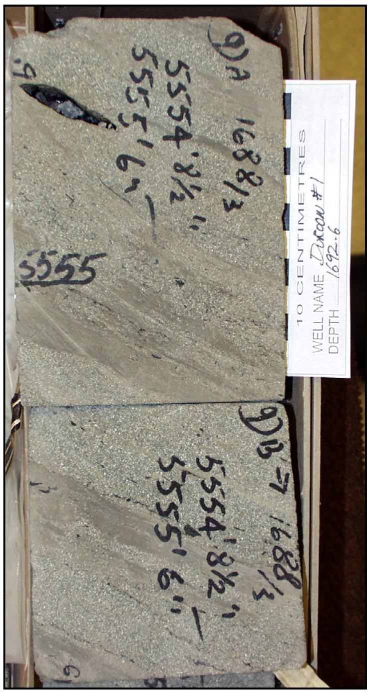
Durroon-1 Interpreted Well Log (Gamma Ray)



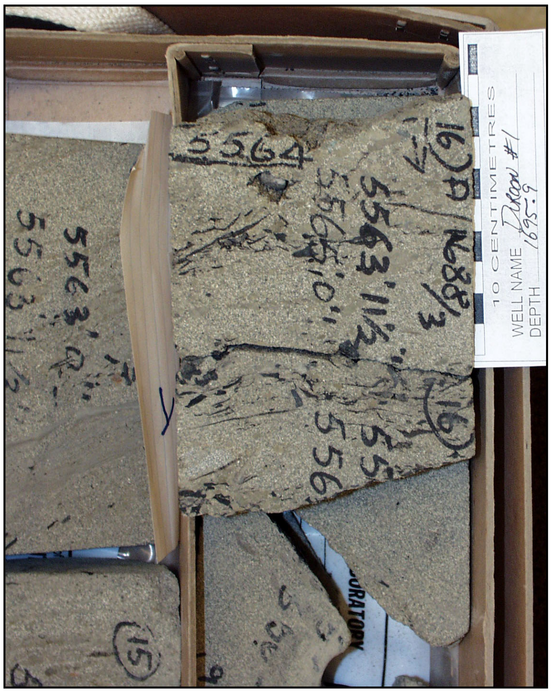


Durroon-1 Core Photos

Core 3, 1693.16 m

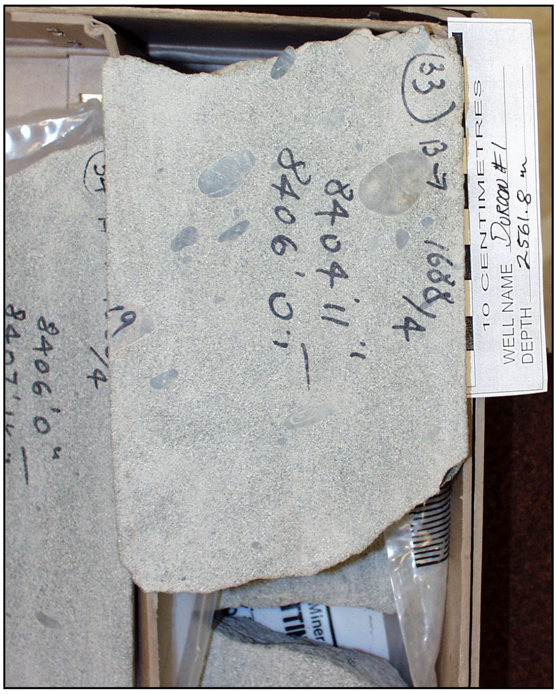


Core 3, 1696.5 m



Core 4, 2555.4 m

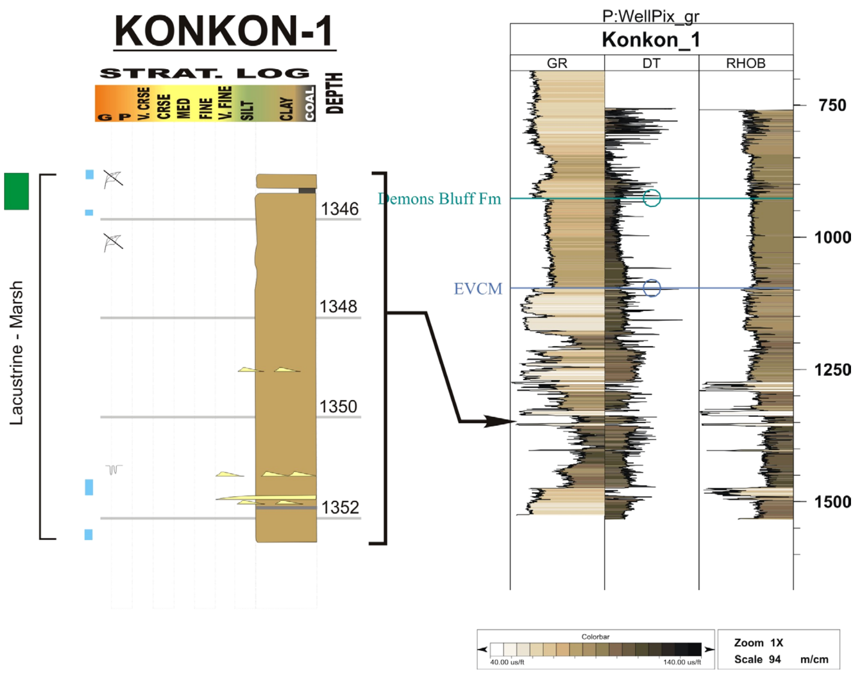
Core 4, 2562.15 m



Durroon-1 Core Photos

Core 5, 3021.5 m

Konkon-1 Interpreted Well Log (Gamma Ray)

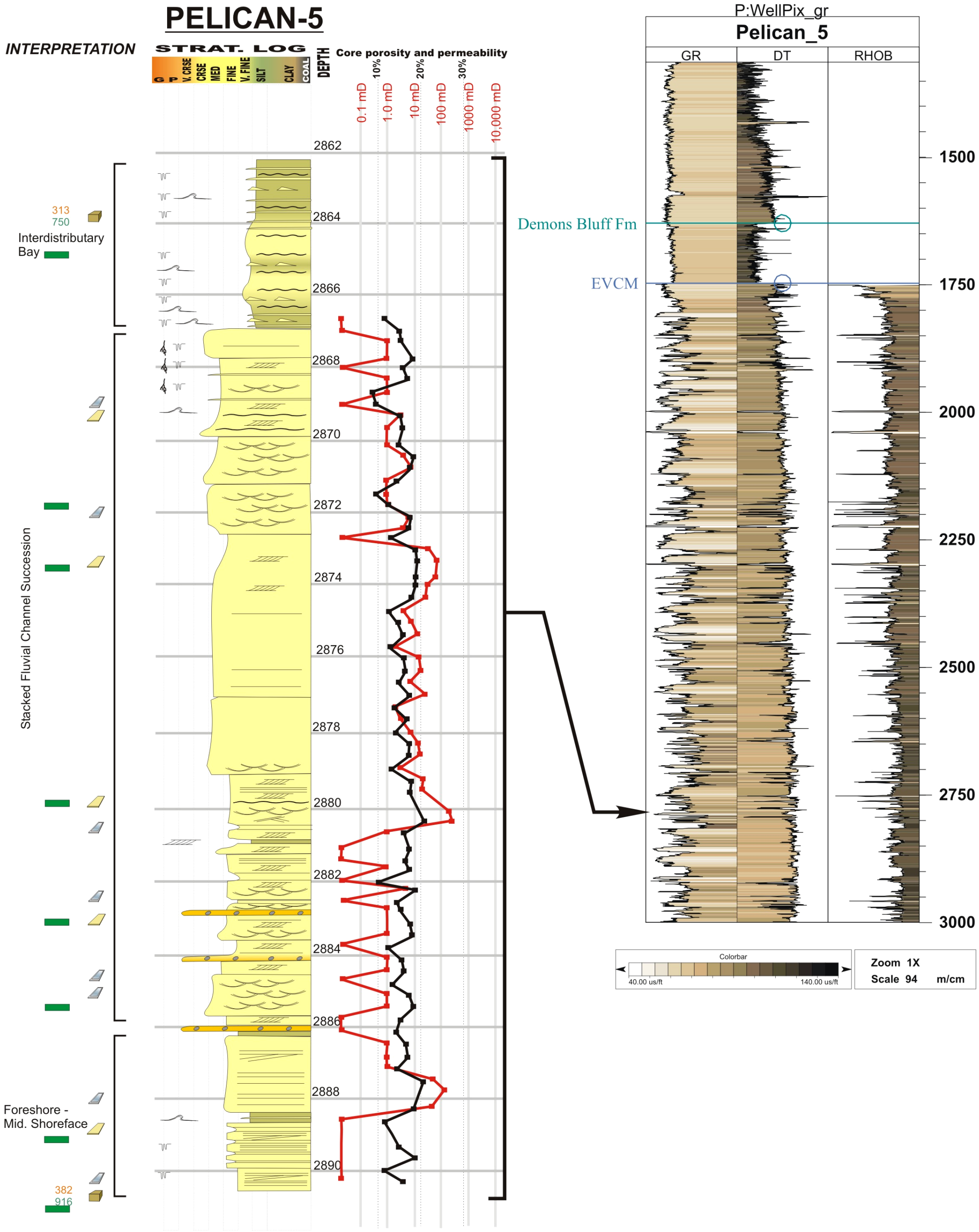


Konkon-1 Core Photos

Core 1, 1345.1 m

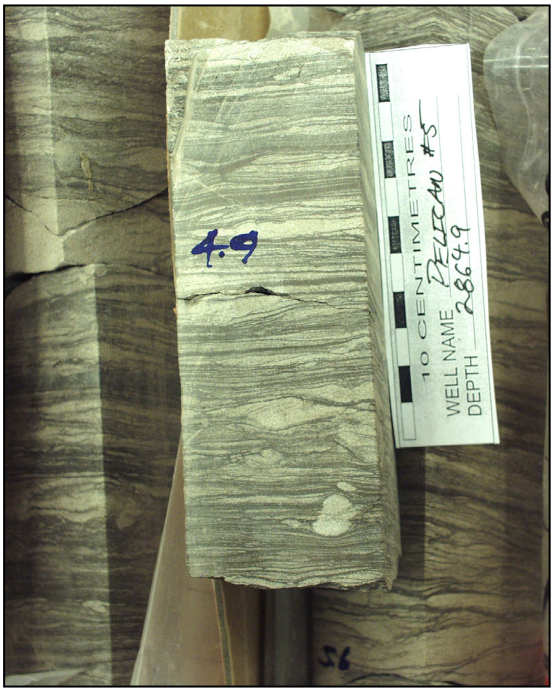
Core 1, 1345.8 m

Pelican-5 Interpreted Well Log (Gamma Ray)

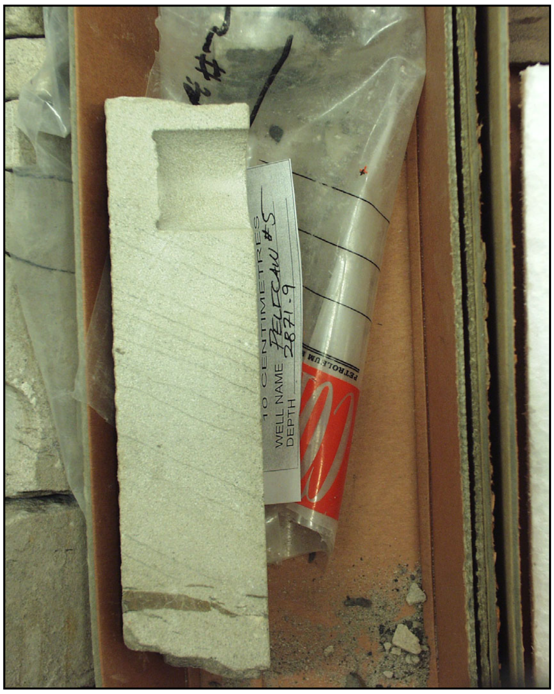


Pelican-5 Core Photos

Core 2, 2864.9 m



Core 2, 2871.9 m

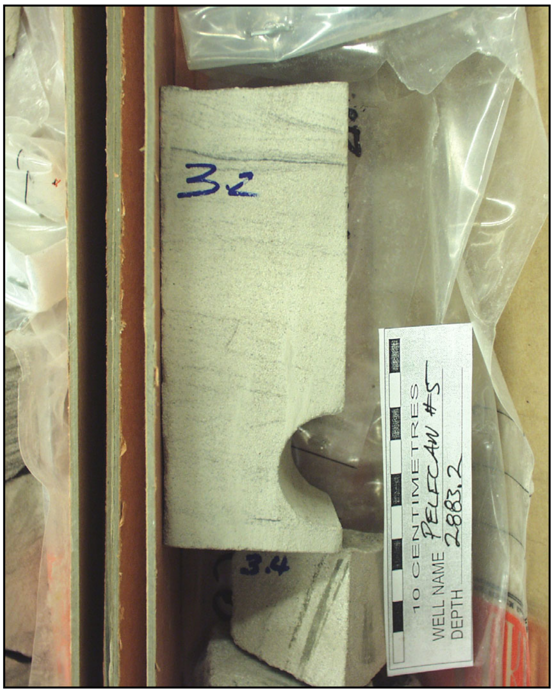


Core 2, 2873.6 m

Core 2, 2879.8 m

Pelican-5 Core Photos

Core 3, 2883.2 m

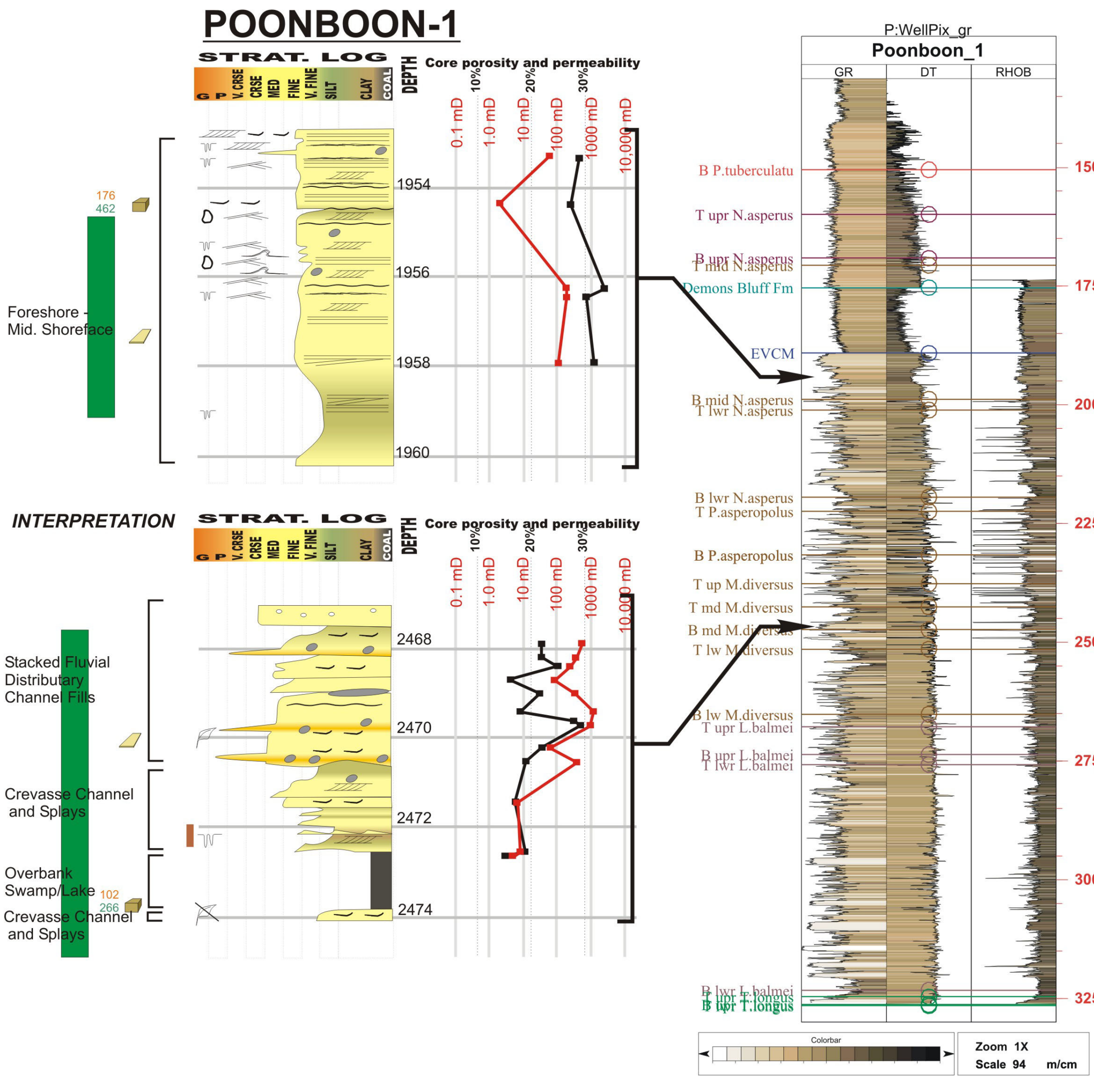


Core 3, 2885.5 m

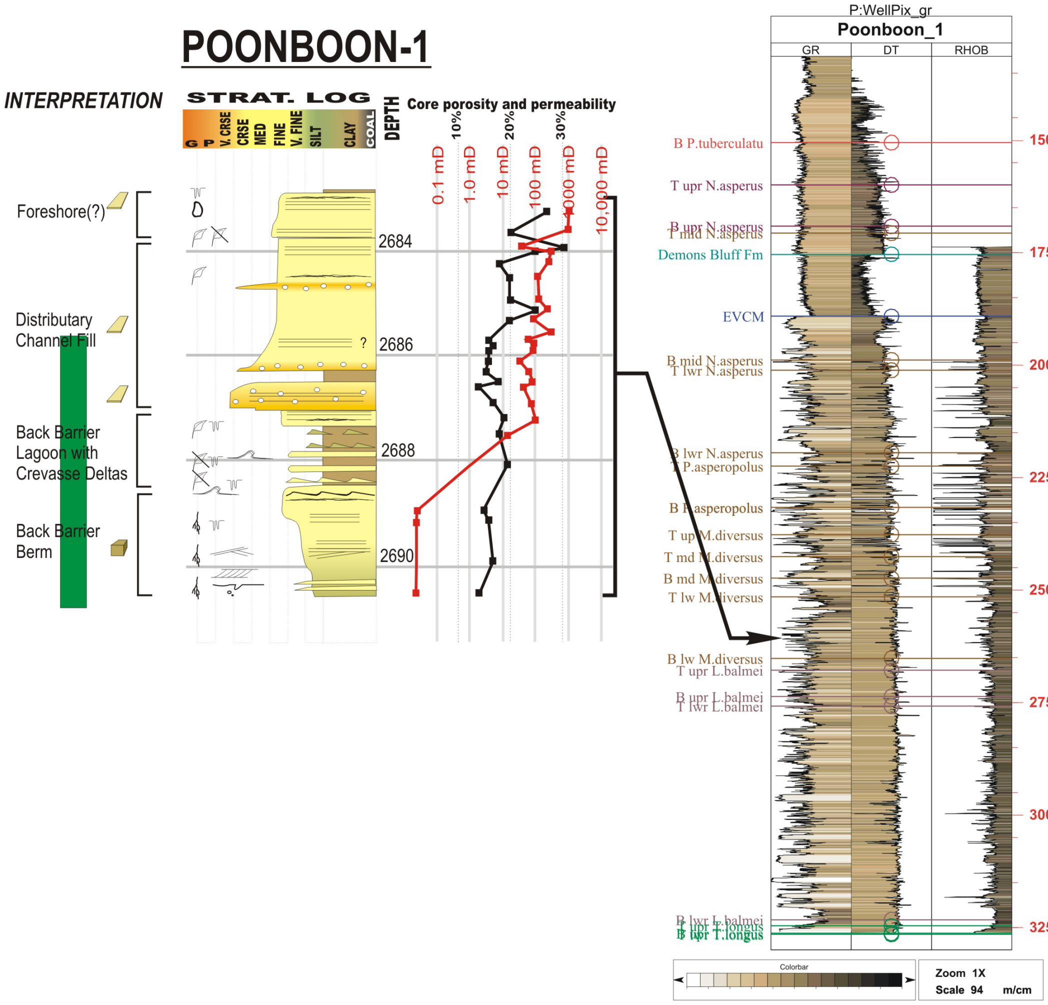
Core 3, 2889.2 m

Core 3, 2891.1 m

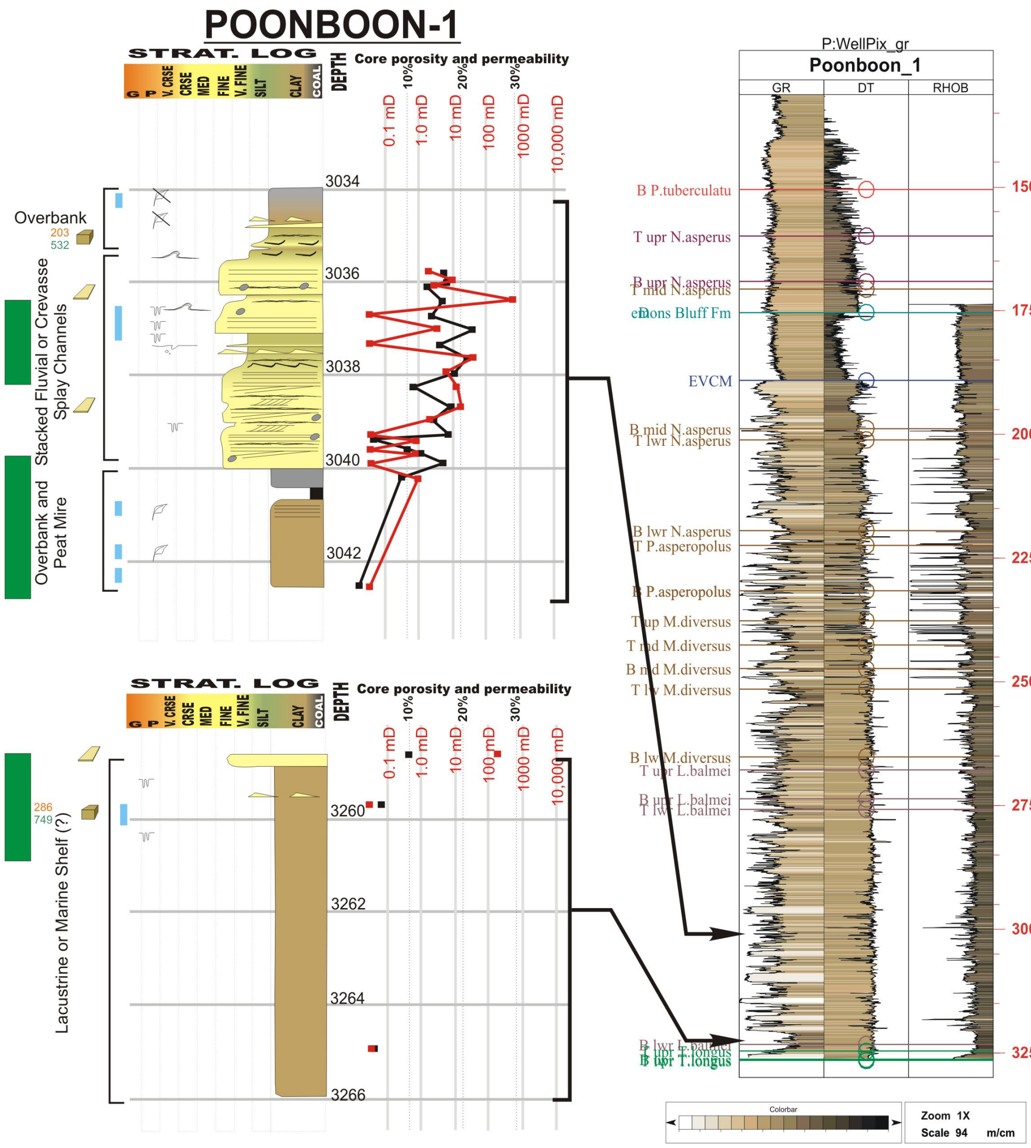
Poonboon-1 Core Photos



Poonboon-1 Core Photos



Poonboon-1 Core Photos



Poonboon-1 Core Photos

Core 1, 1954.77 – 1959.2 m

Core 2, 2467.66 – 2469.79 m

Core 2, 2469.79 – 2474.2 m

Core 3, 2685.6 – 2688.3 m

Poonboon-1 Core Photos

Core 3, 2688.03 – 2690.47 m

Core 4, 3036.41 – 3038.24m

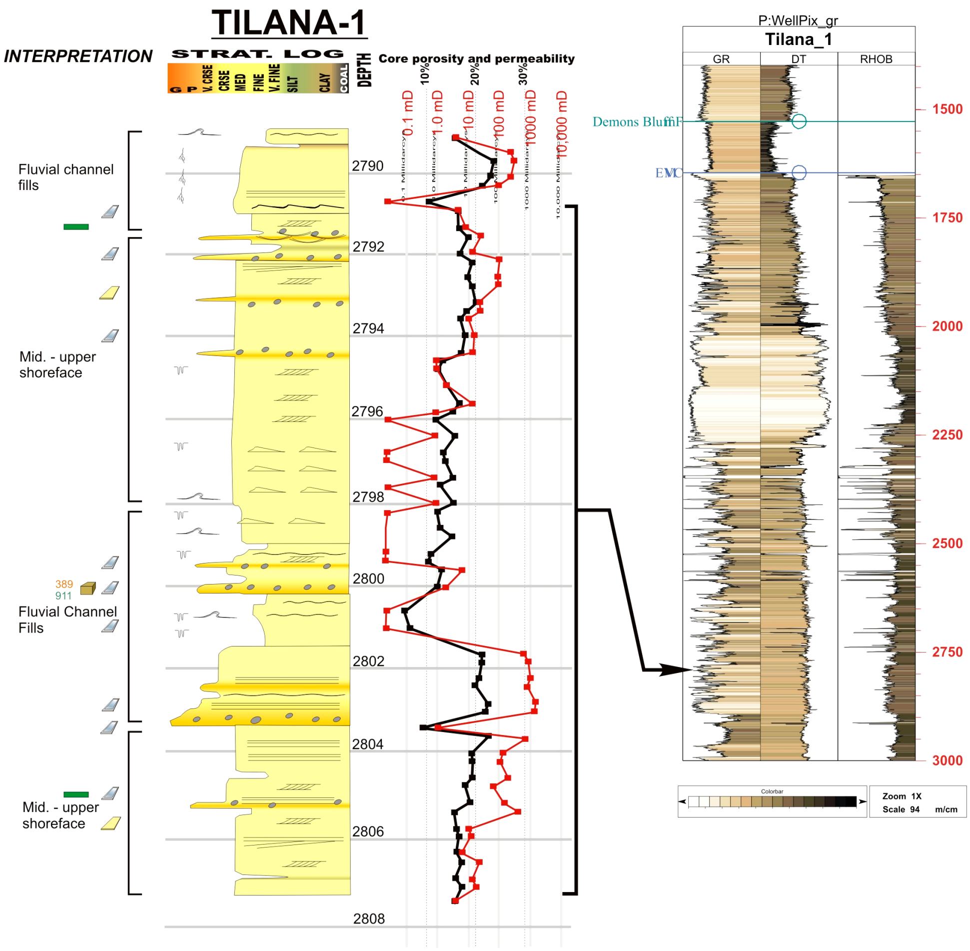
Core 4, 3039.77 – 3041.59 m

Core 4, 3041.59 – 3042.51m

Poonboon-1 Core Photos

Core 5, 3258.61 – 3261.05 m

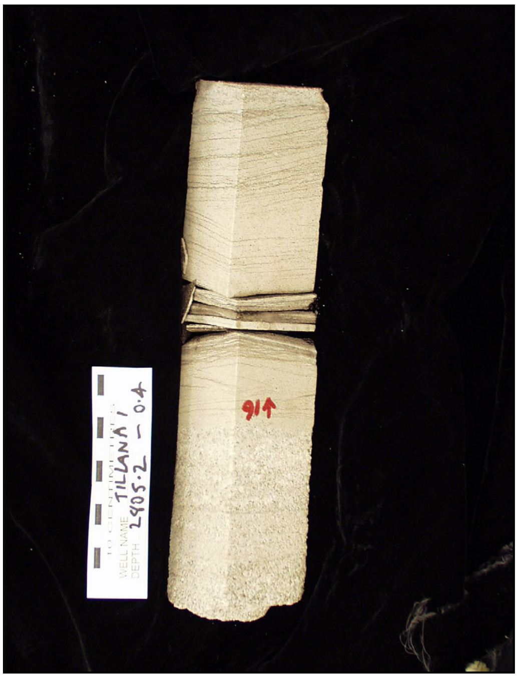
Tilana-1 Interpreted Well Log (Gamma Ray)



Tilana-1 Core Photos

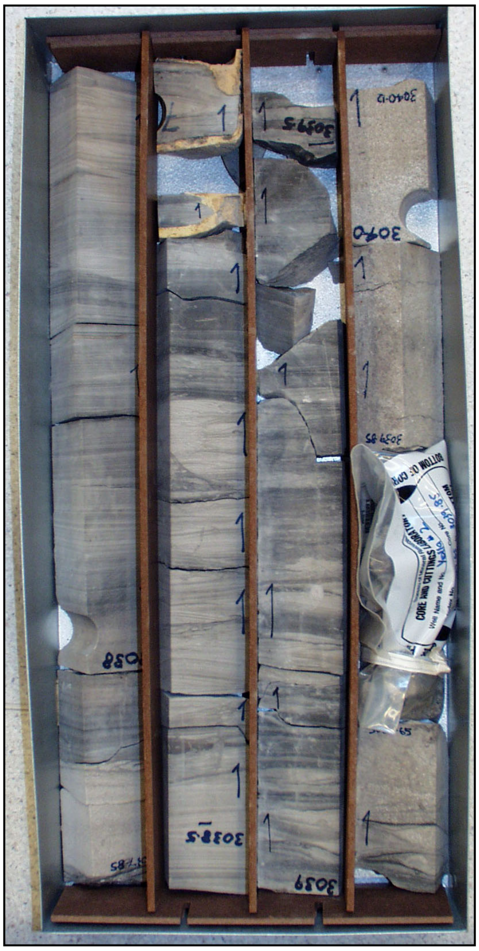
Core 2, 2791.43 – 2791.44 m

Core 2, 2805.2 – 2805.4 m



Yolla-2 Core Photos

Core 1, 3037.85 – 3040.0 m



Core 1, 3047.5 – 3049.23 m